GÖDEL — HILBERT.

— FREGE —

Lógica

moderna

"fuzzy"

y

matemática

1993

Lógica

De la lógica "FUZZY" — (pron. ≠ foësi)
El inventor fue un matemático Lot-fi Zadeh —
de la U. Berkeley de California. "1960" (verdad)

La lógica Fuzzy es un Super-conjunto (de lógica corriente = Booleana) extendida
para manejar el concepto de "verdad-parcial"
Los valores de Verdad entre:

[Completamente Verdadero ←——o——→ y completamente falso]

Keith Devlin. The Language of Mathematics - Making the Invisible Visible -
ed W.H. Freeman (or Scientific American) 1999.
comunica finas ideas matemáticas con un mínimo de ecuaciones (muy)

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Absorbing Dialetheia?

ANTHONY EVERETT

In a series of books and papers Graham Priest has defended a Dialetheian account of the semantic paradoxes, claiming that paradoxical sentences such as the Liar sentence are both true and false. Priest argues that all attempts to provide a consistent account of the semantic paradoxes end up restricting the expressive power of our language in an unacceptable and ad hoc manner, a flaw which he sees his own account as avoiding. However as Priest himself observes, it seems as if his own semantic apparatus generates a version of Curry's paradox and so renders his language trivial. Priest (1987) attempts to block Curry's paradox by rejecting Absorption, offering a countermodel to that principle. It is the purpose of this paper to show that there are slightly modified versions of the Absorption principle for which Priest cannot construct countermodels. It follows that Curry's paradox renders Priest's language trivial after all.

I will begin by briefly rehearsing the Curry argument and Priest's response in §I. Then in §II I will offer two versions of the argument which Priest seems unable to avoid. I consider possible rejoinders in §III.

I

Surprisingly any language which (i) contains modus ponens; (ii) contains the truth schema: "$T\ulcorner A\urcorner \leftrightarrow A$"; and (iii) satisfies the apparently innocuous principle of Absorption:

$$(A \rightarrow (A \rightarrow B)) \rightarrow (A \rightarrow B),$$

will be rendered trivial by the following argument (see Curry (1942)):

Let "S" be the sentence "$T\ulcorner S\urcorner \rightarrow \bot$". Then it follows by the truth-schema:

(1) $(T\ulcorner T\ulcorner S\urcorner \rightarrow \bot\urcorner) \rightarrow (T\ulcorner S\urcorner \rightarrow \bot)$.

From this by our definition of "S" we obtain:

(2) $T\ulcorner S\urcorner \rightarrow (T\ulcorner S\urcorner \rightarrow \bot)$.

But then by Absorption we have:

(3) $T\ulcorner S\urcorner \rightarrow \bot$.

Applying the truth-schema it follows:

(4) $T\ulcorner T\ulcorner S\urcorner \rightarrow \bot\urcorner$.

Our definition of "S" now entails:

(5) $T\ulcorner S\urcorner$.

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And from (3), (5), by modus ponens we get:

(6) ⊥.

Obviously any language in which the Curry inference is valid is rendered trivial.

Observing that Priest accepts the truth schema we might therefore suppose that he will be susceptible to the Curry-argument.[1] However Priest is well aware of this objection ((1980), (1987), and (1990)). Priest attempts to avoid the Curry argument by denying Absorption.

Now Absorption is prima facie an eminently plausible principle. So if Priest is to avoid the charge of ad hocery which he himself levels against consistent accounts of the paradoxes he needs to provide a good reason for rejecting Absorption. Priest tries to do this, going to some length to construct a counter-model (1987).

Priest interprets the entailment connective as a connective of strict implication. After some deliberation he decides that the correct connective for the truth schema is a non-contraposable connective "⇒" which he defines as follows:[2]

"A ⇒ B" is true in a world w iff in all worlds w' such that wRw':

if *True* ∈ v(w', A) then *True* ∈ v(w', B);

"A ⇒ B" is false in a world w iff there is some world w' such that wRw' where:

True ∈ v(w', A) but *False* ∈ v(w', B).

Priest then suggests how, given a suitable reading of possibility, we might construct a counter-model to Absorption (1987, pp. 102-110). Consider the set of worlds <W,Y,Z> (we are intuitively to think of W as being the actual world) where:

v(W, A) = *False* and v(W, B) = *False*,

v(Y, A) = *False* and v(Y, B) = *True*,

v(Z, A) = *True* and v(Z, B) = *False*,

and where we are to restrict R so that all three worlds are possible from the perspective of world W, only world Z is possible from the perspective of world Y, and no worlds are possible from the perspective of world Z.

It can then be easily seen that "(A ⇒ (A ⇒ B)) ⇒ (A ⇒ B)" will be false in world W. First note that "A ⇒ B" will be true in world Z. This follows simply from the definition of "⇒"; no world is accessible to Z and hence it is trivially the case that B is true in all worlds accessible to Z.

Next note that the only world possible in relation to Y is Z. As both "A" and "A ⇒ B" are true in Z but "B" is false in Z it follows that "A ⇒ B" will be false in Y but "A ⇒ (A ⇒ B)" will be true th
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[1] After writing this paper I was pleased to observe that Gupta and Belnap offer a similar argument against Chihara in their (1993).

[2] See Priest (1987, pp. 92-101) for the semantics of the connectives he employs in these definitions.

I do not necessarily endorse Priest's analysis of our natural language entailment conditionals. The area is, of course, one of heated debate. However for the purposes of argument I will assume that Priest is correct.

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in Y but "A ⇒ (A ⇒ B)" will be true there. From this it follows that Absorption will be false in W. Thus we have a counter-model to Absorption.[3]

II

However a little reflection reveals that Priest's counter-model depends upon his denying the unrestricted reflexivity of the possibility relation. To see this note what a counter-model to Absorption needs to look like. We need the world Z to be such that both "A" and "A ⇒ B" are true there while "B" is false. However if possibility were universally reflexive, as both "A" and "A ⇒ B" are true in Z, it would clearly follow that "B" would be true there as well.[4]

In this case "A ⇒ B" would be both true and false in Y. And consequently our "counter-model" would make the Absorption principle both true and false in the actual world. Thus if possibility was reflexive, any counter-model Priest might try to construct would make Absorption both true and false.

Now it is not sufficient for Priest's purposes merely that the Absorption principle be actually false. He also requires that it fails to be actually true. For the only way the Absorption principle can be actually true and also have a true antecedent will be if its consequent is also true (and this will be the case even if the principle is both true and false). So if Absorption is both true and false we will be able to run a version of the Curry argument after all.

This suggests a possible response to Priest: we modify our Curry sentence "T⌜A⌝ ⇒ B" so as to build in the reflexivity of possibility in such worlds as Z. The validity of Absorption now follows by dilemma. Either the Absorption principle is true in all models or there are some models in which it is false. In the former case the Absorption principle is clearly valid and a version of the Curry argument can proceed as before. In the latter case the argument presented above entails that Absorption will be *true* as well as false in the "counter-models", and so once more Absorption will be validated and a version of the Curry argument can proceed as before. Either way Absorption will be true and Priest will be in trouble.

Let us continue. There seem to be two ways in which we might guarantee the desired reflexivity of possibility.

(1) Firstly we might modify the antecedent of our Curry sentence. We might adjoin to sentence "A" another sentence which claims that the world of evalua-

[3] It might be objected that Priest's semantics for "⇒" implies both (i) that in some world not accessible from itself *every* formula of the form "A ⇒ B" is true, and (ii) that the modus ponens inference "A ⇒ B; A so B" is not valid, since in some world it has premises which are true (and not also false) and a conclusion which is false (and not also true). And one might consequently wonder whether "⇒" can reasonably be read as any kind of conditional. If it cannot then so much the worse for Priest. However for the purposes of argument I will assume here that it can.

[4] On its own, the possibility of "B" being both true and false should not of course worry the Dialetheist.

tion is possible relative to itself. For example the English sentence "this world is possible relative to itself" would fit the bill.[5] Our Curry sentence would then be amended to:

A: $T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot$

(where "$\Re$" is an indexical expression asserting the reflexivity of possibility in the world in which it is evaluated). Now consider one half of the truth-schema:

(1*) $[T^{\ulcorner}T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot^{\urcorner}] \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)$.

From this it follows from our definition of "A":

(2*) $T^{\ulcorner}A^{\urcorner} \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)$.

Clearly as "$\Rightarrow$" is a conditional of strict implication we can weaken its antecedent without changing its truth value, hence:[6]

(3*) $(T^{\ulcorner}A^{\urcorner} \& T^{\ulcorner}\Re^{\urcorner}) \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)$.

Since truth distributes across conjunction this entails:

(4*) $T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)$.

Now, given that "$\Re$" asserts the reflexivity of possibility in worlds where it is evaluated, we will be unable for the reasons rehearsed above to construct a genuine counter-model in which the following instance of the Absorption schema fails to be true:

AI: $(T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)) \Rightarrow (T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot)$.

All models will make this Absorption principle actually true, even those which also make it actually false. We are therefore justified in inferring:

(5*) $T^{\ulcorner}A\&\Re^{\urcorner} \Rightarrow \bot$.

And the argument to triviality can now proceed as before.

(2) A second way in which we might gain the desired reflexivity is to define a new modified entailment connective. We might amend the semantics for "$\Rightarrow$" by restricting the worlds over which the defining quantifiers range to those worlds where the possibility relation is reflexive (let us represent this new connective by "$\rightrightarrows$"). The Curry inference will then proceed as follows. Consider the sentence:

A: $T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot$.

By the truth schema we have;

(1**) $T^{\ulcorner}T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot^{\urcorner} \leftrightarrows (T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot)$.

Note of course that the truth schema we employ must be couched in terms of our new connective "$\rightrightarrows$" rather than the connective "$\Rightarrow$" which Priest employs. However this poses no problem for our argument. For if the original truth-schema

[5] The sentence "$(w)wRw$" would be a non-indexical alternative—where the quantifier is interpreted as ranging over the set of worlds which Priest quantifies over when defining his entailment connective and where "R" is Priest's predicate expressing the accessibility relation between worlds.

[6] Of course many would hold that weakening can alter the truth value of our everyday implication conditional. But this is beside the point so far as the current argument against Priest is concerned—here we need consider only Priest's own Strict Implication conditional.

"$T^{\ulcorner}A^{\urcorner} \Leftrightarrow A$" is true, then by the semantics for "$\Rightarrow$", "$T^{\ulcorner}A^{\urcorner}$" will be true in every world where "A" is true and vice versa.

But then it also follows that "$T^{\ulcorner}A^{\urcorner}$" will be true in every world *where possibility is reflexive* and where "A" is true, and vice versa. For the worlds where possibility is reflexive merely form a subclass of those considered when evaluating the original truth schema. If "$T^{\ulcorner}A^{\urcorner}$" is true in every A-world it will also be true in every reflexive A-world. And if "A" is true in every $T^{\ulcorner}A^{\urcorner}$-world then it will also be true in every reflexive $T^{\ulcorner}A^{\urcorner}$-world.

So if we are justified in invoking the full truth-schema in the original Curry-argument we will also be justified in invoking the modified version in our new argument. Substituting for "A" into the schema we can therefore assert:

(2**) $T^{\ulcorner}A^{\urcorner} \rightrightarrows (T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot)$.

The relevant instance of the Absorption scheme will now be:

(3**) $(T^{\ulcorner}A^{\urcorner} \rightrightarrows (T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot)) \rightrightarrows (T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot)$.

Given the fact that our new connective "$\rightrightarrows$" guarantees the reflexivity of possibility in those worlds where it is evaluated, every model will make this instance of Absorption true in the actual world, even those which make it false there as well! So we are justified in inferring:

(4**) $T^{\ulcorner}A^{\urcorner} \rightrightarrows \bot$.

And the argument to triviality can once more proceed as before.

III

I have offered two modified versions of the Curry argument which appear to render Priest's language trivial. How might Priest respond to these?

The first thing to note is that unlike some previous attempts to show Priest's language trivial, I have *not* tried to justify a problematic principle by arguing that its validity follows from Priest's semantics.[7] As Priest ((1989) and (1990)) correctly notes such an argument would have to presuppose the validity of the very principle in question. Instead I argue for the validity of my versions of Absorption, and the corresponding Curry arguments, by showing that my Absorption principles are true in all models. My principles cannot be false in a model without also being true there. Thus in my argument I do not presuppose any Dialetheistically invalid inferences, and in particular I do not presuppose the validity of Absorption.

Could Priest resist my arguments by simply barring such expressions as "$\Re$" and "$\rightrightarrows$" from his language? Not without restricting the expressive power of his language in an ad hoc manner and so rendering himself subject to the very criticisms he makes of his consistent rivals. For the connective "$\rightrightarrows$" is merely a restriction of a conditional Priest himself accepts. And English is rife with suitable indexical expressions to stand in place of "$\Re$". Indeed in his writings Priest

[7] See for example Priest (1989), and Thompson (1986).

seems to provide us with the apparatus for generating such expressions as "$\mathfrak{R}$". His language contains a relational predicate expressing the relative possibility relation, "R". So we can define my sentence "$\mathfrak{R}$" as follows:

"$\mathfrak{R}$" is true in a world w iff wRw.

What if Priest denies that we can meaningfully introduce such expressions into his language, arguing that their introduction fails to produce a conservative extension of his language and then invoking Belnap's (1962) "conservative extension" criterion to rule them out as not meaningful? (Priest (1990) makes this sort of move with respect to a connective expressing classical Boolean negation.)

I have two points to make in reply. The first is just to re-emphasise that English does seem to contain informal versions of "$\mathfrak{R}$", and does seem to be capable of expressing informal versions of "$\rightrightarrows$". Whether or not these would fail to produce a conservative extension if added to an English previously free of them is beside the point. Perhaps English is rendered trivial and incoherent by containing the natural language equivalents of "$\mathfrak{R}$" and "$\rightrightarrows$". But Priest's project is not to reconstruct English to avoid such difficulties, but rather to show how the paradoxes could be accommodated within English as we know it.[8] A failure of Priest's language to contain "$\mathfrak{R}$" will still render his language expressively incomplete, and therefore undermine his project.

In the second place it is not clear that we should accept a failure to satisfy Belnap's conservative extension test as a reason to reject "$\mathfrak{R}$" and "$\rightrightarrows$". Note that the addition of "$\mathfrak{R}$" or "$\rightrightarrows$" to our language will only fail to produce a conservative extension in the presence of the universal truth schema. It is the presence *both* of these expressions *and* of the truth schema which generates triviality. So why should it be "$\mathfrak{R}$" and "$\rightrightarrows$" that we blame for this rather than the universal truth schema?

IV

Although Priest is able to avoid our original version of the Curry argument it seems he cannot avoid the modified versions I have offered without unnaturally restricting the expressive power of his language and falling prey to exactly the same complaint that he levels against consistent accounts of the semantic paradoxes. So Priest seems no better off than his consistent rivals. Indeed he is worse off. For given a choice between an expressively restricted but consistent account and Priest's expressively restricted account with its nasty Dialetheia, I know which I would prefer![9]

[8] Of course if we were in the business of reconstructing English would be better to do it consistently without invoking nasty Dialetheia.

[9] I would like to thank Paddy Blanchette, Mic Detlefsen, Michael Kremer, Timothy Smiley, and in particular Graham Priest and an anonymous r ee for their help and comments.

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Review

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Jan Woleński: "Jan Łukasiewicz on the Liar" Paradox, logical consequence, Truth, and Reduction.

Łukasiewicz's version of the Liar is included in his paper on the concept of on science published in 1915.[3] Explaining the Liar, Łukasiewicz proceeds as follow:

> There are mental constructions which seem to contain an inevitable contradiction. For example, the sentence: line 13 on p. XXXV of this book contains a false sentence, is a construction of this kind.
>
> This sentence contains a contradiction, because, observing that this sentence contains itself in the line 13 on p. XXXV of this book, it is easy to prove that its truth entails its falsity as well as that its falsity entails its truth. [Łukasiewicz *1915*, XXXV]

Then Łukasiewicz offers a solution of the Liar. His proposal is this:

> [...] every logical principle contains v a r i a b l e s .
>
> [...] These variables, like variables in mathematics, can have various values. Now there is a logical law which says that all logical principles concern only t h o s e objects which can be v a l u e s o f v a r i a b l e s . One can show that the above sentence containing the contradiction cannot be value of a variable. Hence logical principles do not apply to this sentence; this construction is outside logic. [Łukasiewicz *1915*, XXXV].

So far Łukasiewicz. Tarski's statement of the Liar in his essay can be taken as a strict formalization of the version proposed by Łukasiewicz. However, there is something more. Łukasiewicz's own solution of the Liar consists in excluding the Liar sentence from the domain of logic. Thanks to Tarski, Łukasiewicz's version of the Liar became standard. But although he proposed a way out from the Liar paradox, he did not explain why the Liar sentence does not adhere to the principles of logic. This was done by Leśniewski and Tarski, who argued that so-called "closed" languages (languages that contain own metalanguages) violate principles for constructing correct formalized languages and thereby must be ruled out of the province of logic.[4]

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[3] This essay is a general introduction to the whole volume, which contains many other interesting papers, in particular by Zygmunt Janiszewski, Wacław Sierpiński and Stefan Mazurkiewicz.

[4] See [Tarski *1933*, chapter 1] and [Tarski *1944*, sect. 8]. These two works contain references to Leśniewski's view on sources of the semantic paradoxes and ways of overcoming them. Unfortunately, Leśniewski had never published anything on semantic paradoxes. It is known that he prepared an extensive monograph on this topic. The sole copy, written in pencil, was destroyed during the Warsaw uprising in 1944.

It is a widespread opinion that Łukasiewicz stated his version of the Liar in an oral discussion.[5] This situation probably stems from the fact, which I have already mentioned, that Tarski gave no textual reference to Łukasiewicz. We can ask why [Łukasiewicz *1915*] is almost entirely overlooked (see [Łukasiewicz *1912*]).

The history of this paper is interesting. In 1912, Łukasiewicz published a paper on creativity in science.[6] Then he was invited to write an introductory essay for *A Guide for Autodidacts*, and he decided to extend his [*1912*] by adding remarks on the Liar paradox and logical consequence. The additions do not form new sections but are inserted into the old text. This may be main reason that references to Łukasiewicz's paper are mostly made to the version published in 1912 which became very influential in Polish philosophy, particularly for Łukasiewicz's classification of arguments given there for the first time.[7] When a selection of Łukasiewicz's logical papers was being prepared, its editor, Jerzy Słupecki, included the 1912 version and then it was translated into English.[8]

Łukasiewicz's paper of 1915 also contains a definition of logical consequence in the semantic sense:

> We say that a sentence *b* follows from a sentence or a group of sentences *a* if *b* must be true, provided that *a* is true. [Łukasiewicz *1915*, XXII]

As far as I know this one of the first (perhaps even the very first) correct definitions of logical consequence in modern logic since Bolzano.[9] In Poland, it was rediscovered by Ajdukiewicz in 1923 and generalized by Tarski in 1936. For Ajdukiewicz [*1923*, 161]:

> A formula $f(x)$ formally entails a formula $\phi(x)$, if for any possible substitutions for x, either $f(x)$ is false or $\phi(x)$ is true.

[5] I heard this opinion on several occasions from many Polish logicians and philosophers, including persons who had direct contact with Łukasiewicz, Tarski, and their students. Unfortunately, no written record confirms this fact.

[6] This situation seems paradoxical, for [Łukasiewicz *1915*] was reprinted twice in Poland in the interwar period.

[7] See [Giedymin *1985*] for general comments on the importance of [Łukasiewicz *1912*] for Polish philosophy and [Woleński *1991*] for Łukasiewicz's classification of types reasoning and its reception.

[8] See [Łukasiewicz *1961*] and [Łukasiewicz *1970*]. Słupecki as well as Borkowski (the editor of [Łukasiewicz *1970*]) probably forgot about additions in [Łukasiewicz *1915*]. In any case, there is no other explanation their editorial choices with respect to the paper in question.

[9] I base this assertion on my own examination of numerous books in logic published in the period under consideration. My evaluation of the matter was also confirmed by several people interested in the history of logic. Of course, this basis does not preclude the possibility that I am mistaken.

From this definition it follows that, if A formally (logically) implies B, then B cannot be false, provided that B is true.[10] For Tarski [*1936*; q.v. *1956*, 417]:

> The sentence X follows logically from the sentences of the class **K** if and only if every model of the class **K** is also a model of the sentence X.

Tarski's formulation is commonly regarded as a modern statement of Bolzano's idea of logical consequence. However, the essential point of this important idea was anticipated, at least in Poland, by Łukasiewicz.

2. Łukasiewicz on the concept of truth. Łukasiewicz, influenced by Aristotle and the Brentanist tradition, accepted the classical (correspondence) theory of truth.[11] His statement of this theory is this:

> A sentence is true or false only if it states that something exists or does not exist. [Łukasiewicz *1910*; 2nd (1987) edition, 14]

> A judgment is true if it ascribes to an object a property which belongs to this object or denies a property which does not belong to it. [Łukasiewicz *1911*, 86]

> If truth consists in conformity of thought to reality, we may say that those propositions are true which conform to [...] reality. [Łukasiewicz *1957*, 208]

These quotations illustrate Łukasiewicz's general position on truth. However, we also can find in [Łukasiewicz *1913*] an idea that remains in Tarski's semantic theory of truth.

For Łukasiewicz, truth and falsity are unconditional and absolute properties of sentences.[12] In particular, probability cannot be used for the logical evaluation of sentences. On the other hand, formulas in which free variables occur ("indefinite proposition" is Łukasiewicz's term) can be characterized by their logical probability. Let **D** be a domain consisting of a finite number of objects and let $F(x)$ be a formula with x as a

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[10] A similar definition can be extracted from [Ajdukiewicz *1934*].

[11] See [Woleński and Simons *1989*] for comments on Łukasiewicz's philosophy of truth. Łukasiewicz was a student of Twardowski in Lvov and Meinong in Graz, both of whom were in turn distinguished students of Brentano.

[12] For Łukasiewicz (and similarly for Tarski), sentences are always objects equipped with meaning. I do enter here into a discussion on whether this conception of sentences is sound or not. I note this point because most English commentators on Tarski's work on truth ask whether sentences (as purely syntactic items) may be true or false. The "Polish" answer is simple: yes, because sentences are meaningful items.

free variable. Now assume that there are n-many objects in D and m-many objects that satisfy $F(x)$. Then the ratio $\frac{m}{n}$ expresses the probability of $F(x)$. Moreover, Łukasiewicz says:

> Indefinite propositions are true if they yield true judgements for all values of the variables.
>
> Indefinite propositions are false if they yield false judgements for all the values of the variables. ([Łukasiewicz *1913*, 16; page number is to the *1970* English translation])

To see how close Łukasiewicz was to the semantic definition of truth, let me recall Tarski's condition for quantified (universal) sentences: $\forall x F(x)$ is true if and only if $F(x)$ is satisfied by all values of a variable x. The right part of this biconditional is equivalent to Łukasiewicz's definition of truth for indefinite propositions. According to Tarski, a sentence is true if it holds (is satisfied) for all objects. Tarski's heuristic strategy is to regard sentences as particular cases of open formulas and truth as a special case of satisfaction. On the other hand, Łukasiewicz was not interested in defining truth *via* satisfaction, probably because he assumed that a gap between sentences and indefinite propositions is so essential that the former cannot be special cases of the latter. Hence, truth cannot be a special case of satisfaction. For Łukasiewicz, the truth of open formulas was nothing more than an auxiliary idea used by him to develop the theory of logical probability.

3. **Łukasiewicz on induction.** Induction was a favourite subject of Łukasiewicz before he concentrated on mathematical logic. He devoted his doctoral dissertation to the problem of induction (published as [Łukasiewicz *1903*]), and he delivered three talks on induction before the Polish Philosophical Society in Lvov in 1906-1909 ([Łukasiewicz *1906*, *1907* and *1909*] are abstracts of these lectures). Induction is also briefly considered in [Łukasiewicz *1912*] and [Łukasiewicz *1915*]. Finally, he discussed induction in the last part of [Łukasiewicz *1929*].[13] At first, Łukasiewicz tried to develop the inverse theory theory of induction proposed by Jevons and Sigwart in the nineteenth century. On other hand, from the beginning of his interests in induction, Łukasiewicz was rather

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[13] This section (§11) is omitted in the second Polish edition (see [Łukasiewicz *1958*]) as well as in the English edition (see [Łukasiewicz *1963*]). Arthur Prior complains of this omission in his [*1968*] review of [Łukasiewicz *1963*]. The German translation of §11 is included in [Pearce and Woleński *1988*]. Note that the problem of induction is not touched upon in [Łukasiewicz *1913*]. One might be surprised that there is a chapter on induction in a very advanced textbook on mathematical logic. However, it was a tradition in Poland to speak on induction at the end of courses in mathematical logic.

sceptical about evaluating inductive conclusions by probability. He expressed this view in his dissertation. There is also an interesting fragment of his letter to Kazimierz Twardowski (August 31, 1902):

> In order to reject (I would like to do this) that view [that experience provides the devices for the estimation of the probability of the inductive conclusions - J. W.] one must prove that particular propositions, independently of their number and kind, cannot serve as the logical basis for the probability of a generalization [...] I am eager to solve this question by admitting that there is only mathematical probability.

An argument against the probabilistic theory of induction is given in [Łukasiewicz *1909*]. The argument is this. Assume that H is a hypothesis which is tested by induction. At first sight, we we could apply Laplace's rule $p = \frac{n+1}{m+2}$. According to this rule, p is the probability that the $(n+1)^{st}$ event has a property, say P, provided that it is established in advance that n events have P. Since this rule applies only to particular events, it is not applicable to genuine inductive generalizations. Laplace's rule is a special case of a more general formula: $p = \frac{n+1}{n+m+1}$, where m is the cardinality of the domain of events to which H refers and n measures the basis of induction, i.e. the number of events already observed. Now m is always greater than n, so p cannot be greater that 2 and, what is more important, if m approaches infinity, p approaches 0. Thus, no finite amount of data acquired by experience is sufficient for confirming any general inductive hypothesis. Łukasiewicz also expresses his anti-inductivism in his papers of 1912 and 1915. The last section of [Łukasiewicz *1929*] contains perhaps his most negative evaluation of induction:

> [...] inductive logic has no scientific value. (p. 95)

> [...] so-called inductive reasoning has neither a scientific value no any application in the science. On the other hand, deductive reasoning plays an essential role in the science. (p. 196).

Clearly, Łukasiewicz anticipated basic tenets of Popper's anti-inductivism. Some commentators see general similarities in the two authors.[14] However, the most interesting point is perhaps that Łukasiewicz had Popper's celebrated mathematical argument against induction.

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[14] This point is stressed in [Prior *1968*].

4. Conclusions. As I have already noted, Łukasiewicz's version of the Liar paradox became standard *via* Tarski's work on truth. Thus, it is clear that Łukasiewicz ideas on the Liar began the development which culminated in the Leśniewski-Tarski account and solution of the paradox. No evidence is available as to whether or not Łukasiewicz's definition of the concept logical consequence influenced Tarski or Ajdukiewicz. This is also true of [Łukasiewicz 1913] and its influence on Tarski's conception of truth. Polish philosophers of science were mostly inductivists and, in general, they were not particularly attracted by Łukasiewicz's criticism of induction as a method of confirmation of empirical generalizations.[15] Thus, if published references provide evidence of how someone's ideas influence the history of logic, we must conclude that the ideas of Jan Łukasiewicz concerning truth, the concept of logical consequence, and induction did not exert any influence even in his own country. However, perhaps one remark is in order. It is known that many important ideas circulated among Polish logicians in conversation.[16] This was an important factor In doing logic in the Warsaw School. So it is quite possible that Łukasiewicz, who was the principal leader of the Warsaw School of Logic, communicated his ideas on truth and logical consequence in informal debates with his students and colleagues and thereby influenced their way of thinking on related topics.

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2.1. The temporal language

In this section, we describe a language for temporal scenarios. The language itself is not a logic, in the sense that it provides no inference rules and therefore has no interpretation. We give intended interpretations for some of the terms of our language, but we leave it to later sections—which describe various theories of temporal reasoning—to enforce these interpretations through particular rules of inference.

We have borrowed much of this language from Hanks and McDermott's [8] presentation of McDermott's temporal logic [21], although we have taken several liberties with that language. The ontology also incorporates a few features of McCarthy and Hayes's situation calculus [20]. However, while the situation calculus takes actions and action occurrences to be fundamental, our language—like McDermott's—is built with time points as primitive. As a result, we allow any number of actions to occur between world states. In this respect, our language resembles the one defined by Haugh in [11].

Several considerably more sophisticated temporal ontologies have been described in the literature (e.g., Allen's interval logic [1]; Hayes's histories [12]; McDermott's full temporal logic [21]; Shoham's modal system [30]). However, the naive ontology that we present here is sufficient to describe the salient features of most nonmonotonic approaches to temporal reasoning, and to demonstrate our claims with respect to the importance of causation. Indeed, the problems that arise in this ontology would only worsen in a more sophisticated logic, and the need for some adequate notion of causation would only be strengthened.

In our ontology, a point in time defines a particular *world state*. This world state is expressed as a set of state–value pairs: $\langle \text{alive}, \top \rangle$; $\langle \text{on(a,b)}, \bot \rangle$; $\langle \text{color(house)}, \text{red} \rangle$. Although the complete state of the world can be expressed by enumerating these pairs, in general we only want to describe a portion of this state. We use the notation HOLDS(t,state) to mean that state has the value $\top$ in the world state with index t. We introduce some syntactic sugar: we define $\neg\text{HOLDS}(\text{t}, \text{state}) \triangleq \text{HOLDS}(\text{t}, \text{not}(\text{state})) \triangleq$ state has the value $\bot$ in the world state with index t; also

$$\begin{aligned}\text{HOLDS}(\text{t}, \text{state}_1 \ \&\ \text{state}_2) &\triangleq \text{HOLDS}(\text{t}, \{\text{state}_1, \text{state}_2\}) \\ &\triangleq [\text{HOLDS}(\text{t}, \text{state}_1) \wedge \text{HOLDS}(\text{t}, \text{state}_2)] \\ &\triangleq \{\text{HOLDS}(\text{t}, \text{state}_1), \text{HOLDS}(\text{t}, \text{state}_2)\}.^{2}\end{aligned}$$

By a slight abuse of notation, we use "predicate" notation to express states with non-boolean value: HOLDS(t, color(house, red)) means color(house) has the value red in the world state with index t, and HOLDS(t,not(color(house,red))) if

[2] Throughout this paper, we treat sets and conjunctions interchangeably.

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nov. 1994

the value of color(house) is not red in the world state with index t.[3] We say that TIME(HOLDS(t, state)) = t; similarly, STATE(HOLDS(t, state)) = state.

The state of the world is changed by *actions*. For example, if a load action occurs in a world state—with index t—in which a gun is not loaded (¬HOLDS(t, loaded)), then t + 1 is a world state in which the gun *is* loaded (HOLDS(t + 1, loaded)). Although we index world states by integers, we do not insist that there be a fixed time interval between world states. For example, the time elapsed between t_0 and t_1 may not equal the time elapsed between t_1 and t_2. We use the notation OCCURS(t,act) to mean that action act occurs in the world state with index t; the resulting world state is t + 1. While actions provide transitions over world states, we do not insist that a single action occur in every world state. That is, we allow both concurrent actions—two or more actions simultaneously providing a transition between world states t and t + 1—or no action at all. When two or more actions occur concurrently, they are constrained to take the same amount of time. The result of no action in a world state is presumably a world state very much like the previous one, although time has changed, the earth has rotated, etc. We also allow statements of the form ¬OCCURS(t, act) that explicitly exclude any occurrence of act in the world state with index t. We define TIME(OCCURS(t, act)) = t and ACT(OCCURS(t, act)) = act.

To connect world states and actions, we introduce the notation

CAUSES(preconditions, excluded_actions, actions, effect). (1)

Intuitively, this means that if preconditions hold when actions (but not excluded_actions) occur, then effect will hold (or occur) in the resulting world state. We allow preconditions to be a set (i.e., a conjunction), so that we can have multiple preconditions. Excluded_actions and actions are always sets, though excluded_actions will generally be empty and actions generally singleton. (See below.) Multiple consequences can be represented using several CAUSES statements. Effect may be either a state or an action. For example, the definition of blocks world's move might read

Estructura recursiva:

CAUSES({clear(a), clear(b)}, {}, {move(a, b)}, on(a, b)). (2)

The excluded_actions are relevant only in cases of interfering concurrent actions. For example, consider (a slight modification of) Lifschitz et al.'s [6] example of lifting a table that is holding a bowl of soup. Lifting only one side of the table will cause the table to tilt and the soup to be spilt. If both sides of

[3] The careful reader will note that color(house,scarlet) will yield not(color(house,red)), even if red ≐ scarlet. We can fix this by allowing multivalued, or set-valued, states; or by rigid designators; or by treating color(house,red) as a boolean-valued state (where color(house, red) ≐ color(house, scarlet)). In any case, these details are not important for the discussion at hand.

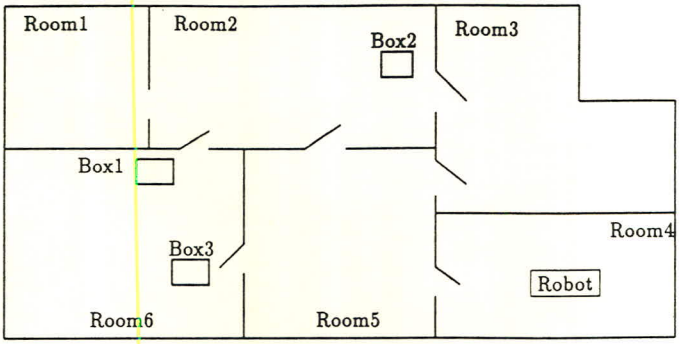


Fig. 8. Robot–box planning domain.

Table 6
Operators for the robot–box domain

	Preconditions	*Adds*	*Deletes*

`pull-thru-door(b,d,r1,r2)`	`IsDoor(d)`
	`IsBox(b)`
	`IsRoom(r1)`
	`IsRoom(r2)`
	`Connects(d,r1,r2)`
	`Attached(b)`
	`BoxInroom(b,r1)`
	`Open(d)`
		`BoxInroom(b,r2)`	`BoxInroom(b,r1)`

`attach-box(b)`	`IsBox(b)` `¬Attached(b)`	`Attached(b)`	`¬Attached(b)`
`load-box(b)`	`IsBox(b)` `¬Loaded(b)`	`Loaded(b)`	`¬Loaded(b)`

`open(d)`	`IsDoor(d)`
	`Openable(d)`
	`¬Open(d)`
		`Open(d)`	`¬Open(d)`

a partially ordered graph of the literals. Each node in the graph denotes a set of literals that are to be assigned the same criticality value in the final hierarchy. If a node n_j precedes n_i in the graph, i.e., if there is a path from n_j to n_i in the graph, then we cannot place n_i above n_j in the final hierarchy; the criticality value of n_j must be greater than or equal to the criticality value of n_i. The algorithm ensures that every total order supported by the graph will yield a hierarchy that has the ordered monotonicity property, whereby every refinement of an abstract plan leaves all the higher-level literals unchanged.

The core of the ALPINE algorithm is the following restriction:

```
SOLVE-NAIVE(P)
10 impose an ordering on the variables: X_1, X_2, ..., X_n
20 initialize iterators I_{1...n} for scanning the domain of each variable
30 i ← 1
40 while true do
50     v ← NEXT(I_i)
60     if v = nil then
70         if i = 1 then
80             return nil
90         else i ← i − 1
100    else if v instantiates X_i then
110        if i = n then
120            return current variable assignments
130        else i ← i + 1
140            RESET(I_i)
```

Fig. 1. The naive backtrack algorithm for solving constraint satisfaction problems.

naive backtrack and other CSP algorithms is provided in [5]. For succinctness, a variable at position i along an imposed ordering will be referred to simply as variable i. We also call the first variable in an ordering the *root* variable, and the others *non-root* variables.

1.2.2. Arc-consistency-based algorithms

Arc consistency [11, 12] is a preprocessing scheme which accepts a CSP and removes all unsupported values from its domains. Using the terminology from [11], an *unsupported* value is one whose assignment alone prevents the satisfaction of some binary constraint involving the assigned variable. We say a value *supports* another value with respect to a particular constraint if their assignments satisfy the constraint. A *width*-1 variable ordering is one where every node in the problem's ordered constraint graph connects to at most one node preceding it in the ordering. For any tree-structured problem, a width-1 ordering exists and can be found in time $O(n)$ by performing a depth-first traversal of the constraint graph.

Width-1 orderings are of interest because determining whether a value instantiates a variable along a width-1 ordering requires testing at most one constraint. After achieving arc consistency, we are guaranteed that given any variable assignment, any constraint involving the assigned variable can be satisfied by some other assignment. Invoking naive backtrack along a width-1 ordering after arc consistency preprocessing therefore achieves a solution backtrack-free, or in time $O(nk)$. By using an arc consistency algorithm that is $O(nk^2)$-bounded

(such as the one from either [1] or [12]), this approach to solving tree-structured problems is optimal in the worst case.

A formal proof that $O(nk^2)$ is optimal for tree-structured problems is provided in [6]. The proof idea is simply that each constraint in the problem must be examined at least once, and each such examination may require checking order k^2 assignments.

Directional arc consistency [6] is a more limited form of preprocessing that accepts a CSP and a fixed variable ordering, and removes from the variable domains any value whose assignment alone prevents the satisfaction of some binary constraint defined on the assigned variable and any other variable following it in the ordering. Directional arc consistency therefore removes only a subset of the domain values removed by arc consistency, enabling both simpler and faster implementations. After directional arc consistency preprocessing given a width-1 ordering, naive backtrack along that ordering achieves a solution backtrack-free. Because directional arc consistency can be performed in $O(nk^2)$ time [6], this scheme is also optimal. Due to its lower constant, this approach is preferable to full arc consistency preprocessing, and has been the algorithm of choice for use in backtrack enhancement schemes which exploit the easiness of tree-structured problems [3, 6].

An algorithm for solving tree-structured problems that performs directional arc consistency preprocessing (DAC) is provided in Fig. 2. This algorithm is essentially a translation of the tree algorithm from [3], although it is slightly simplified due to our additional assumptions: without loss of generality, we from this point on assume a tree-structured problem has a connected constraint graph. This allows us to assume that every variable except the root has exactly one parent, where the *parent* of a variable is a variable both preceding it in the ordering and connecting to it in the constraint graph. A width-1 ordering can be

```
    SOLVE-DAC(P)
 1  impose a width-1 variable order: d = X_1, X_2, ..., X_n
 2  for i = n downto 2 do
 3     p ← position of X_i's parent
 4     REVISE(X_i, X_p)
 5     if X_p's domain is empty then
 6        return nil
 7  return SOLVE-NAIVE(P, d)

    REVISE(X_c, X_p)
 8  for each value v in X_p's domain do
 9     if there is no value in X_c's domain supporting v then
10        delete v from X_p's domain
```

Fig. 2. A directional arc-consistency-based algorithm for solving tree-structured problems.

El árbol, [illegible] siendo una "estructura" crucial!

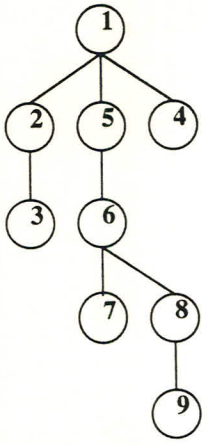


Fig. 4. A TT1 ordering of an acyclic constraint graph.

2.1.1. Correctness

We define the *run* of a particular iterator to be the set of values returned by ti iterator since its most recent reset, excluding those values deleted from t problem and any value currently assigned to its variable. Note that all values the run of a variable's iterator become members of the run while the same value assigned to the variable's parent. This is because after reassignment of the pare variable, before the iterator is advanced again, it gets reset by line 15. We refer the value assigned to the parent during the course of a variable's iterator run the *parent value*.

Lemma 2.1. *At any point during TT1 execution, the values in the run of a iterator over a non-root variable domain do not support the parent value.*

Proof. Given the width-1 ordering, if any value v supporting the parent value encountered by the iterator of a non-root variable, the variable is instantiat with v and control progresses to the remaining variables. For the current run this iterator to be extended, a backtrack must take place to the iterator's variab which causes v to be deleted from the problem. It is therefore impossible for value supporting the parent value to become a member of an iterator's run.

Theorem 2.2. *TT1 returns a non-nil solution if a non-nil solution exists, ar returns nil otherwise.*

Proof. Besides the specific variable ordering policy required by TT1, the or difference between it and naive backtrack is the backtrack scheme which invoked when an iterator exhausts the domain values of a non-root variable (li 9). At this point, the run of the current variable's iterator contains every val

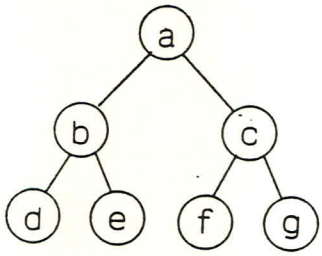


Fig. 1. A uniform binary tree of depth 3.

If the search space is a tree, then step 2 is effectively a depth-first traversal of the tree with cut-off equal to d.

In the agent searching framework, the iterative deepening approach is similar except that it is assumed that a new iteration may not necessarily start at the source node. At the end of an iteration the agent is positioned at a distance d from the source (where d is the depth bound for that iteration). It is assumed that the next iteration starts there itself, so that it does not have to return to the source node after each iteration.

Example 2.1. Consider the tree shown in Fig. 1. Each arc has unit cost. Depth-first search will visit the nodes in the following succession:

abdbebacfcg.

An iterative deepening strategy where the depth bound in the ith iteration is i will visit the nodes in the following succession:

abacfcgcabdbe.

It is easy to see that in this example, the worst-case ratio of the distance traversed by the agent to the shortest distance to goal is 7 for depth-first search (this happens when the goal is at c) and 6 for iterative deepening (when the goal is at e). This suggests that iterative deepening is a safe policy when the goal is at an unknown depth.

2.1. *Searching for a point on a line*

Suppose that the goal lies on a line and the agent is initially positioned at a point on the line. If the goal is at a distance n from the agent, and the agent knows the direction in which the goal lies, then it can arrive at the goal in n steps. If it does not know the direction of the goal, but knows that the goal is at a distance n, then it requires at most $3n$ steps to reach the goal (that is, n steps to the left and an additional $2n$ steps to the right when the goal is to the right).

The above situations are trivial ones. The interesting problem is to determine the best search strategy for the agent when the goal is at an unknown distance and unknown

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Fuzzy - Peluda = Parcial !

Logica Borrosa

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LITTLE BIG

IN THE NATURAL WORLD, SIZE IS DECEPTIVE. THE GREATEST power comes from the smallest sources. The largest objects we know of are the stars, but their power arises from the interaction of atoms too small to be seen, and the energy travels to us in waves too intangible to have mass. Humankind had no idea what real power was until a half-century ago, when we unlocked the forces of the subatomic realm. The same lesson applies to the world of industry: power lies in the ability to squeeze the most information into the tiniest space and in the ability to make ever smaller machines that are ever more efficient. In this special technology report, TIME focuses its lens on the meticulous, wide-ranging research aimed at harnessing the power of the small—from the drive to create denser microchips to the pioneering effort to build machines out of individual atoms. For all the laptop computers and palm-size camcorders that microtechnology has created, the quest to master the miniature is just beginning—and as we peer into the future, the end is nowhere in sight.

Illustration for TIME by Pol Turgeon

Shrinking Chips, Expanding Horizons

Semiconductors keep becoming more powerful, more complex and smaller. Are there any limits?

By JULIAN DIBBELL

THEY CALL IT AN ELECTRON-BEAM LITHography projection system, and some have even called it the future of the semiconductor industry. But if you wanted to, you could call it a printing press.



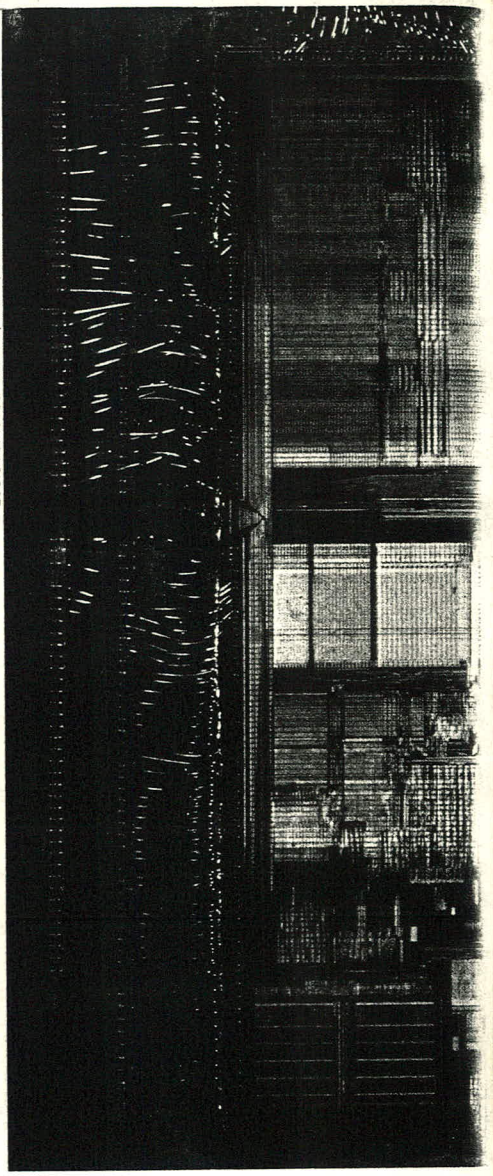
BELL LABORATORIES

SILICON SURGEONS: A Scalpel team views a wafer with hundreds of chips

The hulking tangle of microelectronics and stainless steel sits in a vibration-free testing room at Lucent Technologies' Bell Laboratories in Murray Hill, New Jersey, attended by Ph.D.s who spend long days coaxing the machine to print invisibly minute patterns onto wafers of gray-black silicon. The patterns mimic the intricate circuitry that this experimental system (nicknamed Scalpel) may someday etch into microprocessors and memory chips in high-tech factories from Silicon Valley to South Korea. But there's no reason Scalpel couldn't also stamp its wafers with an image of the same text Johannes Gutenberg printed five centuries ago. The major difference between Gutenberg's Bible and Scalpel's, of course, would be the scale: on an e-beam-printed page, the tail of a comma might span a mere 250 atoms. "Let there be light" would stretch to one-hundredth the width of a human hair at most.

"That's pretty small," deadpans Lucent researcher Joe Kraus, a member of the Scalpel team. It's slightly smaller, in fact, than the tiniest features any lab-bound lithographic prototype has yet reliably produced. And it's nearly an order of magnitude smaller than what today's most advanced manufacturers can print.

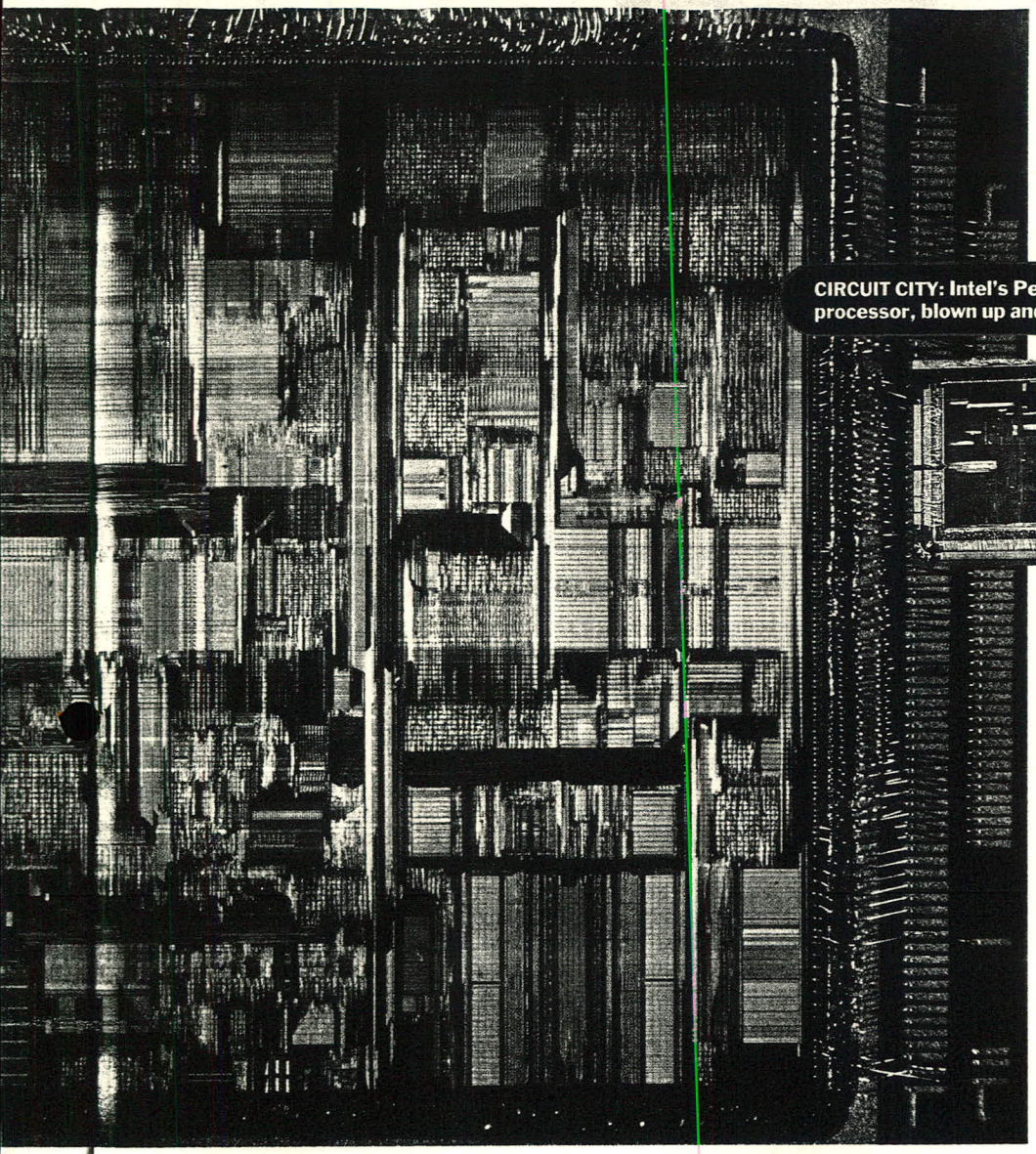
Even so, Scalpel's infinitesimal etchings are barely small enough to stay ahead of the dramatic curve of miniaturization that shapes the history of the microchip. More than a quarter-century ago, Intel cofounder Gordon Moore predicted that the number of microscopic transistors packed onto a chip would double every two years—and ever since, Moore's "law" has performed like clockwork. Its rhythm has become the heartbeat of the information age, pumping steady, stunning increases of ever cheaper power into our digital tools.



LOUIS PSIHOYOS—MATRIX; RIGHT, JOHN MEYER FOR TIME

We've grown accustomed to its pace, and who can blame us if at times we find ourselves almost convinced that Moore's law has become a law of nature?

The truth is, though, that nature has little to do with it. "Microchip design is people intensive, and brilliant people intensive," notes Jeff Weir, a spokesman for the Semiconductor Industry Association. Brain-twisting human effort, in other words, has made the microchip the ubiquitous, world-shaping technology it is today. Two decades of plodding experiments and dazzling insights have steadily shrunk the speed and capacity of 1970 room-size supercomputers down into the sleek, off-white boxes now sitting on desktops around the globe. An epic history of high-tech tinkering has enabled compact silicon intelligence to infiltrate almost every corner of our daily lives: from the car whose dashboard guts are studded with automating, fuel-gauging microprocessors, to the heart that pumps at a rate governed by a digital pacemaker, to the greeting card that sings a cheesy, synthesized tune to all who open it.



CIRCUIT CITY: Intel's Pentium Pro processor, blown up and actual size

Technologists assure us that further mundane marvels are waiting in the wings. Telephones equipped with future multimillion-transistor microchips, they say, will do real-time, automatic translations from Japanese to English and back on Tokyo to Seattle calls. Plastic "smart cards" laced with dirt-cheap slivers of money-tracking silicon will replace dumb, risky cash. Intelligent garbage cans, their slim lids wired with the pattern-recognition capabilities of a present-day spy satellite, will sift your trash for recyclables.

All this and more depends on the willingness of several thousand engineers and physicists to spend several million more person-hours looking for the next two decades' worth of circuit-shrinking tricks. But that shouldn't be a problem. The world's leading chip makers—Intel, NEC, Motorola, Samsung, IBM—have learned it's well worth their while to finance research efforts handsomely.

Sooner or later the forces driving chip miniaturization could run up against one insurmountable physical barrier or another, and then the party will be over at last. The only question is what that barrier will be. Until recently, a leading candidate was the boundary between visible light and the unseen upper reaches of the electromagnetic spectrum. To understand why, it helps to know that after silicon, light has been the most important raw material in the chip business. It's what the industry's traditional lithography systems print with, after all. They shine a beam of light through a tiny, transparent image (or "mask") of the desired circuit pattern; the light then passes through a series of lenses that make the image even tinier; and finally the image hits the treated surface of the silicon wafer, exposing it just like a photograph. Chemicals then etch away either the exposed or the unexposed parts of the wafer, and into the resulting grooves the microscopic wires and switches of an integrated circuit are laid.

It's a remarkably simple process, at bottom, and for as long as there have been microchips, it's been working like a charm. But one of the less charming aspects of working with light is that it's very difficult to make it print anything smaller than its own wavelength—for roughly the same reasons it's hard to draw a blueprint's fine lines with a crayon. And that's bad news for chip manufacturers, because no later than the year 2001 they will be scrambling to print features thinner than the shortest wavelength in the visible spectrum—about 0.193 microns (or millionths of a meter).

Researchers are hopeful that by then they'll be able to cajole the deep ultraviolet light at that wavelength into printing the hoped-for 0.18 micron features, and maybe even the 0.13 microns of the chip generation slated to follow. But beyond that, says Richard Freeman, a top optical scientist at Lawrence Livermore National Laboratories in California, "light just isn't going to do it anymore."

Some workable replacement for light, therefore, has been lithography's holy grail for several years now. And for a while it looked as if the quest might just as likely end in failure as success: proposed alternatives were many and varied, and all were far from proven. But now the field appears to have narrowed to two promising contenders. One is so-called extreme-ultraviolet radiation (or EUV), which on the electromagnetic spectrum occupies a sort of no-man's-land between light and X-rays. The other is the technology embodied, in its most advanced form, by Scalpel: e-beam projection, in which a stream of electrons takes the place of light.

Each approach poses its share of obstacles. The wavelengths used in EUV, for instance, are so small they can't push through the glass of masks and lenses and instead have to be bounced off mirrors shaped with such precision that no one's sure they can be produced in industrial-strength quantity. E-beams, on the other hand, take longer to expose the wafer surface than manufacturers can live with, and speeding up the process doesn't appear to be a simple task. But as far as Livermore's Freeman can tell, there is now "no physics standing between [either approach] and making it work."

So far, with semiconductor giant Intel putting all its market-making bets on EUV, and Lucent dividing its attention between lithography and several other lines of infotech research (the company was formerly AT&T's technology division), the race doesn't appear to favor e-beam projection. But that could change in the five or 10 years left before traditional lithography outlives its usefulness. Manufacturers may throw their investments in both directions, and for that matter, presently unpromising postoptical techniques—X-ray lithography, for example—could start to show some pizazz. "Some ideas have technology challenges, some have cost chal-

lenges," says Sun Lin Chou, an Intel vice president. "Right now, it's still not totally clear which approach is going to win in the end." One way or another, it seems, the daunting wall at the edge of light is going to be breached.

Some years beyond that wall, however, an even more imposing one stands waiting. At about the 0.05-micron generation of microchips, the strange and disruptive effects of quantum mechanics kick in: transistors stop behaving like anything resembling transistors, electrons flicker in and out of place like wayward ghosts. Few people involved in semiconductor R. and D. rule out the possibility that silicon miniaturization could continue past that point, but none of them appear to be counting on it either.

Nor, curiously enough, do any of them seem all that troubled by the prospect of Moore's law finally grinding to a halt. This is partly because by then the power packed into a single chip will have multiplied by the same 1,000 times it already has since the first microprocessor appeared 25 years ago, and because it's hard right now to imagine ever wanting more power than that. But it's also because the youthful growth spurts of other industries have taught the managers of this one not to confuse even a millionfold improvement with the promise of perpetual motion.

"Go back to the days of the Wright brothers," suggests Mark Melliar-Smith, Lucent's chief of microelectronics. From the early days of flight, he says, trace a half-century of advances in speed and capacity;

An epic history of high-tech tinkering has enabled compact silicon intelligence to infiltrate almost every corner of our daily lives

then notice how those advances slow to a permanent crawl around the time Boeing builds the first jumbo jet; then wind up with the punchline question Melliar-Smith now asks and answers: "Well, does that mean that the airline industry has died off? No, absolutely not!"

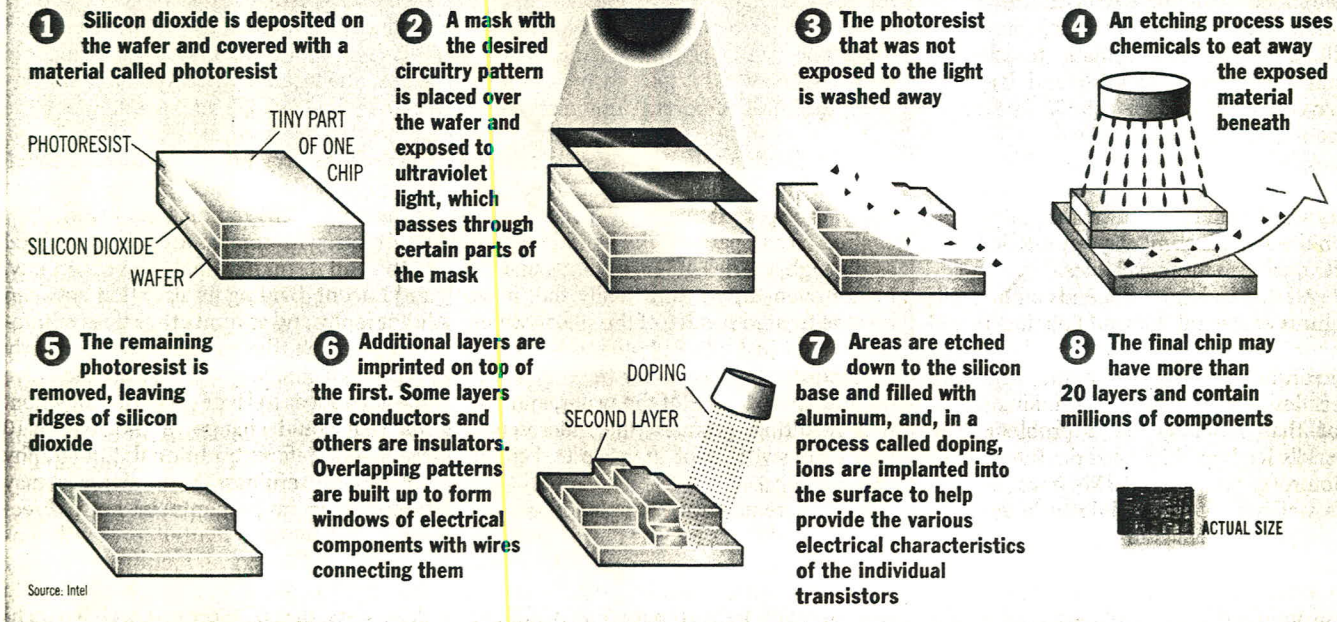
And sure, if the continued health of the microchip industry happens to be your principal interest in life, that comparison must be a comforting one. But it's a rather odd one, truth be told, if you happen to be more interested in understanding just what makes that industry tick. Because it doesn't tick the same way the airlines do. Add bigger and faster to the air-travel equation, after all, and all you really get is bigger and faster. But somehow, every time another round of smaller, faster chips appears, whole new horizons open up: new kinds of software, new kinds of hardware, new corners of our daily lives to sneak compact intelligence into.

In turn these new horizons stir up new demands, which in their own turn drive the industry to serve up yet another round of smaller, faster chips, and so on, and again so on, until eventually the promise of perpetual motion starts to seem perhaps not so illusory after all. Or anyway until the exponential chain of possibilities packed into that tiny device begins to make it seem a very large invention indeed. Much bigger, certainly, than the jumbo jet. And maybe even bigger, come to think of it, than the printing press.

That's a strong claim, to be sure. Gutenberg's invention sparked a cultural, political and economic revolution we are in many ways still living through. But there's a deeper similarity between the microchip and the printing press than the superficial workings of machines like Scalpel imply: each fills the world with information in ways whose consequences tend to be both vast and unpredictable. By now, of course, what print has wrought stands all around us to see, but we can only begin to guess at all the changes that may flow from integrated circuitry. Because as Gordon Moore's remarkable timetable suggests, the microchip is still no more than halfway done with its revolution. ***—Reported by James Branegan/Brussels, David S. Jackson/San Francisco and Barbara Smit/Amsterdam***

THE EVER FINER ART OF CHIPMAKING

Hundreds of microchips, each smaller than 1 sq cm, are etched at the same time on a wafer of silicon through a process involving hundreds of steps. Here's a simplified look at part of the technique



Source: Intel

TIME Graphic by Laurie Grace

A New Lilliputian World Of Micromachines

Scientists are creating wasp-size helicopters and building mechanical systems on slivers of silicon

By LEON JAROFF

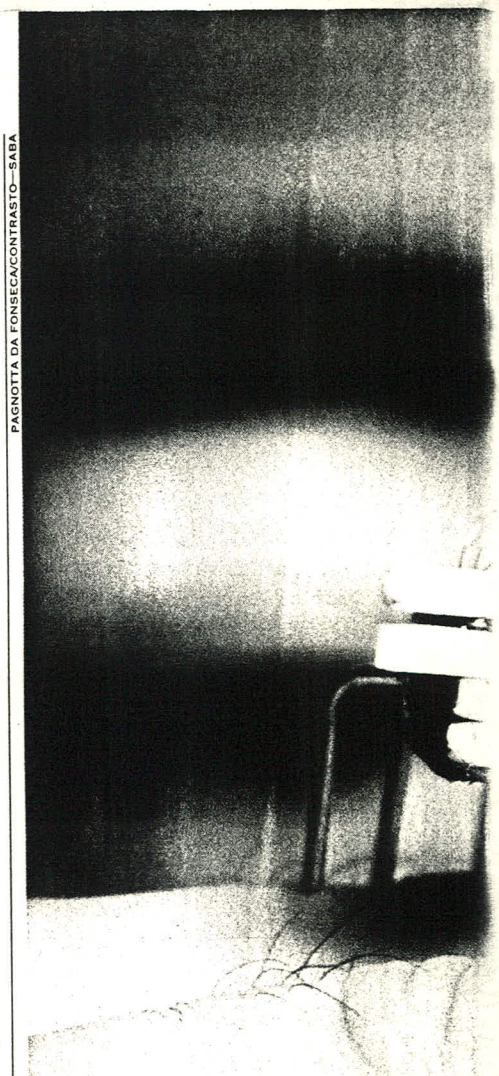
KRIS PISTER DOESN'T MIND HAVING guests in his Berkeley, California, laboratory as long as they abide by the prevailing rule: if something looks like an insect and walks like an insect, do not step on it—because it's probably not an insect.

Not of the biological variety that is. Within a few months, the University of California engineer predicts, his collection of micro-size hinges, gears and motors will be assembled into an ant-size artificial insect. "We're about to pull it off," Pister says. "All of the dreams I've had in the past 10 years about microrobotics are starting to become reality. Putting everything together into one synthetic insect still poses a tremendous challenge, but at this point there are no fundamental scientific issues that need to be resolved."

Pister is just one of thousands of scientists and engineers around the world who have immersed themselves in the Lilliputian world of micromachines, convinced not only that small is beautiful but that it is also the wave of the technological future. One Japanese firm has assembled tiny parts into a working automobile the size of a grain of rice, while engineers at public and private research labs have built electrostatic motors only a millimeter or two in diameter, a working lathe only one ten-thousandth the size of a conventional machine and inchworms only 5.5 mm in diameter that someday might crawl through angled pipes of nuclear plants in search of cracks. German engineers have built a wasp-size helicopter that lifts itself into the air, motors barely visible to the naked eye and matchbox-size reactors for the chemical industry.

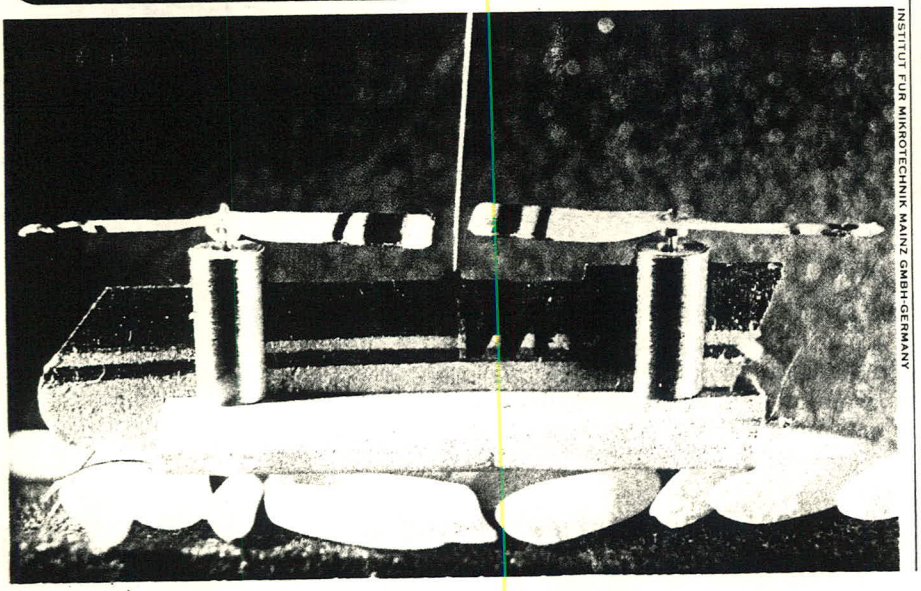
Even more remarkable, scientists have begun using the same lithographic processes employed to make silicon chips to create diminutive micro-electrical mechanical systems (MEMS). These devices combine electronic circuits and working, moving machines in a single microscopic silicon package and, their creators believe, will eventually be as ubiquitious as the electronic silicon chip is today. A few rudimentary MEMS systems are already in widespread use in the U.S., Japan and Germany. One, a hair-thin sensor-actuator installed in millions of cars, deploys the air bags when it "feels" an impact.

Sensing the enormous potential of the Lilliputian devices, researchers can hardly contain their excitement. "We're approaching another revolution that will rival the Industrial Revolution of the 18th century," predicts Takayuki Hirano, executive director of Japan's government-sponsored Micromachine Center. That potential has not been lost on national leaders. Japan is financing a 10-year, $225 million Microsystem Technology project, involving 26 companies, and the German federal government is contributing $65 million annually to support microsystem research. In the U.S., the Defense Department, through its Advanced Research Projects



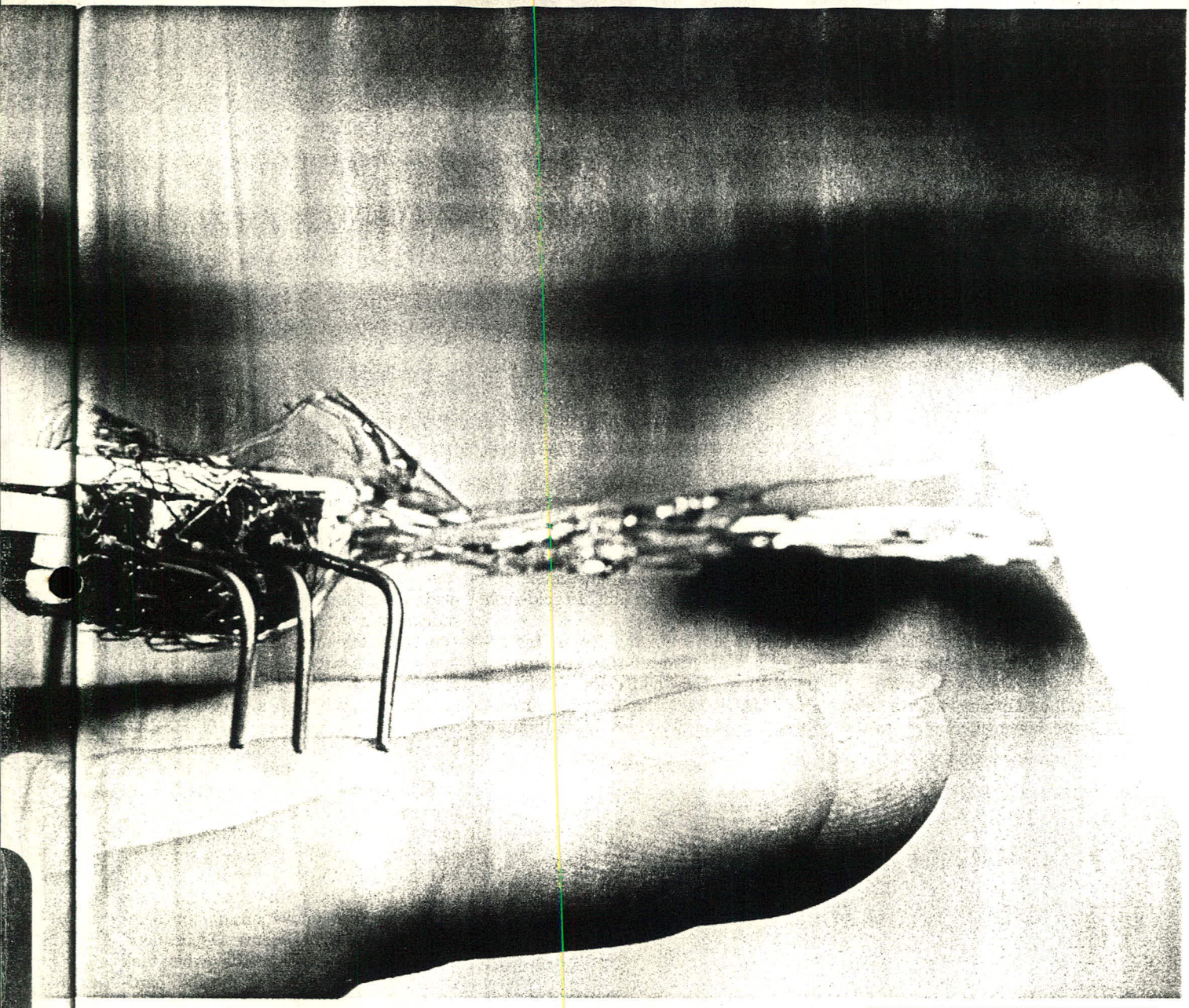
PAGNOTTA DA FONSECA/CONTRASTO—SABA

"Now I know how people felt when they realized they could make integrated circuits. There's a bit of a gold-rush feeling in the air."



INSTITUT FUR MIKROTECHNIK MAINZ GMBH-GERMANY

MINICHOPPER: This petite craft can use grains of rice as a landing pad



ARTIFICIAL ANT: A Japanese entry in the race for the best faux insect

Agency, budgets $35 million each year for microsystem grants to industry.

At Germany's Institute of Microtechnology in Mainz (IMM), managing director and physicist Wolfgang Ehrfeld watches proudly as his banana-shaped, two-rotor helicopter, weighing less than a half gram, rises 130 mm into the air. "Of course, it's a gag," says Ehrfeld, "but it has a serious purpose. The chopper demonstrates that it is possible to build high-performance micromotors. These are not playthings."

Indeed, Ehrfeld believes that the one-volt motors, which can rotate at rates as high as 100,000 revolutions a minute and are only the size of a sharpened pencil tip, can ultimately serve as a drive for electronic displays, watches, camcorders and laser scanners. Perhaps the earliest application, he says, will be in microsurgical instruments. California's Pister too is looking beyond his artificial ant. "I picture miniature robot sweatshops," he says, "where the robots are building electronic products for us." He points out that the minuscule parts in consumer-electronic devices are often still assembled by hand because current automated equipment is not up to the task. "The bugs could do it easily," he says.

Like MMI's Erhfeld, Pister forsees wide application of micromachines in medicine. With other researchers, he hopes to build a copy of a human hand only a few millimeters across that could be mounted inside an endoscope and inserted into a patient. Movements of the doctor's hand, inside a virtual-reality glove, would then be mimicked by the tiny mechanical hand. "All we'd have to do," Pister explains, "is put little pressure and temperature sensors on that little hand and feed that information back to the surgeon. So that if he grabs something, he could feel if something's hot, hard or whatever."

At the University of Tokyo, robotics engineer Hirofumi Miura is creating silicon microinsects that can actually fly a few centimeters. "We need to be able to control insects like we control cows and horses," he says. "But since we can't control real insects, I want to make an artifical insect." Such creatures, he explains, could be used to pollinate flowers in greenhouses and kill insect pests preying on crops.

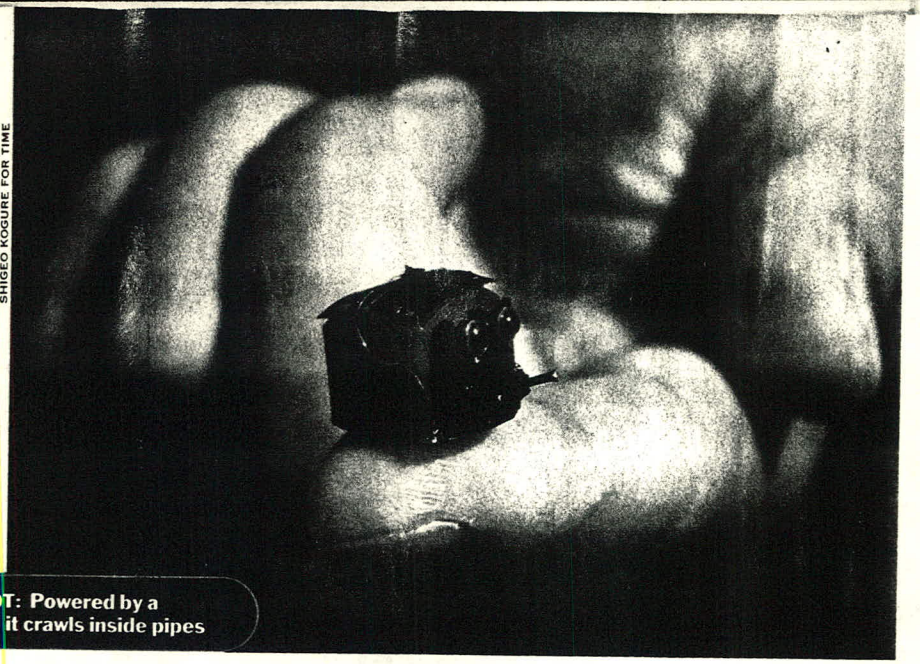
Before that happens, however, Miura will have to devise another way to get his insects airborne. The current models take off only in the laboratory when placed in an alternating magnetic field—which causes a set of 0.2-mm-wide nickel-plated wings to flap and lift the insect into the air.

As the machines they design become smaller and smaller, engineers are finding that many of the assumptions they make about the physical characteristics of large devices simply do not apply to the microworld. "Things like mass and weight become almost negligible when you shrink everything down," says Pister. "But things

associated with surfaces, like surface tension and friction, become very important and very dominant."

At Denso, the Toyota affiliate that built the rice-grain-size car, engineers discovered that their miniature vehicle had trouble moving along. Because of the car's negligible weight and its small wheels, the friction generated between wheels and surface was barely enough to provide traction. And the light oil first used to lubricate the vehicle was too viscous for the little engine to overcome; it stopped the car dead in its tracks.

On the other hand, says David Bishop, a physicist at Lucent Technologies' Bell Laboratories, "the physics is such with micromachines that they're remarkably reliable and mechanically robust." For example, Bell Labs researchers have shaken a micromachine 20 trillion times without breaking it. The answer, says Bishop, lies largely in scale, in smallness. "If a fly falls off a wall and hits the floor, it doesn't get hurt because it's so small," he explains. "But if an elephant fell off the wall, it surely would get hurt."



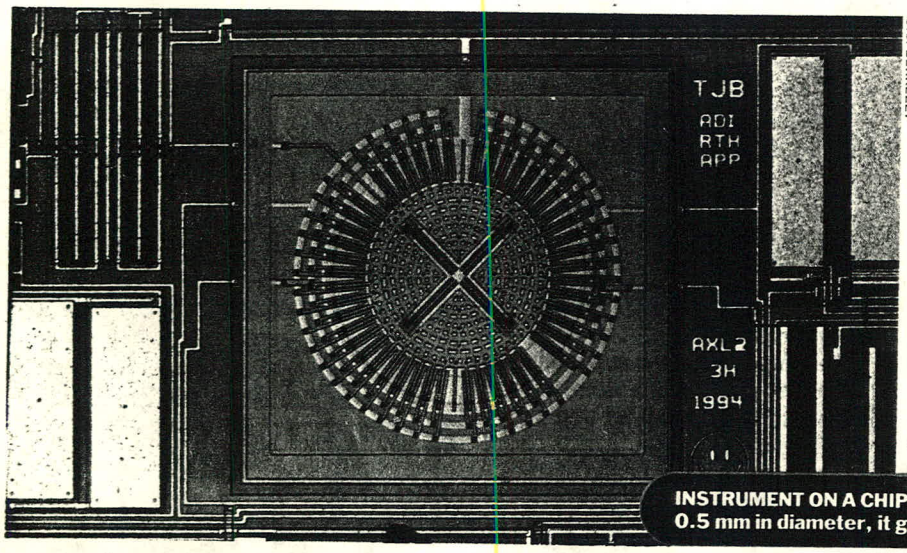
SHIGEO KOGURE FOR TIME

BEETLE ROBOT: Powered by a "solar" panel, it crawls inside pipes

As ingenious and promising as the micromachines are, however, most scientists consider them to be merely an incremental step forward. Bishop likens their impact on technology to the transistor's effect on electronics. "If you think about the electronic revolution," he says, "the transistor wasn't really that much different from the vacuum tube. The breakthrough came with the invention of the silicon chip."

That chip, Bishop says, "enables you to put a million transistors in a small place" and made possible the development of the complex electronic devices of today. In the same way, he explains, micro-electrical-mechanical technology can put a million tiny machines, each complete with an electronic control system, on a silicon wafer. "Now I know how people felt when they realized they could make integrated circuits," he says. "There's a bit of a gold-rush feeling in the air."

One U.S. company, Texas Instruments, has already used MEMS technology to develop such chips for displaying video images. Each chip has on its surface thousands of square, movable aluminum mirrors less than a hair-width in size. With the electronic circuitry in the chip, each mirror can be tilted individually either to reflect or not to reflect light onto a larger screen.



U.C. BERKELEY

INSTRUMENT ON A CHIP: Less than 0.5 mm in diameter, it gauges shock

MEMS technology can also bring about substantial cost savings. At Bell Labs, for example, researchers are using it to produce micro-optical modulators, necessary for two-way communication over optical fiber lines. With ingenious chip-making lithographic techniques, they can for mere pennies create modulators that in conventional versions are priced at $5,000 apiece. "It costs about $1,000 to process a silicon wafer," explains physicist Bishop. "But if you have the technology to fabricate 10,000 micro modulators on the surface of that wafer, and then slice them apart, you've made modulators for 10¢ apiece. All of a sudden your whole mindset is different. You begin thinking about putting these modulators in places you've never thought of before."

Other MEMS devices may also be found soon in unexpected places. One rather blue-sky scheme now being considered by the scientists involves covering airplanes with "tuneable" skins of micromechanical flaps that would sense turbulence, for example, and rise or fall accordingly, literally changing the airfoil to create a smoother and safer ride. Under water a skin of microflaps could provide similar benefits to a submarine. Such innovations do not go unnoticed at the U.S. Defense Department. There, scientists envision a day when tank structures are micromechanically "hardened" upon impact from enemy fire, and when MEMS devices embedded in helmets, clothing or weapons will not only monitor and transmit information about a soldier's vital signs and location, but also about any nearby enemy activity. Between grants from the Defense Department, the National Science Foundation and innovative corporations, MEMS researchers in the U.S. have plenty of money. "The amount of funding we can raise is really beyond what we can spend responsibly," says Thomas Kenny, an engineer overseeing several MEMS projects at Stanford University. "My approach to funding these days is that I don't initiate anything at all. The phone rings and people offer funding out of the blue. It's very strange, and I don't know how long it will last."

If MEMS devices even begin to live up to their enormous promise, Kenny's phone should be ringing for years to come. ***Reported by Dan Cray/Los Angeles, Irene Kunii/Tokyo and Rhea Schoenthal/Bonn***

Como no - fué la evolución

The Jaws of Destiny

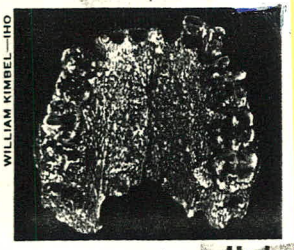
A 2.3 million-year-old fossil from Ethiopia extends the age of the human family line 400,000 years

By MICHAEL D. LEMONICK



THE ARID BADLANDS OF northern Ethiopia's Hadar region have long been a fossil-hunter's paradise. It was there, two decades ago, that paleontologists unearthed the celebrated Lucy, a primitive ancestor of modern humans dating back more than 3 million years. On this trip, though, an international team of scientists was on the trail of something less ancient but much more mysterious. Somewhere between 2 million and 3 million years ago, experts believe, Lucy's descendants had evolved into true humans. But despite decades of searching, scientists had yet to find a single well-dated fossil that showed how, why or precisely when this fateful transition occurred.

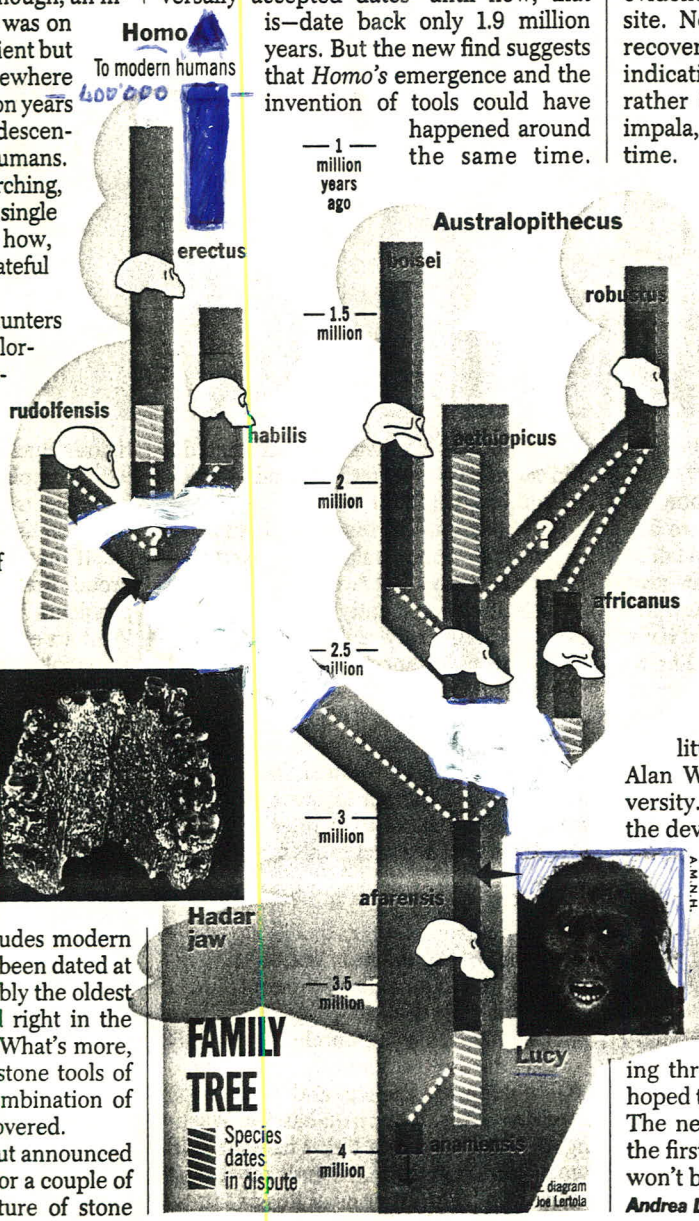
Then two veteran fossil hunters from the local Afar tribe, exploring near a dry stream bed, spotted something out of place: two pieces of a prehistoric upper jaw that had eroded from a hillside. "The instant we fit the jaw together," says William Kimbel, science director of the Institute of Human Origins in Berkeley, California, and a leader of the expedition, "we knew we weren't dealing with an apelike *Australopithecus* [the scientific name for Lucy and her kin]."



WILLIAM KIMBEL—IHO

In fact, as the researchers explain in a report that will appear in the December *Journal of Human Evolution*, the jaw belonged to the genus *Homo*, the line that includes modern *Homo sapiens*. The fossil has been dated at 2.33 million years old—arguably the oldest *Homo* fossil ever found, and right in the middle of the mystery zone. What's more, the bones were found near stone tools of the same age—the oldest combination of bones and artifacts ever discovered.

The find, made in 1994 but announced only last week, is important for a couple of reasons. First, the manufacture of stone tools is considered a key characteristic of the *Homo* line—something, along with brain size, skull shape and other anatomical features, that separates humans from less-than-humans. That has never been proved, though: the oldest known stone tools date back perhaps 2.5 million years, but they were found without any fossils around and could have belonged to anyone. And the oldest *Homo* fossils with universally accepted dates—until now, that is—date back only 1.9 million years. But the new find suggests that *Homo's* emergence and the invention of tools could have happened around the same time.



And the fact that tools and bones were found together strongly implies, though it doesn't prove, that they are related.

Far more important, the discovery may help paleontologists finally figure out when and why the *Australopithecus* clan sprouted a new branch on the hominid tree. According to a leading theory, the trigger was a global cooling trend that began about 2.7 million years ago and transformed much of Africa's moist woodlands into dryer, more open savannah. Was the development of tools and a more upright stance an evolutionary strategy to cope with the rigors of the new environment? Perhaps. But until now nobody had found a *Homo* fossil that dated back anywhere near 2.7 million years.

Now they have. And there's plenty of evidence of climate change at the Hadar site. Near the jaw and tools, the team recovered fossils of grazing antelopes, indicative of an open, fairly grassy habitat, rather than forest-dwelling species like impala, which were so prevalent in Lucy's time.

But while the new discovery brings paleontologists closer to solving the mystery of *Homo's* origin, it still falls frustratingly short. Although the scientists found a nearly complete upper jaw, 10 teeth and a number of tooth fragments, they can't say for certain which species the fossil belongs to. By 1.9 million years ago, the *Homo* line had spawned at least two branches: *Homo habilis* and *Homo rudolfensis*. The new fossil resembles both species in some ways, but without a more nearly complete skull it's impossible to say more. "What we have now is a hypothetical human lineage with very little evidence on it," says anatomist Alan Walker of Pennsylvania State University. "This new fossil is another piece in the developing story."

AMNH

Chances are that if the answer exists, it is waiting in Hadar. Kimbel and his colleagues realized several years ago that it was an ideal place to look for clues to humanity's immediate family because Lucy's bones didn't come from the most recent rocks in the area. By combing through younger rocks, the scientists hoped to uncover clues to what came later. The newly announced jawbone is among the first fruits of that labor, but it probably won't be the last. —***Reported by Andrea Dorfman/New York***

ESTIMADO PADRE GALLO:

LA HOJA ADJUNTA SON IDEAS Y SUGERENCIAS DEL LIC. JORGE RODRIGUEZ SOBRE ALGUNOS ASPECTOS A REFORZAR EN LAS FACULTADES DE INGENIERIA(EN UN GRADO MENOR LAS MISMAS SUGERENCIAS EN LAS FACULTADES DE ARQUITECTURA Y CIENCIAS ECONOMICAS).

EXISTE LA POSIBILIDAD DE TENER UNA REUNIO DURANTE LA PRIMERA QUINCENA DE DICIEMBRE CON LOS PROFESORES DE MATEMATICAS Y LOS PROFESORES DE LOGICA SOBRE ESTOS PUNTOS.

ME COMUNICO PERSONALMENTE CON USTED DURANTE ESTA SEMANA, PARA SUS COMENTARIOS E INDICACIONES SOBRE ESTOS ASPECTOS.

MIL GRACIAS,

ING. RODOLFO MOLINA

PD. HOY MARTES 18, A LAS 1730 HORAS SE INICA EL SEMINARIO SOBRE LOS CURSOS TIPO "A"(CONCLUYE MAÑANA). HOY HABLARA EL PADRE ACHAERANDIO, Y NOS REUNIREMOS TODOS LOS CATEDRATICOS DE DICHOS CURSOS.

Después de analizar detenidamente el contenido de la asignatura de Lógica, me permito sugerir lo siguiente:

1) Se haga énfasis en que el estudiante comprenda lo que se entiende por lógica simbólica y lo que son los razonamientos inductivo y deductivo.

2) Respecto a las conectivas, proporcionar ejemplos utilizando circuitos lógicos e insistir en las variantes de la condicional (inversa, contrarecíproca, etc.) para que el alumno tenga bien claro lo que son "condición suficiente", "condición necesaria" así como, "condición suficiente y necesaria".

3) Es muy importante el tema de cuantificadores (universal y existencial) y la negación de expresiones cuantificadas.

4) Impartir el tema de conjuntos y àlgebra de conjuntos con el objeto de que los estudiantes comprendan mejor ciertas reglas, a través de efectuar analogías entre números, conjuntos y proposiciones.

5) Explicación sobre lo que es la prueba en matemàtica, los ingredientes de la prueba (términos primitivos, axiomas, etc.). Que se explique lo que es una definición, un teorema y un corolario. Las reglas de inferencia, los métodos generales de demostración: Prueba directa y Prueba indirecta (con sus variantes, por contraposición y reducción al absurdo). También el proceso de inducción matemàtica y la prueba por contraejemplo.

6) Que el estudiante conozca lo que es un sistema matemàtico, por ejemplo: conjunto de proposiciones junto con las operaciones binarias $\wedge$, $\vee$, la equivalencia $\leftrightarrow$ y los axiomas de cerradura, propiedades conmutativa, asociativa y distributiva, elementos identidad, inversos y propiedad de complementación.

7) De suma importancia es el uso de ejemplos de caracter matemàtico, sobre todo en las demostraciones. Para el efecto, sugeriero los textos siguientes:

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M. L. Bittinger
Addison Wesley

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S. Lipschutz
Serie Schaum

4) Lógica Simbólica
Librería URL

5) Folletos Lógica I y Lógica II, Unidades 11 y 17
Colección Open University
McGraw-Hill

18 DE MARZO DE 1998

ESTIMADO PADRE GALLO:

EL LIC. JORGE RODRIGUEZ FUE TAN AMABLE DE PROPORCIONARME COPIAS DE TEMAS RELACIONADOS CON LA CLASE, Y CREO QUE LE INTERESARA TENER UN EJEMPLAR.

ASI MISMO QUIERO HACER DE SU CONOCIMIENTO QUE QUEDAN SOLO 50 - 55 EJEMPLARES DEL LIBRO AZUL DE "VER DE VERBO", PUES YA CASI SE AGOTO EN EL PRIMER SEMESTRE. SI USTED ME CONCEDE UN POCO DE TIEMPO, ME GUSTARIA MUCHO HABLAR SOBRE LA REIMPRESION (O NUEVA EDICION DEL LIBRO) PARA PROGRAMAR LA IMPRESION DEL LIBRO.

QUIERO TAMBIEN AGRADECER SU ATENCION A MIS ALUMNOS DE METODOLOGIA, QUIENES LE LLEGARON A PLATICAR SOBRE LAS MAESTRIAS Y DOCTORADOS.

MIL GRACIAS

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- Logic Eprints @ University of Florida (FTP server)
- AMS: Mathematical logic and foundations
- AMS: Set theory

- Bulletin of Symbolic Logic (Bibliography)
- Journal of Symbolic Logic (Bibliography)
- Notre Dame Journal of Formal Logic
- Nordic Journal of Philosophical Logic

- Postal addresses for logic journals

Germany

- Aachen: Rheinisch-Westfälische Technischen Hochschule
- Bonn: Rheinische Friedrich-Wilhelms-Universität
- Freiburg: Albert-Ludwigs-Universität
- Heidelberg: Ruprecht-Karls-Universität
- Münster: Westfälische Wilhelms-Universität
- München: Ludwig-Maximilians-Universität
- Tübingen: Eberhard-Karls-Universität

USA

- California:
  - UC Berkeley
  - UCLA

- Delaware: University of Delaware
- Illinois: UI at Urbana-Champaign
- Indiana:
  - Indiana University
  - University of Notre Dame
- Massachusetts: MIT, Harvard, Boston University, U Mass
- New Jersey: Rutgers University
- Ohio: Ohio State University
- Pennsylvania:
  - Carnegie Mellon University
  - Pennsylvania State University
  - University of Pennsylvania
- Wisconsin: University of Wisconsin

UK

- Cambridge: University of Cambridge
- Leeds: University of Leeds
- London: Queen Mary and Westfield College
- Manchester: University of Manchester

Elsewhere

- Austria, Vienna: Technische Universität Wien
- Belgium, Mons: University of Mons-Hainaut
- Bulgaria, Sofia: Sofia University "St. Kliment Ohridski"
- Czech Republic, Prague: Charles University
- Finland, Helsinki: University of Helsinki
- France, Lyon: Institut Girard Desargues
- France, Paris: Universite Paris 7
- Israel, Haifa: Logic in Israel
- Netherlands, Amsterdam: University of Amsterdam
- Netherlands, Utrecht: Utrecht University
- Russia, Moscow: Steklov Mathematical Institute
- Russia, St.Petersburg: Steklov Institute of Mathematics
- Spain, Barcelona: Universitat de Barcelona
- Sweden, Uppsala: Uppsala University

Events

- ASL Meetings
- Hugh MacColl and the Tradition of Logic, March 29 -- April 1, 1998, Greifswald, Germany
- The first International Workshop on Labelled Deduction, September 7 -- 9, 1998, Freiburg, Germany

Organizations

- Association for Symbolic Logic
- Associazione Italiana di Logica e sue Applicazioni
- British Logic Colloquium
- Kurt Gödel Society
- Swiss Society for Logic and Philosophy of Sciences

Other Links

- Logicians
- Set Theorists
- Recursion / Computability Theorists
- Mathematicians

- Newsgroup sci.logic
- MathSearch (search a collection of mathematical Web material)

- Beginnings of Set Theory
- Famous Mathematicians - Chronological Index
- Foundations of Mathematics
- Logic Notation on the Web
- Modern Logic
- New Foundations
- Various writings on mathematical logic

- Studies in Logic and the Foundations of Mathematics (catalogue at North-Holland)
- Perspectives in Mathematical Logic (book series by Springer)
- UMI (order theses)

- Anbar Award

- Mathematical Logic Group at the University of Bonn (links to our group)
- Department of Mathematics
- University of Bonn

Please note that all links should be relevant to mathematical logic. Though it may not be the main focus. If Your page is appropriate for this table, please let me know.

© *Boris Piwinger, March 2, 1998*

13068

Bibliography, Universal Set

- Notes on logic, proofs, and set theory at CSUSB [UD] [Int]
  ADD. KEYWORDS: Plot functions, Solve a Diophantine Equation, Modulo arithmetic practice, Truth Table Practice, Symbolic Logic
- Set Theory - An Operational Approach [G-P]
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Computational Geometry
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Genetic Algorithms
Differential Geometry
Discrete Mathematics
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Fluid Dynamics
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Mathematical Biology
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*** This is a version of the Table of Contents which uses tables**

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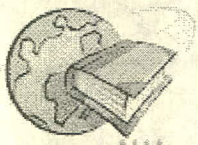
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→ (para a "Alcachofa")

- Adaptive Fuzzy Control
- Fuzzy CLIPS - fuzzy logic expert systems shell developed at NASA.
- Fuzzy Information - at the CMU Artificial Intelligence Repository.
- Fuzzy Logic [unm.edu] - academic fuzzy logic software.
- Fuzzy Logic Archive
- Fuzzy Logic Group
- Fuzzy Logic Resources Page
- Soft Computing and Artificial Life
- FAQ - Fuzzy Logic and Fuzzy Expert Systems = da mucha información
- Index - Fuzzy Logic, Neurofuzzy Resources Page
- Usenet - comp.ai.fuzzy - Fuzzy set theory, aka fuzzy logic.

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Erez
Falke (Horst Knothe = on Fuzzy Logic

{ Part 1. Overview
Part 2. Fuzzy expert System

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Los Congreso AI en Alcalá 4-9, mayo 1998. —

"Fuzzy"

(pron. "fóesi"!) dice Charly!

Lógica a medias = dispersa es una metalógica

Los españoles la llaman "difusa" = lógica difusa

El énfasis que se ha dado a las conexiones intelectuales entre los diversos cápitulos de la lógica, ha sido motivado por la necesidad de que un estudiante de los primeros años logre hacer de esta ciencia un constante marco de referencia para la organización mental de todos sus conocimientos y para ver la posibilidad de coordinar todas las asignaturas de su curriculum en una unidad coherente. Las repetidas referencias a la vida real, pueden contribuir a concebir la lógica como un elemento de nuestra vida diaria, a pesar de que por su propia cuenta pueda alcanzar esferas de gran abstracción y proyección intelectual.

INVITACION A VER

La vista es el sentido más inmediato y completo, para realizar experiencias. Por esta razón le invitamos a aprovechar sus experiencias, antiguas y nuevas, de lo que ve y de lo que ha visto; acostúmbrese a mirar atentamente la realidad que cada día, está delante de sus ojos. A partir de esa mirada concreta y atenta derivan las especulaciones de todas las ciencias. El texto que usted tiene en la mano le enseñará a desarrollar los intrumentos mentales para su vida futura, su actividad científica y profesional.

PLANTEAMIENTO

Un joven, llamado Leonardo, al terminar su bachillerato está a punto de empezar los estudios superiores y desea dedicarse a una materia que realmente le encante. Leonardo es un joven especulativo,no piensa sólo en una carrera utilitaria, para hacer dinero y situarse en la sociedad; ésta va a ser su propia carrera. Pero él quiere algo más: dominar, al mismo tiempo, los secretos del mundo: una ciencia que rebase, o por lo menos que coordine, todas las ciencias.

Leonardo es cualquier persona inteligente que se pregunta acerca de los conocimientos humanos, las ciencias y las diversas dimensiones del universo. Leonardo Da Vinci fue un hombre del Renacimiento, un genio, matemático, constructor, inventor, escultor, pintor y arquitecto pero, sobre todo, un inquieto investigador. Leonardo también puede ser usted. El problema sigue siendo el mismo: ¿Cómo se relaciona una ciencia con otra? ¿Cómo se relaciona mi mente con el mundo?

¿Es posible abarcar la totalidad del saber humano con esquemas mentales generales, que cubran razonablemente cada disciplina y estén abiertos a todo género de objetos: matemáticos, físicos, musicales, estéticos, literarios, cósmicos, electrónicos, o bien económicos, especulativos y políticos?

¿Es posible sentarse ante una poderosa computadora y desde allí explorar las dimensiones del ser y del mundo; encontrar una palabra clave desde la cual partir y al cual regresar, manteniendo abiertas las dimensiones del mundo para que la mente se encuentre confortable frente a las diversas interrogantes y posea los instrumentos para dirigirse en el viaje y seleccionar los caminos ?

Este libro intentará buscar esta respuesta y situar la mente de uno en su estación de partida.

Leonardo se concentra sobre este problema. Su padre le pregunta: ¿Qué carrera piensas escojer en la universidad?

Leonardo - No he decidido todavía porque me parece que cada carrera sólo se preocupa de una parte de la realidad; un fragmento, sin relación con el resto.

Papá - Hoy, con el avance de las ciencias, te es imposible abarcar todos los campos, sin ser un superficial; deberás limitarte a uno.

Leonardo - Sin embargo, las ciencias deben poseer algo en común, un punto de encuentro.

Fuzzy Thinking = 1993 –

DIFUSO { Fuzzy = debilitado
Fuzz = borra, pelusa
Fuzziness = vellosidad

1) Es un pragmatismo escéptico que pretende: dar soluciones a problemas prácticos!
sin llegar a ninguna afirmación científica = solo "fuzzy"

Es un nominalismo empirista que no llegará nunca
la sensación es el concepto!

2) KosKo
Acusa la ciencia de { : abstracción
manipulación
inmovilidad
solo la quiere reducir a "normas - operativas" –

3) Ha descubierto { la "experiencia pre - categorial o a - categorial
que en los hechos hay gradaciones (+ o –) muchos grises
y ningún todo blanco o todo negro

– Lo "da" como una "gran novedad"! (pero ya se sabía!) lo pone como
fundamento - científico

4) Los grises entre blanco y negro no cambian la lógica
Siguen siendo grises gracias al negro y al blanco!
No se puede definir ninguna - experiencia intermedia sin referirla a extremos!
como se define lo gris, sino como entre blanco y negro?

5) Una cosa son los hechos (= realidad - experimental { - material
- o no -)
Otra cosa son los conceptos (= realidad ideal - mental)
El nunca los separa, es un = "nominalista" = los "nombres son cosas"

6) La medem. { es conceptual - (a este nivel es perfecta)
aplicada a las cosas es inadecuada (no las alcanza)

Notas - II PARTE

(1) R. Fuller, El Quinale Peladle - UCAC Guatemala - 1978

(2) George Primov: "Aymara-Quechua Relations in Puno" (p. 167) de: "International Journal of Comparative Sociology". Nov. 1974 XV. 3-4.

(3) Revista Time Marto 17-1970. p.7

(4) Ver también:
- Peter Caws: Science and Theory of Value
———: "Operational, Representational and Explanatory Models". en American Anthropologist. March 1974. Vol. 76.
Carl G. Hempel and Paul Oppenheimer. Studies on the logic of explanation. en Philosophy of Science. 1948
———— Aspects of Scientific Explanation Free press. N.Y. 1965

La matemática es artificial? (= ambiguo)
... no es artificial sino "conceptual" especulativa.

8) Se olvida que todos los "Sistemas" - estructuras (elaborados mentalmente) son artificiales (= abstractos) incluyendo "el que él mismo descubre!

9) Las ideas "borrosas" no son ideas "son pseudo-conceptos" que no llegan a definirse con ideas borrosas no se llega a nada - Las ideas son siempre fijas y definidas aun cuando captan una realidad compleja, incomprensible, fluida, aproximada

Las ideas no son borrosas por ser objeto-ideales = mentales

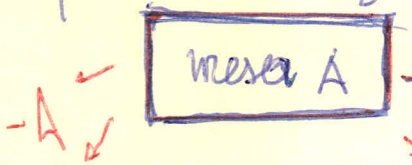
10) El enfoque pragmático de "KoSKo" = estudia un campo de objetos poniendo su enfasis en las limitaciones y las variaciones. Es decir estudia

oposiciones = { Positivo - Negativo / Arriba - abajo / Grande - pequeño / Todo - nada }

Pero no distingue entre { Contradicciones y Contrariedades }

El no analiza la contradicción (= oposición lógica)
solo las contrarias (= oposición experimental)

Ej: Una mesa = límite de la mesa = no-mesa
El no considera este término lógico de "límite."



{ A = mesa = contenido positivo
{ -A = no-mesa = negación de mesa = límite

En las contradicciones solo se define el límite.
El límite -A pertenece a A en cuanto "A tiene un contenido" | "limitado" no-infinito

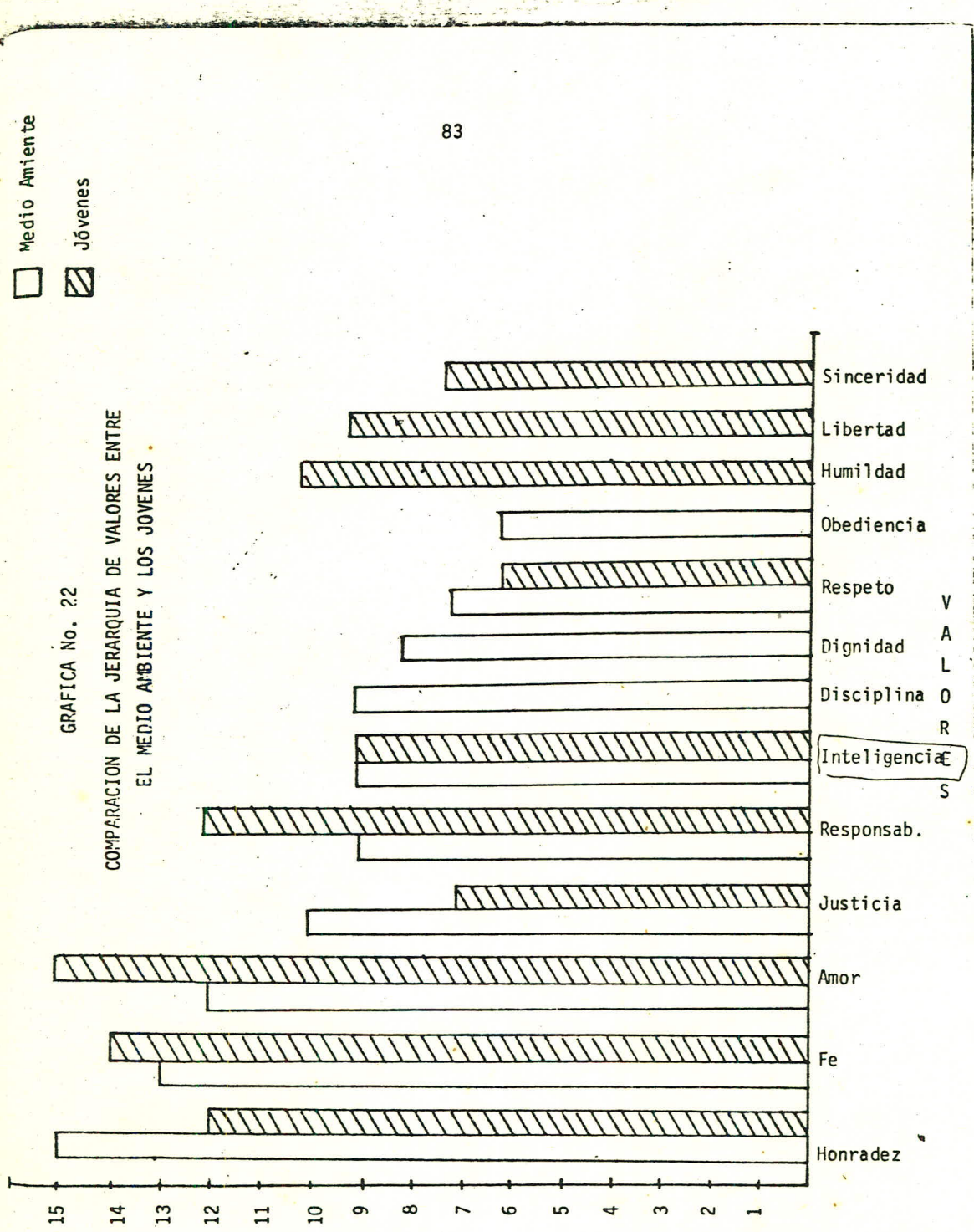
11) Como todas las cosas de la experiencia son finitas, tienen un límite un -A.
Pero este límite es una entidad lógica que pertenece al objeto dado

Todo: A tiene su -A
B tiene su -B
C tiene su -C

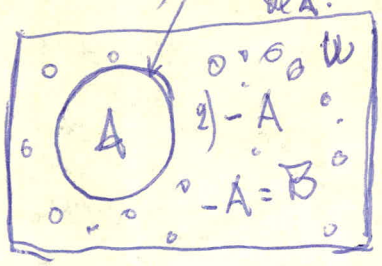
como un carácter de sí mismo
A es una cosa - pero -A no es una cosa = solo es un concepto

GRAFICA No. 22

COMPARACION DE LA JERARQUIA DE VALORES ENTRE EL MEDIO AMBIENTE Y LOS JOVENES



12) Si se toma -A como una cosa (no como el límite de A)
entonces -A tiene contenido y es = a B.
Esto sucede en los conjuntos — Hay dos modos de entender [-A].
Si A es un conjunto entonces { 1. -A es su límite = fuera negación
2. -A es su complemento = lo que falta a A para llegar a U. = es diferencia" y tiene contenido



B = diferencia de U - A.

Korko no considera: { 1 = -A como límite
Solo considera — { 2 = -A como complemento

En ambos casos se puede hablar de (A y -A) = pero con significados diferentes

{ 1_ Entre A y -A = como límite, no hay nada en medio porque -A pertenece a A
2_ Entre A y -A (complemento) = hay una serie de "valores parciales" que separa de la "diferencia"
= A en este caso puede tener multiples valores

Estas "variaciones" de no-A no son conceptos fijos sino "medidas reales", que responden a una acción práctica - que las mide parcialmente la distancia A → U

13) Las Variaciones las presenta Korko como la única realidad - absoluta, los términos fijos = conceptuales, no existen, son falsos (así elimina las "ciencias").
no hay nada claro ni seguro = solo hay probabilidades = borrosas!

14) Según el desplaza el punto de vista { desde una oposición: blanco - negro
desde una { bivalencia a { al gris (abstracta)
una plurivalencia - (concreta)
Pero no se da cuenta que una posición no excluye la otra, una incluye la otra = la bivalencia abstracta soporta fuera todas las plurivalencias concretas.

(15) Una de la terminología mas importantes que debemos aclarar para entender el lugar que ocupa este pensamiento - es Valores parciales en la oposición = contrario ⟷ contradictorio.

A Si ponemos las siguiente palabras

Viviente ⟷	~~estático~~ (fijo)
Sólido ⟷	~~líquido~~ fluido
Material ⟷	~~pensante~~

cada pareja posee características que se desplazan de un extremo a otro, en forma gradual y pueden ser ~~medidas en diferente grado~~ percibidas en situaciones intermedias (en numerosos casos) como en la serie -

Entre lo viviente ---- y lo estático en cuanto extremos con leyes diferentes (hay una continuidad) -

Entre lo material ---- y lo pensante hay un cambio radical de propiedades y también continuidad

Estos casos se llaman oposiciones "contrarias" la oposición es experimental. Entre los extremos hay un eje semántico que permite establecer la continuidad medible, experimentada.

Son contrarias = Todos los hombres son blancos — Ningún hombre es blanco
Las flores son viviente ——— Las flores ~~no son~~ son estáticas
Etc. Alto ⟷ Bajo ; Adelante — atrás ;
Grande — pequeño.

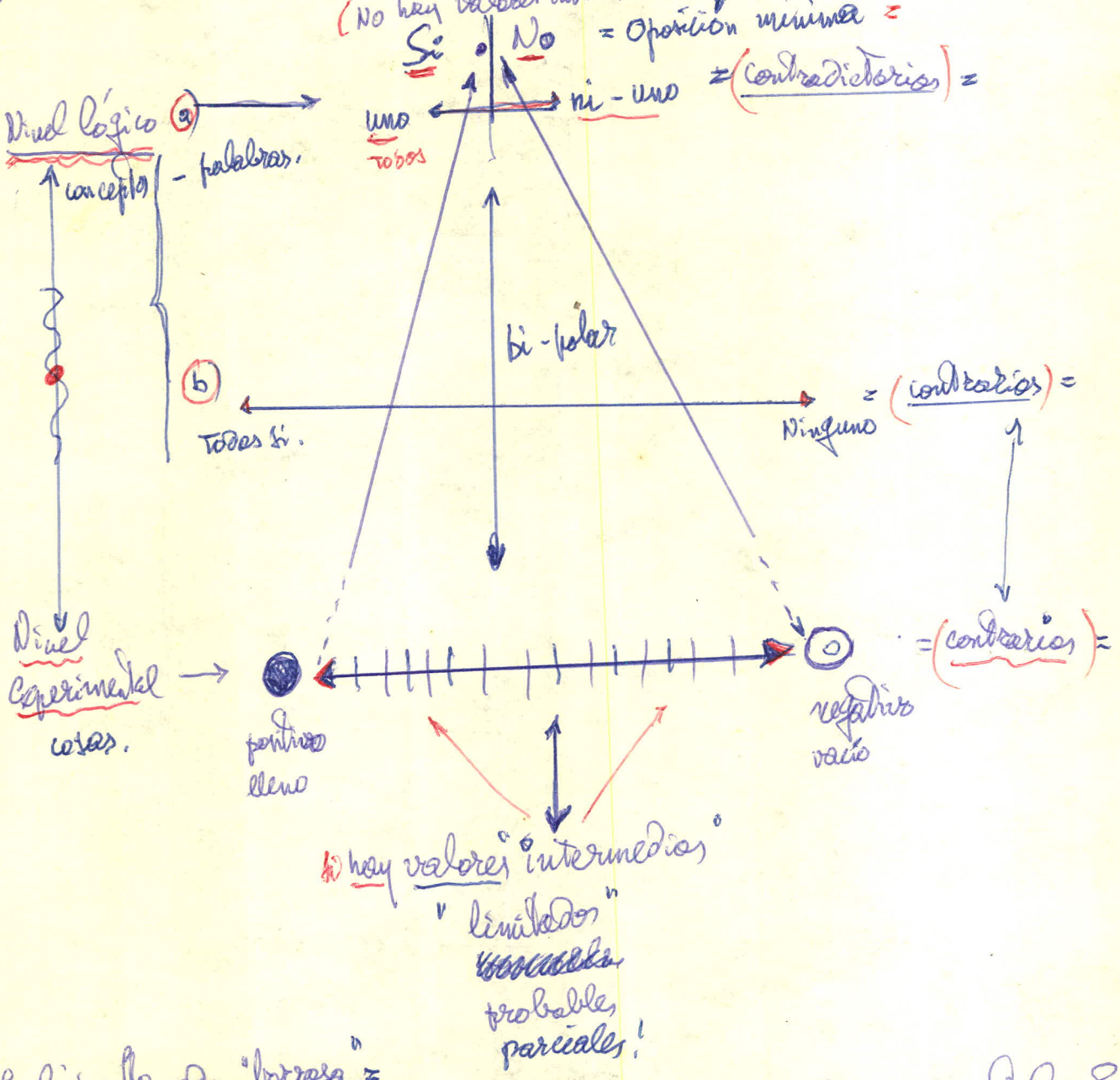
B Si consideramos oposiciones como

La mesa mide 60 cm (versus)	La mesa mide solo 60 cm.
El sol ilumina la Tierra (versus)	El sol no ilumina la tierra
Si — no	
Blanco - no blanco	
Todos los hombres piensan (versus)	Hay un hombre que no piensa
Un Marciano ha llegado a la Tierra (versus)	ningún Marciano ha llegado

Vemos que entre los extremos formulados no hay eje semántico gradual sino un salto. El salto es mínimo y la oposición es lógica y conceptual. Los dos extremos se pertenecen el uno al otro indisolublemente — No hay una escala que pueda medir tal oposición lógica precisamente porque son términos conceptuales y no experimentales

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28 File(s)    9961472 bytes free
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TOEXEC BAT         42     3-18-87   12:00p
3      MEN        561     9-19-86    6:27p
```

Hagamos un esquema ¡que nos ayude a separar los niveles: Lógico y experimental (6)



La lógica llamada "borrosa" =
solo toma en cuenta las oposiciones contrarias = a nivel experimental = Por esto niega el nivel superior lógico = se convierte en un empirismo radical, un pragmatismo que solo considera hechos y no conceptos.
Cuando critica la abstracción de la matemática es porque ignora todo el mundo conceptual.
Para evitar términos fijos "intermedios" extremos, la lógica polivalente, solo considera valores parciales más o menos. = Pero estos términos "+ y −" ya son conceptos fijos y claramente definidos = ideales, no son experimentales!

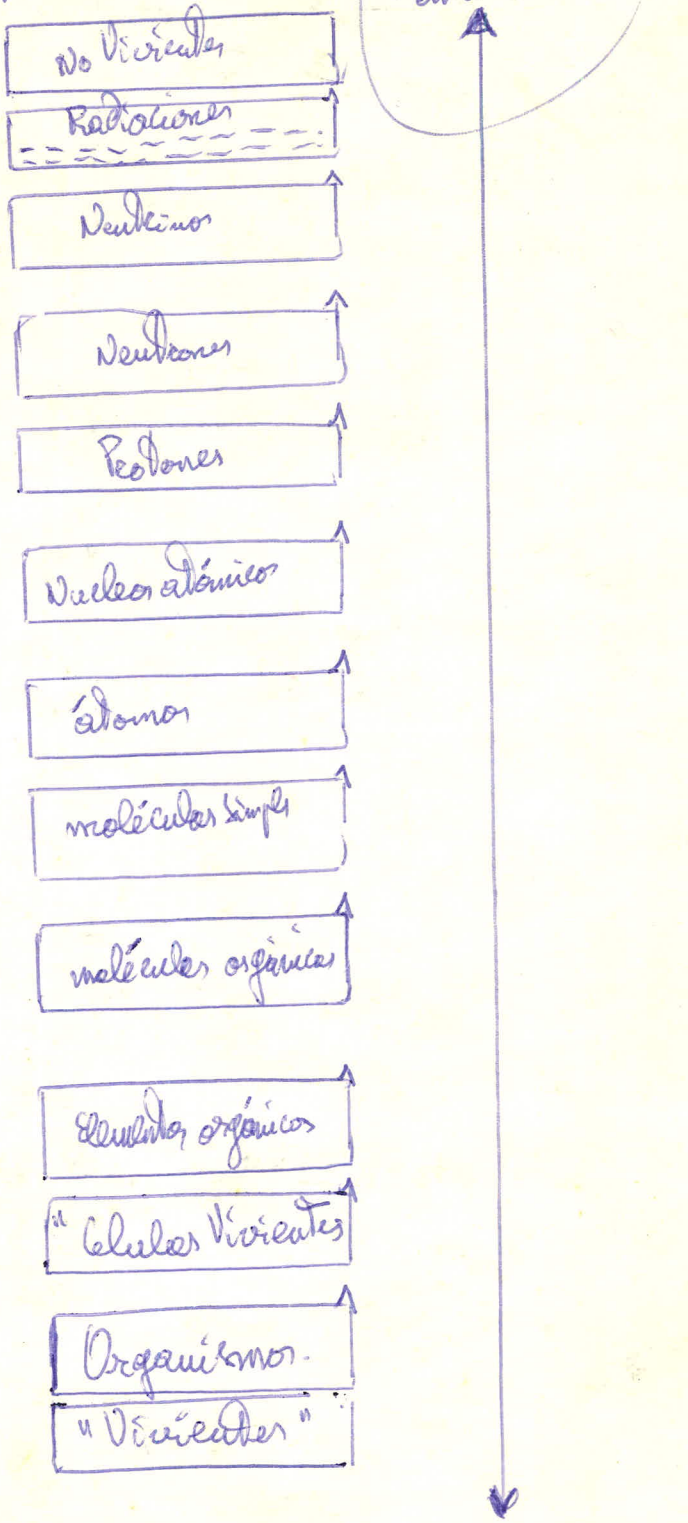
(17) Podemos considerar dos ejemplos para conocer el "mundo" en que opera ese "pensamiento - de valores parciales" — que en su conjunto analizan procesos y variaciones

a) Diversos estados físicos



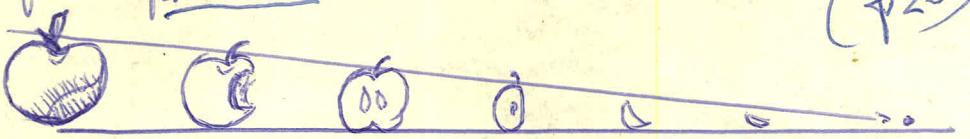
grados de realidades existenciales experimentables bien definidos y estables
= grados lógicos

b) Oposición de Viviente a Edáfico



Pero hay más = no podríamos hacer divisiones "internas" sin referirnos a extremos lógicos.

18) El esquema fundamental de Kosko. (p 25)



Toda una manzana entera | media manzana | 1/4 de maiz | Nada de manzana

En la experiencia el concepto de manzana entera y nada de manzana, son afirmaciones CONTRARIAS
Poseyendo admiten un eje semantico "parcialidad" y medidas intermedias sin límite

Pero

a) Las medidas intermedias, cada una es "conceptualizada por mi" = y en cuanto concepto = este real NO ES BORROSO!

b) Los dos extremos { "Toda" la Manzana / "Nada" de manzana } = son también extremos conceptuales y como tales son claros y fijos (aunque el contenido experimental cambie)

c) Además yo no podría percibir partes de manzana si no tuviera los extremos en mi mente = Todo — Nada.
Y esta exigencia existe en todos los casos que yo observe datos "parciales" — o intermedios o "grises" —

Entre { una manzana / y un pedazo de manzana } no hay contradicción lógica, solo son dos cosas diferentes

El dibujo anterior se puede representar como conjuntos

$A = V$



La nada es = Λ

a) A nivel Lógico la Negación = es un conjunto límite = Λ
A nivel pragmático la negación es una "diferencia" = conjunto - positivo

19) pag. 4 = Sí mismo y No finismo = es como A y { -A = negac. / -A = complement.
Aquí mezcla las contradictorias con los contrario
{ El no-finismo como negación es el límite de uno (negac = -A)
{ El no-finismo como otro es "diferencia" = otro ser

Todo el fluido en el mundo · (p 5) (9)
R/ En cuanto a quanta, quarks = parece el tener
En cuanto a otras partículas = aunque cumplen de identidad en la experiencia
sin embargo se captan con concepto fijo!

No se entiende qué quiere decir con que todo "cambia de identidad"
qué supone? si cambia hay un punto de perdida!

20. Ataca la lógica para trabajar sobre base 2 · { V / F Todo enunciado es V. o F
El fundamento es experimental no-lógico.
Además solo se aplica a ciertos tipos de enunciados (= Declarativos)
Rechaza también el sistema binario { 1 / 0 de la computadora. = { blanco / negro
Las operaciones { A ∨ -A / A ∧ -A = no o pueden Contrarios sino DIVERSOS = 2 conjuntos

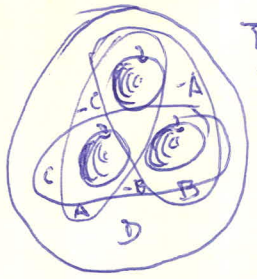
p 17 = "la lógica borrosa comienza donde termina la lógica occidental"
R/ yo diría que es una "pragmática" que interpreta la realidad con los mismos extremos de la lógica occidental pero prescindiendo del puro nivel empírico

p 19 - "Todo es cosa de grados" = R/ en la experiencia de acuerdo, y ni siquiera de grados - las cosas no tienen grados - solo están allí = existen cada una a su modo (+o - verde) (+o - azul) = CONTINUO -

Los grados = los establecemos nosotros | con los conceptos / con el cálculo / con la medida / con el número | que son todas entidades mentales y fijas, discretas y claras

Con su mentalidad puramente empírica Karko trata de definir aplicaciones en que aparezcan VALORES-PARCIALES-

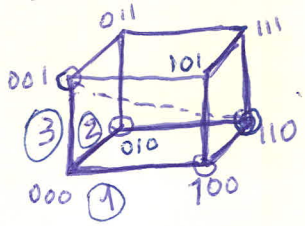
(p 29)



Tres manzanas cuando subconjuntos? = ocho

(A)(B)(C) (-A)(-B)(-C) (D) $\overset{V}{=}$ (-D) = Λ

1 2 3 4 5 6 7 8



= ocho vértices

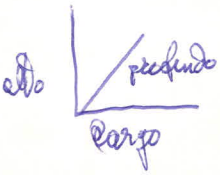
Ocho esquinas

000	010	001
001	011	011
011	001	111
111	000	110
110	100	100
100	110	000
	101	

010

Cubo de Rubik:
Tres manzanas

Tres medidas del cubo



0 = menos-rojo
1 = puro rojo

(p 30) = la lógica "bi-valente" se tiñía en la esquina del cubo
= la borrosa está adentro = conjuntos borrosos o multi-valente!

Aplicando las tres manzanas a las 3 aristas del Cubo. en el fondo (000) no tienen color rojo - en el fondo (111) = todas están rojas al máximo!
Los demás fondos son diferentes = (001, 100, 110, 010, 011, 101)
1 2 3 4 5 6

En las aristas exteriores el color rojo solo puede variar entre 0 → 1 = (bivalentes)

Pero el cubo se llena de conjuntos (a medias) borrosos! ej: 0, 0, 3/4 / 1/2, 1/2, 1/2

el primer ej = indica 75%
el segundo ej = indica el fondo "central" del cubo → está en la misma distancia de las esquinas - angulares!

(p 31)



Preguntó a 2 personas que levantan la mano si están contentas de su trabajo

a) Lógica bivalente  = solo cuatro posibilidades.
(11, 01, 10, 00)
(sí, sí) (no, sí) (sí, no) (no, no)

b) Lógica pluri-valente  3/4, 1/2, 1/5, 1/6, 1/8 = la respuesta es "gradual"

- muchísimo
- mucho
- algo
- medio
- poco
- muy poco

ESTA SEMANA

UNIVERSIDAD LANDIVAR

No. 23

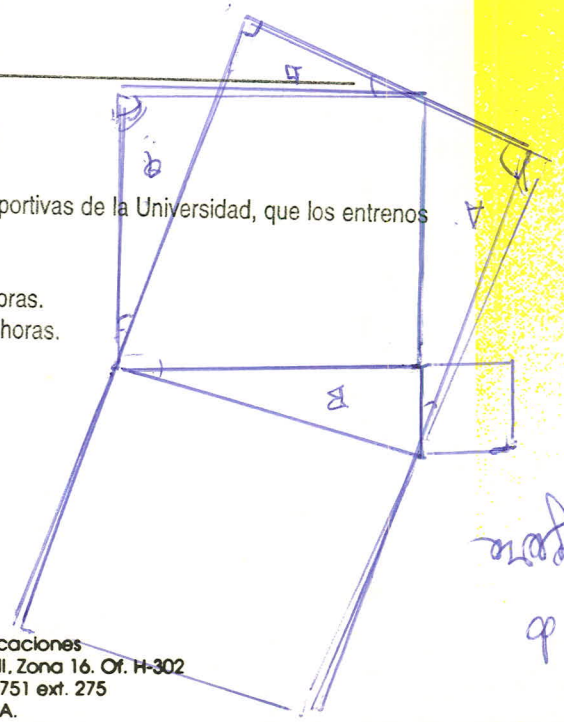
SEMANA DEL 10 AL 15 DE JUNIO

Martes 11	de 16:30 a 18:00 horas Salón H-334	Conferencia EDUCACIÓN DESDE UNA PROPUESTA POLÍTICA, dictada por el Profesor Danilo Gandíu, especialista en planificación co-participativa y Catedrático de la Universidad de Río Grande do Soul de Brasil. **FACULTAD DE HUMANIDADES.**
	de 18:00 a 20:00 horas	Continúa el Curso Académico TESTIMONIO, LITERATURA Y VERDAD HISTÓRICA DE CENTROAMÉRICA, impartido por Mario Roberto Morales. Éste curso se estará llevando a cabo todos los martes de junio. **DIRECCIÓN DE EXTENSIÓN.**
Miércoles 12	18:00 horas Galería Plástica Contemporánea	Presentación del libro EL HOMBRE, MI HERMANO, del Dr. Antonio Gallo,SJ. La presentación estará a cargo del Dr. Oswaldo Salazar y los comentarios al mismo los realizará el Dr. René Poitevin. El Arq. Augusto Vela, Ministro de Cultura y Deportes, hará la formal entrega del libro a su autor. Esta actividad corresponde a los Miércoles Landivarianos. **DIRECCIÓN DE EXTENSIÓN.**
Jueves 13	de 10:00 a 12:00 horas Auditorio	Prosiguen los talleres del SEMINARIO VIDA PLENA, el cual se estará llevando a cabo todos los jueves del més de junio y los primeros dos jueves del mes de julio. Este seminario cuenta con la participación de expositores calificados para dicho evento. **DIRECCIÓN DE EXTENSIÓN.**
	18:00 horas Salón H-309	Se llevará a cabo la conferencia FUNCIÓN DEL ARTE, dictada por el Maestro Dagoberto Vásquez. **FACULTAD DE CIENCIAS JURÍDICAS.**

AVISOS IMPORTANTES

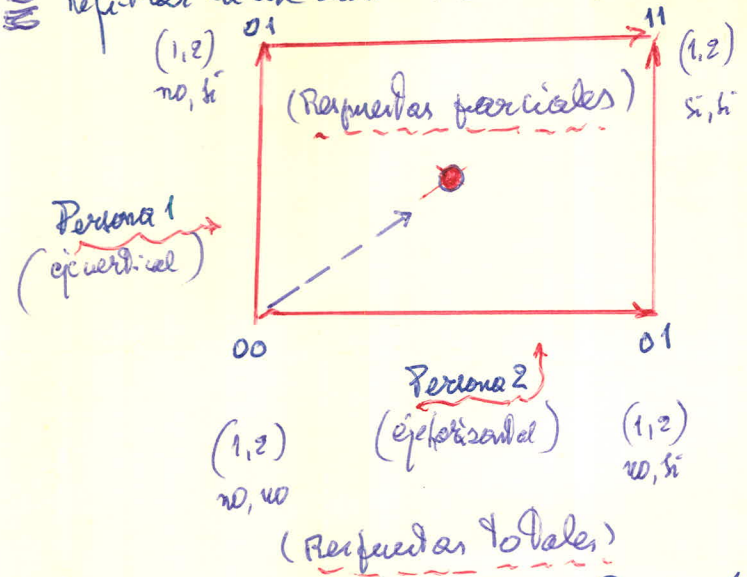
El Departamento de Deportes comunica a los miembros de las selecciones deportivas de la Universidad, que los entrenos se realizan en los días y horarios siguientes:

Voleibol: lunes y miércoles de 12:00 a 14:00 horas y sábado de 10:00 a 12:00 horas.
Baloncesto: martes y jueves de 12:00 a 14:00 horas y sábado de 12:00 a 14:00 horas.
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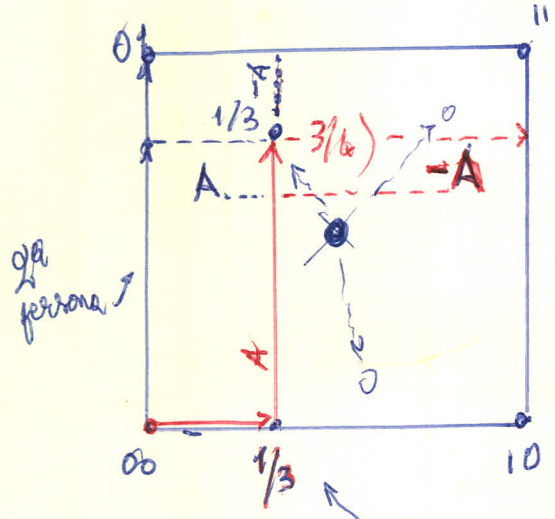
≡ Representar en un cuadrado estas posibilidades:



- La lógica bivalente se coloca en los ángulos: (no, no) (no, sí) (sí, no) (sí, sí)
- La lógica-gradual (borrosa) se coloca al interior
- El punto central es fronterizo $(\frac{1}{2}, \frac{1}{2})$ = de las dos respuestas

Conocimentalmente: se puede recorrer toda el área del cuadrado con valores "parciales" de la primera y segunda persona relativamente

(p-33)



Si 1/3 es A = contenido
Entonces -A = 3/4 = lo contenido
y así en adelante.
Pero siempre se trata de partes de un TODO (= concepto)
Estas partes se consideran como
A = conjunto positivo = dado.
-A = complemento de A = otro conjunto.

1ª persona
Siempre no-borroso — todo borroso.
Ahora vuelve a "considerar" el punto central donde se encuentran
En esto no hay nada de borroso — solo medidas parciales;
Siempre se trata de medidas-parciales: todo, parte, vacío
lleno

- A ∧ -A
- A ∪ -A
- A X -A
- A = -A ?



Tanto las esquinas del cuadrado como el centro no son borrosos, solo tienen diferente contenido
- idea fija = de un TODO ?
- idea fija = de una 1/2 variable
- idea fija = de una "esquina" del cuadrado.

L LANDIVAR

O HUMANIDADES

RAS Y FILOSOFIA

EN FILOSOFIA

CALENDARIO DE EXAMENES

SEMESTRE PRIMERO

PLAN DIARIO

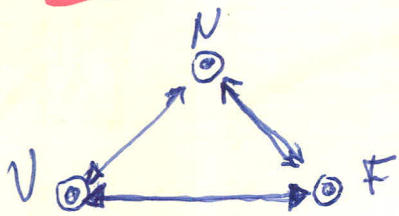
ELABORADO POR: _____

Vo. Bo.

CONVOCATORIA			ASIGNATURA	CATEDRATICO	SALON DE CLASE
1ra.	2da.	3ra.			
20-5-96			Fenomenologia del Valor	Dr. Antonio Gallo, S.J.	Edificio O
22-5-96			Interpretacion Filosófica del Mito	Dr. Antonio Gallo, S.J.	Edificio O
27-5-96			Teorías Esteticas Contemporaneas	M.A.Ernesto Loukota Soler	Edificio O
			TERCER SEMESTRE		
20-5-96			Filosofía del Psicoanálisis	Dra. Ana Rosón de Avignon	Edificio O
27-5-96			Pensa. Filosof. en Literat.Latinoam.	Dr. Rodolfo Arévalo	Edificio O

Qué diferencia hay entre la lógica del Marciano y la "Borrosa"?

A El marciano tiene una lógica en base 3.



SUPONEMOS QUE:

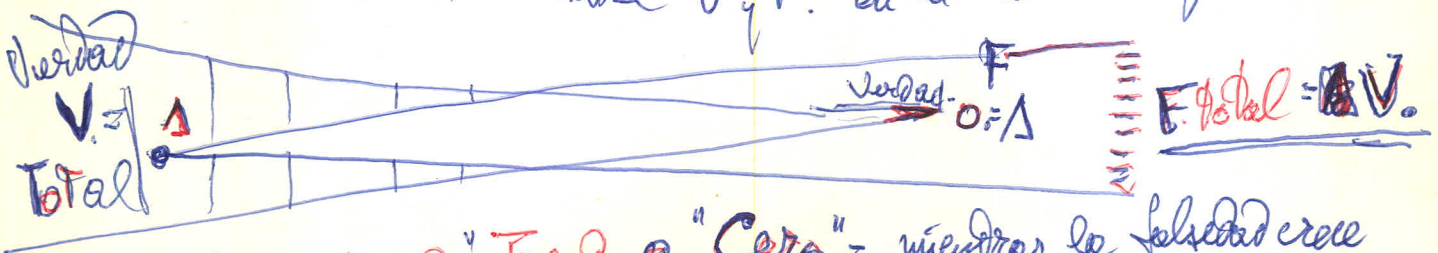
1) { V — son 3 conceptos diferentes!
   { F — cada uno se opone a los!
   { N — otros dos = contradictoriamente!
2) Cada uno a un extremo
3) Dos son contrarios pero contradictorios
4) Entre uno y otro no hay medio = solo mezcla
5) Cada uno marca un límite del otro.

Esta lógica nos muestra coherente; pero no parece comprensible.

Universidad Rafael Landívar
Dr. Antonio Carlos Sá
Residencia San Borja

B La lógica de Valores parciales [="Borrosa" - desbalanceada]

Es existencial: { a) Considera { que V = en alta realidad - concepto
                              { que F = en otra realidad concepto
                { b) Considera los posiciones parciales intermedias entre V y F. en la realidad experimental



V = Total - "parcializado", tiende a "Cero" = mientras la falsedad crece

F = desde cero - crece hasta ser = F - Total. { = La falsedad Total = V implica la Verdad - cero = 1

La Verdad Total = V. implica una Falsedad cero = 1

Vistos como dos conjuntos parciales no presentan ninguna dificultad.

ESTA SEMANA

UNIVERSIDAD LANDIVAR

No. 22

SEMANA DEL 3 AL 8 DE JUNIO

Martes 4	de 18:00 a 20:00 horas Salón H-309	Dará inicio el Curso Académico TESTIMONIO, LITERATURA Y VERDAD HISTÓRICA DE CENTROAMÉRICA, impartido por Mario Roberto Morales. Este curso se estará realizando todos los jueves del mes de junio. **DIRECCIÓN DE EXTENSIÓN.**
Jueves 6	de 10:00 a 12:00 horas Auditorio	Se llevará a cabo el Taller Introductorio al SEMINARIO VIDA PLENA, el cual se estará llevando a cabo todos los jueves del mes junio y los primeros dos jueves del mes de julio. Este seminario contará con la participación de expositores calificados para dicho evento. **DIRECCIÓN DE EXTENSIÓN.**
	18:00 horas Salón H-334	Presentación del informe de la EVALUACIÓN DE CATEDRÁTICOS correspondiente al primer semestre de 1996 a catedráticos y autoridades de la Facultad de Humanidades. **FACULTAD DE HUMANIDADES.**

AVISOS IMPORTANTES

Se comunica a la Comunidad Landivariana que desde el 29 de mayo la oficina de la **Coordinación de Sedes Regionales** se trasladó al **Edificio "O", tercer nivel, oficina 309, extensión 344.**

El **Departamento de Deportes** comunica a los miembros de las selecciones deportivas de la Universidad, que los entrenos se realizan en los días y horarios siguientes:

Voleibol: lunes y miércoles de 12:00 a 14:00 horas y sábado de 10:00 a 12:00 horas.
Baloncesto: martes y jueves de 12:00 a 14:00 horas y sábado de 12:00 a 14:00 horas.
Fútbol: martes, miércoles y jueves de 12:00 a 14:00 horas.

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- Contador General
- Analista de Créditos
- Jefe de Cobros
- Jefe de Control de Calidad
- Jefe de Postcosecha
- Secretaria de Gerencia
- Ingeniero para Mantenimiento de Equipo
- Secretaria
- Operador de Macintosh
- Administrador
- Secretaria Asistente de Gerencia Financiera
- Peritos Agrónomos

Mayor Información podrá obtenerla en el CENTRO DE ORIENTACIÓN UNIVERSITARIA (COU), Edificio J, tercer nivel, oficina 334, teléfonos: 380159, 692151 y 692621; Ext: 248.

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Pero debemos precisar que: tanto como { V = Total V, F = Total cero = Λ } o bien y { V = cero Λ, F = Total V }

son extremos "fijos" = conceptos lógicos claros y definidos (en su contenido variable)

Igualmente las "medidas" intermedias = V = 3/4, 1/2, 1/3, 1/4, 1/5 .... que son medidas parciales = son conceptos fijos, claros, definidos aunque su contenido deba ser calculado caso por caso

y las medidas intermedias de F = 0, 1/5, 1/4, 1/3, 1/2, 3/4, ... V ... son también medidas parciales definidas, conceptos definidos y claros aunque su contenido sea variable -

{ Entre: V = Total V y V = cero = Λ = hay una variación de más → a menos
y entre F = cero Λ y F = Total V = hay otra variación de menos → a mas.

Ahora = Todos los términos extremos = Verdad - Falsedad = contrarios
Como los términos intermedios (V = 1/2) (F = 3/4) hacen referencia a 2 términos → VF
→ menos mas

y si encontramos un "punto" de igualdad = (F = 1/2) (V = 1/2) este punto de "igualdad" es otro concepto lógico básico, del cual no se puede prescindir para "medir" con valores intermedios

EL PROBLEMA DEL PUNTO

El problema del punto es importante -
El punto es una Variable (en el espacio dentro del cuadrado) p. q. r. s.
1, 2, 3, 4, 5, 6, ... son Variables.
Como se define una Variable en el cuadrado? R/ con dos valores

tipos lógicos no tiene numeración, solo posee un orden: hacia arriba se generaliza cada vez más; hacia abajo se subdivide una vez mas, es decir se reparte en unidades más pequeñas. Lo que hay que conservar es el orden. Siguiendo ese orden podemos pormenorizar más nuestro análisis.

Por ejemplo tomemos los entremeses: El jamón se subdivide en rodajas y cada rodaja en áreas. Las aceitunas se subdividen en pulpa, pepita y piel; los cebollines se subdividen en hojas, raíces y tallo. Todas estas divisiones pertenecen evidentemente a un tipo lógico inferior, que podria todavía subdividirse ulteriormente, y esto más y más, sin un límite fijo.

Entonces, hemos encontrado una *estructura* que está abierta tanto hacia arriba como hacia abajo: hacia arriba encontramos tipos lógicos superiores, hacia abajo tipos lógicos inferiores. No se asuste. No puede perderse.

¿Entonces no hay un punto de partida ni hay uno de llegada? La respuesta es si, hay un punto de partida: su **experiencia**, la abstracción de lo que usted ve le lleva diractamente a un objeto-lógico. Usted partirá entonces de ahí, de este primer *objeto* que descubrió. De ahí usted puede ir hacia arriba buscando otros niveles lógicos, o hacia abajo, analizando el objeto, descomponiéndolo en sus elementos y encontrando tipos lógicos inferiores.

Ya tiene delante el esquema general: si parte de las cosas de la experiencia, ejercítese a formar los tipos. Haga memoria de cuantos tipos está manejando constantemente: cada *palabra* que expresa una noción, es un tipo. Pero si en lugar de partir de la experiencia prefiere partir de una palabra, recuérdese que esta es un *tipo*, y si la quiere ubicar deberá someterla a un análisis: hacia arriba, sube a niveles superiores; hacia abajo desciende a niveles inferiores. Hacia arriba se agrupa (se suma); hacia abajo se reparte (subdivide) Hacia arriba encuentra *super-conjuntos*, hacia abajo *sub-conjuntos*.

Pongamos dos ejemplos evidentes:

a) Un malabarista hace volar bolas con las manos: empieza con dos bolas, añade una tercera, luego una cuarta y así hasta cinco o seis a la vez. Mientras juega, siempre maneja un conjunto de bolas. Pero a este conjunto va sumando elementos. Cada vez que añade una bola crea un conjunto más grande. Su operación es jugar con conjuntos. Es lo mismo que hacemos nosotros cuando creamos *tipos* hacia arriba, con solo sumar, agrupar individuos, tipificamos, creamos conjuntos.

b) Un mecánico desmonta el motor de su carro. Primero saca tornillos, luego saca las bielas, luego los cilindros. Al final obtiene varias canastas homogéneas de objetos,varios sub-conjuntos del super-conjunto carro. Está creando tipos hacia abajo. Obtiene una serie de tipos diferentes, derivados de el análisis (descomposición) de un solo motor (del super-conjunto a los subconjuntos).

Tercer Contenido:

CONOCIMIENTOS JERARQUIZADOS. (Título)

1.3 Con este tercer paso, usted llega a poseer un instrumento siempre a-la-mano , para organizar sus conocimientos. Pongamos que usted entra en una tienda, y ve una cosa que nunca en su vida había encontrado. Se pregunta: *¿Qué será eso?*

EL ANALISIS

Se acerca el vendedor y le dice: *"Es un nuevo extractor-de-jugos; vea lo que tiene": (A ^ B ^ C ^ D ^ E)*

"1. un motor eléctrico con todas sus partes,

a) 2 coordinadas cartesianas — ↑→ horizontal - vertical

b) 2 valores verdaderos = V. F.

c) 2 posiciones de una sucesión : 0 - 1.

¿Qué es una sucesión? R/ una serie ordenada entre - 2.

0-1, 1-2, 2-3, 3-4, 4-5)

Siempre hay "un" orden repetido entre "dos"

La medida la da el "cambio".

De cero a uno $(0,1)$ hay "una" unidad

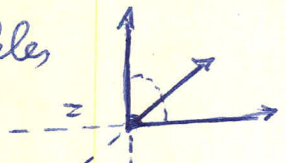
De uno a dos $\begin{cases} = (1,2) \\ \text{binario} \end{cases}$ hay la misma unidad $\begin{cases} = (1,1) \end{cases}$

Cada cambio fija una "pareja". ---.

El código siempre es binario, aún cuando no se hable de superficie sino de espacios con 3, 4, 5, 6... dimensiones

Lo que cambian son las VARIABLES = $2^2, 2^3, 2^4, 2^5, \ldots 2^n$.

El cubo tiene [3] variables

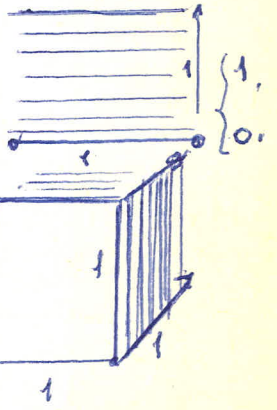


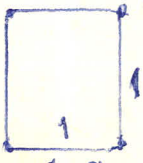
Los puntos en el espacio se determinan con "pares-valores", en sucesión

Pero la "sucesión" es "orden de 2", que se repite.

Ej. Hagamos el proceso opuesto.

1) Agarre una línea → y extiéndala en "Una" dimensión y nos da una superficie.



2) Agarre una superficie  y extiéndala en Otra Dimensión: con otra unidad:

y tendrá un espacio = un cubo de 3 dimensiones!!

3) Agarre un espacio (= un cubo) y extiéndalo en Otra dimensión (el movimiento) y obtendremos un espacio de 4 dimensiones

cada dimensión que se añade la imaginamos porque tenemos una experiencia previa
Pero podemos "calcularla" sin imaginarla, como "pura posibilidad lógica", añadiendo
una VARIABLE.

Cuando hablamos no debemos mezclar un tipo lógico con otro. Por ejemplo, usted no podría decir: *"Tengo un racimo de uvas, tres bananos, un melón y fruta"*. Alguien le preguntaría: *¿Qué fruta?*. Porque esta palabra es de un tipo-lógico superior, y no debe mezclarse con los tipos inferiores. Sería como decir: *"En esa calle hay un chalet, un supermercado, una farmacia, un taller, una cantina y un barrio"*. ¿Qué tiene que ver el barrio con una enumeración de casas? **El barrio es de otro tipo lógico**, pertenece a otro nivel de abstracción.

Así se "construye un "espacio lógico-matemático"! pero no habría matemática sin
la lógica.

Pero se podría decir: *"Hay dos barrios a orilla de un barranco o la ciudad tiene cinco barrios"*; por que la ciudad (objeto ideal) es de un nivel lógico superior a barrio, y cada barrio es un elemento de ciudad; igual como a su vez los edificios son elementos del barrio; la expresión lingüística (oración) en este caso respeta las diferencias de nivel.

Si al hablar, uno mezcla los tipos lógicos poniéndolos al mismo nivel, construye oraciones sin sentido. Es como decir: *"Mi barrio posee una ciudad y un mercado"* y cosas por el estilo.

Haga ejercicios, organizando sus oraciones según los tipos lógicos. Si en un oración queremos utilizar diversos tipos lógicos, debemos conservar la diferencia de niveles; esto nos obliga a usar una estructura jerarquizada. Los tipos lógicos superiores incluyen a los inferiores. Lo veremos en la siguiente práctica.

Ahora regresemos al objeto *fruta*. El termino *fruta* puede ser un simple elemento que se combina con otros *super-objetos* que se relacionen con él.

ANALISIS DE NIVELES

Pongamos el caso que usted esté preparando un menú (objeto) para el almuerzo. Ya tiene la fruta, entonces pondrá otros elementos del mismo tipo lógico : entremeses, sopa, carne, verdura y fruta. Hagamos nuestra estructura.

Como usted puede comprobar, el nivel cero es el nivel de la verdad, de las cosas particulares: lo que se ve, y lo que verán los invitados. Toda la construcción superior es únicamente una construcción lógica, un castillo de abstracciones que, sin embargo, son necesarias y útiles si tenemos que conservar nuestra mente ordenada y eficiente.

Lo interesante es que este esquema ha sido desarrollado por los lingüistas, utilizado por los antropologos, y es corriente en todas las ciencias.

Un *menú* incluye, como *super-super-conjunto*, los diferentes tipos de alimentos: entremeses, sopas, carnes, verduras, frutas y dulces. A su vez cada uno de estos objetos, incluye los ingredientes que los componen. Los entremeses incluyen: jamón, aceitunas, cebollines, y otros; las sopas, incluyen diferentes clases de sopas: de arroz, de espárragos, de ajos, de pasta etc. Las carnes hacen pensar en diferentes clases de carnes, etc. Consecuentemente el *menú* pertenece a un tipo lógico de tercer nivel, los platos pertenecen al segundo nivel, los ingredientes pertenecen al nivel cero.

1.2.3. ANALISIS EN PROFUNDIDAD.

Ahora usted se preguntará: *"¿Es posible encontrar tipos lógicos, más abajo del nivel cero?"* La respuesta es si. Igual como es posible ir para arriba, a un cuarto y quinto nivel lógico, se puede descender a niveles inferiores, a menos uno, menos dos, etc. La numeración es una ocurrencia nuestra. En realidad la estructura de los

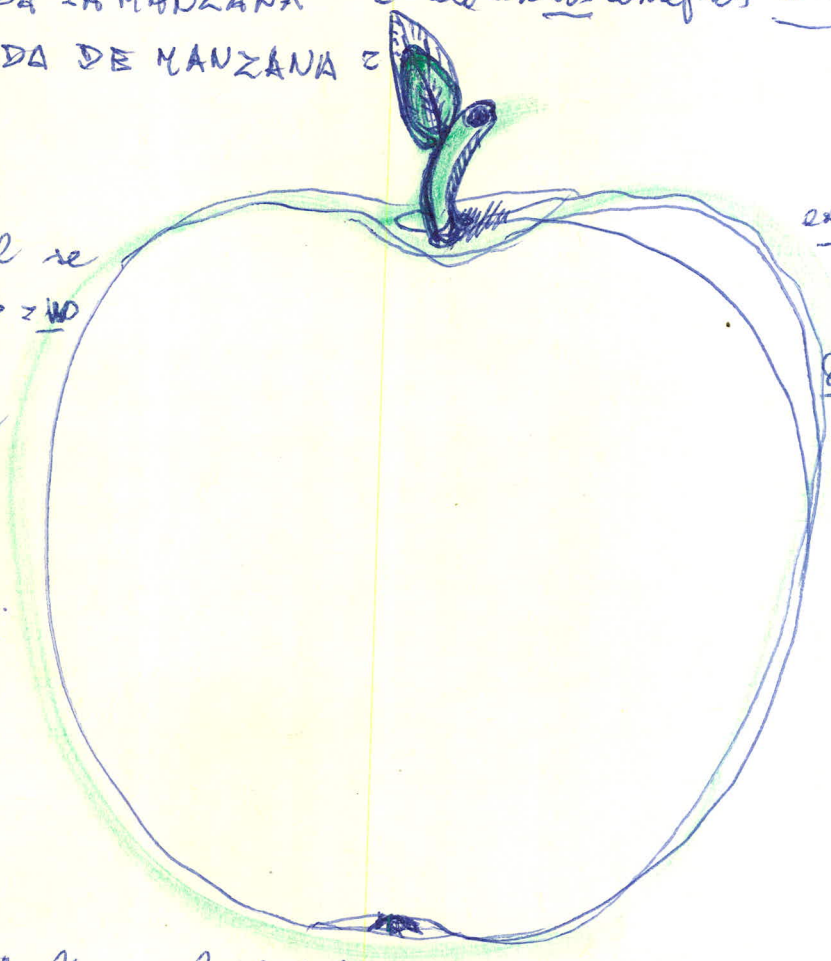
"Fuzzy = Logic."

No existen! | TODA LA MANZANA = Solo son dos "conceptos" contrarios!!
NADA DE MANZANA =

como experiencias

la manzana real se medidas toscas = no parciales ...
pero ello no quiere

Solo quiere decir medidas inexactas.
afinables.



experimento con precisión = aproximaciones, y

decir borrosas o confusas !!

Nota: Compare el inglés con el español

Fuz = dejado con pelos = peludo → borra = pelo de tabla, que se corta el borde. pelusa del algodón = corresponde al inglés.

Fuzzy = deshilachado peludo — con borra → borroso = indefinido = nublado = con contorno mal trazado = confuso —

NO corresponde al inglés. —
(no se puede usar.)

Nota: para realizar una medición: ej. este bejo mide 8 ½ pulgadas 1) no basta con aplicarle una regla 2) hay que saber que esta regla "es una medida" = concepto - preciso de una variable!

Antonio Gallo

VER DE VERBO

(CURSO DE INTRODUCCION A LA LOGICA)

Guatemala C.A. 1993

VER DE VERBO

Introducción

"Es necesario tomar al pie de la letra lo que nos enseña la visión: que por ella tocamos el sol, las estrellas, estamos al mismo tiempo en todas partes, tan cerca de las cosas lejanas, como de las próximas, y aún nuestro poder de imaginarnos en otra parte".

(Maurice Merleau-Ponti, *El Ojo y el Espíritu.*)

INTRODUCCION

Nota Didactica

(sangria)

VER DE VERBO es un manual de introducción a la lógica, concebido para alumnos de los primeros años de la carrera universitaria. Dada la variedad y diversidad de exigencias de cada carrera, el libro ha sido pensado como un instrumento flexible que pueda ser adaptado por el Catedrático según el caracter específico de alumnos en carreras humanísticas, o técnicas, o de negocios, etc... La adaptación consistirá esencialmente en la selección de aquellos capítulos, o bien unidades, que sean más útiles e interesantes para la carrera.

(sangria!)

El texto está dividido en ocho unidades. Las cuatro primeras desarrollan los temas corrientes de una introducción a la Lógica. Estas, sin duda podrán ser desarrollados integralmente por los catedráticos de las carreras técnicas, sistemas de información o de comunicación. Los anteriores se complementan naturalmente con la unidad siete (una introducción a la investigación) y la ocho que presenta reflexiones un poco más avanzadas acerca de la Lógica aplicada a la ciencia moderna. En ocasiones podrán ser ampliados por el mismo catedrático, en cuanto a los desarrollos de procesos lógicos y ejercicios. El aspecto especulativo puede ser cubierto con algunas de las lecturas que se añaden a cada unidad.

Los catedráticos de carreras de Letras, Psicología o afines, podrán limitarse a las primeras dos o tres unidades, y continuar con la sexta (estructura lógica del lenguaje) y la séptima, dando mayor énfasis al aspecto linguístico y a la investigación. La unidad cinco, de reflexión, podrá ser objeto de discusión en clase o de comentarios escritos, según los intereses particulares del grupo. Las lecturas que acompañan los diversos capítulos, pueden, por sí solas, ofrecer un material para un curso menos práctico; pero igualmente útil, desde la perspectiva de la formación mental del estudiante.

El enfoque pedagógico y fenomenológico que se ha dado a todo el desarrollo, tiene en cuenta la función que el libro debe desempeñar principalmente en las Sedes Departamentales de la Universidad, donde el estudiante no posee los complementos que de ordinario se encuentran en la Capital. Por esta razón trata de crear un clima, un ambiente cultural en el cual la Lógica adquiera su verdadero significado. De hecho está pensado como una especie de Texto programado, que permita al estudiante avanzar con sus propios medios, sirviéndose de los conocimientos que la vida misma le proporciona, para llegar a una especulación abstracta de alto nivel. Esta se encuentra principalmente en las unidades cuatro, cinco y ocho. Si alguien deseara una mayor amplitud en la explicación de los mecanismos de los procesos formales, deberá complementarlos con cualquiera de los textos de lógica que se conocen.

toda la manzana ≠ Nada de manzana aplicado

- a) a nivel experimental son terminos indefinidos - informes
- b) a nivel conceptual son terminos precisos - formales

Lógica Borrosa = NUBLADA

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(1) Las "Variables parciales" = son prácticamente "todos" los Valores que se captan en la experiencia — limitada

La experiencia (Husserl) genera la "opinión" = δόξα.

La experiencia no es Verdadera ni falsa! pero va acompañada por imágenes

La experiencia fundamenta el conocimiento y habla - que responde a imágenes mentales -

La verdad y falsedad (formalidad) están en el conocimiento y en el habla.

A decir a la "experiencia - variable" { no es salirse de la lógica ni inventar otra lógica
- Sino hacer cálculos para resolver problemas
- El cálculo no puede ser borroso si no claro y fijo. lo más posibles.

Si uno separa los dos niveles { a) Experiencial = δόξα ico = opinión
b) Medidor — = τέλος = validador epistemológico — lógico o axiológico!

De que no puede haber contradicción entre los dos niveles sino independencia, y complementariedad

La variabilidad - de la experiencia como "aproximación al mundo real" - no es ninguna novedad. { = El contenido de la experiencia es variable
= Cada nueva experiencia, modifica la antigua, confirma o cambia

Las Variaciones son:

... desconocido --- pre dado - dado -- conocido ... comprobado -- certificado = Verdadero

En la "verdad" hay también variaciones =
-- posible ... probable ... cierto ... innegable ... ABSOLUTO ?

Sin embargo nosotros medimos por términos conceptuales fijos (como grandes?))

La invariabilidad de los términos - conceptuales es "estructural" -

Ej: Toda la Tierra, casi Toda: 90/100 80/100 70/100 50/100 10/100 2/100 ...
Todos estos conceptos son fijos y relativos a la supuesta TOTALIDAD

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Lógica borrosa? DIFUSA

R/ mejor sería definida como: "Cálculo de Valores-parciales". La experiencia es global y sin términos fijos pero su contenido es borroso!

Entonces — Yo experimento una "totalidad" sin límites y separo las partes! las defino como entidades ideales.

En ese cálculo se formulan expresiones, figuras, porcentajes, probabilidades.

Pero en esta formulación se utilizan conceptos y estos conceptos no son borrosos, sino "parciales" y bien preciso ej: 1/3 1/5 1/8, un pedazo

cada uno de estos conceptos "parciales" hace referencia a dos extremos contrarios Ej: Todo — Nada
Completo — Inexistente
Blanco — Negro

Estos conceptos son "entidades ideales" como las llama Husserl.

Todos los extremos como los parciales

La llamada "Lógica" borrosa" | no es una nueva lógica
a la aplicación lógica a objetos-parciales y
teniendo a una serie "variable" entre dos extremos

Los dos extremos, son = términos conceptuales = "contrarios" entre sí
(no son experimentables, solo formales) (no son contradictorios)

Ej:- { A y -A (no-A niega simplemente A. no es otro conjunto.
-A es el límite de A. = el límite es experiencia conceptos
A + Ã = dos conjuntos / A = conjunto - lenible
Ã = complemento de A. = otro conjunto

KosKo = confunde estas dos formulas

Dos conceptos diferentes:

Ej: { (A) -A -A = solo indica el límite hasta donde llega A
= contradicción

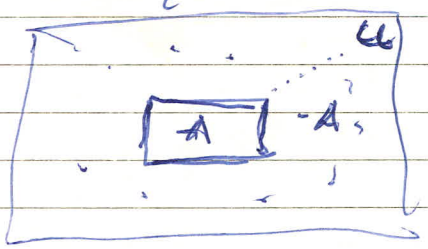
[(A) Ã U] = Ã = complemento de A es el conjunto = diferencia
Si se une A + Ã = se consigue U = Dominio
= contrarios.

Ej: A | -A
1) montaña | no montaña
afirmación | negación simple

Si tomo Ã como diferencia o conjunto complemento de A.
Entonces hasta el mar es Ã.

donde llega la montaña? R/ = hasta el límite, -A.

A ∧ -A { A + Λ
A + (U - A)



paideia3.gif (8894 bytes)

Logic and Philosophy of Logic

Below please find the schedule for contributed papers in this section. If you have accessed the Congress Web Site using Microsoft Internet Explorer, Netscape Navigator, or a similar program, it is possible to search for a name or paper title using the **find** function under the heading **edit**. Otherwise, you must browse through the page below in order to locate your name and paper title.

Wednesday, August 12, 12-13:50

Name	Title of Paper
Saul Fisher	*'Probabilist' deductive inference in Gassendi's Logic*
Yvon Gauthier	*Frege and Kronecker on the Internal Logic of Arithmetic*
Joseph Gruenfeld	*Haack on Fuzzy Logic*
Young Soo Kim	*A New System of Modal Logic*
Rubicon Rodrigo Soberano	*Disarming Stove's Paradox: In Defense of Formal Logic*

Wednesday, August 12, 14-15:50

Name	Title of Paper
John Howes	*Faithful and Fruitful Logic*
S.L. Katretchko	*Between Logic and Heuristics*
George Shpenkov and L.G. Kreidik	*Philosophy and the Language of Dialectics and the Algebra of Dialectical Judgments*
George Weaver	*The Model Theory of Dedekind Algebras*
Andrzej Wisniewski	*Erotetic Logic and Explanation by Abnormic Hypotheses*

Wednesday, August 12, 18-19:50

Name	Title of Paper
Salah al-Fadhli	*Logical Foundation of Logic Programming*
Jean-Yves Beziau	*Do Sentences Have Identity?*
Katalin Bimbo	*Dual Identity Combinators*
Raymond D. Gumb	*Does Identity Precede Existence?*
Sergey Pavlov	*Sentential Falsehood and Logic FL4*

Wednesday, August 12, 20-21:50

Name	Title of Paper
Hanoch Ben-Yami	*Why One Grain Doesn't Make a Heap*
Vladimir Bryushinkin	*Metapsychologism in the Philosophy of Logic*
Teodor Dima	*Esquisse d'une etio-logique inductive*
David Hitchcock	*Inductive Extrapolation*

John Kearns	*Logic, An Empirical Study of A Priori Truths*
A. A. Zenkin	*Super-Induction Method: Logical Akupuncture of Mathematical Infinity*

Thursday, August 13, 14-15:50

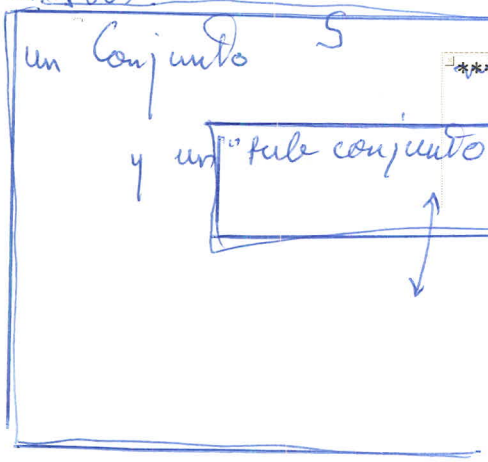
Name	Title of Paper
Andres Bobenrieth	*Paraconsistent Logic and Philosophy: A Two-Way Relationship*
Mustafa M. Dagli	*Modus Ponens, Modus Tollens and Likeness*
Don Faust	*Conflict Without Contradiction: Non-Contradiction as a Scientific Modus Operandi*
Pardeep Kumar	*A Comparative Study of Nyaya System (Indian Logic) and Aristotelian System (Western Logic)*
Patricia Morey and Sandra Vi Sokolskis	*Una Aparente Violacion del Principio del No Contradiccion. El Caso de los Azande. Nuevas Perspectivas (An Apparent Violation of the Principle of Non-Contradiction: The Case of the Azande—New Perspectives)*
Carlos A. Oller	*The Story of the Defeasible O*

Thursday, August 13, 20-21:50

First Name	Title of Paper
Gut Arkadiusz	*Two Types of Philosophical Analysis*
George Boger	*The Modernity of Aristotle's Logical Investigations*
Eduard F. Karavaev	*Logic and Moral Dilemmas*
Volodimir Navrotskiy	*Interval Description of Change*
Charles Reitz	*Wittgenstein's Ghost*
Peter Swiggart	*Two Dogmas of Modern Semantics*

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= Entonces:

se definen como "un conjunto de pares-ordenados" cada uno con un "primer" elemento, que es elemento del conjunto S, y un "2° elemento que es elemento del conjunto [0,1] con exactamente solo un par de ordenados, por cada elemento de S.

Valores usados:
{ 0 = no miembro! = ausente
{ 1 = miembro! = presente

Es verdadero si el 2° elemento es [1] y es falso si es [0]

Lotfi Zadeh

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FUZZY LOGIC - AN INTRODUCTION

PART 1

by Steven D. Kaehler

INTRODUCTION

This is the first in a series of six articles intended to share information and experience in the realm of fuzzy logic (FL) and its application. This article will introduce FL. Through the course of this article series, a simple implementation will be explained in detail. Each article will include additional outside resource references for interested readers.

WHERE DID FUZZY LOGIC COME FROM?

The concept of Fuzzy Logic (FL) was conceived by Lotfi Zadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. This approach to set theory was not applied to control systems until the 70's due to insufficient small-computer capability prior to that time. Professor Zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control. If feedback controllers could be programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement. Unfortunately, U.S. manufacturers have not been so quick to embrace this technology while the Europeans and Japanese have been aggressively building real products around it.

WHAT IS FUZZY LOGIC?

In this context, FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster.

HOW IS FL DIFFERENT FROM CONVENTIONAL CONTROL METHODS?

FL incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. The FL model is empirically-based, relying on an operator's experience rather than their technical understanding of the system. For example, rather than dealing with temperature control in terms such as "SP =500F", "T <1000F", or "210C <TEMP <220C", terms like "IF (process is too cool) AND (process is getting colder) THEN (add heat to the process)" or "IF (process is too hot) AND (process is heating rapidly) THEN (cool the process quickly)" are used. These terms are imprecise and yet very descriptive of what must actually happen. Consider what you do in the shower if the temperature is too cold: you will make the water comfortable very quickly with little trouble. FL is capable of mimicking this type of behavior but at very high rate.

HOW DOES FL WORK?

FL requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time-differentiated to yield the error slope or rate-of-change-of-error, hereafter called "error-dot". Error might have units of degs F and a small error considered to be 2F while a large error is 5F. The "error-dot" might then have units of degs/min with a small error-dot being 5F/min and a large one being 15F/min. These values don't have to be symmetrical and can be "tweaked" once the system is operating in order to optimize performance. Generally, FL is so forgiving that the system will probably work the first time without any tweaking.

SUMMARY

FL was conceived as a better method for sorting and handling data but has proven to be a excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. It is very robust and forgiving of operator and data input and often works when first implemented with little or no tuning.

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FUZZY LOGIC - AN INTRODUCTION

PART 2

by Steven D. Kaehler

INTRODUCTION

This is the second in a series of six articles intended to share information and experience in the realm of fuzzy logic (FL) and its application. This article will continue the introduction with a more detailed look at how one might use FL. A simple implementation will be explained in detail beginning in the next article. Accompanying outside references are included for interested readers.

In the last article, FL was introduced and the thrust of this article series presented. The origin of FL was shared and an introduction to some of the basic concepts of FL was presented. We will now look a little deeper.

WHY USE FL?

FL offers several unique features that make it a particularly good choice for many control problems.

1) It is inherently robust since it does not require precise, noise-free inputs and can be programmed to fail safely if a feedback sensor quits or is destroyed. The output control is a smooth control function despite a wide range of input variations.

2) Since the FL controller processes user-defined rules governing the target control system, it can be modified and tweaked easily to improve or drastically alter system performance. New sensors can easily be incorporated into the system simply by generating appropriate governing rules.

3) FL is not limited to a few feedback inputs and one or two control outputs, nor is it necessary to measure or compute rate-of-change parameters in order for it to be implemented. Any sensor data that provides some indication of a system's actions and reactions is sufficient. This allows the sensors to be inexpensive and imprecise thus keeping the overall system cost and complexity low.

4) Because of the rule-based operation, any reasonable number of inputs can be processed (1-8 or more) and numerous outputs (1-4 or more) generated, although defining the rulebase quickly becomes complex if too many inputs and outputs are chosen for a single implementation since rules defining their interrelations must also be defined. It would be better to break the control system into smaller chunks and use several smaller FL controllers distributed on the system, each with more limited responsibilities.

5) FL can control nonlinear systems that would be difficult or impossible to model mathematically. This opens doors for control systems that would normally be deemed unfeasible for automation.

HOW IS FL USED?

1) Define the control objectives and criteria: What am I trying to control? What do I have to do to control the system? What kind of response do I need? What are the possible (probable) system failure modes?

2) Determine the input and output relationships and choose a minimum number of variables for input to the FL engine (typically error and rate-of-change-of-error).

3) Using the rule-based structure of FL, break the control problem down into a series of IF X AND Y THEN Z rules that define the desired system output response for given system input conditions. The number and complexity of rules depends on the number of input parameters that are to be processed and the number fuzzy variables associated with each parameter. If possible, use at least one variable and its time derivative. Although it is possible to use a single, instantaneous error parameter without knowing its rate of change, this cripples the system's ability to minimize overshoot for a step inputs.

4) Create FL membership functions that define the meaning (values) of Input/Output terms used in the rules.

5) Create the necessary pre- and post-processing FL routines if implementing in S/W, otherwise program the rules into the FL H/W engine.

6) Test the system, evaluate the results, tune the rules and membership functions, and retest until satisfactory results are obtained.

LINGUISTIC VARIABLES

In 1973, Professor Lotfi Zadeh proposed the concept of linguistic or "fuzzy" variables. Think of them as linguistic objects or words, rather than numbers. The sensor input is a noun, e.g. "temperature", "displacement", "velocity", "flow", "pressure", etc. Since error is just the difference, it can be thought of the same way. The fuzzy variables themselves are adjectives that modify the variable (e.g. "large positive" error, "small positive" error ,"zero" error, "small negative" error, and "large negative" error). As a minimum, one could simply have "positive", "zero", and "negative" variables for each of the parameters. Additional ranges such as "very large" and "very small" could also be added to extend the responsiveness to exceptional or very nonlinear conditions, but aren't necessary in a basic system.

SUMMARY

FL does not require precise inputs, is inherently robust, and can process any reasonable number of inputs but system complexity increases rapidly with more inputs and outputs. Distributed processors would probably be easier to implement. Simple, plain-language IF X AND Y THEN Z rules are used to describe the desired system response in terms of linguistic variables rather than mathematical formulas. The number of these is dependent on the number of inputs, outputs, and the designer's control response goals.

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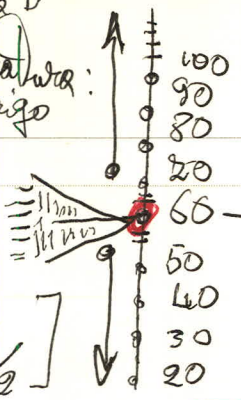
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Ahead to Part 3

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LOGICA · GRADUAL

Sea la temperatura del frigo:



a) Si el movimiento contribuye arriba tiene la lógica-clásica ? — "lugar del cambio"!

b) Si se para en [59 59½ 59,3/4 60⅕ 60¼ 6½] y acaba entonces Fuzzy.

What is Fuzzy Logic?

Fuzzy Logic was invented by Lofti Zadeh at the University of California at Berkeley. Many systems are too complex to be modeled using mathematics. Fuzzy logic is a methodology for expressing operational laws of a system in linguistic terms instead of mathematical equations. These linguistic terms are often expressed in the form of logical implications, such as If-Then rules. For example, we could define the rule:

If temperature is HOT, Then set heater to LOW. (H) (L) = 2 conjuntos = regla de cambio

The terms HOT and LOW are actually sets that define a range of values known as membership functions. By choosing a range of values we can control the temperature more precisely. To illustrate this, consider a non-fuzzy logic controller for this problem.

If temperature >= 60 degrees, then set heater dial to 5 = si es más de 60 o igual = fuerza 5 !
If temperature < 60 degrees, then set heater dial to 10 = si es menos de 60 = fuerza 10 !

This non-fuzzy controller relies on a discrete value decision point. The temperature must reach 60 degrees before the controller can react and set the heater dial to 5. But what if the temperature fluctuates between 59.5 degrees and 60.5 degrees. Then for a non-significant change in temperature, the controller will alter the heater settings wildly. Fuzzy Logic systems solve this problem.

= cuando fluctúa? entre → + 60.5 / 5.5

Fuzzy Logic is implemented in 3 phases:

1) Fuzzification → cambiar de datos precisos a fuzzy
2) Inference
3) Defuzzification. → = cambiar de datos fuzzy a precisos

cuando se cambiará? quedará abajo o arriba?

1) The fuzzification step involves transferring input (called crisp input) into a fuzzy set. The inference then generates the fuzzy rules and the defuzzification process converts the fuzzy output back into crisp value (figure 1.)

2) "Inferencia" = genera reglas fuzzy ! → establecer cuán flexible es la regla

o se vuelve loco cambiando ?

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FUZZY = [flexible!] "gradual"
"difusa"
"a-medias"

1. What is Fuzzy Logic?
2. How is Fuzzy Logic used in FLAME?
3. Where else is Fuzzy Logic used?

---

1 What is Fuzzy Logic? = LÓGICA GRADUAL

Fuzzy logic measures the degree to which something occurs or that some condition exists. Fuzzy logic can control or describe a system by applying 'common sense' rules that refer to indefinite quantities, when there is no specific mathematical algorithm that can be applied. In principle, Fuzzy logic can be used to model any continuous system and may be more useful and accurate than the standard bivalent mathematical ones. It is built on the principle that the world is gray, not black and white. In standard set theory, an object either does or does not belong to a set. Sets that are Fuzzy are not so constrained, and it is possible for an item to be only partially within a set. If-then rules govern Fuzzy sets, and are generally applied by experts, but may also be learned through an adaptive process. A full description of Fuzzy logic is beyond the scope of this page, and so we have included a brief bibliography, and some useful web sites.

Recent Articles on Fuzzy Logic

1. Kosko, B. & Isaka, S. 'Fuzzy Logic', Scientific American, July, 1993, pp. 76-81.
2. Walsh, B. 'Fuzzy Logic: The American Market', AI Expert, Nov., 1993, pp. 35-39.
3. Viot, G. 'Fuzzy Logic: Concepts to Constructs', AI Expert, Nov., 1993, pp. 26-33.
4. I. Bondarenko, P. Van Espen, B. Treiger, R. Van Grieken, & F. Adams 'Classification of Coal Mine Dust Particles Through Fuzzy Clustering of Their Energy-Dispersive Electron Microprobe X-Ray Data', Microbeam Analysis, Jan./Feb. 1994, pp.33-37

World Wide Web

- Fuzzy Logic Archive
- Neural Nets, Fuzzy Logic
- Fuzzy Logic Annotated Bibliographies
- The Law of Relational Identity
- FLLL - A brief course in Fuzzy Logic
- Fuzzy Logic

Usenet News

- comp.ai.fuzzy Fuzzy Logic Newsgroup

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2 How is Fuzzy Logic used in FLAME?

FLAME applies membership functions to various processing steps, such as the identification of elements, deconvolution, etc., rather than applying rigid constraints. The membership functions are constantly adapted as **FLAME** is being used for analysis. For example instead of saying an element is either present or not present, a membership probability is calculated, based on many parameters, with the result that the element may be classified as most probably present, or as unlikely. Deconvolution proceeds using whatever method is necessary, depending on the degree and complexity of overlap. Quantitation is dependent on analytical conditions. As **FLAME** is used, it learns from its input, and modifies its AI database as necessary, to compesate for the many inadequacies in the x-ray energy tables, absorption coefficients, and other physical parameters.





Where else is Fuzzy Logic used?

Fuzzy Logic controllers are used in most modern cameras and camcorders to relate image data to various lens settings for auto-focus and image clarity, and to nullify image jitter that may be caused by a shaking hand. Fuzzy controllers are used in automobiles to control fuel injection, braking, and transmission systems. Many new home appliances such as vacuum cleaners and washing machines use Fuzzy Logic to improve their overall performance. Perhaps the most famous Fuzzy application is the Sendai subway train in Japan. It has outperformed both human operators and conventional controllers, in providing safe, efficient, and comfortable performance. In all cases where Fuzzy controllers are being used, they have greatly improved performance over their human counterpart.



What is Fuzzy Logic?

Fuzzy logic is a form of logic that extends on the widely used Boolean logic to allow the definition of unclear events.

Boolean logic, as used throughout digital technology, relies on Boolean set theory where an event is described as being either true or false. This is demonstrated in digital processes by the use of either a 1 or a 0 to represent the state of a true/false bit.

The Boolean logic system, although only recently popularised through the growth of computer technology, has been practised by mathematicians since the times of ancient Greece as a method of dealing with numbers. In combination with logical operators, e.g. + - x /, Boolean logic forms the basis behind the science of arithmetic.

The application of Boolean logic is firmly seated in our education from an early age. For example, the solution to a mathematical problem is either right, or wrong.

1 + 2 = 3 True

1 + 2 = 4 False

Through the use of such a true/false method, further arithmetic techniques can be applied allowing extrapolation and interpolation over an infinite range.

However, such a rigid system of true or false conclusion (often called bivalence) is only acceptable for special cases like arithmetic. If the same concepts are applied to real situations, problems are soon encountered. For example, the statement

"Peter is a tall man"

is only true if Peter's height is above the height that we call tall. But how high is tall? This is a value that we cannot accurately judge. A tall man is not the same height as a tall building. The traditional mathematical remedy to this problem involves the use of a range. This is illustrated in Figure 1 below.

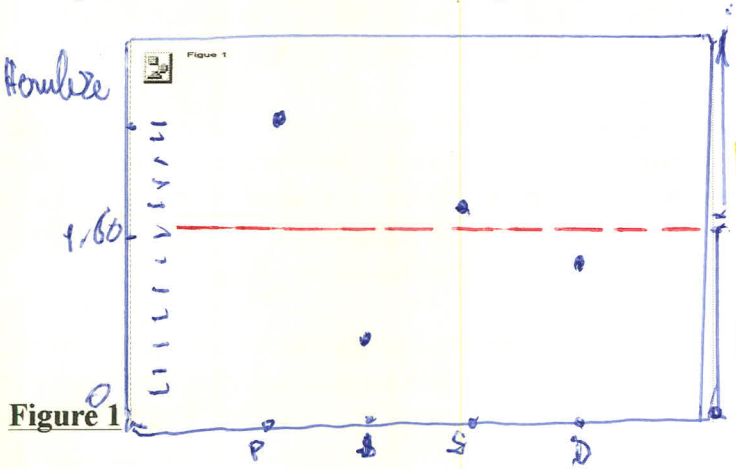


Figure 1

Figure 1 shows that in this example, heights below 1.60m are described as short and heights above

1.60m are described as tall. As with In other words the statement

men below the height of 1.60m are Short

is *true* and

men below the height of 1.60m are Tall

is *false*. Likewise, the statement

men above the height of 1.60m are Tall

is *true* and

men above the height of 1.60m are Short

is *false*. In this example, the range of height of short men is zero to 1.60m and the range of tall men is 1.60m to infinity. In logic systems, these ranges are usually called Sets and the men are Elements. The conclusion (true or false) denotes whether the element is a member of the set, which in Boolean logic systems is commonly abbreviated to 1 (for True) and 0 (for false).

Consider the following group of men :

Table 1

Name	*Height*	*Tall*	*Short*
Peter	1.80	1	0
John	1.50	0	1
Stephen	1.61	1	0
David	1.59	0	1

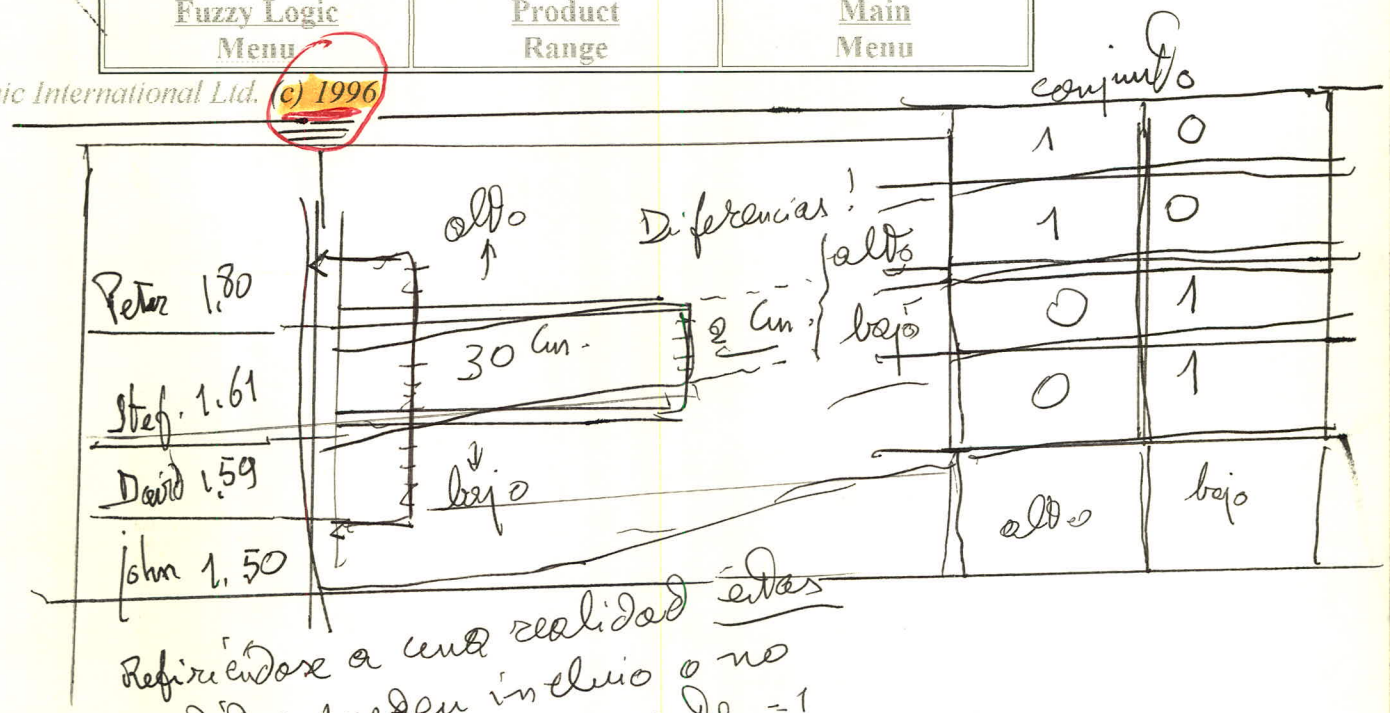
The sets, Tall and Short, are defined as in Figure 1 where 1 indicates True and 0 indicates False. The membership of each man to each set is summarised in the third and fourth columns of Table 1.

Now, look carefully at the heights. Clearly, Peter is tall and John is short as indicated by their membership to the sets. However, Stephen is almost the same height as David, although Stephen is described as tall whereas David is short. In this case those two centimetres between Stephen and David have had the same effect as the thirty centimetres between Peter and John. This is a main drawback of Boolean logic when used in realistic situations.

If Stephen is nearly the same height as David, then common sense would say that they are both of a similar height, therefore what applies to Stephen should also apply similarly to David. Quite clearly, there is a difference between Boolean logic and human thinking. The Boolean logic states that Stephen and David must be either tall or short and nowhere in between, whereas a human would interpret the situation differently.

The reason for this discrepancy involves the label *tall*. As our language develops, the meaning applied to *tall* develops to recognise different degrees of *tallness*. This recognition is not mathematically founded, in that there is no precise formulae to calculate tallness, rather the language accommodates the many heights that apply to the *tall men* label. This powerful technique is used throughout our lives, allowing humans to generalise about situations.

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Refiriéndose a una realidad estas medidas pueden incluir o no a un individuo { — presente -1 — ausente - 0

El inconveniente de la "lógica Booleana" → fija categoría { alto bajo — a dos que miden solo 2 Cm. como a 2 que miden 30 Cm. en darle la misma

Historia

fuzzy logic = grados de verdad.

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language (like most other activities in life and indeed the universe) is not easily translated into the absolute terms of 0 and 1. (Whether everything is ultimately describable in binary terms is a philosophical question worth pursuing, but in practice much data we might want to feed a computer is in some state in between and so, frequently, are the results of computing.)

Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

Fuzzy logic seems closer to the way our brains work. We aggregate data and form a number of partial truths which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction. A similar kind of process is used in artificial computer neural networks and expert systems..

It may help to see fuzzy logic as the way reasoning really works and binary or Boolean logic is simply a special case of it. More information is available in the FAQ: Fuzzy Logic and Fuzzy Expert Systems.

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Fuzzy Logic

According to forecasts, the total revenue worldwide from the Fuzzy Logic industry is projected to be $6.1 billion by 1997. Commercial applications of controllers using fuzzy logic are increasing and new products are appearing on the market place everyday. Typical applications already in use are vacuum cleaners, engine management, battery chargers, subway systems, camera auto-focusing, washing machines, helicopters and many more.

Fuzzy Logic is the technology that everyone needs to know about. As such Bytronic are developing a range of products to aid the understanding of Fuzzy Logic. The first product in the range is a software based package called FCP, the Fuzzy Control Package. Combining software with concise course notes and user manuals. The package is suitable for beginners and experts alike, detailing the basics of Fuzzy Logic and its uses before discussing the design, implementation and testing of fuzzy controllers using the FCP software with its internal simulations.

The FCP package also includes the ability to control external hardware via an interface card and is ideal for controlling the Pendulum Control System, which allows users to make comparisons between analogue, digital and fuzzy logic control.

What is Fuzzy Logic	Fuzzy Control Package	Pendulum Control System	Training Packages

Product Range	Main Menu

Fuzzy Logic

What is Fuzzy Logic?

Classical logic or Boolian logic has two values or states often expressed as true or false, yes or no, on or off, black or white, start or stop. Yet in the real world we know that there are many situations where events are not black or white but some shade of grey. Fuzzy logic is a continuous form of logic that allows us to describe the shades of grey.

If asked to describe your day in Boolian logic it would be good or bad. Fuzzy logic might recognise the day as being very bad, bad, poor, average, better than average, good, very good.

What is Fuzzy Logic used for?

Fuzzy logic has been used in fuzzy controllers which are widely used in control applications including refrigerators, washing machines, welding machines, cameras and robots; Fault and failure diagnosis, image processing, pattern classifying, traffic problems, collision avoidance, decision support, project planning, fraud detection and in conjunction with neural nets and expert systems.

Who uses Fuzzy Logic?

The Japanese use fuzzy logic controllers widely in their consumer goods. Electrical, mechanical and process engineers, equipment designers, managers, planners, data base designers, neural network users.

Why is Fuzzy Logic Better?

Fuzzy logic is an extension of Boolian logic into the real world where many events are more accurately described by continuous logic.

Jump to Fuzzy Logic Software | Return to Applications Menu

Some Further Reading:

1. Cox E. (1992) Applications of fuzzy system models. **AI Expert** October, pp 34-39.
2. Viot G. (1993) Fuzzy Logic: Concepts and constructs. **AI Expert** November, pp 26-33.
3. Greany M (1993) Fuzzy Logic: The American market. **AI Expert**, November, pp 35-39.
4. Cox E. (1995) Relational database queries using fuzzy logic. **AI Expert**, January, pp 23-29.
5. Jablonowsky M (1994) Fuzzy risk analysis: using AI systems. **AI Expert**, December, pp 34-37.
6. Yager, Ronald R. Goldstein, Larry S. Mendels, Ernest. (1994) FUZMAR: an approach to aggregating market research data based on fuzzy reasoning. **Fuzzy Sets & Systems**. 68, 1-11.

Return to Applications Menu

Fuzzy Logic Overview

I've seen a lot of confusion in the first few articles posted to this newsgroup about what, exactly, fuzzy logic is. Since I've been working in the field for five years, I thought I'd help get things started by posting some introductory material. This article covers the question "What is Fuzzy Logic?" from a mathematical point of view. Succeeding articles will cover the questions "What is a Fuzzy Expert System?" and "What is Fuzzy Control?".

Warning: If you're not already familiar with fuzzy logic, you're going to see a lot of new terms defined in this article. I'll try to put _underscores_ around terms that are likely to be new. You may need to read it a few times, just to pick up all the terms.

What is Fuzzy Logic?

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false". It was introduced by Dr. Lotfi Zadeh of U.C. Berkeley in the 1960's.

Fuzzy Subsets

There is a strong relationship between Boolean logic and the concept of a subset. There is a similar strong relationship between fuzzy logic and fuzzy subset theory (Note: there is no fuzzy set theory, as far as I am aware - only a fuzzy subset theory).

A subset U of a set S can be defined as a set of ordered pairs, each with a first element that is an element of the set S, and a second element that is an element of the set { 0, 1 }, with exactly one ordered pair present for each element of S. This defines a mapping between elements of S and elements of the set { 0, 1 }. The value zero is used to represent non-membership, and the value one is used to represent membership. The truth or falsity of the statement

```
x is in U
```

is determined by finding the ordered pair whose first element is x. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

Similarly, a fuzzy subset F of a set S can be defined as a set of ordered pairs, each with a first element that is an element of the set S, and a second element that is a value in the interval [0, 1], with exactly one ordered pair present for each element of S. This defines a mapping between elements of the set S and values in the interval [0, 1]. The value zero is used to represent complete non-membership, the value one is used to represent complete membership, and values in between are used to represent intermediate _degrees of membership_. The set S is referred to as the _universe of discourse_ for the fuzzy subset F. Frequently, the mapping is described as a function, the _membership function_ of F.

The degree to which the statement

```
x is in F
```

is true is determined by finding the ordered pair whose first element is x. The _degree of truth_ of the statement is the second element of the ordered pair.

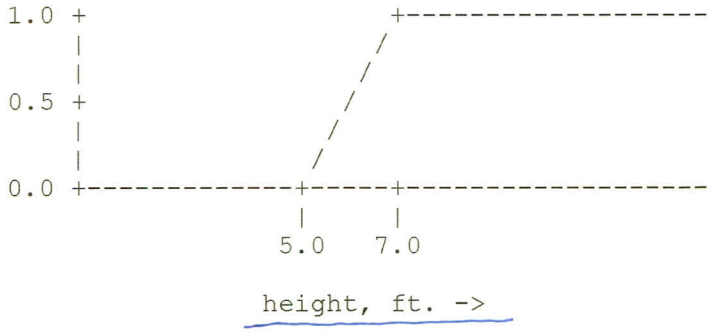
That's a lot of mathematical baggage, so here's an example. Let's talk about people and "tallness". In this case the set S (the universe of discourse) is the set of people. Let's define a fuzzy subset TALL, which will answer the question "to what degree is person x tall?" To each person in the universe of discourse, we have to assign a degree of membership in the fuzzy subset TALL. The easiest way to do this is with a membership function based on the person's height.

```
[erik - I hope this notation is clear]

tall(x) = { 0,                      if height(x) < 5 ft.,
            (height(x)-5ft.)/2ft., if 5 ft. <= height (x) <= 7 ft.,
            1,                      if height(x) > 7 ft. }
```

A graph of this looks like:

Warning: put on your peril-sensitive sunglasses. Bad ASCII graphics follow!



Given this definition, here are some example values:

Person	Height	degree of tallness
Billy	3' 2"	0.00 [I think]
Yoke	5' 5"	0.21
Drew	5' 9"	0.38
Erik	5' 10"	0.42
Mark	6' 1"	0.54
Kareem	7' 2"	1.00 [depends on who you ask]

So given this definition, we'd say that the degree of truth of the statement "Drew is TALL" is 0.38.

Note: Membership functions almost never have as simple a shape as tall(x). At minimum, they tend to be triangles pointing up, and they can be much more complex than that. Also, I've discussed membership functions as if they always are based on a single criterion, but this isn't always the case, although it is the most common case. One could, for example, want to have the membership function for TALL depend on both a person's height and their age (he's tall for his age). This is perfectly legitimate, and occasionally used in practice. It's referred to as a two-dimensional membership

function. It's also possible to have even more criteria, or to have the membership function depend on elements from two completely different universes of discourse.

Logic Operations

Ok, we now know what a statement like

```
X is LOW
```

means in fuzzy logic. The question now arises, how do we interpret a statement like

```
X is LOW and Y is HIGH or (not Z is MEDIUM)
```

The standard definitions in fuzzy logic are:

```
truth (not x)   = 1.0 - truth (x)
truth (x and y) = minimum (truth(x), truth(y))
truth (x or y)  = maximum (truth(x), truth(y))
```

which are simple enough. Some researchers in fuzzy logic have explored the use of other interpretations of the AND and OR operations, but the definition for the NOT operation seems to be safe. Note that if you plug just the values zero and one into these definitions, you get the same truth tables as you would expect from conventional Boolean logic.

Some examples - assume the same definition of TALL as above, and in addition, assume that we have a fuzzy subset OLD defined by the membership function:

```
old (x) = { 0,                          if age(x) < 18 yr.
          (age(x)-18 yr.)/42 yr.,       if 18 yr. <= age(x) <= 60 yr.
          1,                            if age(x) > 60 yr. }
```

And for compactness, let

```
a = X is TALL and X is OLD
b = X is TALL or X is OLD
c = not X is TALL
```

Then we can compute the following values.

height	age	X is TALL	X is OLD	a	b	c
3' 2"	65?	0.00	1.00	0.00	1.00	1.00
5' 5"	30	0.21	0.29	0.21	0.29	0.79
5' 9"	27	0.38	0.21	0.21	0.38	0.62
5' 10"	32	0.42	0.33	0.33	0.42	0.58
6' 1"	31	0.54	0.31	0.31	0.54	0.46
7' 2"	45?	1.00	0.64	0.64	1.00	0.00
3' 4"	4	0.00	0.00	0.00	0.00	1.00

Where is Fuzzy Logic Used?

Directly, very few places. The only pure fuzzy logic application I know of is the Sony PalmTop, which apparently used a fuzzy logic decision tree algorithm to perform handwritten (well, computer lightpen) Kanji character recognition.

The only common use of fuzzy logic, to my knowledge, is as the underlying logic system for fuzzy expert systems, which will be the subject of the next article in this series, titled "What is a Fuzzy Expert System?".

Whew. A lot of words, wasn't it?

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Fuzzy System

Gideon Langholz (Ed.) Abraham Kandel, H. Kandel

Modi Schneider, M. Schneider

Daniel Mc.Neill, Paul Freiberger

Fuzzy logic: The Revolutionary Computer Technology that is Changing our World

F. Martin, Mc. Neill, Ellen Thro: "Fuzzy logic: A Practical Approach With 3.5' Disk."

Fuzzy Expert Systems

This is the second part in a three-part series of introductory articles on the fuzzy field. The preceding article was titled "What is Fuzzy Logic?", and the next article will be titled "What is Fuzzy Control?".

One point I didn't make in my previous article, "What is Fuzzy Logic", is that in practice, the terms fuzzy subset and membership function get used nearly interchangeably. I'll probably slip up and swap back and forth some - my apologies in advance.

What is a Fuzzy Expert System?

Put as simply as possible, a fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. In other words, a fuzzy expert system is a collection of membership functions and rules that are used to reason about data. Unlike conventional expert systems, which are mainly symbolic reasoning engines, fuzzy expert systems are oriented toward numerical processing.

The rules in a fuzzy expert system are usually of a form similar to the following:

```
if x is low and y is high then z = medium
```

where x and y are input variables (names for know data values), z is an output variable (a name for a data value to be computed), low is a membership function (fuzzy subset) defined on x, high is a membership function defined on y, and medium is a membership function defined on z. The part of the rule between the "if" and "then" is the rule's _premise_ or _antecedent_. This is a fuzzy logic expression that describes to what degree the rule is applicable. The part of the rule following the "then" is the rule's _conclusion_ or _consequent_. This part of the rule assigns a membership function to each of one or more output variables. Most tools for working with fuzzy expert systems allow more than one conclusion per rule.

A typical fuzzy expert system has more than one rule. The entire group of rules is collectively known as a _rulebase_ or _knowledge base_.

The Inference Process

With the definition of the rules and membership functions in hand, we now need to know how to apply this knowledge to specific values of the input variables to compute the values of the output variables. This process is referred to as _inferencing_. In a fuzzy expert system, the inference process is a combination of four subprocesses: _fuzzification_, _inference_, _composition_, and _defuzzification_. The defuzzification subprocess is optional.

For the sake of example in the following discussion, assume that the variables x, y, and z all take on values in the interval [0, 10], and that we have the following membership functions and rules defined.

```
low(t)  = 1 - t / 10
high(t) = t / 10

rule 1: if x is low and y is low then z is high
rule 2: if x is low and y is high then z is low
rule 3: if x is high and y is low then z is low
rule 4: if x is high and y is high then z is high
```

Notice that instead of assigning a single value to the output variable z, each rule assigns an entire fuzzy subset (low or high).

Notes:

1. In this example, low(t)+high(t)=1.0 for all t. This is not required, but it is fairly common.
2. The value of t at which low(t) is maximum is the same as the value of t at which high(t) is minimum, and vice-versa. This is also not required, but fairly common.
3. The same membership functions are used for all variables. This isn't required, and is also *not* common.

Fuzzification

In the fuzzification subprocess, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise. The degree of truth for a rule's premise is sometimes referred to as its _alpha_. If a rule's premise has a nonzero degree of truth (if the rule applies at all...) then the rule is said to _fire_.

For example:

x	y	low(x)	high(x)	low(y)	high(y)	alpha1	alpha2	alpha3	alpha4
0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
0.0	3.2	1.0	0.0	0.68	0.32	0.68	0.32	0.0	0.0
0.0	6.1	1.0	0.0	0.39	0.61	0.39	0.61	0.0	0.0
0.0	10.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0
3.2	0.0	0.68	0.32	1.0	0.0	0.68	0.0	0.32	0.0
6.1	0.0	0.39	0.61	1.0	0.0	0.39	0.0	0.61	0.0
10.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0
3.2	3.1	0.68	0.32	0.69	0.31	0.68	0.31	0.32	0.32
3.2	3.3	0.68	0.32	0.67	0.33	0.67	0.33	0.32	0.32
10.0	10.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0

Inference

In the inference subprocess, the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule.

I've only seen two _inference methods_ or _inference rules_: _MIN_ and _PRODUCT_. In MIN

inferencing, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth. This corresponds to the traditional interpretation of the fuzzy logic AND operation. In PRODUCT inferencing, the output membership function is scaled by the rule premise's computed degree of truth.

Due to the limitations of posting this as raw ASCII, I can't draw you a decent diagram of the results of these methods. Therefore I'll give the example results in the same functional notation I used for the membership functions above.

For example, let's look at rule 1 for x = 0.0 and y = 3.2. As shown in the table above, the premise degree of truth works out to 0.68. For this rule, MIN inferencing will assign z the fuzzy subset defined by the membership function:

```
rule1(z) = { z / 10,  if z <= 6.8
             0.68,    if z >= 6.8 }
```

For the same conditions, PRODUCT inferencing will assign z the fuzzy subset defined by the membership function:

```
rule1(z) = 0.68 * high(z)
         = 0.068 * z
```

Note: I'm using slightly nonstandard terminology here. In most texts, the term "inference method" is used to mean the combination of the things I'm referring to separately here as "inference" and "composition." Therefore, you'll see terms such as "MAX-MIN inference" and "SUM-PRODUCT inference" in the literature. They mean the combination of MAX composition and MIN inference, or SUM composition and PRODUCT inference respectively, to use my terminology. You'll also see the reverse terms "MIN-MAX" and "PRODUCT-SUM" - these mean the same things as the reverse order. I think it's clearer to describe the two processes separately.

Composition

In the composition subprocess, all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable.

I'm familiar with two _composition rules_: _MAX composition_ and _SUM composition_. In MAX composition, the combined output fuzzy subset is constructed by taking the pointwise maximum over all of the fuzzy subsets assigned to the output variable by the inference rule. In SUM composition the combined output fuzzy subset is constructed by taking the pointwise sum over all of the fuzzy subsets assigned to the output variable by the inference rule. Note that this can result in truth values greater than one! For this reason, SUM composition is only used when it will be followed by a defuzzification method, such as the CENTROID method, that doesn't have a problem with this odd case.

For example, assume x = 0.0 and y = 3.2. MIN inferencing would assign the following four fuzzy subsets to z:

```
rule1(z) = { z / 10,     if z <= 6.8
             0.68,       if z >= 6.8 }
```

```
rule2(z) = { 0.32,        if z <= 6.8
             1 - z / 10,  if z >= 6.8 }

rule3(z) = 0.0

rule4(z) = 0.0
```

MAX composition would result in the fuzzy subset:

```
fuzzy(z) = { 0.32,        if z <= 3.2
             z / 10,      if 3.2 <= z <= 6.8
             0.68,        if z >= 6.8 }
```

PRODUCT inferencing would assign the following four fuzzy subsets to z:

```
rule1(z) = 0.068 * z
rule2(z) = 0.32 - 0.032 * z
rule3(z) = 0.0
rule4(z) = 0.0
```

SUM composition would result in the fuzzy subset:

```
fuzzy(z) = 0.32 + 0.036 * z
```

Defuzzification

Sometimes it is useful to just examine the fuzzy subsets that are the result of the composition process, but more often, this _fuzzy value_ needs to be converted to a single number - a _crisp value_. This is what the defuzzification subprocess does.

There are more defuzzification methods than you can shake a stick at. A couple of years ago, Mizumoto did a short paper that compared roughly thirty defuzzification methods. Two of the more common techniques are the CENTROID and MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable. There are several variations of the MAXIMUM method that differ only in what they do when there is more than one variable value at which this maximum truth value occurs. One of these, the AVERAGE-OF-MAXIMA method, returns the average of the variable values at which the maximum truth value occurs.

For example, go back to our previous examples. Using MAX-MIN inferencing and AVERAGE-OF-MAXIMA defuzzification results in a crisp value of 8.4 for z. Using PRODUCT-SUM inferencing and CENTROID defuzzification results in a crisp value of 6.7 for z.

Note: sometimes the composition and defuzzification processes are combined, taking advantage of mathematical relationships that simplify the process of computing the final output variable values.

After all this ...

http://www.wargaming.net/Programming/Algorithms.htm

Where are Fuzzy Expert Systems Used?

To date, fuzzy expert systems are the most common use of fuzzy logic. They are used in several wide-ranging fields, including:

- Linear and nonlinear control.
- Pattern recognition.
- Financial systems.

and many others I can't think of. It's late. I'm going home! :-)

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Programming Algorithms:

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- Assembly Language programming
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- Fuzzy Logic
- Genetic
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- Rendering and Ray Tracing
- Software Design
- Structured Desig

Refeito

Fuzzy Environmental Control

For those looking for practical applications of fuzzy logic in a real-world product, please read on. This isn't a sexy application with millions of dollars thrown at it - it's just a company trying to build a better product using fuzzy logic. They did just that ...

Number 31 October 92

The Huntington Technical Brief
By David Brubaker Ph.D.

FUZZY ENVIRONMENTAL CONTROL

INTRODUCTION

In January 1992, Liebert Corporation of Columbus, Ohio, specialists in environment control units for computer installations, introduced the LogiCool, a precision temperature and humidity controller with a fuzzy control unit at its heart. This Technical Brief briefly discusses both the design of LogiCool's fuzzy controller, and the process through which Liebert elected to use a fuzzy approach.

DESIGN GOALS

Control of the environment for large computing systems is often a far greater challenge than for rooms inhabited by people. Not only do the systems themselves generate heat, but they are often specified by their manufacturers to be maintained in as little as a plus-or-minus 1 degree (Fahrenheit) range. Humidity is also a challenge, causing, for example, corrosion and jamming of associated mechanical systems at high humidity levels and the enhanced possibility of static discharge with low levels. Humidity control is often specified to be 50% relative humidity, with a maximum swing of plus-or-minus 3% per hour.

In addition, the design of a precision environmental control system also faces nonlinearities, caused by such system behavior as air flow delay and dead times, uneven airflow distribution patterns, and duct work layouts. Uncertainties in system parameters are often present, for example, room size and shape, location of heat-producing equipment, thermal mass of equipment and walls, and amount and timing of external air introduction.

Recognizing these challenges, Liebert undertook the design of a control system requiring (in general terms):

- Precision temperature and humidity control;
- Minimization of cycling times (i.e., the opening and closing of the damper and turning on and off of the compressor), thereby increasing reliability and component life, and also resulting in increased energy efficiency;

- Straightforward and therefore inexpensive control electronics.

In short, Liebert wanted to precisely control with simple hardware a nonlinear system with significant uncertainties. Several traditional linear approaches were considered but proved inadequate. A fuzzy logic approach was investigated and ultimately implemented. Design specifics - The LogiCool control system has six fuzzy inputs, three fuzzy outputs, and 144 principles (rules). It runs on a Motorola 6803 microprocessor, and is programmed in C.

LogiCool's fuzzy input variables are: e_temperature, the temperature relative to a setpoint; delta_T/delta_t, the rate of temperature change; e_humidity, the humidity relative to a setpoint; delta_H/delta_t, the rate of humidity change; and two proprietary variables associated with the action of the controllers.

Fuzzy outputs control: 1) amount of cooling, 2) amount of dehumidification, and 3) heat. Outputs can also be treated as fedback input variables, and time delays are treated as fuzzy outputs as well. Each fuzzy variable is assigned seven membership functions as values, with the traditional Large_Negative, Medium_Negative, Small_Negative, Near_Zero, Small_ Positive, Medium_Positive, and Large_Positive as labels. Ranges for the values of each variable are proprietary.

An example of a temperature control principle, using the as ...then ... (rather than the if ... then ...) syntax, is:

> as temperature relative to set point is small_positive and temperature rate of change is medium_positive then amount of cooling is small_positive;

The Liebert design also incorporates time delays into their principles. The following demonstrates both this as well as the use of a fuzzy output as a feedback variable.

> as temperature relative to setpoint is small_negative and amount of cooling is small_positive then wait delay to cooling change is medium_positive;

A fuzzy OR operator (maximizer) is used as the defuzzification technique, avoiding the complicated calculations associated with a centroid approach. Liebert has found that with the large number of principles, a more elaborate approach is unnecessary. Inputs are sampled, the principle-base accessed, and outputs are updated once a second. The "long" inter-sample delay allows the 6803, a simple eight-bit microprocessor, to implement this rather large fuzzy system.

ECONOMIZER

A key feature of the system is LogiCool's Economizer, which also runs under fuzzy control. When appropriate (for example in the cool of the morning), the outdoor ambient temperature is used to assist in internal temperature control. While on/off control of the Economizer could have been used, fuzzy logic greatly reduced the number of system cycles, thereby significantly reducing wear on the damper.

DESIGN PROCESS

The sequence that resulted in the decision to use fuzzy logic started roughly eighteen months ago. From the engineering side, the decision was driven by being able to meet difficult requirements. Two Liebert engineers, Terry Bush and Dennis Weber, had already read, become interested in, and familiarized themselves with fuzzy technology, and were therefore able to recognize that a fuzzy approach could satisfy the stringent requirements. Simultaneously, Liebert marketing was both aware of fuzzy logic controlled air conditioning systems available outside the United States, and was also getting feedback from customers indicating that an improved method of handling complex internal environmental control was needed. Putting the two together, engineering was asked to investigate a fuzzy controller.

Liebert engineers designed and implemented the system in-house, with the entire fuzzy logic controller portion completed in two to three months. A commercially available fuzzy development tool was not used, primarily because in the beginning there was insufficient confidence in the approach to justify the expense of such a tool. Liebert is still satisfied with the decision to "roll its own" system, as it resulted in a design that incorporates a number of features not easily provided in the tools available at the time, for example the delaying of output actions by fuzzily defined wait delays.

Liebert engineers did ultimately write a PC-based simulator to test the fuzzy design under simulation prior to committing it to hardware. Conclusion - Although quantitative metrics are not available, Liebert reports that LogiCool has fully met its design goals. Damper and compressor cycling times have been greatly reduced, especially during Economizer operation. This reduction in cycling times results in increased reliability and increased expected component life. LogiCool also meets Liebert's operational requirements associated with precisely controlling temperature and humidity in rooms with uncertain and nonlinear characteristics. Moreover, installation includes no tuning procedure - the same set of principles satisfies all installations.

Liebert is completely satisfied with the response to LogiCool. Sales since its introduction last January are better than expected, and production run sizes are being increased to respond to the demand. In addition, in recognition of the innovation in overall design, the LogiCool has been recognized by HVAC News as a 1992 Design Winner. For more information on the LogiCool, call Liebert Corporation, at 1-800-877-9222.

The Huntington Technical Brief is published, monthly and free of charge, as part of the marketing effort of Dr. David Brubaker of The Huntington Group. A full collection of past issues (starting with number 5 -- issues 1 through 4 are unrelated to fuzzy logic and are unavailable) may be obtained directly from Dr. Brubaker by calling 415-325-7554. There is minimal charge for getting back issues.

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Repetido : vea Fuzzy Log.

Elkan's "The Paradoxical Success of Fuzzy Logic" paper

The presentation of Elkan's AAAI-93 paper

> Charles Elkan, "The Paradoxical Success of Fuzzy Logic", in Proceedings of the Eleventh National Conference on Artificial Intelligence, 698-703, 1993.

has generated much controversy. The fuzzy logic community claims that the paper is based on some common misunderstandings about fuzzy logic, but Elkan still maintains the correctness of his proof. (See, for instance, AI Magazine 15(1):6-8, Spring 1994.)

Elkan proves that for a particular set of axiomatizations of fuzzy logic, fuzzy logic collapses to two-valued logic. The proof is correct in the sense that the conclusion follows from the premises. The disagreement concerns the relevance of the premises to fuzzy logic. At issue are the logical equivalence axioms. Elkan has shown that if you include any of several plausible equivalences, such as

> not(A and not B) == (not A and not B) or B

with the min, max, and 1- axioms of fuzzy logic, then fuzzy logic reduces to binary logic. The fuzzy logic community states that these logical equivalence axioms are not required in fuzzy logic, and that Elkan's proof requires the excluded middle law, a law that is commonly rejected in fuzzy logic. Fuzzy logic researchers must simply take care to avoid using any of these equivalences in their work.

It is difficult to do justice to the issues in so short a summary. Readers of this FAQ should not assume that this summary is the last word on this topic, but should read Elkan's paper and some of the other correspondence on this topic (some of which has appeared in the comp.ai.fuzzy newsgroup).

Two responses to Elkan's paper, one by Enrique Ruspini and the other by Didier Dubois and Henri Prade, may be found as

> ftp.cs.cmu.edu:/user/ai/areas/fuzzy/doc/elkan/response.txt

A final version of Elkan's paper, together with responses from members of the fuzzy logic community, will appear in an issue of IEEE Expert sometime in 1994. A paper by Dubois and Prade will be presented at AAAI-94.

==========

Go to the index previous next

Fuzzy Logic

Hyperlogic Corporation, USA = PROGRAMAS de PC

CubiCalc

Cubicalc is a fuzzy logic package that is consistently rated best in its class in the USA. It lets you use fuzzy rules interactively in a desk top environment. No programming is needed to set up your own plots, numeric displays, input and output data files. CubiCalc is the fuzzy logic tool of choice for analysts and engineers around the world. Ideal for data analysis and decision support problems, prototyping and control systems.

CubiQuick

This is a simpler and less expensive version of CubiCalc designed primarily for students and those interested in learning fuzzy logic methodology. It lacks only a few of CubiCalc's graphical and computational facilities and is limited primarily in the size of the rule base. This has been a popular seller with Australian Unis. Excellent academic rates for this product.

CubiCalc RTC

This is a run time code generator for those who wish to embed their fuzzy logic code into other programs via C code. Source code available.

CubiCard

This is a plug in card for PC based data acquisition and control. It includes a version of the CubiCalc interactive shell with extensions for direct hardware I/O. Using CubiCard you can create a PC-based fuzzy controller. Break out board also available.

CubiCalc Rule Maker

An add-on to CubiCalc, CubiCalcRTC and CubiCard, the rule maker provides a fast way to create fuzzy systems from data sets.

Return to Products Info / Fuzzy Logic Info

Lo que le falta q manejar los niveles { concepto = termino mental / palabra = termino linguistico / cosa = conjunto de cosas objetos particulares

A veces habla de cerebro = biología = células nerviosas

a veces de { mente = intelecto - pensamiento

como si fueran lo mismo -

Lógica fuzzy

Casa = no es parte de un conjunto a menos que se "defina" el conjunto !

Repite el mismo juego de contrarios que Kosko = ignora el contradictorio.

A y -A = repite el mismo concepto con la misma falacia !

-A = no es un conjunto, a menos que te especifique (como lo hace ?)

A no es igual a -A = en ningún caso ! ni se habla de conjuntos ! a lo mas puede ser equivalente en nº.

Las palabras son parte de conjuntos. La palabra casa representa muchas casas. Esto representa diferentes casas para cada persona porque cada persona, vive y sueña en diferentes casas. La gente habla y escribe las mismas palabras pero no piensa las mismas palabras. Las palabras son públicas pero los conjuntos que cada quien aprende son privados. Y se piensa en conjuntos.

→ cuando se piensa algo con precision - hay una palabra que acompaña el concepto

Casa es parte del conjunto de casas, una lista de casas, un grupo o colección de cosas, y cada cosa que se puede apuntar y llamar casa. Pero ¿cuáles estructuras son casas y cuales no? Usted puede apuntar algunas cosas como casas más fácilmente que otras. Por ejemplo los castillos y las casa móviles, y las cuevas, etc. Esto es cuestión del grado. Algunas estructuras son más "una casa" que otras. Ellas son en algún grado una casa y en otro grado no lo son. Los límites son borrosos entre una casa y una no casa. Entonces A y NO A. El sustantivo casa pertenece a un conjunto fuzzy de casas. [13]

?

Esto no para en los sustantivos. Súmele un adjetivo y seguirá teniendo un conjunto fuzzy. Casa vieja pertenece a un conjunto fuzzy de casas más pequeño. Esto pertenece a un subconjunto del conjunto de casas. Toda casa vieja es una casa pero no toda casa es vieja. Pero ¿cùánto vieja es vieja? Algunas casas son más viejas que otras. Esto es cuestión de grados. Algunas casas viejas pertenecen más al conjunto de casas viejas que otras. Se puede aún asignar un valor de acuerdo al año, mes o minuto. Casas muy viejas pertenecen a un conjunto de casas más pequeño, un subconjunto del conjunto de casas viejas. También podemos asignar valor a

Fuente:

las casas muy viejas por su edad. Las cabañas de la historia medieval son mucho más viejas que las cabañas de madera de la guerra civil.

Piense en esto: Nuestro cerebro está lleno de conjuntos fuzzy. Pensamos en conjuntos fuzzy y cada uno define sus límites fuzzy en diferentes formas y con diferentes ejemplos. Colocamos los muebles del universo dentro de conjuntos fuzzy. Agrupamos cosas dentro de conjuntos fuzzy perdidos y luego jugamos con los grupos y buscamos conexiones. Pensar es jugar. Esto es solamente lo que la lógica fuzzy hace, razonar con conjuntos fuzzy.

La lógica fuzzy hace a nuestra computadora pensar en conjuntos fuzzy. Y esta es la ventaja, conseguir que la computadora razone con conjunto fuzzy. No palabras o lista de símbolos u otros lenguajes, o como los científicos de las computadoras lo llamen, pero conjuntos borrosos.

Los conjuntos fuzzy no son una idea caprichosa o un dispositivo de computadora. El conjunto fuzzy es la unión entre el humano y las máquinas inteligentes, o dicho de otra forma, la boda de los símbolos con las ideas, la forma de cubrirnos con un mundo gris. El conjunto fuzzy es expresivo.

3.1 Los números también son fuzzy[14]

Todo es cuestión del grado. Entonces ¿qué sucede con los números? Los números son el sello de precisión. ¿Se pueden volver borrosos también? ¿Son los números fuzzy posibles?

La vieja respuesta era no. ¿Cómo pueden ser fuzzy los números? Los números son "formas puras" y ellos también son y no son. Los números pertenecen todos o ninguno al conjunto de números. Números impares. Números pares. Todo entero puede ser también par o impar, no en ambos. Los científicos tienen trazada una matemática que parece tener olvidado lo inclinado de los conjuntos fuzzy de todos los días y pensamientos fuzzy. También se sabe que han tratado de tener a los conjuntos fuzzy fuera de las computadoras. Y han tenido éxito, y las computadoras son tontas. Las computadoras son buenas para agregar números, pero no pueden reconocer una cara o una casa en muchas imágenes. ¿Dónde podría esconderse el concepto fuzzy dentro del mundo blanco y negro de las matemáticas.?

Considere el número cero. Tomó algunos miles de años el encontrar el cero. Ahora se puede encontrar echando un vistazo a una línea de números. El número cero pertenece 100% al conjunto cero y ningún otro número pertenece a ese conjunto. Todo número está en el conjunto cero o fuera de él. Todos o ninguno. En este sentido el número cero sólo, pertenece al conjunto cero.

todo "orden" es una sucesión binaria, no es borrosa: es conceptual.

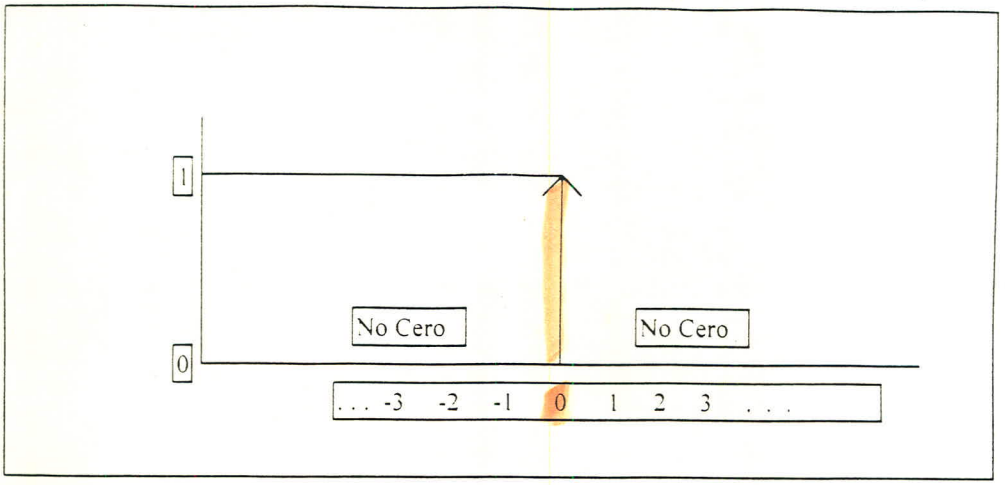


***Figura* 4.1** Número cero No fuzzy

Pero ¿qué sucede con los números cercanos a cero o casi cero? Estos números, como grandes números, números medianos o muy pequeños números, son números fuzzy. Ellos definen un espectro de números cercanos a cero y algunos pertenecen más al conjunto que otros. Mientras más cercano es un número pequeño a cero, más pertenece al conjunto fuzzy de números pequeños. El número 1 está más cerca a cero que el 2, y 2 está más cerca que 3, y así sucesivamente. De la misma forma los números negativos -1 está más cerca a cero que -2 y -2 está más cerca que -3. El número 0 pertenece 100% al conjunto cero pero los números cercanos pueden pertenecer solamente un 80%, 50% ó 10%. A continuación se muestra el número cero fuzzy como una curva o triángulo centrado exactamente en el número 0.

Quién le dice que (-3) y (+3) coinciden en el mismo punto?
Solo satisface un tipo de "medida" por otro más incompleto = progresivo

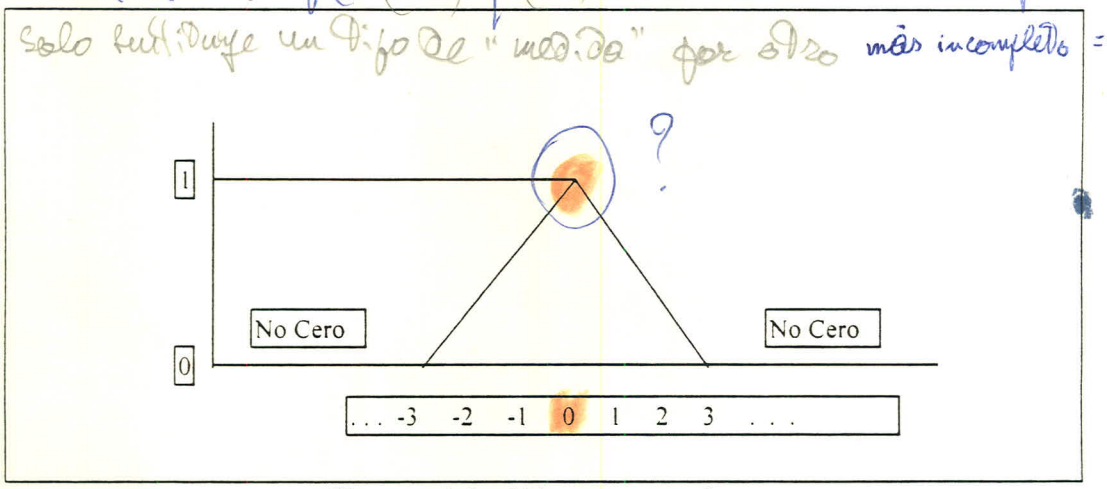


***Figura* 4.2** Número cero fuzzy

Cero y Todo = son términos "conceptuales" y lingüísticos.
En la realidad no existe ni el Todo ni el Cero, ni las partes intermedias
Lo que existe no tiene medida es el que mide.

Si se dibuja el triángulo lo suficientemente estrecho, entonces se tendrá el concepto clásico de las matemáticas. Esta es otra sorpresa: Las matemáticas como las conocemos son un caso especial de matemática fuzzy, un caso límite especial, el degenerado caso de los extremos blanco y negro dentro de un mundo gris de matemáticas. Podemos sumar o restar triángulos igual que cuando sumamos o restamos números. También podemos dibujar el número cero fuzzy de infinitas formas. Cada persona puede dibujarlo diferente tal y como cada persona piensa diferente de una casa, o pequeña, o bonita o limpia, etc.

3.1.1 ¿Qué se puede hacer con números fuzzy?

Se puede razonar con ellos. De hecho lo hacemos todo el tiempo. "Lógica Fuzzy" significa razonar con números fuzzy y conjuntos fuzzy. En la práctica significa hacer que las computadoras razonen con números fuzzy de la misma forma que las sentencias "Si, Entonces" o reglas del dedo: Si el carro va muy rápido, Entonces bajar velocidad. Si el carro está girando demasiado a la izquierda, Entonces de un pequeño giro a la derecha. Si el tráfico está pesado en la dirección norte-sur, Entonces mantener la luz del semáforo en verde por largo tiempo. Cada término se apoya en conjuntos fuzzy. Toda carretera se pone pesada en cierto grado. Toda luz verde del semáforo está por largo rato en cierto grado. El conocimiento o inteligencia viene de la asociación de estos dos eventos fuzzy.

Por ahora se ha probado el punto: Los números también son fuzzy. Y trabajamos con números fuzzy todo el tiempo. Y si los números son fuzzy, entonces todas las cosas son fuzzy. Y en realidad todo es fuzzy.

La siguiente pregunta es especial para los conjuntos fuzzy. ¿Son los conjuntos fuzzy la primicia de algo nuevo? Los conjuntos fuzzy comenzaron con los bordes borrosos, cuando las cosas no coincidían con nada, cuando A coincidía con No A. ¿Nos lleva esto a algo especial? El estado de coincidir o contradecir A y No A no puede mantenerse en una lógica bivalente. De esto que los científicos han perdido alguna propiedad aquí. Ellos perdieron la entropía fuzzy. Si no hay conjuntos fuzzy, entonces no hay propiedades para los conjuntos fuzzy. Pero los conjuntos fuzzy si existen y la primer pregunta es ¿qué tan fuzzy son? ¿Cómo se mide la cantidad de fuzzy que tienen los conjuntos fuzzy?.

3.2 Entropía fuzzy

La entropía fuzzy es la que mide que tan fuzzy son los conjuntos fuzzy. Esto contesta la pregunta, y es cuestión de cierto grado, ya que algunos conjuntos son más fuzzy que otros.

Entropía significa lo incierto o el grado de desorden que tiene un sistema. Un conjunto describe un sistema o conjunto de cosas. Un conjunto es fuzzy, cuando los elementos pertenecen a él en cierto grado, el conjunto es incierto y vago en algún grado. La entropía fuzzy mide ese cierto grado.

Un ejemplo de como la gente puede darnos conjuntos fuzzy sucede cuando levantan sus manos para contestar una pregunta. ¿Es usted casado(a)? Levante sus manos si lo está. Esto separa a la audiencia en dos grupos, el grupo A y el grupo No A, el grupo de los casados y el grupo de los No casados. La ley marca una línea gruesa entre los casados y los no casados. Ahora bajen sus manos. ¿Qué tan feliz es?, ¿Qué tan joven es?, ¿Qué tan liberal es?, ¿Qué tan delgado es?, ¿Qué tan alto es? o inteligente. Levanten sus manos. Ahora las manos no se levantaron hasta arriba ni se quedaron hasta abajo. La ley no marca líneas entre feliz y no feliz, joven o no joven, honesto o deshonesto. Nuestra lógica fuzzy no marca líneas entre los opuestos. Vivimos con una mezcla de felicidad e infelicidad, honestidad y deshonestidad.

El ejemplo de la audiencia muestra que los conjuntos fuzzy son reales. Los conjuntos fuzzy viven fuera de las matemáticas, pero en algún grado todos pertenecemos a un grupo.

3.3 Bivalencia vrs. Multivalencia

Binario significa si ó no, blanco ó negro, verdadero ó falso, matemática simplificada y procesamiento de computadoras. Con 0's y 1's se puede trabajar más fácil que con fracciones. Pero al trabajar con bivalencia se necesita hacer redondeos para llegar al valor.

En lógica bivalente una contradicción implica todo. Esto permite aprobar y desaprobar cualquier declaración. Los matemáticos depuran sus axiomas para no permitir que algunos contradigan algunas declaraciones de otros. Hasta aquí nadie ha probado que los axiomas de la matemática moderna no se contradigan unos a otros. En el futuro es posible que cambie y la armazón de la matemática moderna colapse. Mientras tanto el temor continúa. Entonces hay una pequeña tolerancia en la ciencia para admitir contradicciones, que admitan coincidir una cosa con una no cosa. La lógica fuzzy confronta esta tolerancia. Lo borroso comienza en donde las contradicciones comienzan, donde A y No A se acepta en cierto grado.[15]

La siguiente tabla muestra un resumen de algunas de las ideas claves de la multivalencia respecto de la bivalencia.

Bivalencia	Multivalencia
A ó NO A	A y NO A
Exacto	Parcial
Todo o nada	Algo en cierto grado
0 ó 1	Contínuo entre 0 y 1
Computadora digital	Redes neurales (cerebro)
Lenguaje de computadora	Lenguaje natural
bits (unidades binarias)	fits (unidades fuzzy)

Tabla 3.1 Tabla de comparación, bivalencia vrs.

Un valor fit (unidad fuzzy) es un grado o valor entre cero y uno. Un valor bit es un valor cero ó uno.

Suponga que tiene una manzana en su mano y luego la muerde. Al principio lo que tenía en su mano era 100% una manzana. O el 100% de la manzana estaba ahí. O su manzana pertenecía 100% al conjunto de todas las manzanas. Mientras más muerde la manzana, el porcentaje más baja a tal punto de llegar a 0% cuando ya se comió toda la manzana. A la mitad del proceso usted sostenía en su mano la mitad de la manzana ó el 50% de la manzana. El valor fit describe a la manzana de su total presencia hasta su total ausencia, desde el valor bit 1 hasta el valor bit 0. En este sentido los valores fit caben entre los valores bit. A continuación se grafica el proceso de como la manzana baja desde un 100% manzana hasta el 0% de manzana.



La línea horizontal con los números muestra el conflicto matemático entre bivalencia y multivalencia. La bivalencia se mantiene solamente en las esquinas, es decir, en los extremos de la línea. Los valores bit 0 y 1 están como opuestos.

La multivalencia se mantiene en todos lados entre los extremos. Esto incluye los dos extremos como casos especiales. Cuando un vaso tiene un poco de agua y llamamos a eso un vaso vacío, estamos redondeando un valor fit a un valor bit, un 5% ó 10% a un 0%. Si se toma como referencia la anterior línea horizontal, significa que primero vemos el valor fit y luego saltamos al extremo más cercano, para tomar un valor bit.

Ahora la pregunta es: ¿Cómo se encuentra el opuesto de un valor fit? en la línea anterior. El opuesto de 1 es 0 y el de 0 es 1. Vea la línea de nuevo. Los opuestos, A y No A, se reflejan con referencia al valor fit medio (0.5). Los valores bit 1 y 0 tienen la misma distancia desde el punto medio. Lo mismo se mantiene para el resto de los valores fit. El valor opuesto de 0.25 es 0.75, el valor opuesto de 0.3 es 0.7, y así sucesivamente. Esto significa que el valor opuesto de 0.5 es 0.5, A es igual a No A en el punto medio. Se puede trabajar con valores fit de la misma manera como se trabaja con valores bit, con la diferencia que no se debe redondear.

Redondear los valores fit a bit trabajan bien cuando se puede saltar al extremo más cercano. Pero ¿qué pasa si se quiere redondear el punto medio?, se redondea 50% a 0% ó a 100%. Esta pregunta no es igual a la pregunta del vaso medio vacío o el vaso medio lleno. Si se tiene que decir todo ó nada, la pregunta es, ¿está el vaso lleno ó vacío?.

El punto medio es un paradoja de la matemática moderna. Los matemáticos le dicen paradoja al punto medio, en parte para decir que el punto medio es una excepción.

La interpretación fuzzy considera el caso del vaso y el de la manzana como el fenómeno del punto medio. Las declaraciones que los describen son verdades a medias literalmente. Son 50% verdaderos. Si se insiste en un vaso 100% lleno, caemos en la paradoja bivalente. El vaso mitad-vacío/mitad-lleno muestra esto. Hay 50% de agua en el vaso, esto es un estado real del mundo. No se pretende que hay 50% de probabilidad que el vaso esté lleno, se pretende un vaso con agua hasta la mitad.

material = { cerebro o mente ?
in - material = { mente ?

3.4 Más precisión, más fuzzy

La información ayuda a dibujar el mundo. Cada segundo nuestros ojos transmiten millones de bits de información a nuestro cerebro. Nuestra mente se alimenta de: periódico, programas de televisión, faxes, llamadas telefónicas, etc. Nuestros sentidos se expanden con microscopios, binoculares, telescopios, y muchos otros aparatos que nos ayudan a convertir el mundo en información.

Cada nuevo dato cambia nuestra mente. Dentro de nuestro cerebro todo cambia como nuestras células cerebrales o neuronas se encienden. Esto cambia ligeramente los patrones de aprendizaje o los recuerdos de nuestras synapsis, (conexiones entre las células cerebrales). Mientras más información se tiene, más claros se ven los hechos y se puede describir el mundo con más detalle. Se ven más claros los hechos, pero ¿se toma la parte fuzzy separada de los hechos?.

Suponga que Juan tiene 30 años. ¿Es Juan viejo? ¿Si o no? ¿Es Juan joven? ¿Si o no? Agregue más información. Haga de cuenta que hoy está cumpliendo 30 años Juan. Entonces ¿Es joven o es viejo? ¿Qué nos dice la información precisa de Juan? Esto solamente nos indica que Juan será viejo cuando tenga 35 años más. Esto nos dice que los términos de viejo y joven son cuestión de cierto grado. Son conceptos fuzzy, viejo y joven son subconjuntos del conglomerado humano. Todo esto viene a: ¿Dónde dibujamos la línea? Es una pregunta de un razonamiento blanco y negro, dentro de un mundo gris. El gobierno dice que una persona comienza a ser adulta el primer segundo de su cumpleaños número 18. Se puede ver la línea como una línea imaginaria que parte el ser adulto del ser no adulto en la escala de los años.

Este no es un problema lógico sino lingüístico!

R/ No son subconjuntos del conglomerado sino de un concepto (= humano) que los "incluye" conceptualmente
Las medidas son arbitrarias
La realidad es concreta y continua = no es ni conjunto ni subconjunto!

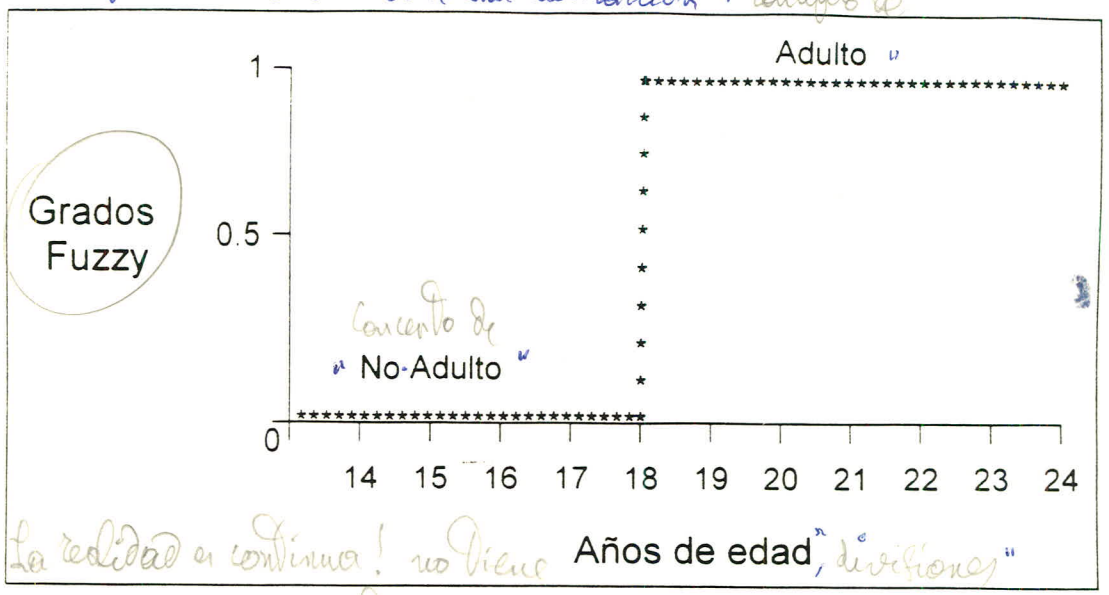


Figura 4.3 Proceso de no adulto a adulto en forma de línea

Se pueden dibujar diferentes líneas en diferentes años cerca de 18, pero no se puede dar una buena razón para ellas. Se sabe que la persona no pasa a ser adulta de un momento a otro. El llegar a ser adulto tiene un proceso que varía de acuerdo a ciertas circunstancias, pero por lo común comienza a los 14 años y termina por lo regular a los 25 años. También se sabe que el proceso de llegar a ser adulto es creciente de acuerdo a la edad. Entonces de acuerdo al concepto fuzzy se dibuja el proceso como una curva y no como una línea.

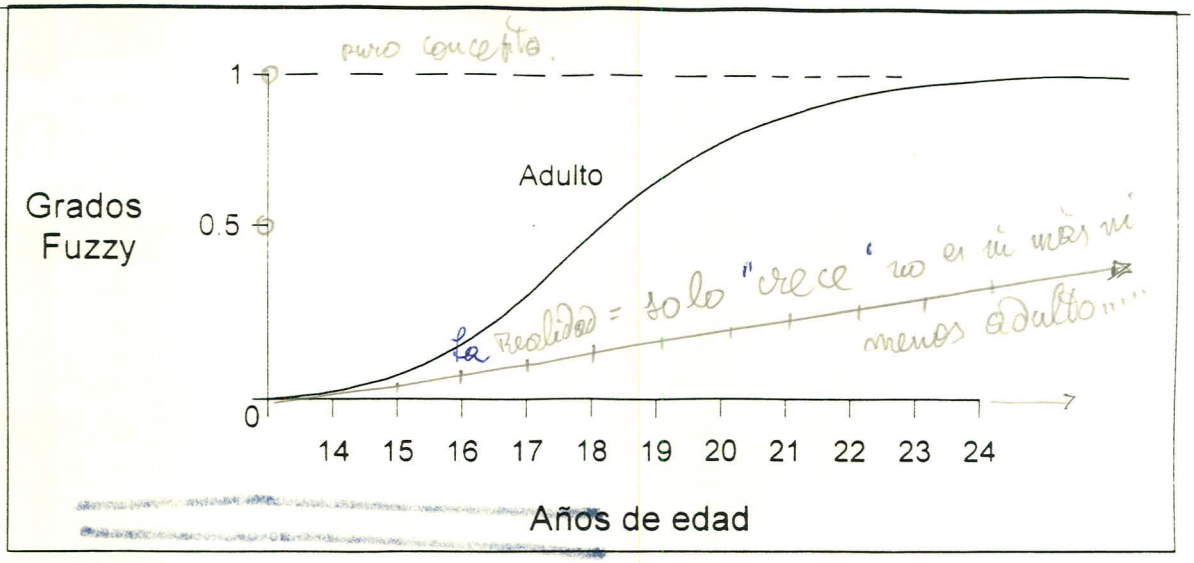


Figura 4.4 Proceso de no adulto a adulto en forma de curva

La teoría fuzzy dibuja una curva entre los opuestos, entre A y No A. Más información, más hechos, esto nos ayuda a dibujar la curva. Si se tiene suficiente información, las nociones vagas de viejo y joven se pueden convertir en un conjunto de curvas fuzzy.

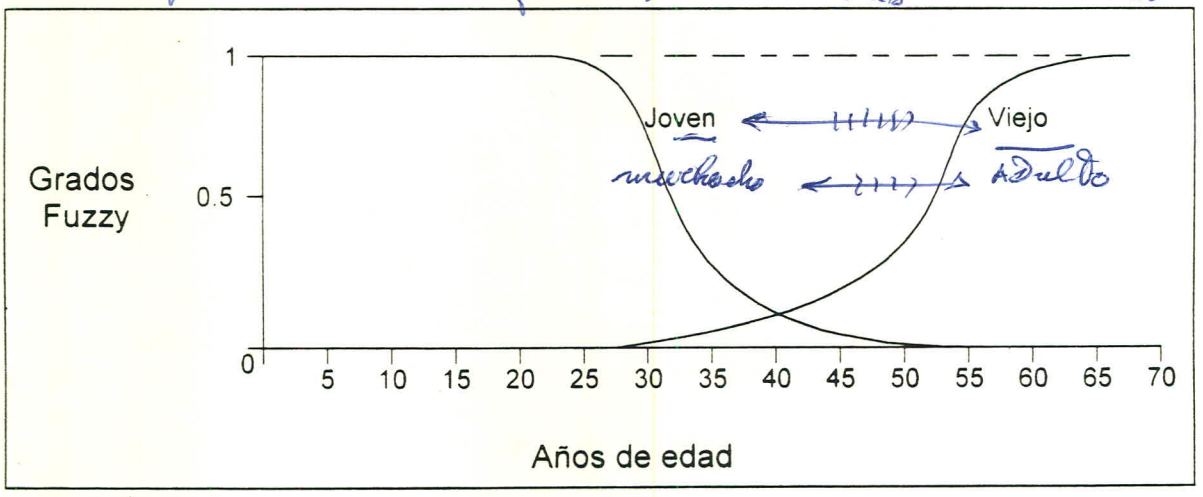


Figura 4.5 Curvas de conjuntos fuzzy joven y viejo

Mientras más información se tiene, más combas tendrá la curva y representará mejor la realidad.

Teoría de conjuntos fuzzy

En matemática, los conceptos y propiedades pueden describirse especificando subconjuntos de un conjunto de referencia. Por ejemplo, si se toma el conjunto **N** de los números naturales como el conjunto de referencia, la propiedad que un número tenga dos dígitos puede ser expresada usando el conjunto.

$$Z = \{ 10, 11, 12, ..., 97, 98, 99\} \subseteq \mathbf{N}$$

Además de esta representación, la cual tiene una estructura simple pero no siempre aplicable, la misma propiedad también puede entenderse como un predicado, por ejemplo, *un número n de dos dígitos* es verdadero para un número natural n, si y sólo si la representación decimal de n consiste de exactamente dos dígitos. El conjunto *Z* de todos los números naturales que satisfacen el predicado de los *números de dos dígitos* se define así:

$$Z = \{ n \in \mathbf{N} \mid \textit{número n de dos dígitos} \}$$

Una tercera forma de representar los datos de *números de dos dígitos* es el uso del concepto de función característica, según el ejemplo se define así:

$$\Pi_Z : \mathbf{N} \rightarrow \{ 0, 1 \}$$

$$\Pi_Z(n) = \begin{cases} 1. & \text{Si el número n tiene dos dígitos} \\ 0. & \text{En otro caso.} \end{cases}$$

Los miembros de *Z* están marcados con el valor 1, para diferenciarlos de los demás miembros del conjunto de referencia. Los dos valores 0 y 1 de la función característica a veces son llamados *grados de pertenencia.*

5.1 Ejemplo de función característica

A continuación se muestra una figura que describe el conjunto de todos los números reales no negativos menores de 1.05. El punto de descontinuidad en 1.05 parece ser natural, si la función característica es interpretada como el conjunto de las estaturas de niños que son más bajos de 1.05 metros.[16]

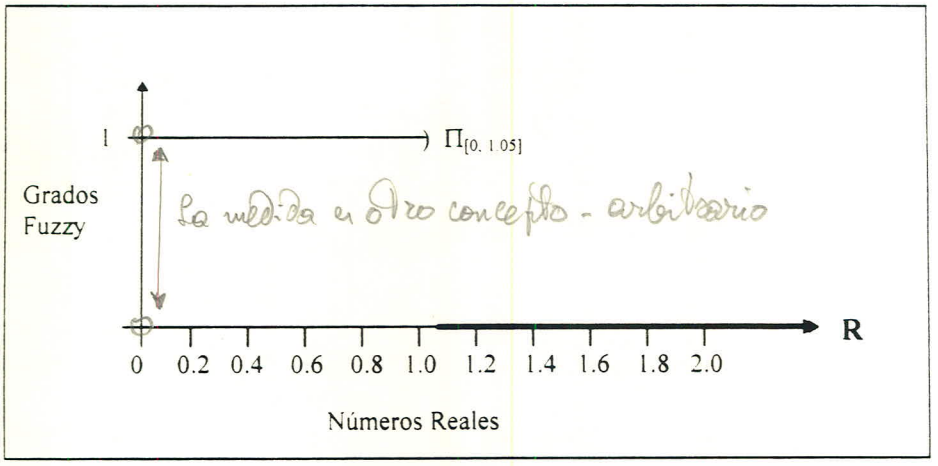


Figura 5.1 Función característica para el intervalo [0, 1.05]

La adecuación de funciones características con codominio { 0, 1 } tienen que ser cuestionadas si, por ejemplo, esas estaturas corresponden a un niño considerado como alto. Dado que el significado de niño alto puede tener diferente interpretación en cada persona.

Lo más importante del anterior problema de caracterización es tener una descripción con la ayuda de conjuntos ordinarios. Esto requiere que se fije un valor de estatura, de tal forma que un niño cuya estatura exceda este valor, debe ser llamado alto, y que ningún otro valor por debajo del valor fijado tiene la misma propiedad. Pero el punto de descontinuidad no coincide con la concepción que hay una ligera transición de la estatura de un niño que debe ser llamado

alto, de la de un niño que debe ser llamado no alto. Un método para modelar transiciones graduales es el uso de otros grados de pertenencia.

5.2 Funciones de pertenencia

Refleja el grado de pertenencia de ciertos elementos u objetos al conjunto fuzzy. La función asigna un número del intervalo [0, 1], que puede verse como "el valor de verdad" en el cual, 1 indica verdad completa o pertenencia total, y 0 indica falsedad completa y no pertenencia.

Sea X una colección de elementos (objetos), donde x representa un elemento genérico de X, es decir, $X = \{x\}$, entonces el conjunto fuzzy A en X es el conjunto de pares ordenados $\{(x,\mu_A(x))\}$ donde $\mu_A(x)$ se le llama la función de pertenencia de A y μ_A se define como

$$\mu_A : X \rightarrow [\,0\,,\,1\,]$$

"El número $\mu_A(x)$ tiene una interpretación natural como nuestro grado de aceptación del enunciado x es un miembro de A y por tanto como un valor verdadero asociado a este enunciado".

Las funciones de pertenencia son subjetivas. Como se esperaba, pueden variar de un individuo a otro en grupos homogéneos. El problema de evaluar la función de pertenencia, es decir, estimar la función usando los puntos muestra del conjunto fuzzy, será generalmente difícil en situaciones prácticas. Dada la existencia de borrosidad en disciplinas ampliamente diversas, los procedimientos para la evaluación de funciones de pertenencia estarán, en parte, dictadas por el medio del sistema bajo estudio.

5.2.1 Cómo se determinan los valores de la función de pertenencia

5.2.1.1 Evaluación subjetiva y escogencia

Los conjuntos fuzzy se usan con frecuencia para modelar los estados cognocitivos de las personas, pueden ser determinados de dos formas: procedimientos simples y procedimientos complejos, cuando se usan procedimientos simples, se dibujan diferentes curvas de pertenencia apropiadas al problema y luego se escoge la que mejor se ajusta. Las personas que hacen esto, por lo común son personas expertas en el área. Cuando se aplican procedimientos complejos, los usuarios pueden probar el valor de la función de pertenencia usando métodos psicológicos.

5.2.1.2 Formas ad-hoc

Mientras hayan muchas formas de posibles funciones de pertenencia, actualmente más operaciones de control fuzzy son dibujadas de un conjunto muy pequeño de curvas diferentes, por ejemplo: los números fuzzy recientemente estan siendo utilizados para muchas aplicaciones de control, la representación de números fuzzy puede tener desde formas sencillas como la triangular y trapezoidal hasta funciones más complicadas como las curvas exponenciales

similares a la función de densidad de probabilidad gaussiana. El hecho de tener un conjunto reducido de curvas simplifica el problema.

5.2.1.3 Frecuencias convertidas o probabilidades

Algunas veces, la información se presenta en forma de histogramas de frecuencias u otras curvas de probabilidad, entonces se usa esta característica para construír la función de pertenencia. Hay una variedad de posibles métodos de conversión, cada uno con sus ventajas y desventajas matemáticas. De todas formas es importante recordar que la función de pertenencia no es necesariamente probabilidad.

5.2.1.4 Medida física

Muchas aplicaciones de lógica fuzzy usan medidas físicas, pero usualmente ninguna mide directamente el grado de pertenencia. En lugar de eso, la función de pertenencia es calculada por otro método, y luego los valores individuales de los datos son calculados a partir de ahí.

5.2.1.5 Aprendiendo y adaptando

Este es el método que usan los sistemas expertos, ya sea que el sistema aprenda por si solo y modifique automáticamente los valores de las funciones de pertenencia, o que sea la persona experta en la materia, quien constantemente esté monitoreando los valores y en base a su experiencia los adapte.

Se debe tener cuidado con la teoría de medición psicológica que ha estado, en parte, históricamente interesada en la evaluación de lo que en teoría sobre el conjunto fuzzy se clasifica como "función de pertenencia". Por ejemplo, los intentos para medir magnitudes psicológicas o subjetivas son, en esencia, intentos de abstraer funciones de pertenencia. La extensa investigación en esta área, parecería ciertamente aplicable a las funciones de pertenencia, pero dos estudios recientes apuntan hacia dos enfoques prometedores. Un ejemplo, del problema general de la evaluación de la función de pertenencia, también se encuentra en el modelamiento de los sistemas de diagnóstico. Ahí, lo fuzzy aparece como una característica de la función de pertenencia del grado de normalidad o anormalidad de una variable o síntomas particulares, o de la importancia de una variable con respecto a una enfermedad particular. En todos los casos, lo que se incluye son grados de pertenencia y clases mal definidas. La teoría sobre el conjunto fuzzy es un intento por definir estas clases precisamente, además proporciona un instrumento para describir la ambigüedad separadamente de la incertidumbre.

5.3 Ejemplo de función característica generalizada

En la siguiente figura se muestra la función característica generalizada, la cual describe el predicado vago *alto* desde el punto de vista de un físico quien investigó todos los valores $x \in \mathbf{R}$ que corresponden a las estaturas que un niño de 4 años puede asumir.

Cada valor x es relacionado con un grado de pertenencia, por ejemplo la altura 1.20 m. es relacionada a 0.7. Esto significa que la altura 1.20 m. sastisface el predicado *alto* con un grado de pertenencia de 0.7 en la escala de 0 a 1. Mientras más se acerca a 1 el grado de pertenencia $\mu_{alto}(x)$, más satisface el valor x al predicado *alto*.

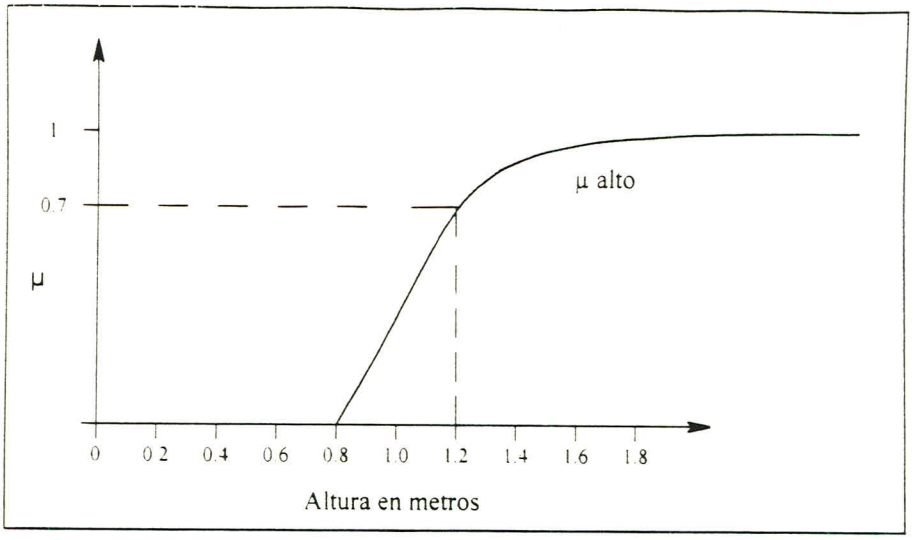


***Figura* 5.2** Función característica generalizada de μ alto

5.4 Formas simples de representar conjuntos fuzzy

Las funciones características y la forma de representarlas varían de acuerdo al sistema que se quiera trabajar. Cualquier conjunto fuzzy μ de X puede obviamente ser descrito asignando un grado de pertenencia μ(x) a cada elemento $x \in X$, esto es factible solo cuando el conjunto de referencia X contiene un número finito de elementos. Si el número de elementos en X es muy grande, infinito o contínuo, entonces μ(x) es representado con la ayuda de un término apropiado y posiblemente parametrizado, donde los parámetros puedan ser ajustados de acuerdo al problema dado.[17]

Si $X = \mathbf{R}$, entonces en muchos casos las expresiones lingüisticas como "alto", "viejo", "casi 10", "aproximadamente entre a y b", las cuales pueden ser interpretadas como elementos de conjuntos fuzzy parametrizados apropiadamente $\mu : X \rightarrow [0, 1]$ que satisface la condición de normalidad $\exists x \in X : \mu(x) = 1$ también pueden ser llamados conjuntos fuzzy normales. En la práctica una interpretación de "alto" como una función monótona y no decreciente se puede representar así:

$$\mu_{a,b}(x) = \begin{cases} 0, & \text{si } x \le a \\ (x-a)/(b-a), & \text{si } a \le x \le b \\ 1, & \text{si } x \ge b \end{cases}$$

donde a<b.

Otra interpretación son las funciones lineales por tramos, cuyos parámetros son las coordinadas de los puntos definidos. Un ejemplo de estas funciones se muestra a continuación.

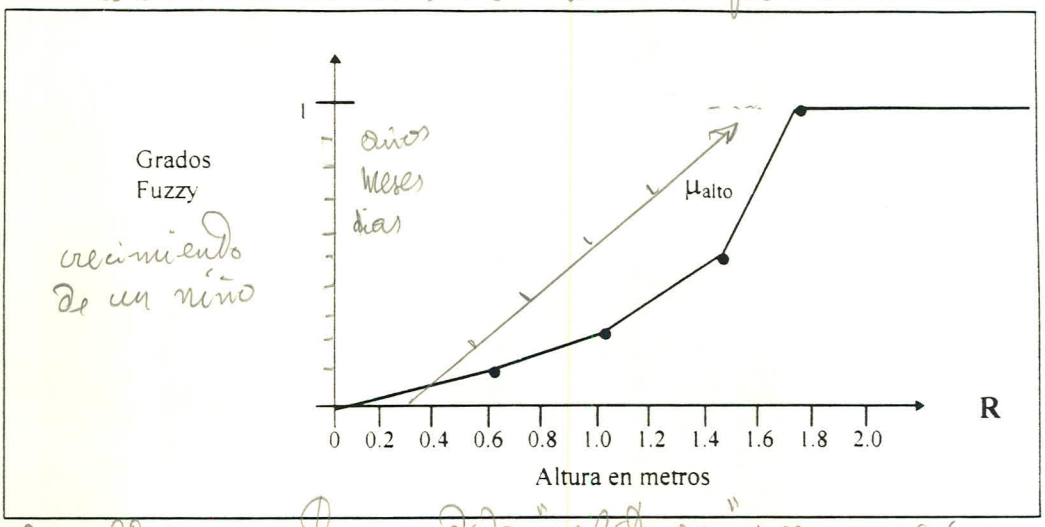


Figura 5.3 Interpretación del concepto vago "*alto*" por una función lineal por tramos

La función exponencial se define así:

$$\mu_{a,b}(x) = \begin{cases} 1 - e^{(-a(x-b))}, & \text{si } x \ge b \\ 0, & \text{si } x < b \end{cases}$$

donde $a > 0$ y $b \in \mathbf{R}$.

Para interpretar las expresiones lingüísticas como "casi 10", las cuales son a menudo representadas por los pseudo-llamados números fuzzy, sencillamente se adopta una función triangular simétrica como:

$$\mu_{m,d}(x) = \begin{cases} 1 - |(m-x)/d|, & \text{si } m-d \le x \le m+d \\ 0, & \text{si } x < m-d \text{ ó } x > m+d \end{cases}$$

donde d>0 y m ∈ **R**.

Por analogía la expresión "aproximadamente entre b y c" es más simple caracterizarla por la función trapezoidal.

$$\mu_{a,b,c,d}(x) = \begin{cases} (x-a)/(b-a), & \text{si } a \le x < b \\ 1, & \text{si } b \le x \le c \\ (x-d)/(c-d), & \text{si } c < x \le d \\ 0, & \text{si } x < a \text{ ó } x > d, \end{cases}$$

donde $a < b < c < d$ y $a,b,c,d \in \mathbf{R}$.

Note que los números reales *t* pueden descritos por:

$$\mu_t(x) = \Pi_{[t,t]}(x) = \begin{cases} 1, & \text{si } x = t \\ 0, & \text{si } x \neq t \end{cases}$$

y en intervalos [a,b] por:

$$\mu_{a,b}(x) = \Pi_{[a,b]}(x) = \begin{cases} 1, & \text{si } a \le x \le b \\ 0, & \text{si } x < a \text{ ó } x > b \end{cases}$$

Por estas razones los números reales y los intervalos pueden verse como casos especiales de los conjuntos fuzzy normales.

5.5 Conceptos y operaciones básicas de conjuntos fuzzy

1.- El conjunto fuzzy *A* está contenido en el conjunto fuzzy *B* ó $A \subseteq B$, si y sólo si $\mu_a(x) \le \mu_b(x)$ para toda x.

2.- La intersección de los conjuntos fuzzy *A* y *B*, $A \cap B$ se define como el conjunto más pequeño contenido tanto en *A* como en *B*; es decir,

$$A \cap B = \{ (x, \mu_{A \cap B}(x)) \} \quad \text{donde} \quad \mu_{A \cap B}(x) = \text{Min}(\mu_a(x), \mu_b(x)).$$

3.- La unión de los conjuntos fuzzy A y B, $A \cup B$, se define como el conjunto fuzzy más grande, que contiene tanto a A como a B, es decir

$A \cup B = \{ (x, \mu_{A \cup B}(x))\}$ donde $\mu_{A \cup B}(x) = \text{Max}(\mu_a(x), \mu_b(x))$.

4.- El conjunto fuzzy B se dice que es el complemento de A si, y sólo si

$\mu_B(x) = 1 - \mu_A(x)$ para toda x.

Como una simple ilustración de intersección, cosidere que el conjunto borroso "alto" se caracteriza por el conjunto de pares

$A = \{ (x, \mu_A(x))\} = \{ (50,0), (55,0.2), (60,0.7), (65,0.95), (70,1)\}$

donde x es la altura en pulgadas, y $\mu_a(x)$ es el valor de la función de pertenencia. Sea B el conjunto fuzzy "no alto" donde $\mu_B(x) = 1 - \mu_A(x)$.

$B = \{ (x, \mu_B(x))\} = \{ (50,1), (55,0.8), (60,0.3), (65,0.05), (70,0)\}$

Entonces la intersección A y B sería

$A \cap B = \{(50,0), (55,0.2), (60,0.3), (65,0.05), (70,0)\}$

donde cada par se obtiene mediante la aplicación de la definición: por ejemplo
$\mu_{A \cap B}(60) = \text{Min}(\mu_A(60), \mu_B(60)) = \text{Min}(0.7,0.3) = 0.3$

Nótese que si la anterior representación de los conjuntos "alto"y "no alto" usaron el enfoque convencional de lógica de dos valores, la intersección en este caso es el conjunto vacío. En el caso de los conjuntos fuzzy, hay algunos elementos que "pertenecen en algún grado"a ambos conjuntos "alto" y "no alto". Esto se puede observar en la siguiente figura. La función de intersección ($\mu_A \cap \mu_B$) está formada por la sección de cada función ($\mu_A(x)$ y $\mu_B(x)$) que parte de cero en el eje μ hasta el punto en donde se intersectan ambas funciones.

→ eso solo se debe a una "medida" mas pormenorizada "parcial" que detalla conceptos mas generales

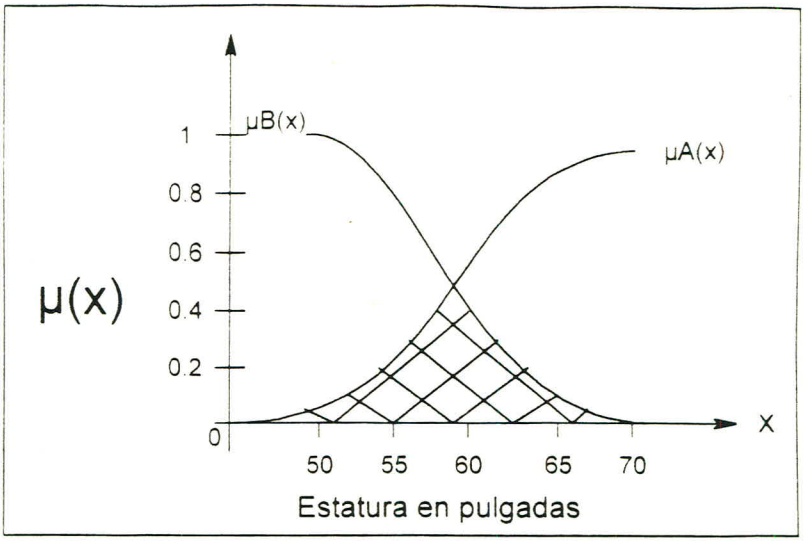


***Figura* 5.4** Intersección de los conjuntos fuzzy $\mu_A(x)$ y $\mu_B(x)$

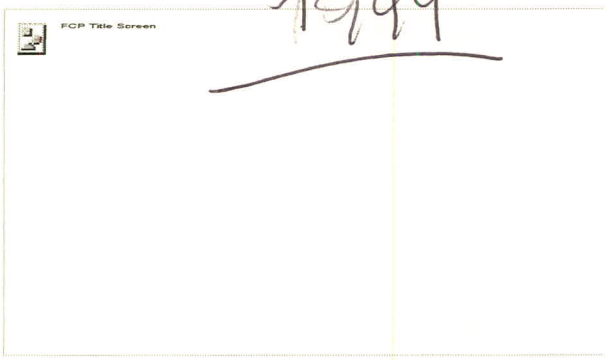
5.6 De los conjuntos fuzzy a los sistemas

Las palabras se basan en un conjunto de cosas. Estos conjuntos son fuzzy. Las cosas pertencen a ellos en algun grado. Eso significa que las cosas, también pertenecen a sus opuestos en algun grado. De esto que la lógica de Budha (A y No A) es verdadero en cierto grado se acepta en lugar de la lógica de Aristóteles (A ó No A). El hombre que mide un metro 90 centímetros es alto y no alto, talvez más alto que no alto. El hombre que tiene 30 años es viejo y no viejo en cierto grado.

Desde hace tiempo se han definido conjuntos fuzzy tal como alto, solmente una palabra en una oración. Las oraciones tienen muchas palabras y nos muestran conjuntos borrosos de forma que nosostros razonemos. Sentido común. Si está lloviendo, te mojarás. Si el aire está caliente, enciende el aire acondicionado.

Un grupo de oraciones nos dan sistemas fuzzy. En el más simple de los casos alguien da las oraciones, y con esto sus consejos expertos, o reglas, o su sentido común. Un sistema fuzzy toma este conocimiento y modela el mundo con él. El sistema puede controlar una lavadora o dar señales de compra y venta en un inventario. En el caso adaptivo el sistema fuzzy comienza con sus propias oraciones. Este no solamente razona con su conocimieno, sino también crece su conocimiento de los datos. Aprende de experiencias. Eso es un sistema fuzzy adaptivo.

Are you in the picture with Fuzzy Logic?



Bytronic International Ltd. unveils it's latest development - a complete PC training package for those wishing to learn more about Fuzzy Logic and its implementation in an industrial environment.

The Fuzzy Control Package (FCP) combines Windows-based software with concise tutorials and practical courseware to assist the user in developing modern fuzzy controllers.

Fuzzy logic technology is taking the control community by storm. Controllers can now be developed that make use of human experience and understanding without the need for rigorous mathematical solutions. By designing simple controller objectives in 'if...then...' type rules, hand-held camcorder focusing can be stabilised, vacuum cleaners can adapt and subway trains can run without hitch. But how do you sort through the baffling array of fuzzy logic products and high-tech services?

The Fuzzy Control Package

The Fuzzy Control Package consists of two main components. The FCP software program and the accompanying manual set.

The FCP Software

FCP is a Windows based development environment, designed to suit the specific needs of a fuzzy controller designer. It offers the user a visual rulebase structure and may be configured to control either internal simulations or external devices. Simple point and click commands can be used to activate a wide array of fuzzy development tools such as visual fuzzy set editors, graphical control surface and interactive debuggers. It also offers a full on-line HELP facility and development tutorial to guide the user through the controller design process.

Controller Structure



FCP takes the general structure of a two input, one output error based discrete fuzzy controller. The signal flow is shown above and illustrates the general controller structure of a closed loop system. From this screen users can define the Set Point reference signals, inputs and outputs to the controller, the type of controller to use and the application to control, either an internal simulation or external device.

Fuzzification and De-Fuzzification



Fuzzy logic transforms vague concepts like 'tall', 'almost zero' and 'far away' into truth values known as degrees of membership. It is possible, therefore, to represent any measurement in terms of its degree of membership to a fuzzy set. This transformation of measurements to fuzzy values is known as fuzzification and is achieved in FCP by using the Fuzzy Set editor to define the membership functions of the fuzzy sets.

Once signals have been fuzzified they can be manipulated using the rulebase in the controller to provide a fuzzy output. This output signal must then be de-fuzzified back to a form that the application can recognise. This is achieved in FCP using a separate fuzzy set editor that is simliar to the input set editor.

Defining a Rulebase



One of the main benefits of using fuzzy logic is the fact that we can enter commands for the controller to perform in an English-type form using IF...AND...THEN statements. These commands are known as the controller RULEBASE and take into account the actions and reactions

required for any particular input signal(s). This is achieved in FCP using the membership states defined in the Fuzzification and De-Fuzzification set editors.

Graphical Tuning of Your Fuzzy Controller


FCP 3D Graphical Control Surface

Once you have stated the membership functions of the input and output signals and defined the controller rulebase, you are in a position to analyse the developed controller action as a three dimensional control surface. For this feature it is assumed that the two controller inputs and one controller output make up the necessary three dimensions of a solid object.


FCP Plan View of 3D Surface

By representing the control action as a surface, the fuzzy controller may be considered as a map relating inputs to outputs. The control action response to any input combination may be visualised in terms of its overall strength of output. The surface can be rotated to inspect any areas of the surface that are hidden in any particular view. The surface can also be viewed in 'Plan', which represents an overhead view of the 3D surface with control action being represented as a series of shaded colour to show the various controller strength indications.

By changing the rulebase it is possible to alter the characteristics of the controller and this can be viewed on the 3D surface.

Testing your Fuzzy Controller

Fuzzy controllers can be tuned in a general format using the graphical tuning methods above. However, for more accurate tuning, FCP provides the user with an interactive debugging platform, from which precise controller inputs and outputs can be measured.


FCP Debugging Screen

On entering values for the inputs 1 and 2, the debugger calculates the various firing strengths for all the appropriate fuzzy sets and displays the height of each appropriate membership function. Once the debug engine is activated, the debugger calculates the precise control action corresponding to the two inputs and displays the appropriate output sets.



The performance of the fuzzy controller can be evaluated further by testing the ability of the closed loop system against the set point reference signal. There are two display modes available to the FCP user; the Chart Recorder and the Polar Plot.

The Chart Recorder is a virtual charting device, that has the ability to display all data signals within the closed loop system onto a scrolling background. Before the test commences, the user has the option to configure the chart recorder to display only selected signals.

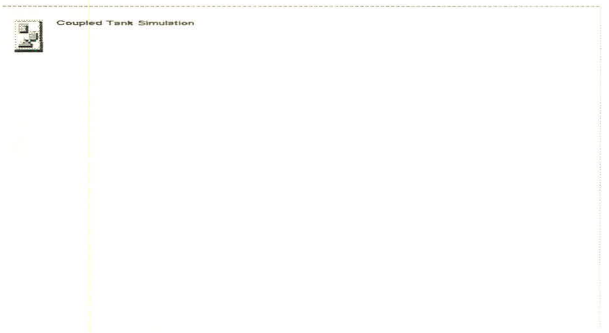


A fuzzy Polar Plot allows the control designer to see the usage of the rulebase during a test. Analysis of the test will show whether rules are being used or not. Any rules not being used can be removed from the rulebase thus improving the efficiency of the controller.

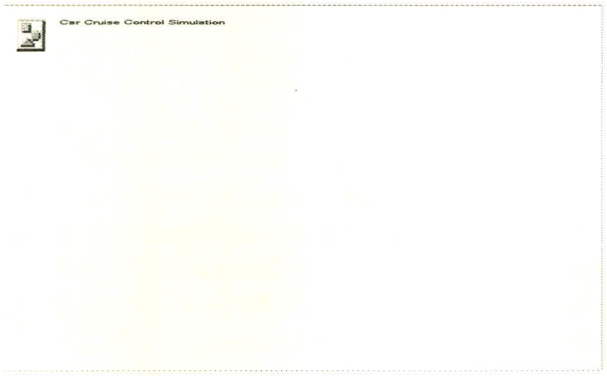
While testing the fuzzy controller using the polar plot it is possible to manipulate the rulebase for the controller **on-line** and immediately see its effect.

Internal or External Control



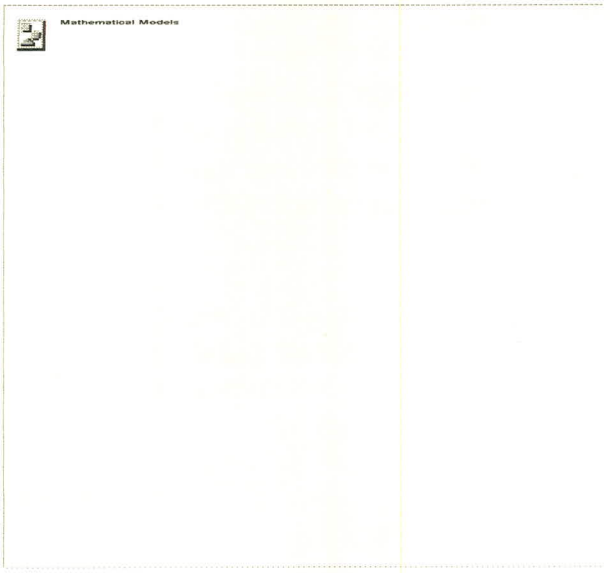


FCP comes with four built in simulation models for which users can develop fuzzy controllers. Each simulation model is based on a easily recognisable scenario that students will understand. The first model is based on achieving control of the level in a tank. The second model takes this concept a step further and looks at the control of the level in two tanks coupled together. The third model represents that of a cruise control system on a car where you have to adjust the throttle dependant on the rise or fall of the road. The fourth simulation looks at maintaining the temperature of a refrigerator taking into account the changes that occur when the door is opened.





Apart from these set internal models, FCP also has four models that represent general control systems for fuzzy development. Model A represents a simple first order type system, Model B, a Second Order type system, Model C, a Non-minimum phase type system and Model D, a Non-linear type system.



The Fuzzy Control Package is **not** just a package for the simulation of controllers in software. Controllers can be developed for control of external apparatus via a Bytronic Analogue and Digital Interface card with the Pendulum Control System being an ideal target application. The use of the Pendulum allows the student to study the effects of analogue, digital and fuzzy logic control all on one system. Thus enabling comparisons of the three methods of control to be made.

Saving and Exporting Data

Any fuzzy controller developed within FCP can be saved away for future use. FCP also has the added feature of being able to export data from the tests performed so that the results can be analysed in a data processing package.

System Requirements

The Fuzzy Control Package requires a PC Microcomputer with a minimum specification of 486 33Mhz, 4Mb RAM and running Windows 3.1 or higher. If you wish to use FCP with external devices you will also need the MPIBM3 Analogue and Digital Interface Card.

The FCP Manual Set

There are 3 manuals provided with the Fuzzy Control Package software. The first is the Tutorial manual, which covers the basic principles of fuzzy logic and some of the reasons behind its success in industry. The second is the Documentation manual, this describes the key features and functions of the FCP software and how to design and implement your fuzzy controller. It also includes useful tips for good controller design, where appropriate. Finally, but perhaps most importantly, is the Courseware manual. This gives the reader a series of labworks and course material to complete using the FCP software tools provided.

By developing a foundation of practice and theory, all aspects of fuzzy control can be covered in a time effective manner.

The Fuzzy Control Package

FCP shows clearly what fuzzy logic has to offer. In a step-by-step format, the design, development and application of fuzzy controllers are explored from a practical perspective, making use of modern graphical tuning techniques. While FCP can be used as a standalone teaching aid with its library of internal simulations, it has the added benefit of being capable of controlling real applications via a PC interface card.

The Fuzzy Control Package is available direct from Bytronic or via one of our authorised distributors. FCP is available in stand-alone and multi-user formats including network support. If you would like to receive a free demonstration of FCP or make any comments on the package please feel free to contact us!

Fuzzy Logic Menu	Product Range	Main Menu

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TERMINOLOGIA

Computer and Technology Division

Expert Systems Interest Group - Frequently Asked Questions (FAQ's)

- What is an expert system?
- What is artificial intelligence (AI)?
- What is a knowledge base?
- What is rule-based reasoning?
- What is an inference engine?
- What is case-based reasoning (CBR)?
- What is fuzzy logic?
- What is a neural network?
- What is a bayesian network?
- What are validation and verification?
- What is the difference between an expert system and document assembly software?
- What are the foundations of practical applications of AI?
- How did the practical applications of AI come about?
- Can expert systems perform legal analysis?
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- Why should outside counsel use an expert system where the billable hour is the rule?
- What practice areas are best suited for expert system use?
- Who owns the intellectual property when co-developing an expert system with programmers, employees or clients.?
- Who is leading the development of legal expert systems?
- Where can I take courses in AI and law?
- What law-related books or articles are available on expert systems, law and AI?
- What other books or articles are available on expert systems, law and AI?

What is an expert system?

Simply put, an expert system represents information and searches for patterns in that information. They are known as expert systems because they model how a human expert analyzes a particular situation by applying rules to the facts (or compares the current case with similar cases) in order to

reach a conclusion. Expert systems can include different types of reasoning like rule-based, case-based, fuzzy logic, neural networks, bayesian networks, etc.

The most common expert system is rule-based, containing a knowledge base (rules) and an inference engine (routing mechanism) which analyzes fact patterns and matches the applicable rules. Fact patterns are analyzed until either the goal succeeds or all of the rules are processed and the goal fails.

What is artificial intelligence (AI)?

According to the Artificial Intelligence Dictionary, AI is a "Multi-disciplinary field encompassing computer science, neuroscience, philosophy, psychology, robotics, and linguistics; and devoted to the reproduction of the methods or results of human reasoning and brain activity."

In other words, AI involves the development of computational techniques for pattern-matching and search which closely model the human thought process. A chess program searches for patterns in the game position, a natural language program searches for patterns in a list of words, a neural network learns patterns in bit maps and case-based reasoning searches for and recognizes patterns in cases.
Merritt

What is a knowledge base?

A representation of expertise, wisdom or rules-of-thumb, often represented by rules containing "if-then-else" conditional statements or cases containing various fact patterns. Knowledge bases may also consist of representative objects (excited utterance) within a sub-class (rules against hearsay) and class (rules of evidence) of information. Knowledge bases typically focus on narrow issues, known as a domain, within a particular fact situation.

What is rule-based reasoning?

A particular type of reasoning which uses "if-then-else" rule statements. As mentioned above, rules are simply patterns and an inference engine searches for patterns in the rules that match patterns in the data. The "if" means "when the condition is true," the "then" means "take action A" and the "else" means "when the condition is not true take action B." Here is an example with the rule PROBABLE CAUSE:

IF robbery is TRUE
AND
suspect witness identification is TRUE
AND

```
suspect physical evidence is TRUE
AND
suspect lacks alibi is TRUE
THEN
probable cause is TRUE
ELSE
round up usual suspects
```

Rules can be forward-chaining, also known as data-driven reasoning, because they start with data or facts and look for rules which apply to the facts until a goal is reached. Rules can also be backward-chaining, also known as goal-driven reasoning, because they start with a goal and look for rules which apply to that goal until a conclusion is reached.

What is an inference engine?

Software code which processes the rules, cases, objects or other type of knowledge and expertise based on the facts of a given situation. Most AI tools contain some form of deductive or inductive reasoning capability.

What is case-based reasoning (CBR)?

An AI technique whereby "cases" consisting of a number of key facts are created. Then cases similar to the current problem are retrieved and their "solutions" modified to work on the current problem. A number of academics have applied CBR to legal analysis in prototype systems or tools including Rissland, Skalak and Ashley.

What is fuzzy logic?

An AI technique where truth values become real values in the closed interval [0..1]. The definitions of the boolean operators, "if-then-else" rules, are extended to fit this continuous domain. By design, fuzzy logic does not attempt to discern clear cut values therefore it avoids some of the problems inherent in either/or conclusions. Instead, the rules are designed to return vague values like "very hot" or "closer."

Fuzzy Logic is an area of research based on the work of L.A. Zadeh. It is a departure from classical two-valued sets and logic, that uses "soft" linguistic (e.g. large, hot, tall) system variables and a continuous range of truth values in the interval [0,1], rather than strict binary (True or False) decisions and assignments.

Fuzzy logic is used where a system is difficult to model exactly (but an inexact model is available), is controlled by a human operator or expert, or where ambiguity or vagueness

is common. A typical fuzzy system consists of a rule base, membership functions, and an inference procedure. For more details, check out fuzzy logic sites.

What is a neural network?

A neural network is a processing device, either an algorithm, or actual hardware, whose design was motivated by the design and functioning of human brains and components thereof. It contains many very simple processors ("units"), each possibly having a (small amount of) local memory. The units are connected by unidirectional communication channels ("connections"), which carry numeric (as opposed to symbolic) data. The units operate only on their local data and on the inputs they receive via the connections.

Most neural networks have some sort of "training" rule whereby the weights of connections are adjusted on the basis of presented patterns. In other words, neural networks "learn" from examples, just like children learn to recognize dogs from examples of dogs, and exhibit some structural capability for generalization.

One of the most well-known neural network applications analyzes credit transactions searching for a particular set of incidents that may indicate fraud. For more details, check out neural network sites.

What is a bayesian network?

Also known as belief networks or causal probabilistic networks, use the techniques of probability theory to reason under conditions of uncertainty. Unlike "artificial" neural networks, Bayesian networks can explain their reasoning and can incorporate probabilistic data from published literature. They are useful for representing uncertain relationships where prior knowledge and statistical data are available. Analysis is based on cause and effect, confidence factors, probabilities, polynomial algorithms, heuristics and related controls or concepts. Bayesian networks have been used widely in statistics, decision analysis and artificial intelligence to model expert systems, diagnosis, dynamic reasoning, control and decision making. For more details, check out bayesian network sites.

What are validation and verification?

Validation is the process of confirming the correctness of a given model or assumptions by using measurable inputs to produce definable outputs, both of which can be confirmed and verified. Verification is the process of confirming that an implemented model works as

intended.

What is the difference between an expert system and document assembly software?

While both have the ability to process rules, document assembly systems process the rules based on a hard-coded procedural path, pre-determined by the developer. This script-based rule branching is extremely rigid or "brittle" in IA parlance. An expert system has no hard-coded path thus can reach new or different conclusions using deductive or inductive reasoning. To learn more, contact the Document Assembly Interest Group Co-Chair Marc Lauritsen.

What are the foundations of practical applications of AI?

While the foundation of AI began hundreds of years ago with work by mathematicians like Boole and others, practical applications of AI began to appear in the seventies and eighties. For a brief history, review our AI timeline.

How did the practical applications of AI come about?

Beginning in the early sixties, AI research was conducted in research labs at Stanford, SRI, MIT and Carnegie-Mellon. By 1984, a number of financial institutions began using some sort of AI programming technique or tool. Most of the initial financial applications involved decision making systems, including commercial and individual loans, credit card applicant screening and fraud pattern detection. The most well-known early commercial system was American Express's "Authorizer's Assistant" that was the basis of their expert systems still in use today to approve credit limits and identify unauthorized purchases.

Can expert systems perform legal analysis?

Yes, based on the existence of a vast numbers of prototypes and several production expert systems for law. For more detail, check out papers from past ICAIL conferences.

Will expert systems eventually replace attorneys?

Just like computers, an expert system is a tool. While many were convinced technology would replace "knowledge workers," it is clear that is not the case. However, expert systems will likely replace the many transactional

functions attorneys currently perform.

Why should outside counsel use an expert system where the billable hour is the rule?

Maybe you shouldn't. That is, bill by the hour. With alternative billing methods becoming increasingly popular among corporate counsel, it may be difficult to remain competitive if other attorneys adopt a fixed fee or value-based billing. Reed, "Beyond the Billable Hour"; ABA Alternative Billing Task Force

The bottom line is the bottom line. If you bill hourly, you must decide whether the corresponding increase in quality, risk management and consistency will result in an increased profit margin. Bidding a fixed fee requires exacting project estimating and management to remain profitable; this could be an incentive or disincentive, depending on your viewpoint.

Using an expert system could allow entry into a totally new practice area for you, creating the ability to change the rules and set the standard in your community. Computer-literate attorneys who are in a position to reposition their practice or work part-time may wish to experiment with different approaches. Unemployed or under-employed attorneys have a special incentive to be creative and try expert system development. It's a question of risk versus reward, plain and simple.

What practice areas are best suited for expert system use?

While it may be surprising and perhaps unbelievable to many skeptics, most practices could benefit from the use of expert systems to some extent, even litigation. However, transaction-based practices, where fixed fee billing is the standard or may become popular, are best suited for full knowledge-leveraging.

Obvious areas to consider include banking, bankruptcy, estate planning, family law, immigration and naturalization, landlord-tenant, mergers and acquisitions, probate, patents, real estate and trademark. Additionally, compliance-related practices may also be appropriate for automation, including environmental, labor and employment, securities and tax.

Who owns the intellectual property when co-developing an expert system with programmers, employees or clients,?

Whoever has the most leverage. Usually, the one who pays owns the IP but occasionally it makes sense to share the risk with others. Hired guns such as programmers or consultants typically do not retain any IP rights unless the

contract specifically requires such ownership. Ditto for employees. In fact, both groups should sign a non-disclosure that explicitly clarifies ownership.

Clients/attorney joint ownership and royalties can be very tricky and could be messy unless all contingencies are addressed. If another party helps finance the development, either through discounted rates, expertise or cash contribution, a buy-sell agreement based on financial or time milestones may make sense.

Who is leading the development of legal expert systems?

Corporate counsel, government attorneys and academics have all developed legal expert systems. However, one must be careful to distinguish between prototype and production systems. Up to this point, corporate counsel have taken the lead and developed most of the production expert systems.

Legal and computer science experts in academia have developed many highly sophisticated AI tools and expert systems as prototypes. Government attorneys have developed few expert systems except for the IRS, of course, who has developed around fifty advanced expert systems for identifying and analyzing tax issues.

Where can I take courses in AI and law?

Many of the leading AI centers like MIT, Stanford and Carnegie-Mellon offer some classes but you may wish to contact those within the AI and law academic community.

- Prof. Laymen Allen, University of Michigan
- Prof. Kevin Ashley , University of Pittsburgh
- Prof. Donald Berman, Northeastern University
- Prof. Karl Branting , University of Wyoming
- Anne Gardner
- Prof. Carol Hafner, Northeastern University
- Marc Lauritsen, Harvard Law School
- Prof. Thorne McCarty, Rutgers University
- Prof. Edwinna Rissland, University of Massachusetts

What publications are available on expert systems and AI for legal analysis?

- Prof. Karl Branting, University of Wyoming
- Profs. Ashley, Rissland et. al , Case-Based Reasoning Group
- Past International Conference for Artificial Intelligence and Law - Proceedings (1987-1995). Richard Susskind, "Expert Systems in

Law"

What publications are available on expert systems and AI generally?

- The appendix to Ray Kurzweil's book "Intelligent Machines" (MIT Press, 1990, ISBN 0-262-11121-7, $39.95) gives a timeline of the history of AI.
- Pamela McCorduck, "Machines Who Think", Freeman, San Francisco, CA, 1979. Allen Newell, "Intellectual Issues in the History of Artificial Intelligence", Technical Report CMU-CS-82-142, Carnegie Mellon University Computer Science Department, October 28, 1982.
- Charniak and McDermott's book "Introduction to Artificial Intelligence", Addison-Wesley, 1985 contains a number of historical pointers.
- Daniel Crevier, "AI: The Tumultuous History of the Search for Artificial Intelligence", Basic Books, New York, 1993.
- Henry C. Mishkoff, "Understanding Artificial Intelligence", 1st edition, Howard W. Sams & Co., Indianapolis, IN, 1985, 258 pages, ISBN 0-67227-021-8 $14.95. Margaret A. Boden, "Artificial Intelligence and Natural Man", 2nd edition, Basic Books, New York, 1987, 576 pages.

ABA Home Page

American Bar Association 750 N. Lake Shore Dr., Chicago, IL 60611 312/988-5000 info@abanet.org
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*1999

PUERTA = DE ENTRADA.

Gateway To The World: United States

Fuzzy Logic Pacific Northwest National Laboratory

Description:

This page contains links to universities, research groups, and companies involved in Fuzzy Logic and related activities in United States. For more general information about this country, please try other sources such as City Net, Yahoo, or the CIA Factbook!

URL:

The URL of this page is
http://www.emsl.pnl.gov:2080/proj/neuron/web/fuzzy/gateway/USA.html

Additions:

We always welcome additions! To add a link or make a correction, please use the Add Web Site form or send e-mail to the address given at the bottom of this page.

Links:

represents a working link, represents a broken link, and represents a verified dead link, as determined during the last link check on 1 June 1997. "NEW" represents a link added in the last 90 days (i.e., since 1 December 1998) Please help us keep this service useful by letting us know when you change your URLs.

United States

en: U.S.A.

ALife **(United States)**

- What is Artificial Life?

American **Heuristics Corporation - AHC (United States)**

- Home Page
  - *Software technology consulting and training company.*

Aptronix **(United States)**

- Fuzzy Inference Development Environment
- What is Fuzzy Logic?
- How does Fuzzy Logic work?
- Why use Fuzzy Logic?
- How to use Fuzzy Logic?

Association for Computing Machinery - ACM (United States)

- Home Page
  - *The largest and oldest international scientific and educational computer society in the industry today.*

Auburn University (United States)

- The Fuzzy Truck Simulator
  - *The goal is to design a fuzzy system truck back up so that it arrives at a loading dock at a right angle (relative to the horizontal axis (truck angle = 90 degrees)) and the (x,y) coordinates at the same position as the loading dock. This applet shows that through direct manipulation of the fuzzy set rules, the system is dynamic enough to compensate to a certain degree.*

Battelle Memorial Institute (United States)

- Cognitive Systems Technology
  - *Battelle is a contract Research and Development firm. This site describes Battelle's capabilities to assist its clients in the implementation of cognitive system in their products and services.*
- Fuzzy Logic Overview

University of _California_ at Berkeley (United States)

- Initiative in Soft Computing
- Dr. Lotfi Zadeh
  - *Father of fuzzy logic and fuzzy set theory.*

University of _California_ at Davis (United States)

- Fuzzy Logic with Visual C++
- Fuzzy Logic Tutorial

University of _California_ at Irvine (United States)

- FTP Repository of Machine Learning Databases
- Machine Learning Databases

Carnegie Mellon University - CMU (United States)

- Machine Learning Group
- What is Fuzzy Logic?
- Statlib Dataset Archive

***Charles* River Analytics - CRA (United States)**

- Home Page
  - *A pioneer in developing custom solutions for intelligent interactive systems.*

***Clark* Atlanta University (United States)**

- Artificial Intelligence Research

***Cognizer* (United States)**

- Cognizer Almanac
- Fuzzy Milestones

***Complexity* & Artificial Life Research Concept for Self-Organizing Systems (United States)**

- Home Page
- Neural Networks
- Fuzzy Logic
- Evolutionary Computation
- Artificial Intelligence

***Computists* International (United States)**

- Home Page
  - *Computists International is a professional association for artificial intelligence, information science, and computer science researchers. Several concise email newsletters are available to members each week, covering AI research funding, software industry trends, leading-edge technologies, job opportunities, research software announcements, and other useful news. Our technical topics frequently include neural networks, intelligent agents, fuzzy logic, robotics, artificial life, machine learning, genetic algorithms, intelligent scheduling, logic programming, expert systems, knowledge-based systems, case-based inference, intelligent databases, data or scientific visualization, data mining, natural language, machine translation, computational linguistics, and information retrieval.*

***Electrical* Engineering (EE) Times (United States)**

- Smart Systems SIG

***Encyclopaedia* Britannica (United States)**

- On-line definition of fuzzy logic

Enterprise Integratation Network - EINet (United States)

- Fuzzy Logic

Excalibur Technologies (United States)

- Home Page

Jaime _Fernandez_ (United States)

- Fuzzy Logic

_Flexible_Intelligence Group, LLC., (United States)

- Home Page
  - *Explore the FlexTools range of product suites and services. Build Computationally Intelligent Systems using Soft Computing techniques and apply them to your diverse application domains.*

Florida AI Research Society - FLAIRS (United States)

- Home Page
  - *FLAIRS was founded in 1987 to promote and advance Artificial Intelligence within the State of Florida, including interaction between researchers at the various colleges, universities, and industry. Membership is open to all (Florida residents and non-residents) that attend their yearly conference.*

Fuzzy Systems Engineering (United States)

- Home Page

_G6G_ Consulting (United States)

- Directory of Intelligent Software

Generation 5 (United States)

- Artificial Intelligence Repository

Gensym (United States)

- Home Page

Gordian Institute (United States)

- Home Page
  - *Advanced technology training and demonstration.*

Harvard University (United States)

- The Logic of Fuzziness

Rick *Hillegas* (United States)

- Fuzzy Java Toolkit
  - *Shareware toolkit for developing fuzzy logic applications in the Java programming language. Adds a fuzzy switch statement to Java.*
- Demo of Fuzzy Furnace Controller
  - *Demo of a furnace controller built with Java shareware toolkit.*

***HyperLogic* (United States)**

- Home Page
  - *Here you will find information on Fuzzy Logic, Neural Networks, and HyperLogic's exciting line of tools for using these powerful modern technologies.*

***IC* Tech Inc. (United States)**

- Home Page

***Institute* of Electrical and Electronic Engineers - IEEE (United States)**

- IEEE Transactions on Fuzzy Systems
- IEEE Fuzzy Systems
- Home Page
  - *The IEEE is the world's largest technical professional society. Founded in 1884 by a handful of practitioners of the new electrical engineering discipline, today's Institute is comprised of more than 320,000 members who conduct and participate in its activities in 147 countries. The men and women of the IEEE are the technical and scientific professionals making the revolutionary engineering advances which are reshaping our world today.*
- IEEE Robotics and Automation Society

***Instrument* Society of America - ISA (United States)**

- Home Page
  - *ISA is the international society for measurement and control. A non-profit engineering society with nearly 50,000 members around the world, ISA offers a wide range of programs and activities of interest to anyone involved in measurement and control in the process and discrete manufacturing industries.*

***Intel* (United States)**

- Fuzzy Logic Documents
- Fuzzy Anti-Lock Brake System Solution

- Fuzzy Logic Overview

Intelligent Inference Systems Corporation (United States)

- Home Page

International Society for Computers and Their Applications - ISCA (United States)

- Home Page
  - *The ISCA promotes the advancement of science and engineering in the area of computers and their applications, and disseminates this technology throughout the world.*

International Society for Productivity Enhancements - ISPE (United States)

- Home Page

Iowa State University (United States)

- Artificial Intelligence Research Group
- Cognitive Systems: Integrated and Hybrid Architectures and Algorithms

Lawrence Livermore National Laboratory - LLNL (United States)

- Multisensor Data Fusion Systems

Loyola College in Maryland (United States)

- Knowledge-Based Systems in Japan
- Fuzzy Logic Research and Life

Los Alamos National Laboratory - LANL (United States)

- Fuzzy Control for an Oil Field Centrifuge

Marketing-fuzzy-logic (United States)

- Home Page

University of _Maryland_ (United States)

- DOCBIB - Online Bibliographies
  - *This service permits you to search the DOCBIB database which includes publications in feature extraction, OCR, on-line recognition, text/graphics discrimination, signature verification and related document references. It is maintained by the Laboratory for Language and Media Processing (LAMP).*

Massachusetts Institute of Technology - MIT (United States)

- comp.ai.fuzzy F.A.Q.

***MathWorks* (United States)**

- Fuzzy Logic Toolbox for Matlab

***Metus* Systems Group (United States)**

- Home Page

***Michigan* State University - MSU (United States)**

- What is Soft Computing?

University of *Missouri* Columbia (United States)

- Fuzzy Logic

University of *Missouri* Rolla (United States)

- Smart Engineering Systems Lab - SESL
- What is an Expert System?

***Motorola* (United States)**

- The Seven Noble Truths Of Fuzzy Logic
- Fuzzy Applications Archive
  - *Free software and information about fuzzy logic.*
- Fuzzy Controller for Air Conditioning

***National* Aeronautics and Space Administration - NASA (United States)**

- Computational Intelligence Group at NASA Ames
  - *The computational intelligence group is involved in long term basic research involving utilization and development of Soft Computing technologies (Neural Network, Fuzzy Set, and Genetic Algorithm) supporting NASA Programs.*

***National* Institute of Standards - NIST (United States)**

- Fuzzy FTP Archive

***Naval* Research Laboratory - NRL (United States)**

- Navy Center for Applied Research in Artificial Intelligence - NCARAI

University of *New* Mexico (United States)

- Fuzzy Logic

State University of *New* York at Binghamton (United States)

- Center for Intelligent Systems

***North* American Fuzzy Information Processing Society - NAFIPS (United States)**

- Home Page
  - *As the premier fuzzy society in North America established in 1981, our purpose is to help guide and encourage the development of fuzzy sets and related technologies for the benefit of mankind. In this role, we understand the importance of, and the need for, developing a strong intellectual basis and encouraging new and innovative applications. In addition, we acknowledge our leadership role to foster interaction and technology transfer to other national and international organizations to bring the benefits of this technology to North America and the world.*

***North* Carolina State University - NCSU (United States)**

- FANGroup - Fuzzy and Neural Group

***Northeastern* University (United States)**

- Fuzzy Logic

***Northwest* Artificial Intelligence Forum (NaiF) (United States)**

- Home Page
  - *NaiF embraces the widest possible definition for AI, including Knowledge Gathering, Expert Systems, Speech & Pattern Recognition, Neural Networks, Robotics, Natural Language Processing, Virtual Reality and simulation technologies.*

***Ohio* State University - OSU (United States)**

- Control Research Laboratory - CRL
- EE 858: Intelligent Control
  - *The course involves (i) gaining an understanding of the functional operation of a variety of intelligent controllers, (ii) the study of control-theoretic foundations of intelligent control systems, and (iii) use of the computer for simulation and evaluation of intelligent control systems. The objective is to gain a 'hands-on' working knowledge of several of the main techniques of intelligent control and an introduction to some promising research directions.*

***Optical* Society of America - OSA (United States)**

- Home Page

- *The OSA was organized to increase and diffuse the knowledge of optics, pure and applied, to promote the common interests of investigators of optical problems, of designers, and of users of optical apparatus of all kinds; and to encourage cooperation among them. The purposes of the corporation are scientific, technical, and educational.*

Ortech Engineering Inc. (United States)

- FuzzyFuzzy Logic Reservoir Logic
- Fuzzy Logic - A Tutorial

Oxford University Press (United States)

- The Computational Intelligence Library
- Handbook of Fuzzy Computation

Pacific Northwest National Laboratory - PNNL (United States)

- Cognitive Systems at PNNL
  - *Summary of our activity in cognitive systems along with links to other web sites around the world.*
- Computational Intelligence at PNNL
  - *Summary of our activity in computational intelligence along with links to other web sites around the world.*
- Fuzzy Logic at PNNL
  - *Summary of our activity in fuzzy logic along with links to other web sites around the world.*

Parallel Performance Group, Inc. (United States)

- Neural Networks Page

Partek Incorporated (United States)

- Home Page
  - *Partek provides quality software for data analysis and modeling, including data mining and pattern recognition tools based on methods of statistical analysis and modeling, neural networks, fuzzy logic, genetic algorithms, and data visualization.*

_PC_ AI Magazine (United States)

- Fuzzy Logic Page
- Glossary of Fuzzy Logic Terms

_PC_ Webopaedia (United States)

entry has been annotated by more than one student, it will be followed by a list of initials of the students who have summarized it, so you can see the different versions.

_US_ Army AI Center (United States)

- Home Page
- Fuzzy Logic

University of _Washington_ (United States)

- Intelligent Systems Laboratory
  - *The lab was started to handle research activities in computer vision and artificial intelligence.*
- Computational Intelligence Applications Laboratory
- BioRobotics
  - *Our mission is to develop science, technology, and human resources at the interface between robotics and biological movement systems.*

University of _West_ Florida (United States)

- Institute for the Interdisciplinary Study of Human & Machine Cognition (IHMC)
  - *The IHMC acknowledges the changing structure and practice of scientific enquiry by providing an umbrella under which researchers from a broad variety of academic disciplines may gainfully collaborate. At IHMC, interdisciplinary research is underway addressing important issues in artificial intelligence, cognitive science, knowledge representation, pattern recognition, fuzzy logic, computers in education, and other related areas.*
- Dr. Jim Bezdek

West Virginia University - WVU (United States)

- Consortium for Virtual Operations Research
  - *Consortium for Virtual Operations Research is a member oriented, applied research and development group that focuses on solving petroleum and natural gas engineering problems using computational intelligence.*
- CpE 321: Applied Fuzzy Logic
- Fuzzy Logic
- Frequently Asked Questions

***whatis?.com* (United States)**

- What is Fuzzy Logic?

University of *Wisconsin* Madison (United States)

- Hyper-Weirdness on the Web: Artificial Intelligence, Cognitive Science and Robotics

Yahoo (United States)

- Index of Fuzzy Logic

***Yokogawa* Corporation of America (United States)**

- Home Page

***Zaptron* Systems Inc. (United States)**

- Home Page
  - *A spin-off of Aptronix which specializes in fuzzy logic design tools. Zaptron Systems is a solution provider of intelligent systems with core technologies in neural networks, fuzzy logic, data fusion, data mining, intelligent controls, industrial engineering, and operations research. Zaptron Systems, Inc. develops and delivers advanced solutions in business automation, factory automation, and intelligent controls.*
-
-
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-

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Pacific Northwest National Laboratory (PNNL) is a multiprogram national laboratory operated by Battelle Memorial Institute for the US Department of Energy (DOE) under Contract DE-AC06-76RLO 1830.

This web site is hosted by the William R. Wiley Environmental Molecular Sciences Laboratory.

Page History: *Last revised on Monday 1 March 1999*

Pagemaster: *Paul E. Keller / Paul.Keller@pnl.gov / Tel: +1 (509) 375-2254* [VCard]

URL: *http://www.emsl.pnl.gov:2080/proj/neuron/web/fuzzy/gateway/USA.html*

Repetido

Companies Supplying Fuzzy Tools Date: 15-APR-93

*** Note: Inclusion in this list is not an endorsement for the product. ***

Accel Infotech Spore Pte Ltd:

Accel Infotech is a distributor for FUZZ-C from Byte Craft.

FUZZ-C generates C code that may be cross-compiled to the 6805, Z8C and COP8C microprocessors using separate compilers.
FUZZ-C was reviewed in the March 1993 issue of AI Expert.

For more information, send email to accel@solomon.technet.sg, call +65-7446863 (Richard) or fax +65-7492467.

Adaptive Informations Systems:

continua pag siguiente

Note: The AL220 was named Innovation Of the Year '94 by EDN Magazine in the microprocessor category. Data sheets and application notes are available on the products plus local application assistance.

Adaptive Logic Inc.
800 Charcot Ave., Suite 112
San Jose, CA 95131
Phone: 408-383-7200
Fax: 408-383-7201
Email: 75471.2025@compuserve.com

Europe:
Applied Marketing & Technology Ltd.
Saville Court, Saville Place, Clifton
Bristol BS8 4EJ
Phone: 117-9237594
Fax: 117-9237598
Email: 100435.1630@compuserve.com

Japan:
Nippon Precision Device
Nichibei Time 24 Bldg.
35 Tansu-cho
Shinjuki-ku, Tokyo 162
Phone: 332601411
Fax: 332607100

Adaptive Logic Inc.-R&D facility
411 Central Park Drive
Sanford, Fl 32771
Phone: 407-322-5608
Fax: 407-322-5609
Email: 75471.2032@compuserve.com or info@adaptivelogic.com
URL: http://www.adaptivelogic.com/

Aptronix:

Products:
Fide — A MS Windows-hosted graphical development environment for fuzzy expert systems. Code generators for Motorola's 6805, 68HC05, and 68HC11, and Omron's FP-3000 are available. A demonstration version of Fide is available.

Aptronix, Inc.
2150 North First Street, Suite 300
San Jose, Ca. 95131 USA
Phone: 408-261-1888
Fax: 408-261-1897
Fuzzy Net BBS: 408-261-1883, 8/n/1

Aria Ltd.:

Products:
DB-fuzzy — A library of fuzzy information retrieval for CA-Clipper. See ftp.cs.cmu.edu:/user/ai/areas/fuzzy/com/aria/ for more information.

Aria Ltd.
Dubravska 3
842 21 Bratislava

This is a new company that specializes in fuzzy information systems.

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Main products of AIS:

- Consultancy and application development in fuzzy information retrieval and flexible querying systems

- Development of a fuzzy querying application for value added network services

- A fuzzy solution for utilization of a large (lexicon based) terminological knowledge base for NL query evaluation

Adaptive Informations Systems
Hoestvej 8 B
DK-2800 Lyngby
Denmark
Phone: 45-4587-3217
Email: hll@dat.ruc.dk

Adaptive Logic (formerly American NeuraLogix):

Products:

AL220	8 bit fuzzy microcontroller(18 pin DIP or 20 pin SOIC) with A/D & D/A(4I/O).
NLX221	4-8 bit digital I/O single chip fuzzy microcontroller with EEPROM memory.
NLX222	4-8 bit analog and digital I/O single chip fuzzy microcontroller.
NLX230	8 bit microcontroller utilizing fuzzy logic at 30 million rules per second.
NLX110	Fuzzy Pattern Comparator.
NLX112/113	Fuzzy Data Correlators.
INSiGHT IIe	Real time emulator, programmer and development software for AL220.
INSiGHT	Development software for NLX22X family.
INStANT	Programmer for NLX22X family.
ADS230	Development System for NLX230.
ADS110	Development System for NLX110

SLOVAKIA
Phone: (+42 7) 3709 286
Fax: (+42 7) 3709 232
Email: aria@softec.sk

ClippArt Ltd. is the exclusive distributor of DB-fuzzy.
Any additional information about DB-fuzzy you can obtain
from this company.

ClippArt Ltd. Polianky 15 Tel. (+42 7) 786 160
841 02 Bratislava Fax (+42 7) 786 160
Slovakia

ByteCraft, Ltd.:

Products:
Fuzz-C "A C preprocessor for fuzzy logic" according to the cover of its manual. Translates an extended C language to C source code.

Byte Craft Limited
421 King Street North
Waterloo, Ontario
Canada N2J 4E4
Phone: 519-888-6911
Fax: 519-746-6751
Support BBS: 519-888-7626

Fril Systems Ltd:

FRIL (Fuzzy Relational Inference Language) is a logic-programming language that incorporates a consistent method for handling uncertainty, based on Baldwin's theories of support logic, mass assignments, and evidential reasoning. Mass assignments give a consistent way of manipulating fuzzy and probabilistic uncertainties, enabling different forms of uncertainty to be integrated within a single framework. Fril has a list-based syntax, similar to the early micro-Prolog from LPA. Prolog is a special case of Fril, in which programs involve no uncertainty. Fril runs on Unix, Macintosh, MS-DOS, and Windows 3.1 platforms.

For further information, write to

Dr B.W. Pilsworth
Fril Systems Ltd
Bristol Business Centre,
Maggs House,
78 Queens Rd,
Bristol BS8 1QX, UK.

A longer description is available as
ftp.cs.cmu.edu:/user/ai/areas/fuzzy/com/fril/fril.txt

Fujitsu:

Products:
MB94100 Single-chip 4-bit (?) fuzzy controller.

FuziWare:

1200 training patterns
- Up to 7 membership functions
- COP8 Code Generator
- COP8 In-Circuit Emulator "Debug Module"
  - Real-Time Emulation Microcontroller EPROM Programming
  - Real-Time Trace
  - Complete Source/Symbolic Debug
- One-Day Training on Customer Request
- Access to Factory Expert via Telephone (Maximum 16 hrs.)

NeuFuz4-C Learning Kit, Product ordering code (NSID): NF2-C-KIT
- Up to 2 inputs, 1 output 50 training patterns
- Up to 3 membership functions
- ANSI Standard C Language Code Generator
- Tutorial Examples for Neural Network Learning and Fuzzy Rule Generation

NeuFuz4-C Software Package, Product ordering code (NSID): NF4-C
- Up to 4 inputs, 1 output and 1200 training patterns
- Up to 7 membership functions
- ANSI Standard C Language Code Generator
- One-Day Training on Customer Request
- Access to Factory Expert via Telephone (Maximum 16 hrs.)

Oki Electric:

Products:
MSM91U111 A single-chip 8-bit fuzzy controller.

Europe:

Oki Electric Europe GmbH.
Hellersbergstrasse 2
D-4040 Neuss, Germany
Phone: 49-2131-15960
Fax: 49-2131-103539

Hong Kong:

Oki Electronics (Hong Kong) Ltd.
Suite 1810-4, Tower 1
China Hong Kong City
33 Canton Road, Tsim Sha Tsui
Kowloon, Hong Kong
Phone: 3-7362336
Fax: 3-7362395

Japan:

Oki Electric Industry Co., Ltd.
Head Office Annex
7-5-25 Nishishinjuku
Shinjuku-ku Tokyo 160 JAPAN
Phone: 81-3-5386-8100
Fax: 81-3-5386-8110

USA:

Oki Semiconductor
785 North Mary Avenue
Sunnyvale, Ca. 94086 USA
Phone: 408-720-1900
Fax: 408-720-1918

```
                K&R or ANSI C source to implement the specified fuzzy system.
      MicroFPL  An FPL compiler and runtime module that support using fuzzy
                techniques on small microcontrollers by several companies.
      TILGen    A tool for automatically constructing fuzzy expert systems from
                sampled data.
      TILShell+ A graphical development and simulation environment for fuzzy
                systems.

   USA

      Togai InfraLogic, Inc.
      5 Vanderbilt
      Irvine, CA 92718 USA
      Phone: 714-975-8522
      Fax: 714-975-8524
      Email: info@til.com


Toshiba:

   Products:
      T/FC150   10-bit fuzzy inference processor.
      LFZY1     FC150-based NEC PC fuzzy logic board.
      T/FT      Fuzzy system development tool.


TransferTech GmbH:

   Products:
      Fuzzy Control Manager (FMC)       Fuzzy shell, runs under MS-Windows

   TransferTech GmbH
   Cyriaksring 9A
   D-38118 Braunschweig
   Germany
   Tel: +49 531 890255
   Fax: +49 531 890355
   Email: info@transfertech.de
   URL: http://www.transfertech.de

================================================================
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Go to the index previous next

Products:

FuziCalc	An MS-Windows-based fuzzy development system based on a spreadsheet view of fuzzy systems.

FuziWare, Inc.
316 Nancy Kynn Lane, Suite 10
Knoxville, Tn. 37919 USA
Phone: 800-472-6183, 615-588-4144
Fax: 615-588-9487

FuzzySoft AG:

Product:

FuzzySoft	Fuzzy Logic Operating System runs under MS-Windows, generates C-code, extended simulation capabalities.

Selling office for Germany, Switzerland and Austria (all product inquiries should be directed here)

GTS Trautzl GmbbH
Gottlieb-Daimler-Str. 9
W-2358 Kaltenkirchen/Hamburg
Germany
Phone: (49) 4191 8711
Fax: (49) 4191 88665

Fuzzy Systems Engineering:

Products:

Manifold Editor	?
Manifold Graphics Editor	?

[These seem to be membership function & rulebase editors.]

Fuzzy Systems Engineering
P. O. Box 27390
San Diego, CA 92198 USA
Phone: 619-748-7384
Fax: 619-748-7384 (?)

HyperLogic Corporation:

Products:

CubiCalc	Windows-based Fuzzy Logic Shell. Includes fuzzy and plant simulation, plots, file I/O, DDE.
CubiCalc RTC	Windows-based Fuzzy Logic Development Environment. Superset of CubiCalc includes run-time generator, code libraries, DLL for Windows Applications (incl Visual Basic).
CubiCard	Superset of CubiCalc RTC with data acquisition capabilties via hardware interface board.
CubiQuick	Inexpensive version of CubiCalc with limited capabilties for classroom and small projects. Academic discounts available.
Rule Maker	Add-on to CubiCalc and higher products for automatic rulebase generation. Provides four

London, SW18 3SX, UK.

Web: http://www.lpa.co.uk
US Toll Free: 1-800-949-7567
Tel: +44 181 871 2016
Fax: +44 181 874 0449
Email: lpa@cix.compulink.co.uk

Metus Systems Group:

Products:

Metus Fuzzy Library	A library of fuzzy processing routines for C or C++. Source code is available.

The Metus Systems Group

1 Griggs Lane
Chappaqua, Ny. 10514 USA
Phone: 914-238-0647

1999

Modico:

Products:
Fuzzle 1.8 A fuzzy development shell that generates either ANSI FORTRAN or C source code.

Modico, Inc.
P. O. Box 8485
Knoxville, Tn. 37996 USA
Phone: 615-531-7008

National Semiconductor, Santa Clara CA, USA
http://www.commerce.net/directories/participants/ns/home.html

NeuFuz is aimed at low end controls applications in automotive, industrial, and appliance areas. NeuFuz is a neural-fuzzy technology which uses backpropagation techniques to initially select fuzzy rules and membership functions. Initial stages of design using NeuFuz technology are performed using training data and backpropagation. The result is a fuzzy associative memory (FAM) which implements an approximation of the training data. By implementing a FAM, rather than a multi-layer perceptron, the designer has a solution which can be understood and tuned to a particular application using Fuzzy Logic design techniques.

NeuFuz4 Learning Kit, Product ordering code (NSID): NF2-C8A-KIT
- NeuFuz2 Neural Network Learning Software
- Up to 2 inputs, 1 output
- 50 training patterns
- Up to 3 membership functions
- COP8 Code Generator (COP8 is National's family of 8-bit microcontrollers)

NeuFuz4 Software Package, Product ordering code (NSID): NF4-C8A
- NeuFuz4 Software
- Neural Network Learning Software - Up to 4 inputs, 1 output and 1200 training patterns
- Up to 7 membership functions
- COP8 Code Generator

The NeuFuz4 Development System, Product ordering code: (NSID): NF4-C8A-SYS.
- Neural Network Learning Software - Up to 4 inputs, 1 output and

OMRON Corporation:

Products:

C500-FZ001	Fuzzy logic processor module for Omron C-series PLCs.
E5AF	Fuzzy process temperature controller.
FB-30AT	FP-3000 based PC AT fuzzy inference board.
FP-1000	Digital fuzzy controller.
FP-3000	Single-chip 12-bit digital fuzzy controller.
FP-5000	Analog fuzzy controller.
FS-10AT	PC-based software development environment for the FP-3000.

Japan

Kazuaki Urasaki
Fuzzy Technology Business Promotion Center
OMRON Corporation
20 Igadera, Shimokaiinji
Nagaokakyo Shi, Kyoto 617 Japan
Phone: 81-075-951-5117
Fax: 81-075-952-0411

USA Sales (all product inquiries should be directed here)

Pat Murphy
OMRON Electronics, Inc.
One East Commerce Drive
Schaumburg, IL 60173 USA
Phone: 708-843-7900
Fax: 708-843-7787/8568

USA Research

Satoru Isaka
OMRON Advanced Systems, Inc.
3945 Freedom Circle, Suite 410
Santa Clara, CA 95054
Phone: 408-727-6644
Fax: 408-727-5540
Email: isaka@oas.omron.com

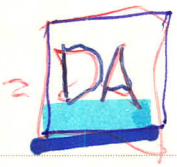
Togai InfraLogic, Inc.:

Togai InfraLogic (TIL for short) supplies software development tools, board-, chip- and core-level fuzzy hardware, and engineering services. Contact info@til.com for more detailed information.

Products:

FC110	(the FC110(tm) Digital Fuzzy Processor (DFP-tm)). An 8-bit microprocessor/coprocessor with fuzzy acceleration.
FC110DS	(the FC110 Development System) A software development package for the FC110 DFP, including an assembler, linker and Fuzzy Programming Language (FPL-tm) compiler.
FCA	VLSI Cores based on Fuzzy Computational Acceleration (FCA-tm).
FCA10AT	FC110-based fuzzy accelerator board for PC/AT-compatibles.
FCA10VME	FC110-based four-processor VME fuzzy accelerator.
FCD10SA	FC110-based fuzzy processing module.
FCD10SBFC	FC110-based single board fuzzy controller module.
FCD10SBus	FC110-based two-processor SBus fuzzy accelerator.
FCDS	(the Fuzzy-C Development System) An FPL compiler that emits

Soft Decision Analysis



BISC -SIG on Decision Analysis

The *Special Interest Group on Decision Analysis* will focus on several different aspects of decision analysis:

- **single criterion decision making under certainty, randomness and uncertainty;**
- **linear programming modelling (including variants for transportation, scheduling, networks, goal programming, etc.) and optimal decisions;**
- **multiple objective linear programming (including variants for utility function trade off, reference points, interactive bargaining among nondominated points, interdependence, etc.), multiple criteria decision making (mcdm) multiple criteria decision aid (mcda) and optimal decisions;**
- **decision support systems (DSS) and intelligent systems for decision support as means for building optimal decision processes;**

In all these approaches attempts have been made at fuzzyfying the standard modelling techniques, which is easy to do in a technical sense, but which does not make much sense otherwise, as the modelling substance is missing and it is not clear - from the perspective of a decision maker - why we need the fuzzy set theory.

The SIG on DA will work on a new theory base for decision analysis to anchor it in a real life decision making context and work out a conceptual modelling framework for better decision making with the help of soft computing technology.

The theory base is partly to be found in the literature. The base will probably evolve in several stages:

1. **state of the art surveys,**
2. **identifying sound key contributions to serve as cornerstones,**
3. **picking out obvious shortcomings missing parts of the theory base,**
4. **proposing and validating new elements and theory segments, and**
5. **writing a proposed new theory base.**

The elements and problems we will have to tackle include:

- **some consistent conceptual framework(s) for tackling real life decision problems using fuzzy modelling and approximate reasoning;**
- **modify, unify and expand fuzzy DA theory;**
- **develop a conceptual basis for fuzzy lp, molp, mcdm and mcda;**

- **work out a conceptual framework for using fuzzy logic in decision support technology;**

When the theoretical issues have been solved or resolved, the next step will be to work out specifications for soft computing software which should be designed to be instrumental for implementing the new DA approach in real world decision making.

In order to get the methods and the software launched sets of good test cases for each one of the areas listed above should be worked out and offered as a way to both demonstrate the new methods and to offer easy ways of questioning their substance and testing the new algorithms. Cases could also be used to encourage people to find alternative methods and modelling techniques, which would both initiate debate and create a bandwagon effect. Finally, cases would help spread the new DA approach by offering good teaching material for undergraduate programs.

Cases are not enough. Fairly early on the challenge of making sense to corporate decision makers should be undertaken. This could be done by tackling either classical $-saving problems in a new, more effective ways or by working on problems for which classical optimisation techniques do not make sense, but for which soft computing techniques would produce more effective and more productive results than plain experience and intuition. The problem is, of course, that the problems need to be worthwhile in $ terms and that these problems are not readily accessible for research people wanting to test and prove a new theory and an improved technology.

The problems we want to tackle and the goals we want to attain thus include:

1. **to find a soft computing paradigm for DA;**
2. **to create a consistent theory for soft decision analysis;**
3. **to develop a methodology for optimal decision making with the help of soft computing;**
4. **to create a recommended implementation program for soft DA and to develop a taxonomy for successful implementation to be used for follow up studies of implementation programs;**

The SIG on DA will be formed as a network of task forces with a minimum of 3-5 members per task force. A task form will be formed for each of the following areas:

- **traditional single criterion decision making;**
- **linear programming modelling and optimal decisions;**
- **multiple objective linear, multiple criteria decision making (mcdm) multiple criteria decision aid (mcda) and optimal decisions;**
- **decision support systems (DSS) and intelligent systems for decision support;**

Each task force will,

1. **do an initial state-of-the-art report of its assigned area;**
2. **collect 3-5 obvious shortcomings or areas of potential improvement with standard DA**

approaches;

3. **work out a proposal for how these improvement could/should be carried out;**
4. **work out solutions in detail with theory, models, solutions cases and follow up taxonomy;**

The task forces will report their results on a Web-site, at BISC workshops, through invited sessions at international meetings or through IFORS SPC:s.

The SIG on DA will collect reports in edited books on Kluwer (or corresponding) and will work out implementation programs for the results in co-operation with ERUDIT and kindred groups.

When preliminary results are at hand funding for large scale research programs will be applied for through the ESPRIT V or corresponding programs.

Interdependent MCDM One of the main goal of BISC-SIG on DA is to develop a conceptual framework for tackling real life decision problems with interdependences.

In their classical text *Theory of Games and Economic Behavior* John von Neumann and Oskar Morgenstern (1947) described the problem with *interdependence*; in their outline of a social exchange economy they discussed the case of two or more persons exchanging goods with each others (page 11):

"then the results for each one will depend in general not merely upon his own actions but on those of others as well. Thus each participant attempts to maximize a function ... of which he does not control all variables.

This is certainly no maximum problem, but a peculiar and disconcerting mixture of several conflicting maximum problems. Every participant is guided by another principle and neither determines all variables which affects his interest.

This kind of problem is nowhere dealt with in classical mathematics. We emphasize at the risk of being pedantic that this is no conditional maximum problem, no problem of the calculus of variations, of functional analysis, etc.

It arises in full clarity, even in the most "elementary" situations, e.g., when all variables can assume only a finite number of values."

The interdependence is part of the economic theory and all market economies, but in most modelling approaches in multiple criteria decision making there seems to be an implicit assumption that objectives should be independent. This appears to be the case, if not earlier than at least at the moment when we have to select some optimal compromise among the set of nondominated decision alternatives. Milan Zeleny [*Multiple Criteria Decision Making}, McGraw-Hill, New-York, 1982*] recognizes one part of the interdependence (page 1),

"multiple and conflicting objectives, for example, "minimize cost" and "maximize the quality of service" are the real stuff of the decision maker's or manager's daily concerns.

Such problems are more complicated than the convenient assumptions of economics indicate.

Improving achievement with respect to one objective can be accomplished only at the expense of another."

but not the other part: objectives could support each others. We explore the consequences of allowing objectives to be interdependent.

Situations with multiple interdependent objectives are not only derived from some axiomatic framework as logical conclusions, or built as illustrations of complex decision problems in classical text books, there are real life situations which, if we ponder them systematically, reveal themselves to have interdependent objectives.

The Buyer/Seller dilemma

A well-known negotiation problem is the *Buyer/Seller* dilemma, in which it is unclear for both parties at which price they are going to settle when they start the negotiation process:

Their objectives are clearly conflicting:

the Buyer wants the price to be as low as possible;
the Seller tries to keep the price as high as possible.

There are two points, the reservation prices, beyond which the negotiations break down.

The Buyer will not discuss a price higher than the (Buyer)-point; the Seller will find a price lower than the (Seller)-point insulting.

If both parties compromise they can eventually settle on a price somewhere at the mid-point of the interval.

The problem becomes interesting and challenging when none of the parties can be sure of the other party's reservation price, but the setup is simple in the sense that the objectives are conflicting, and the problem can be solved with standard methods.

Let us now assume that there is a third party, the *Government*, involved and that the Government reacts to the negotiation process by working out consequences of both the reservation prices and the offers made during the negotiations. Let us also assume that the Government wants to intervent in the process in order to promote its own objectives.

In this way the negotiation problem becomes much more complex as there are a number of new objectives involved over which the primary parties have no control.

The Buyer and the Seller influence two different objectives of the Government respectively (Obj 1 and Obj 2):

- **a low Seller reservation price will support Obj 1, but a high Seller reservation price will be in conflict with Obj 1 after some point G1 ;**
- **a high Buyer reservation price will support Obj 2, but a low Buyer reservation price will be in conflict with Obj 2 after some point G2 ,**
- **Obj 1 and Obj 2 are conflicting (as often is the case with political objectives).**

The negotiation process ((1), (2), (3)) influences Obj 3 of the Government:

- **short steps and a small interval both support the attainment of Obj 3, but**
- **large, oscillating steps and a large interval are hinders for the attainment.**

There are a number of cases of labor market negotiations in which these types of interdependences are present. Because Obj 1-3 are influenced by the Buyer-Seller negotiations the Government can not remain passive, but will influence the objectives of the primary negotiators.

Then we get a set of decision problems for all parties involved, in which we have multiple interdependent objectives; these problems are not easy to cope with and to resolve.

In some labor market negotiations in the spring 1996 the Finnish government managed to both define such levels of its own objectives and to push the reservation prices of the primary negotiators to levels which were unattainable.

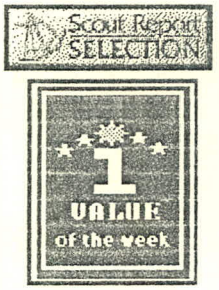
When the government finally agreed to face-saving compromises the country was 12 hours from a general strike.

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Dennis Tedlock: (translator)
Popol Vuh: The Mayan Book of the Dawn of Life
$12 - Amazon.com - 1996 -

al Lic. Jorge Rodriguez · mate-lógico!

Introduction to Logic for Liberal Arts and Business Majors



comparación del índice de este libro con: "VER DE VERBO"

A Complete Text Resource on the World Wide Web

by

Stefan Waner and Steven R. Costenoble

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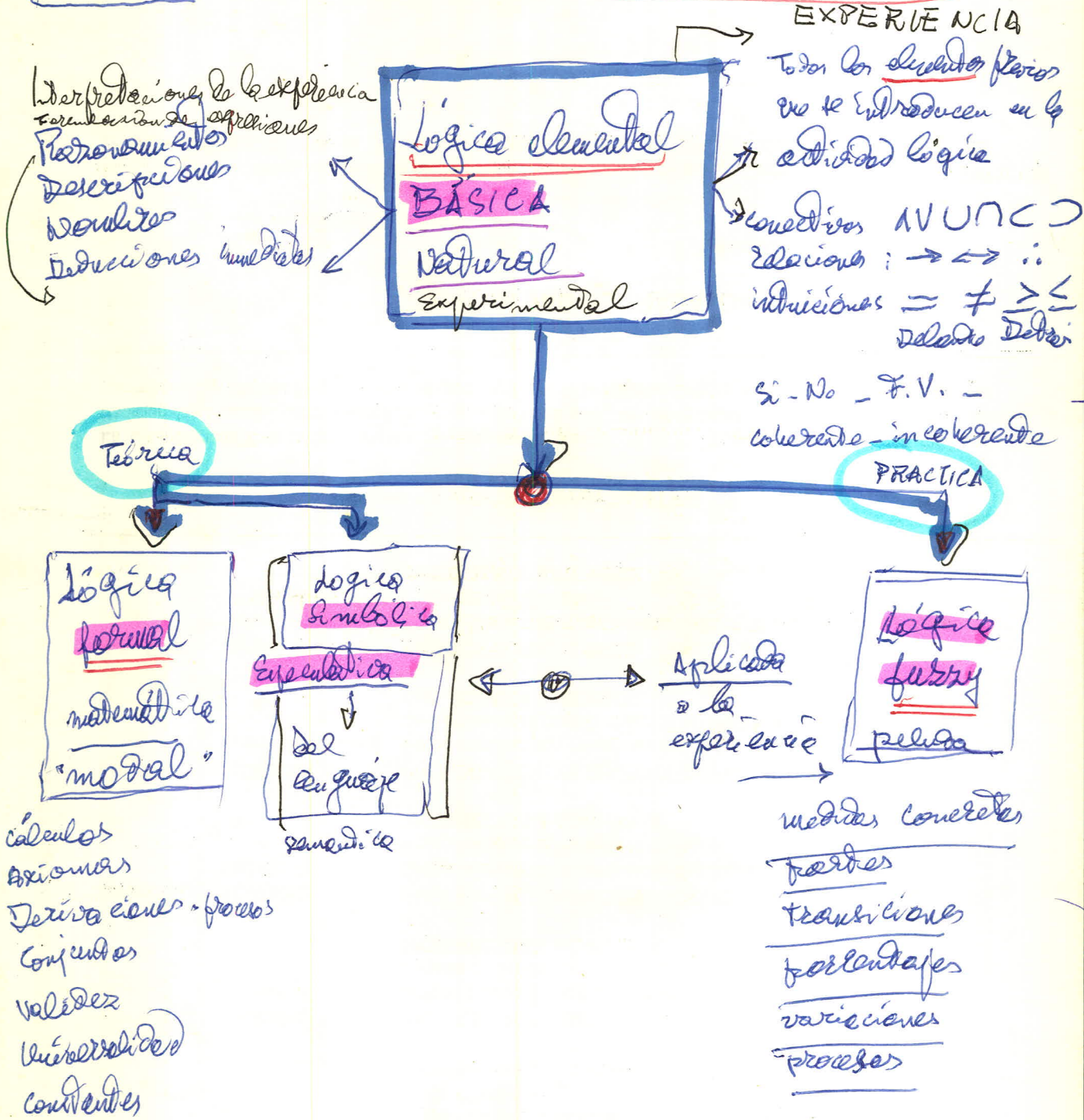
- 1. Statements and Logical Operators p. 21, 23 · p. 25, p. 76 — Exercises
- 2. Logical Equivalence, Tautologies and Contradictions p. 115 — Exercises p. 110 - 113
- 3. The Conditional and the Biconditional p. 77. — Exercises
- 4. Tautological Implications and Tautological Equivalences — Exercises p. 116 - 119
- 5. Rules of Inference p. 68 (2.2.2) — p. 73. — Exercises
- 6. Arguments and Proofs p. 79 p. 84 — Exercises
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Introduction

You have been assigned the job of evaluating the attempts of mortals to prove the existence of God. And many attempts there have been. Three in particular have caught your attention: they are known as the cosmological argument, the teleological argument, and the ontological argument.

Cosmological Argument (St. Thomas Aquinas): No effect can cause itself, but requires another cause. If there were no first cause, there would be an infinite sequence of preceding causes. Clearly there cannot be an infinite sequence of causes, therefore there is a first cause, and this is God.

NIVELES GENERALES DE LA ACTIVIDAD ESTRUCTURA LOGICA



La lógica pragmática, involucra en su análisis la actividad de un sujeto.

Esta Semana

EVENTOS

No. 43

SEMANA DEL 10 AL 15 DE NOVIEMBRE

Martes 11	17:00 horas Salón H-334	TALLER DE ACTUALIZACIÓN DOCENTE. Dirigido a catedráticos de recién ingreso a la Universidad, a cargo del Dr. Charles Beirne, SJ., Vicerrector Académico. ***VICERRECTORÍA ACADÉMICA.***
Miércoles 12	17:00 horas Salón H-334	TALLER DE ACTUALIZACIÓN DOCENTE. Dirigido a catedráticos de primer año, a cargo de la Licda. María Eugenia de Sandoval y el Ing. Mario Sosa. ***VICERRECTORÍA ACADÉMICA.***
Jueves 13	17:00 horas Salón H-334	TALLER DE ACTUALIZACIÓN DOCENTE. Dirigido a catedráticos del curso Metodología de la Investigación, a cargo de la Licda. Hilda de Mazariegos. ***VICERRECTORÍA ACADÉMICA.***
Viernes 14	20:30 horas Parroquia San Antonio Pádua, Retalhuleu	PRESENTACIÓN DEL GRUPO DE CORO DE LA URL. Grupo coral formado por estudiantes de las distintas facultades de la Universidad, bajo la dirección del maestro Raúl Padilla. ***DIRECCIÓN DE EXTENSIÓN.***
Sábado 15	Durante la mañana Salones asignados	INICIO DE CURSOS LIBRES. En las especialidades de Gerencia Cultural, Jardinización de Exteriores y Cómo Hablar en Público. ***DIRECCIÓN DE EXTENSIÓN.***

AVISOS IMPORTANTES

La Dirección de Extensión comunica por este medio que del 18 al 28 de noviembre se estarán realizando las tradicionales Posadas Landivarianas, así mismo como ha sido costumbre habrá un concurso donde se premiará al nacimiento más original. Mayor información podrán obtenerla en Asuntos Culturales, ubicado en la Plaza Landívar.

OPORTUNIDAD DE TRABAJO

- Capacitador
- Administrador de Sistemas
- Asistente Administrativo

Mayor información podrá obtenerla en la Universidad Rafael Landívar, Campus Central, CENTRO DE ORIENTACIÓN UNIVERSITARIA (COU), Edificio "J", tercer nivel, oficina 334, teléfonos: 3692151, 3692621 y 3692751; Ext: 248.

Dirección de Comunicaciones
UNIVERSIDAD RAFAEL LANDIVAR
Campus Central, Vista Hermosa III, zona 16 Of. H-302
Tels: 3692151 - 3640159 - 3692621 - 3692751 Ext. 133 - 135 Fax: 3640459
Guatemala C.A.

Diferencias de niveles entre: { Lógica teórica - especulativa. / Lógica aplicada - práctica. }

Figura:

Tratando de 2 categorías.

Lógicas teóricas = conceptos abstractos fijos - estables - precisos - nítidos

Mundo de abstracción

V. Blanco

No blanco F (Negro)

Lógicas aplicadas

Blanco

1/2 = 1/2

Negro

Nivel pragmático

= medios materiales "concretos"

= números aproximados, variables, improbables, conjuntos.

Si fijamos = nada saldrá "inadvertidamente", de un nivel pragmático a un nivel especulativo (A).

Conjunto blanco = presente = 1

Conjunto negro = ausente = 0

En la lógica Booleana = abstracta hay un salto entre 1 y 0

aaaaaa

aaaaa

Esta Semana

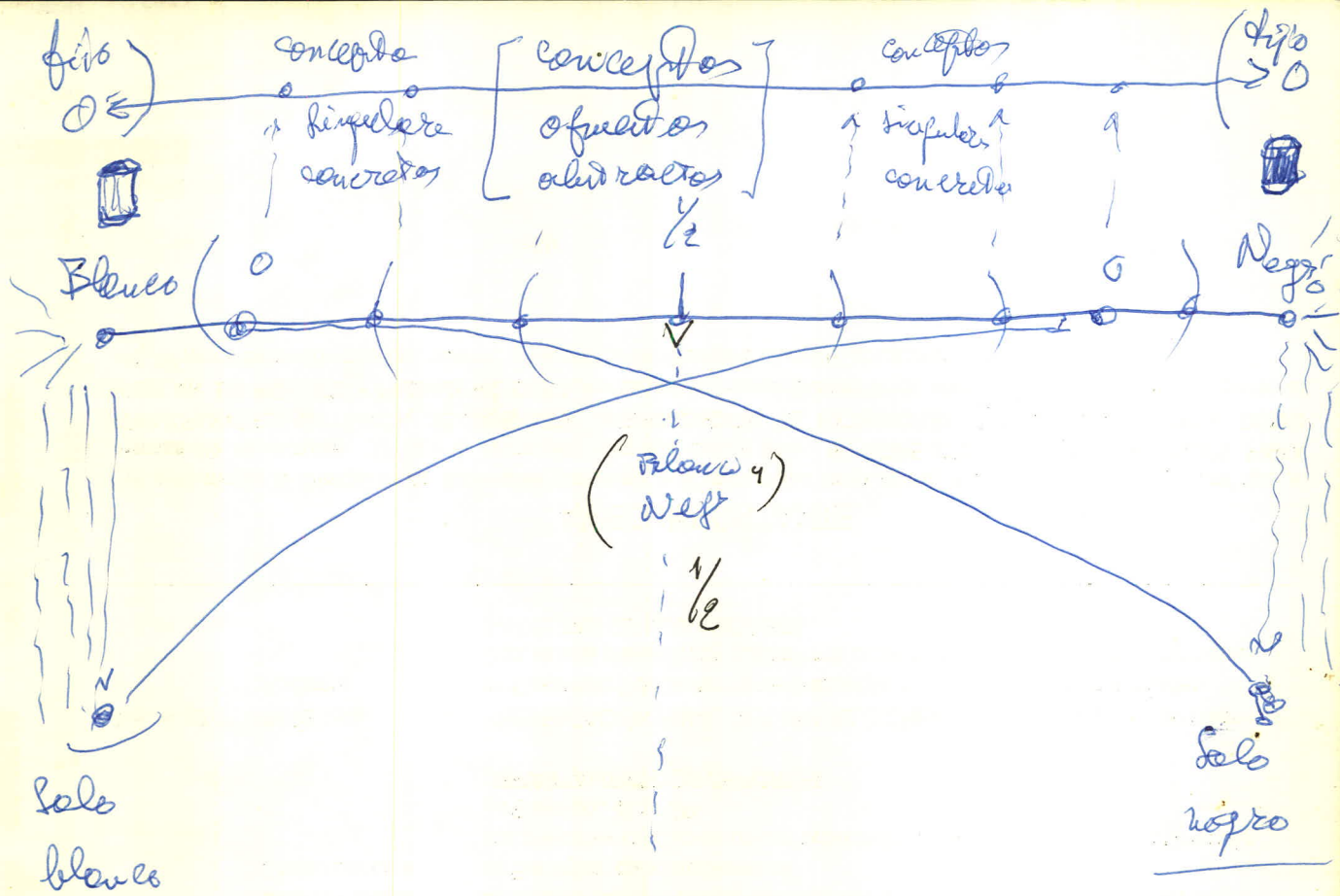
EVENTOS

OPORTUNIDAD DE TRABAJO

- Psicometrista
- Maestra de Inglés (Pre Primaria y Primaria)
- Maestro (a) de Artes Industriales
- Entrenadora para Cheer Leaders
- Entrenadores de Fútbol y Basquetbol
- Catedrático de Biología, Química y Ciencias Naturales
- Ejecutivo Financiero
- Ejecutiva de Ventas
- Catedrático (a) de Contabilidad
- Encargado (a) de Lab. de Cómputo
- Vendedores
- Analista Programador
- Secretaria Ejecutiva
- Auxiliar de Auditoría
- Jefe de Bodega
- Gerente de Marca

Mayor información podrá obtenerla en el CENTRO DE ORIENTACIÓN UNIVERSITARIA (COU), Edificio "J " , tercer nivel, oficina 334, teléfonos: 3692151, 3692621 y 3692751; Ext: 248.

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Nivel de operaciones reales = variables - medias mezcladas —

Esta Semana

No. 40

EVENTOS

SEMANA DEL 21 AL 25 DE OCTUBRE

Durante la Semana	Universidad Iberoamericana, México	VIII ENCUENTRO DE ESCUELAS DE DISEÑO GRÁFICO Participación de miembros del Departamento de Diseño Gráfico y estudiantes de la carrera. Encuentro que estrechará los lazos académicos de la URL y la Universidad Iberoamericana para conocer nuevas corrientes del diseño ***FACULTAD DE ARQUITECTURA.***
Martes 21	19:00 horas Salón H-334	REUNIÓN DE DEPORTISTAS LANDIVARIANOS Participantes en el Torneo INTER UIAS-ITESO, MÉXICO. El Torneo es una actividad deportiva que organiza y realiza la Universidad Iberoamericana de México. ***DEPARTAMENTO DE DEPORTES.***
Miércoles 22	18:00 horas Auditorio	ACTO DE JURAMENTACIÓN de los miembros de los equipos deportivos landivarianos que participarán en el próximo Torneo INTER UIAS- ITESO, a realizarse en México. El Torneo es una actividad deportiva que organiza y realiza la Universidad Iberoamericana de México. ***DEPARTAMENTO DE DEPORTES.***
	18:00 horas Galería Plástica Contemporánea	PANEL: LA DANZA COMO EXPRESIÓN PLÁSTICA con la participación de Sabrina Castillo, Carlos Andrade, Tasso Hadjidoudou y María del Carmen de Farrington como moderadora. Los Miércoles Landivarianos son actividades culturales que organiza la Dirección de Extensión de la URL. ***DEPARTAMENTO DE DEPORTES.***
Jueves 23	18:00 horas Auditorio	PRESENTACIÓN FINAL: DESARROLLO CREATIVO, de estudiantes del curso de Desarrollo II de la carrera de Psicología de la Facultad de Humanidades. Esta es una presentación que se hará como examen final del curso mencionado ***FACULTAD DE HUMANIDADES.***

AVISO IMPORTANTE

Por este medio la **Dirección de Extensión** comunica a la comunidad landivariana, como al público en general que el **viernes 24 de octubre** finaliza la inscripción para los cursos libres de **GERENCIA CULTURAL; FRANCÉS PARA PRINCIPIANTES, BOTÁNICA DE JARDINES; JARDINIZACIÓN DE EXTERIORES; GUITARRA ACÚSTICA; CÓMO HABLAR EN PÚBLICO Y PAISAJE AL ÓLEO,** los cuales se estarán desarrollando en noviembre y diciembre del presente año. Mayor información podrán obtenerla en la oficina de Asuntos Culturales, ubicada en la Plaza Landívar.

de Dirección Comunicaciones
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Guatemala C.A.

1) Alavista → Digital.com.

2) What is fuzzy Logic ?

3) Presenta una lista { 1 2 3 . . . } "13 Web pages found"

- Gateway to the World Alphaliedical [A]

http://www.emsl.pnl.gov:2080/proj/neuron/web/cogsys/gateway/A.html

Fuzzy Logic Tutorial = en el nº ...

Es muy completo → { introd. historia

1.2 Regresemos a la dos manzanas en el plato. Hemos aprendido a reducir lo *multiple* de las dos unidades a lo *uno* del objeto-manzana.

Pero, si en la mesa hay también: una canastita con uvas, una frutera con mangos, un racimo de bananos, un jarrón con fresas y una bolsa con melones, y alguien de repente le pregunta: *¿Qué hay en la mesa?* Usted le responde: *fruta*.

Automáticamente, usted ha recojido todo lo que había en la mesa en un super-objeto que se expresa con la palabra fruta. Este Objeto-fruta es, evidentemente, superior a los objetos: uva, mango, banano, fresa, melón. En realidad hemos partido de cosas individuales: tres racimos de uva, dos mangos, cuatro bananos, 50 fresas, tres melones. Este es el nivel cero, el nivel de la realidad individual; realidad que se ve por que veo los individuos singulares y concretos. Los *objetos*: uva, mango, banano, fresa, melón, están en un segundo nivel, y la palabra *frutas* en un tercer nivel. Veamos la estructura: Figura 1.8

El nivel cero es el nivel de la experiencia inmediata, el de los individuos.

El primer nivel (de abstracción) corresponde al *tipo* de cosas que estoy viendo, *objetos* que son efecto de la primera generalización. El segundo nivel, *fruta* es una palabra o super-objeto, que indica la *especie*, un *objeto-ideal* y que abarca más que los inferiores ; efecto de una segunda generalización.

Ahora que conocemos la técnica podemos alcanzar niveles todavía más altos.

1.2.1. LOS *TIPOS* LOGICOS.

A proposito de este diagrama, debemos hacer una observación. Cada nivel representa un diferente *tipo lógico*, para usar la terminología de Bertrand Russell. Russell publicó en 1908 un famoso estudio (en: *American Journal of Mathematics*) titulado *"La Lógica matemática y sus fundamentos en la teoría de los tipos"*, que se refiere precisamente a estos niveles.

Regresando a la figura 1.7, si usted dice: *"La Ciencia es: biología, quimica, psicología, matemática , etc."*, usted construye una oración que define el *tipo* ciencia. (este tipo de objeto). Y puede expresarse con la fórmula:

Es CIENCIA (biología, física, antropología, psicología, química, etc...)

En la cual, CIENCIA es la *Función* de los argumentos que están en paréntesis. Ahora podemos definir el *tipo* con las palabras de Russell: "*Es el campo de significación de una función proposicional*" (Log. y Conocim. p. 103).

Es decir: la *función* CIENCIA tiene valor por los *Argumentos* que van entre paréntesis (y son su campo de significación), los cuales son *sub-tipos* del anterior (= de la función).

Russell lo expresa así: *"Lo que determina el tipo de una expresión son las variables aparentes contenidas en esta"* (= los argumentos entre paréntesis). Lo mismo hay que decir de todos los *Tipos* de que estamos hablando, sin excepciones y a todos los niveles. Por esta razón es preciso mantener la distinción entre niveles.

Neural Network Computing

The Sudden Rise of Neurocomputing

The majority of information processing today is carried out by digital computers. This has led to the widely held misperception that information processing is dependent on digital computers. However, if we look at cybernetics and the other disciplines that form the basis of information science, we see that information processing originates with living creatures in their struggle to survive in their environments, and that the information being processed by computers today accounts for only a small part - the automated portion - of this. Viewed in this light, we can begin to consider the possibility of information processing devices that differ from conventional computers. In fact, research aimed at realizing a variety of different types of information processing devices is already being carried out, albeit in the shadows of the major successes achieved in the realm of digital computers. One direction that this research is taking is toward the development of an information processing device that mimics the structures and operating principles found in the information processing systems possessed by humans and other living creatures.

Digital computers developed rapidly in and after the late 1940's, and after originally being applied to the field of mathematical computations, have found expanded applications in a variety of areas, to include text (word), symbol, image and voice processing, i.e. pattern information processing, robot control and artificial intelligence. However, the fundamental structure of digital computers is based on the principle of sequential (serial) processing, which has little if anything in common with the human nervous system.

The human nervous system, it is now known, consists of an extremely large number of nerve cells, or neurons, which operate in parallel to process various types of information. By taking a hint from the structure of the human nervous system, we should be able to build a new type of advanced parallel information processing device.

In addition to the increasingly large volumes of data that we must process as a result of recent developments in sensor technology and the progress of information technology, there is also a growing requirement to simultaneously gather and process huge amounts of data from multiple sensors and other sources. This situation is creating a need in various fields to switch from conventional computers that process information sequentially, to parallel computers equipped with multiple processing elements aligned to operate in parallel to process information.

Besides the social requirements just cited, a number of other factors have been at work during the 1980's to prompt research on new forms of information processing devices. For instance, recent

neurophysiological experiments have shed considerable light on the structure of the brain, and even in fields such as cognitive science, which study human information processing processes at the macro level, we are beginning to see proposals for models that call for multiple processing elements aligned to operate in parallel. Research in the fields of mathematical science and physics is also concentrating more on the mathematical analysis of systems comprising multiple elements that interact in complex ways. These factors gave birth to a major research trend aimed at clarifying the structures and operating principles inherent in the information processing systems of human beings and other animals, and constructing an information processing device based on these structures and operating principles. The term "neurocomputing" is the name used to refer to the information engineering aspects of this research.

The Biological Foundation of NeuroComputing

Neurocomputing involves processing information by means of changing the states of networks formed by interconnecting extremely large numbers of simple processing elements, which interact with one another by exchanging signals. Networks such as the one just described are called artificial neural networks (ANNs), in the sense that they represent simplified models of natural nerve or neural networks.

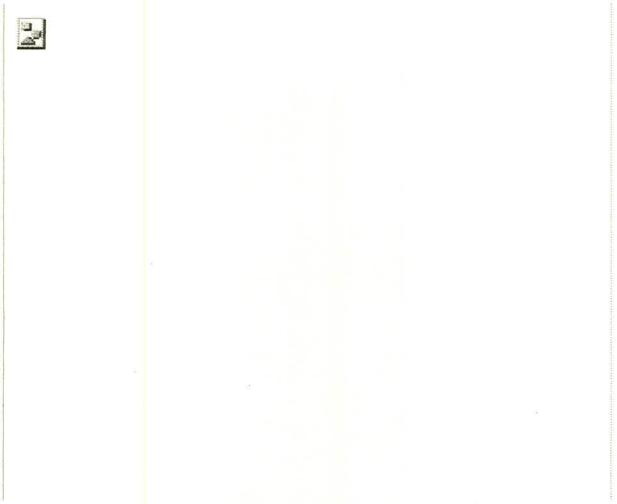


Fig. 1. A simple neuron cell

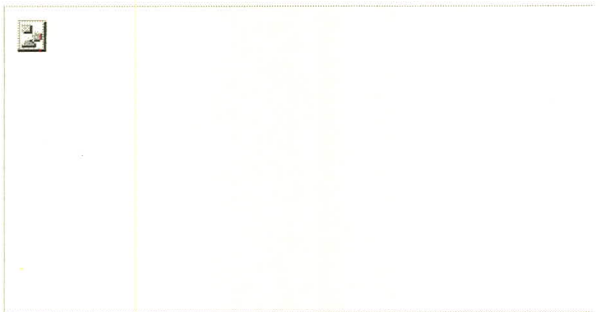


Fig. 2. A schematic diagram of a neuron



Fig. 3. A feed forward neural network

The basic processing element in the nervous system is the neuron. The human brain is composed of about 1011 of over 100 types. Tree-like networks of nerve fiber called dendrites are connected to the cell body or soma, where the cell nucleus is located. Extending from the cell body is a single long fiber called the axon, which eventually branches into strands and substrands, and are connected to other neurons through synaptic junctions, or synapses.

The transmission of signals from one neuron to another at a synapses is a complex chemical process in which specific transmitter substances are released from the sending end of the junction. The effect is to raise to lower the electrical potential inside the body of the receiving cell. If the potential reaches a threshold, a pulse is sent down the axon - we then say the cell has "fired".

In a simplified mathematical model of the neuron, the effects of the synapses are represented by "weights" which modulates the effect of the associated input signals, and the nonlinear characteristics exhibited by neurons is represented by a transfer function which is usually the sigmoid function. The neuron impulse is then computed as the weighted sum of the input signals, transformed by the transfer function. The learning capability of an artificial neuron is achieved by adjusting the weights in accordance to the chosen learning algorithm, usually by a small amount *Wj = **Xj where * is called the learning rate and * the momentum rate.

Building A Neural Network

Since 1958, when psychologist Frank Rosenblatt proposed the "Perceptron," a pattern recognition device with learning capabilities, the hierarchical neural network has been the most widely studied form of network structure. A hierarchical neural network is one that links multiple neurons together hierarchically, as shown in Figure 3. The special characteristic of this type of network is its simple dynamics. That is, when a signal is input into the input layer, it is propagated to the next layer by the interconnections between the neurons. Simple processing is performed on this signal by the neurons of the receiving layer prior to its being propagated on to the next layer. This process is repeated until the signal reaches the output layer completing the processing process for that signal.

The manner in which the various neurons in the intermediary (hidden) layers process the input signal will determine the kind of output signal it becomes (how it is transformed). As you can see, then, hierarchical network dynamics are determined by the weight and threshold parameters of each of their units. If input signals can be transformed to the proper output signals by adjusting these values (parameters), then hierarchical networks can be used effectively to perform information processing.

Since it is difficult to accurately determine multiple parameter values, a learning method is employed. This involves creating a network that randomly determines parameter values. This network is then used to carry out input-to-output transformations for actual problems. The correct final parameters are obtained by properly modifying the parameters in accordance with the errors that the network makes in the process. Quite a few such learning methods have been proposed. Probably the most representative of these is the error back-propagation learning method proposed by D. E. Rumelhart et al. in 1986. This learning method has played a major role in the recent neurocomputing boom.

The back-propagation paradigm has been tested in numerous applications including bond rating, mortgage application evaluation, protein structure determination, backgammon playing, and handwritten digit recognition. Choosing the right methodology, or backpropagation algorithm, is another important consideration. In working with the financial applications, many have found that the back-propagation algorithm can be very slow. Without using advanced learning techniques to speed the process up, it is hard to effectively apply backpropagation to real-world problems. Overfitting of a neural network model is another area which can cause beginners difficulty. Overfitting happens when an ANN model is trained on one set of data, and it learns that data too well. This may cause the model to have poor generalization abilities - the model may instead give quite poor results for other sets of data.

For an in-depth coverage of other neural network models and their learning algorithms, please refer to the Technical Reading at the end of this User's Guide, the Technical Reference (sold separately), those papers listed in the Reference, or any other reference books on neural networks and relevant technology.

Some Real-World Applications

ANNs can be regarded, in one respect, as multivariate nonlinear analytical tools, and are known to be very good at recognizing patterns from noisy, complex data, and estimating their nonlinear relationships. Many studies have shown that ANNs have the capability to learn the underlying mechanics of the time series, or, in the case of trading applications, the market dynamics. In general, ANNs are known to possess these capabilities:

A number of development projects involving ANN technology have been publicized in the media recently. For example, Nippon Steel Corp. has built a blast furnace operation control support system that makes use of ANNs. The neural network employed in this system has been equipped with functions that enable it to learn the relationship between sensor data and the eight kinds of temperature distribution patterns known from experience to pertain to the overall operation of blast furnaces, and to instantaneously recognize and output that pattern which most closely approximates sensor data input into the system. The neural network learns very quickly, and achieves a better than 90% pattern recognition ratio following learning. Since this system has been performing extremely well during operational testing, Nippon Steel is planning to introduce it into other aspects of its operations in addition to blast furnace control, to include the diagnosis of malfunctions, and other control processes.

A second example is the experimental work started by Daiwa Securities Co., Ltd. and NEC Corporation on applying neural network technology to the learning and recognition of stock price chart patterns for use in stock price forecasting. NEC had already developed neural network

simulation software for use on its EWS 4800 series of workstations, and, by limiting stock price chart pattern learning to a few dozen major stocks, has improved the accuracy of this software's forecasting capabilities. Based on these results, the Daiwa Computer Services Co., Ltd., an information processing subsidiary of the Daiwa Securities Group, transferred the NEC system to its supercomputer and taught it to recognize the stock price chart patterns for 1,134 companies listed on the Tokyo Stock Exchange. DCS has since been putting this system to good use in the performance of stock price forecasting.

Mitsubishi Electric has combined neural network technology with optical technology to achieve the world's first basic optical neurocomputer system capable of recognizing the 26 letters of the alphabet. The system comprises a set of light-emitting diodes (LED) that output letter patterns as optical signals, optical fibers, liquid crystal displays (LCD) that display letter patterns and light receiving devices that read these letters. When letter data is input into this system, light emitted from the LEDs is input to the light receiving devices through the LCDs. At that time, the light receiving devices that receive the light, as well as the strength of the light they receive, is determined by the manner in which that light passes through the LCDs. The letter in question is delineated by the light receiving devices that receive the strongest light. This system is capable of 100% letter recognition even when slightly misshapen handwritten letters are input.

A fourth example is a development project for a facilities diagnosis system that employs a neural network system commenced by the Nippon Oil Co., Ltd. in cooperation with CSK Research Institute. This project is attracting considerable attention as it is the first time research has been carried out on applying neural network systems to facilities diagnosis. Initially, the project will be aimed at developing a diagnosis system for pump facilities that employs vibration analysis. Nippon Oil operates a total of 1,500 pumps at its Negishi Oil Refinery in Yokohama, Kanagawa Prefecture alone, and must retain large numbers of experienced personnel to maintain these pumps. The company decided to apply neural network technology to pump facilities diagnosis operations with the ultimate goal of saving labor in mind.

Bond rating is another successful ANN application. Bond rating refers to the process by which a particular bond is assigned a label that categorizes the ability of the bond's issuer to repay the coupon and par value of that bond. Thus, for example, the Standard and Poor's organization might assign a rating varying from AAA (very high probability of payment) to BBB (possibility of default in times of economic adversity) for investment grade bonds. The problem here is that there is no hard and fast rule for determining these ratings. Rating agencies must consider a vast spectrum of factors before assigning a rating to an issuer. Some of these factors, such as sales, assets, liabilities, and the like, might be well defined. Others such as willingness to repay are quite nebulous. Thus a precise problem definition is not possible. Dutta (1988) maintains that problems with non conservative domains (the class of problem domains that lack a domain model) such as that seen in the bond-rating problem could be better solved by training a network using back-propagation than by trying to perform a statistical regression. The latter is inappropriate because it is unclear what factors the regression should be performed with, that is, it is not clear what factors the dependent variable (the default risk) really depends on. They describe details of experiments that they conducted with networks having no hidden layers and with networks with one hidden layer (with different numbers of nodes in the hidden layer). Bond ratings for 30 companies together with ten financial variables were used as data in the training of the neural network using back-propagation. The network was then used to predict the ratings of seventeen other issuers and consistently outperformed standard statistical regression techniques.

The Adaptive Decision Systems (ADS) founded by Murray Smith to apply the advances in neural network technology to an area that he knows well, the financial world. Smith earned an MBA from Harvard before working with a financial service corporation for eighteen years. After he saw the potential for using new technology to solve common financial problems such as credit scoring or evaluation, he decided to start ADS. Smith sees ADS's mission as having three principle components:

- working with large financial institutions,
- building predictive models, and
- using neural network technology wherever possible.

ADS is using its expertise in two areas: credit scoring and target marketing. This type of credit scoring is used to screen applicants for credit cards, based on known facts about the individuals applying. These facts usually include such things as salary, number of checking accounts, and previous credit history. Large banks and other lenders lose millions each year from bad debts. Even a small increase in the ability to predict accurately which accounts will go unpaid can result in hundreds of thousands of dollars saved each year for large lenders. To help fight this problem, major banks and finance companies are actively pursuing new technologies and systems that can aid in credit prediction.

Using the techniques outlined above, ADS has been successful in using ANNs to predict credit account futures. The average ADS credit prediction models performance gains over standard statistical methods are 5%. Even this small increase in ability to predict a credit account's future performance means a large savings for credit grantors. In little over two years, ADS has provided neural network predictive models to four major clients, who for contractual reasons cannot be named. Of these clients, one is using an ADS model for credit scoring in its standard system, while the other three are further refining and integrating the process.

ADS has also applied neural network techniques to the field of marketing. For years, advertising agencies and other companies have been trying to identify and sell to target, or specific, markets. For example, a company selling life insurance might send out an advertisement enclosed in a monthly credit card bill. What the company would like to be able to do is to send out a small percentage of these advertisements to consumers, and keep information on what type of person responds. Once the company has data on who responded, it can then built a predictive model to analyze potentially good customers. Thus, a life insurance company may be able to save money by only sending out advertisements to a select 1 million credit card holders who are more likely to buy life insurance, rather than to all credit card holders. Successful target marketing can save large companies hundreds of thousands of dollars each year.

ADS provides consulting services to large credit financial services companies. According to Smith, the majority of this work has been in developing and testing neural network models for data sets supplied by the companies. These firms provide ADS with raw data from the applications department. For example, a typical data set might have 40,000 records, with each record having between 30 and 100 different data fields. These fields contain data such as the credit card holder's age, occupation, salary, phone number, and past payment history. It may also include information obtained from credit bureaus, such as the number of other charge accounts, the number of times the applicant has applied for credit recently, and the existence of prior bankruptcies.

Each record also has a data field that specifies whether the account is good or bad, that is, whether that account was written off as a bad debt or not. For example, a data set may have information on

past payment histories (ie: a one year payment history with the number of 1, 2, and 3 month delinquencies) and a good or bad score based on whether the account was delinquent after 5 months.

All of this data is processed and used to build a predictive applicant credit scoring model. In building a model, the typical data set provided by the financial institution travels through four steps: reading, analyzing, building a model, and implementation.

The first step in the ADS process is reading the raw data set into a PC. This data is generally in an ASCII (text) format, and is pre-processed to yield a more compact and faster-access binary format. In addition, during the creation of the binary data file, data fields that are obviously not needed or helpful for credit prediction are discarded. An example of such a field would be the credit card holder's phone number, or the credit card holder's birth date when the age is already given. Once the raw data is read into a compact binary data file, predictive variables have to be found.

The second step in ADS's process is to use the pre-processed data file and specially designed data analysis programs to determine which data fields are predictive of the actual result of each record. It is important that the inputs to the backpropagation network be at least somewhat predictive. Data fields that have little predictability will only add extra degrees of freedom to network, and can contribute to the network overfitting the training set.

This happens when the network learns the training set so well that it loses one of neural networks greatest strengths - its ability to generalize. For example, by using these special programs, ADS may see that the age of a credit card holder is predictive of the account delinquency. They might see that 18-25 year old tend to default more often than 55-80 year old. If so, the most predictive categories for each record type are stored for later processing. In this example, the age record may be broken down into three categories: 18-25, 26-55, and 56-80. Analysis may show that some records, such as spouse's length of time at job, are not predictive at all, and they are noted for later deletion. For each data set, all the variables (age, occupation, payment histories, etc.,) are run through these decision programs to determine their predictability. If a variable is predictive, it is broken down into different categories (typically 1-10) for processing by the neural network.

ADS then takes the processed data and the associated categories and develops a backpropagation neural network predictive model for the data set. The backpropagation network uses the delta-bar-delta rule. the input nodes for the backpropagation network are determined by the categories that the deciding step has yielded. Thus a typical application might have approximately 100 input nodes for 40 different data fields. Some fields may merely have a single node, such as whether the applicant has declared bankruptcy, while others, such as the card holder's age, may have as many as 5. The data set is fed through the network, and a predetermined set is held back for testing, typically 25% of the original data set. Training and testing sets of data are run alternatively to measure the error as training progresses. When optimal error reduction is reached, training is halted, and the network weights and configuration are saved.

Once ADS has developed a predictive neural network model for a data set, the customers can then use the neural network in a feed forward, non-learning mode to judge applications credit risks. The network can be implemented on their mainframes as a function call in their applications processing system.

A statistical-based hybrid neural network at Chase Manhattan Bank is one of the largest and most successful AI applications in the United States. It addresses a critical success factor in the bank's

strategic plan: reducing losses on loans made to public and private corporations. Most of Chase's business for corporations involves assessing their creditworthiness. Chase loans $300 million annually and has long searched for tools to improve loan assessment. This assessment allows Chase to mitigate risk and seek out new business opportunities. Financial-restructuring deals are promising business opportunities for the bank.

In 1985 Chase began a search for new quantitative techniques to assist senior loan officers in forecasting the creditworthiness of corporate loan candidates. Chase located Inductive Inference Inc. (headed by Dr. David Rothenberg), a New York City company with a history of successfully applying neural-network technology to statistical pattern analysis. A test model was built, evaluated, and independently audited. The results were reviewed by the Chase CEO committee in 1987 and Inductive Inference was granted a multimillion dollar contract. Consequently, Chase established a 36-member internal consulting organization called Chase Financial Technologies to oversee the development of pattern-analysis network models for evaluating corporate loan risk.

The resulting models, called the Creditview system, perform three-year forecasts that indicate the likelihood of a company being assigned a Chase risk classification of good, criticized, or charged-off. In addition to the overall forecast, Creditview provides a detailed listing of the items that significantly contributed to the forecast, an expert-system-generated interpretation of those items, and several comparison reports. Creditview models run on a Chase Financial Technologies host computer. A user system resides at each user's PC and communicates with the host through telephone lines. In addition, conventional financial statement analysis may be performed using Chase's Financial Reporting System, an independent financial spreading and analysis package designed for conventional financial statement analysis. The Financial Reporting System also resides on the user's PC and permits a company's standard financial statements to be accessed and displayed. System data is obtained from COMPUSTAT.

It took 15 years for Inductive Inference to develop ADAM, a tool that generates the models such as those used in Creditview. ADAM is a statistically based technique that extracts a collection of Boolean formulae from historical data and captures rules most significant in determining the obligor's creditworthiness. ADAM identifies rules and their combinations that, based on historical data, may be expected to do three-year forecasts reliably. The historical data is also used to embed the Boolean formulae in a network that evaluates the significance of each possible formulae combination that may be satisfied by a particular company.

ADAM's pattern-analysis technology provides the ability to construct a hybrid neural network, if enough high-quality historical data is available. Each hybrid net represents a separate "model" produced by ADAM. The PCLM (Public Loan Company model), the first model implemented at Chase, derives from Chase's extensive loan history of large, publicly traded companies and their past financial data. (Chase has both publicly and privately owned corporations in its base of clients and prospects. Separate credit-risk forecasting models will be developed for public and private companies because their particular characteristics will probably mandate separate assessments and analysis by the bank.). The input to ADAM includes: (1) Historical financial-statement data on good and bad obligors (the learning sample), (2) Industry norms calculated using financial-statement data from companies in specific industries.

These norms reflect industry characteristics. The historical data analyzed by ADAM to produce forecasting models consists of a large collection of data units. Each data unit contains as much as six years of consecutive financial data for a particular company, corresponding industry norms, and the

company's status three years after the last year of data. (The last of the six years is called the "year of the data unit.") The data unit's status is the company's rating - G stands for good, C stands for criticized, and X stands for charged-off. ADAM uses this data to construct a large set (say, a thousand) of candidate variables that may or may not indicate a company's future financial condition. These variables are used to form patterns.

A pattern is fundamentally a statement about the value of a particular financial variable or set of variables. A very simple pattern may have the form: C1< V1 < C2 or V1 < C1, where V1 is a financial variable and C1 and C2 are constants. For example: 1.75< QuickRatio < 2.00 could be a simple pattern. Typically, patterns are more complex; they have several elements of this kind and are combined by using and, or, and not. This example could be one of a small complex pattern:

C1 < V1 < C2

V2 < C3

C4 < V3 < C5 .and. C6 < V4 < C7

C8 < V5 < C9

where all the C's are constants and V's financial variables. Candidate variables are arranged into thousands of complex patterns and analyzed by ADAM to produce an optimal set of variables and patterns that form a pattern network called the Forecaster. The criteria for selection of patterns are:

Score: The score (as observed in the historical data) measures the ability of the pattern to differentiate between the categories good, criticized, and charged-off; in other words, the ability of the pattern to classify correctly.

Complexity: Complexity is a measure of how complicated the pattern is (in terms of number of variables), simple patterns within it, and the amount of historical data it satisfies.

Spuriousness: A measure of the likelihood that the pattern's score (how well it predicts) is due solely to chance.

These statistics are used to evaluate the predictive power of the patterns and ensure that whatever predictive power is uncovered is not by chance. To each pattern and status a probability (called the "precision") exists that a data unit corresponding to the pattern will have that status. ADAM uses a proprietary network-balancing technique that selects the patterns for the network to maximize precision and minimize bias.

ADAM was used to develop the PCLM, an expert system based on historical data that can predict the likelihood of a public firm being rated good, criticized, or charged-off three years in advance. The PCLM comprises two parts: the Forecaster built by the ADAM technology from large publicly traded companies (residing on a Chase host computer), and a PC-based user system that allows access to the model on the host computer to generate forecasts for particular companies, perform various analyses, and print reports. Note that information about an obligor's specific credit facility (whether the facility is secured, covenants, and so on) is not considered by the PCLM. The system evaluates the company itself rather than the risk of its defaulting in specific credit payments.

The PCLM produces these reports: Contributing Variables, Expert-System Interpretation, Two-Year Comparison: Items of Increased Significance, Two-Year Comparison: Items of Decreased Significance, and Two-Year Comparison: Items That Changed Risk Category. Of these reports, Contributing Variables contains PCLM's primary output; the others derive from the data contained in it. Contributing Variables comprises an overall forecast for the company in question along with a list of the variables that most strongly contributed to the forecast. The basic report consists of these sections:

Section 1: General information. Contains the company name, forecast year, standard industrial code (SIC), data source, date, and years of data that were used in generating the forecast.

Section 2: Industry peer group. Defines the industry peer group as determined by the model for the company. The company's asset size and geographic location are shown in this section. Information on the industry peer group consists of its SIC, the latest year for which industry norms were calculated, the number of firms in the peer group, and the peer-group reference number (useful in determining the peer group's members).

Section 3: Overall forecast. Shows the forecast rating for the company (G, C, or X). These ratings are mathematically combined into a single "vulnerability index" that helps compare the relative risk among different forecasts (different companies or years for the same company). In addition, to assist the analyst in evaluating the forecast's significance, the company's forecast compared to others in Chase's experience is shown in several ways. Chase Rank shows the relative percentile of this company's good rating compared to all Chase obligors in the years 1986-1988 (for example, if the company's Chase Rank was 25%, for all Chase obligors from 1986-1988, 75% have a higher and 25% have a lower rating for good), and Percent Going to Criticized and Charged-off shows the historical outcome of similarly ranked companies.

Section 4: A list of contributing variables most strongly influencing the forecast. These variables are organized into categories and by contributions to strength and weakness within each category: profitability, asset efficiency, cash flow, capital structure and liquidity; and market.

Section 5: A list of contributing variables compared to the best or worst quartile of companies in the industry (defined as its peer group) that most strongly influence the forecast.

PCLM benefits the user because it identifies the strengths and vulnerabilities in the financial structure of the obligor and forecasts the impact of these factors on the firm's financial health three years into the future. Chase tested the system extensively and, having identified many potentially troublesome loans.

Many recent studies and success stories have been reported in various international conferences (eg. International Joint Conference on Neural Networks, World Congress on Neural Networks, IEEE World Congress on Computational Intelligence) and journals and magazines (eg. IEEE Expert Systems, AI in Finance, AI Experts, Technical Analysis of Stocks & Commodities, PC AI). A number of real applications can also be found in the NeuroForecaster package. Based on these successful applications, it is therefore evident that the neural network technology can be applied to many real-world problems especially those related to business, financial and engineering modeling.


Home


Online Order

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1999

WHITE PAPER #4

Fuzzy Logic Technology

: Lógica de lo "impreciso"

by Suzanne M. Rodriguez, Ph.D.

Consultant

1. What is Fuzzy Logic?

: Es una Infra-lógica sectorial.. Una lógica aproximada

- Fuzzy logic is an alternative to traditional Boolean (true/false) logic. Boolean logic requires all statements to be either completely true or completely false. Fuzzy logic allows statements to assume degrees of truth ranging from completely false to completely true and including all intermediate degrees. By providing a framework for reasoning with imprecise information, fuzzy logic technology enables computer systems to reach specific conclusions in accordance with general guidelines.

  Many business decisions, such as determining assortment levels, setting prices or evaluating the success of a marketing program, are guided by broad strategies rather than precise rules. For example, a rule of thumb might dictate that "if a product is very popular then the assortment should be extensive." Without fuzzy logic, this rule of thumb is too imprecise to be utilized directly by a computerized system to make assortment recommendations. A fuzzy system, however, would be able to use the rule as stated to recommend stocking all five colors of a top-selling pump shoe.

2. What's wrong with precision?

- Continuing with the assortment example, Boolean logic requires that every product be classified absolutely as either "very popular" or "not very popular" in order to determine whether to recommend an extensive assortment. For example, we might declare that a monthly unit sales value of exactly 900 units defines "very popular." Therefore, a product with monthly sales of 901 units is "very popular" while a product with monthly sales of 899 units is "not very popular." Because different decision-making rules will be applied based on product popularity, there may be an abrupt change in the recommended assortment even though there is only a 2 unit difference in monthly sales. In addition, moving the cutoff value by only 2 units in either direction has a significant impact on the resulting assortment decisions. At this point we shrug and move on, suspecting that our precise cutoff is a bit too precise.

  We add a second rule of thumb: "if the product margin is low, the assortment should be limited." The problem is that we now have

conflicting directives for products which are both popular and low margin. In the world of Boolean logic, an assortment can never be both extensive and limited at the same time. There is no compromise. To work around the problem, we make the existing rules more specific and add an explicit compromise such as "if the product margin is low and the product is very popular then the assortment should be moderate." Over time we create an unwieldy set of cutoff points and highly specialized rules. There is, however, an alternative -- fuzzy logic.

3. **How do Fuzzy Systems work**?

- Fuzzy logic permits a more natural representation of concepts by acknowledging gradual contrasts. Instead of being represented by a single value in the form of a cutoff point, the concept of "very popular" is represented by a fuzzy set. We can construct a fuzzy set such as the following:
  - Products with monthly sales <= 700 units are absolutely not (0%) "very popular"
  - Products with monthly sales > 1000 units are absolutely (100%) "very popular"
  - All other products are "very popular" to the following extent:

    ((monthly unit sales - 700) / (1000 - 700)) x 100%

A product with monthly unit sales of 901 units is 67% "very popular." A product with monthly unit sales of 899 units is only slightly less "very popular" at 66%.

We still choose some cutoff points at the edges in order to define a fuzzy set, but we have solved the problem of abrupt transitions from absolutely not "very popular" to absolutely "very popular" based on small differences in the monthly sales figure. In addition, the choice of cutoff points is not as critical because relatively large differences have only minor effects on the popularity rating instead of causing a complete about face. For example, if we increase the requirement for absolutely "very popular" to 1100 units, a product with monthly unit sales of 901 units is still 50% "very popular."

By defining additional fuzzy sets we can also reason about "low" margins, "extensive" assortments and "limited" assortments. Any assortment over 3 colors may be considered "extensive," although 5 colors is obviously more "extensive" than 4 colors. The extent to which a product matches the popularity requirement determines just how "extensive" the selection should be. If a product is 100% "very popular," then the assortment should be 100% "extensive" (perhaps 6 colors). If a product is only 50% "very popular," then the assortment should be only 50% "extensive" (5 colors). Once the fuzzy sets are defined, the system can produce many different recommendations all

based on the same general policy.

In a fuzzy system, all rules with some degree of truth contribute to the final solution. Through a process called defuzzification, the system produces a single answer that represents a compromise between all of the suggested conclusions. Rules that are 90% true influence the final solution more than rules that are only 50% true. In the case of a popular but low margin product, the popularity rule may suggest that 5 colors would be appropriate while the margin rule suggests that 1 color would be appropriate. Both of these suggested conclusions are combined to recommend, for example, that 3 colors should be stocked. Conflict resolution occurs automatically without an increase in the complexity of the knowledge base.

This very brief introduction illustrates some of the basic differences between fuzzy logic and Boolean logic. The bottom line (literally) is that fuzzy logic provides a more natural and compact problem representation in many situations characterized by inherent imprecision and conflicting points of view.

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Fuzzy Logic

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What is Fuzzy Logic ?

Fuzzy logic recognises that real-world propositions are often not strictly true or false. A liquid does not suddenly change from being "warm" at 39°C to being "hot" at 40°C. Instead, the concepts of cold, warm and hot have *degrees of truth* that depend on the temperature.

Fuzzy logic provides a precise way of defining such imprecise concepts.

For example, we could decide that anything above 38°C was definitely hot (truth value = 1), and anything below 25°C was definitely not hot (truth value = 0). A temperature in between would be hot to a degree(!) somewhere between 0 and 1.

Similarly, warm and cold could have spreads of truth values, depending on the temperature. We can show this idea graphically as follows:



Of course, these relationships between temperature and truth value need not be straight lines. It is also possible to provide precise meanings to terms such as "very", "nearly", "almost" and so on. Having done so, we can write rules of the form:

IF vapour-temperature is very hot AND level-of-vessel-A is almost empty

THEN decrease pressure by 15%

This rule represents a sophisticated function relating the temperature of the vapour, the level of vessel A, and the pressure. The complexity is hidden in a number of places: within the definitions of *hot*, *empty*, *very* and *almost*; within the reasoning mechanism that combines fuzzy truth values (i.e. how AND and OR operate on fuzzy truth values); how the reasoning mechanism deals with the action part of the rule (e.g. working out to *what degree* the pressure is decreased by 15%).

The beauty of fuzzy logic is that a very complex relationship can be represented by a rule that is simple to express and very easy to understand. Just a few rules of this nature can be used to cover all ranges of temperature and level. Together they would constitute a complete control system for pressure adjustment that is intuitive, comprehensible, and could be developed without needing advanced mathematical skills.

Fuzzy logic is clearly related to knowledge-based systems. The fuzzy rules are the way to represent knowledge, whilst the principles of fuzzy logic constitute the reasoning mechanism.

Fuzzy systems have proved to be very effective in many control applications, and an increasing number of controller chips are based on the technology. These are finding their way into washing machines, cameras, electric drills and other equipment. The technology has also been used very successfully in certain areas of the process industries, particularly the cement industry.

The benefits of fuzzy systems for control applications are:

- they can deal with noisy and uncertain data
- application knowledge can be directly encoded into the rules
- no programming is needed
- their operation can be intuitively understood - as opposed to being a 'black box'
- development times can be very short
- they can operate quickly
- they can be implemented in hardware for even greater speed of operation

As well as control applications, fuzzy rules can be used for decision support applications. In this case the technology is very similar to rule-based expert systems but with the added feature of being able to represent and reason with fuzzy concepts.

Neuro-Fuzzy Systems

Fuzzy systems, as described above, are ideal in situations where the data is noisy and/or uncertain, and where the knowledge is already known. Where the knowledge is *not* already known but where there are historical examples available, it is necessary to use a learning technology. The most obvious choice might be neural nets which can be used to cope with the noisy and uncertain data. However, neuro-fuzzy systems can also be used.

The term 'neuro-fuzzy' is itself fuzzy and means different things to different people. However, what is common to all the meanings is that there is an element of learning involved. One approach to this is to assign a weight to each rule in the fuzzy rule-base. The weight determines *the degree of relevance* of the rule. A 'learning algorithm' is used to examine the historical data and adjust the weights so as to obtain the required results. This is similar to the way in which neural networks are trained. **In fact, by linking a neural net to a set of fuzzy rules with weights, the powerful neural net learning algorithms can be used to set the weights for the rules.**

Neuro-fuzzy systems thus combine the advantages of fuzzy rules and of neural nets:

- the ability to deal with noise and uncertainty,
- the ability to learn from past examples, and
- the ability to be understood by humans.

Suppliers of Fuzzy Logic Products and Services

- Comdale
- Gensym
- LPA
- TransferTech

Comdale

Comdale Expert Optimizer

Comdale Technologies Inc.

HQ. Other outlets: **Canada**, USA

Case Study

Description

A powerful real-time expert system component which can run either embedded into the Comdale ProcessVision (CPV) environment or integrated into another platform.

Using both quantitative data from the field and qualitative information from fuzzy sets within the tool, CEO continuously applies the reasoning, strategies and techniques of your best operators and technical personnel to achieve both optimization and improved economic return.

Platforms and Costs: First Released:

Gensym

G2 Diagnostic Assistant *Gensym*

Case Study

HQ. Other outlets:
USA, Canada , Germany, Italy, Netherlands , UK , France, Sweden, Tunisia, South Africa, Japan, Australia, Hong Kong, Korea

Description

The GDA is an integrated visual application environment that aids engineers throughout the life-cycle of an intelligent process management application, and features graphical components which provide decision support, operating rules, procedure enforcement, fuzzy control and smart alarming.

Platforms and Costs: First Released: ???? 19??

Logic Programming Associates

FLINT

Logic Programming Associates

Case Study

HQ. Other outlets:
UK, USA

Description

FLINT stands for Fuzzy Logic INferencing Toolkit, a toolkit which allows the development of fuzzy logic expert systems within either LPA Prolog or the LPA FLEX expert system shell.

FLINT supports fuzzy variables, such as speed, temperature, size and so on, fuzzy qualifiers, such as fast, hot and large and also fuzzy modifiers, like very, extremely, quite, and not very. It supports two standard defuzzifiers, the centroid and peak methods, and also allows the nomination of user-defined defuzzifiers.

Interfaces to external applications and languages are provided by means of DDE, DLLs and a rich set of formatted input/output routines.

Platforms and Costs: First Released:

Windows, Macintosh

TransferTech

Fuzzy Control Manager

TransferTech GmbH

Case Study

Company Description

HQ. Other outlets:
Germany

Description

The **Fuzzy Control Manager (FCM)** provides an intuitively usable GUI running under MS Windows. It is used to define fuzzy systems of any complexity. As a result of the window-oriented user interface of the FCM, all relevant data may be displayed simultaneously while developing, debugging, and optimizing. Several software interfaces are available for data exchange with other applications or target systems. An integrated, speed-optimized generation of source code for any hardware enables you to use fuzzy systems even in time critical high-performance applications.

Platforms and Costs:
Windows, DM 3100

First Released:

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What are Knowledge Based Systems?

Recognising that the people in an enterprise are one of its most important assets, companies have been continuously providing them with more and more computer support.

Until recently, this meant providing them with more

Examples of such expertise are

- machine fault diagnosis
- process control
- equipment configuring
- maintenance planning
- quality control

accurate, more timely and more readily-available information. But this has not been enough.

- risk assessment
- medical diagnosis
- software support systems
- demand forecasting
- task scheduling
- process design
- advising on safety
- financial analysis

Companies are realising that the major distinguishing characteristic between them and their competitors is the expertise of their staff: the skill and judgement being applied to the information.

So, to make even better use of its assets, a company needs to automate key parts of the tasks that require expertise. Early attempts to do this failed because these tasks are too complex, too unstructured, and not readily analysable using conventional techniques.

The reason for the difficulty was because the programming paradigm that was being used does not allow for knowledge to be represented explicitly and these tasks rely on the application of knowledge to a much greater extent than previous tasks that were automated.

The conventional view of a program is:

PROGRAM = ALGORITHM + DATA

This view does not recognise that the algorithm has two components: knowledge and control.

To take an example, consider a payroll program.

The knowledge is the rules and regulations set out by the government's tax and other legislation and the company's remuneration, overtime and other policies.

With this new insight, we have:

PROGRAM = KNOWLEDGE + CONTROL + DATA

The control is that which determines the order in which the processing operations are to be performed. (The data is the information about a particular employee - his or her rate of pay, hours worked, tax code and so on.)

This is where the new programming paradigm of knowledge-based systems (KBS) (also called expert systems) comes in.

In a KBS, the knowledge is made explicit, rather than being implicitly mixed in with the algorithm.

The end result is:

PROGRAM (KNOWLEDGE-BASED SYSTEM) = EXPLICIT KNOWLEDGE + REASONING MECHANISM + CONTROL + DATA

When this is done, the algorithm also has to include a reasoning or inference mechanism so that deductions and conclusions can be drawn from the knowledge.

With this approach, the success rate of automating the knowledge-intensive tasks in an organisation increased dramatically.

Thus, we could have:

The most common and simplest way of representing knowledge is in the form of rules - and this type of programming is sometimes referred to as rule-based programming.

IF it is evening AND the sky is red
THEN expect good weather tomorrow

IF furnace_temp > 800 AND
operate_time < 15 THEN close Feed1
AND display Warning3

Another way to represent knowledge is using frames. A frame is very similar to the concept of an object in object-oriented programming, but is rather more powerful and pre-dates it by about ten years.

Knowledge-based systems and knowledge technology can be used for an extremely wide variety of tasks since, as has been shown above, it is in essence a more advanced programming paradigm. The use of the technology should not be restricted to cases where human expertise is being automated. Rather, it should be considered wherever an application embodies a high degree of complexity.

In cases where the knowledge has never before been written down but is in the head of an expert, special analysis techniques and skills are required. These are commonly referred to as knowledge elicitation techniques.

The benefits of knowledge-based systems in general include:

- **delivering consistent decisions throughout an organisation;**
- **preserving the know-how of the most talented specialists by capturing their experience;**
- **transferring experience from the skilled specialist to the novice;**
- **building a corporate memory by sharing individual experience.**

The term "knowledge-based systems" covers a broad area and encompasses particular specialities such as those on the right among others.

- Case-Based Reasoning
- Constraint-Based Reasoning
- Fuzzy Systems
- Rule Induction

These usually employ alternative methods to represent knowledge, combined with different reasoning mechanisms. The four technologies mentioned are described in separate sections on this Website.

Suppliers of KBS Products and Services

- American Heuristics Corporation
- Brightware
- Comdale Technologies Inc.
- Gensym
- Integral Solutions
- Logic Programming Associates
- MultiLogic Inc.

American Heuristics Corporation

ICIAS

American Heuristics Corporation

HQ, Other Outlets
USA



Description

The Intelligent Case Identification and Allocation System is a hybrid system combining various artificial intelligence technologies such as, neural networks, fuzzy logic and **expert systems**.

The two main modules of ICIAS are: (1) **Case Identifier**, and (2) **Case Allocator**. The Case Identifier's (CI) function is to identify cases and rank them according to selected criteria such as the revenue each case can generate. The Case Allocator's (CA) function is to assign the ranked cases from the CI to investigators for follow-up. ICIAS will allow revenue departments to quickly and efficiently identify under-reporters from thousands of cases, thereby greatly increasing revenues.

The system operates in three modes: (1) *training mode*, (2) *operational mode*, and (3) *maintenance mode*. In training mode, new case profiles can be developed, trained and stored in a library of profiles. In operation mode, potential cases for audit are identified and allocated. In maintenance mode, system's intelligence update and maintenance tasks are performed.

Once the system has been trained to identify different types of cases in the training mode, the effort required during operational mode will be minimal. In operational mode, all that is required from the user is to specify the type of cases to be identified.

Platforms and Costs:
Platform independent, ICIAS is a customizable solution integrated into the clients existing system.

First Released: **August 1997**

ICIAS Solution starts at **$80,000**. Various modules, customization, integration and training affect price.

Brightware

ART*Enterprise

Brightware Inc. HQ, Other Outlets **USA**

Description

Brightware claim that **ART*Enterprise** is the only complete Web-enabled client/server application development tool that offers rules, cased-based reasoning and advanced object-oriented programming for building intelligent applications.

ART*Enterprise is ideally suited for applications where corporate knowledge and experience can be applied to improve key business operations. **ART*Enterprise** provides rapid prototyping, object modeling and reuse ,case-based retrieval and a sophisticated rule processing capability, with portability across multiple platforms and database management systems.

Platforms and Costs:

First Released: **1993**

Microsoft Windows (3.1, 95, NT)

OS/2 Presentation Manager
Unix/Motif (Solaris, HP-UX, AIX
MVS (Kernel Only)

Database Support:
Oracle, Sybase, Informix, DB2, Q+E, ODBC

Contact Brightware for pricing

Comdale

Comdale Expert Optimizer

Comdale Technologies Inc. HQ, Other outlets: **Canada**, USA

Description

A powerful real-time expert system component which can run either embedded into the Comdale ProcessVision (CPV) environment or integrated into another platform.

Using both quantitative data from the field and qualitative information from fuzzy sets within the tool, CEO continuously applies the reasoning, strategies and techniques of your best operators and technical personnel to achieve both optimization and improved economic return.

Platforms and Costs:

First Released:

Comdale ProcessVision

Comdale Technologies Inc.

HQ, Other outlets:
Canada, USA

Description

A state-of-the-art software platform for supervisory control. CPV provides a flexible distributed modular architecture with an easy to use graphical tool for operator interface development.

Platforms and Costs:

First Released:

Comdale Smart Alarm

Comdale Technologies Inc.

HQ, Other outlets:
Canada, USA

Description

An embedable inference engine for intelligent alarm detection and management that can be integrated into any operator interface. CSA is capable of reasoning about multiple historical and real-time values.

Platforms and Costs:

First Released:

Gensym

G2

Case Study

Gensym Corporation

HQ, Other outlets:
USA, Canada, UK, France, Germany, Italy, The Netherlands, Sweden, Tunisia, Hong Kong, Japan, Korea, Singapore, Australia

Description

Gensym's G2 software offers a graphical, object-oriented environment for creating intelligent applications that monitor, diagnose, and control dynamic events in on-line and simulated environments. Featuring a structured natural language for creating rules, models, and procedures, G2 is the foundation of all Gensym application products and end-user applications. G2 includes concurrent execution of rules and procedures and the ability to reason about behavior over time. G2 GUIDE allows users to easily create graphical end user interfaces and real-time displays. Gensym also offers many G2 Bridge Products for off-the-shelf connectivity to real-time data systems.

Platforms and Costs:

First Released: **1988**

Hardware: Digital, Hewlett-Packard, SUN, IBM, NEC, Silicon Graphics, Motorola, Intel-based PCs, Power PC

Operating Systems: UNIX, Open VMS, Windows NT, Windows 3.1, Windows 95

Costs: apply to Vendor

Fault Expert

Gensym Corporation

HQ. Other outlets:
USA, Canada, UK, France, Germany, Italy, The Netherlands, Sweden, Tunisia, Hong Kong, Japan, Korea, Singapore, Australia

Case Study

Description

Fault Expert provides intelligent fault management of distributed client/server environments. It can detect and filter events from any object within a distributed environment - including network devices and equipment, operating system components, or even applications. Then, using sophisticated rules and procedures, Fault Expert correlates and analyzes the faults, advises operators of probable root causes, and initiates automated corrective actions.

Platforms and Costs:
Apply to vendor.

First Released: **1997**

G2 Diagnostic Assistant

Gensym

HQ. Other outlets:
USA, Canada , Germany, Italy, Netherlands , UK , France, Sweden, Tunisia, South Africa, Japan, Australia, Hong Kong, Korea

Description

The GDA is an integrated visual application environment that aids engineers throughout the life-cycle of an intelligent process management application, and features graphical components which provide decision support, operating rules, procedure enforcement, fuzzy control and smart alarming.

Platforms and Costs:
Apply to Vendor

Integral Solutions

CommonKADS Workbench

Integral Solutions

Company Profile | News

HQ. Other outlets: **UK**, USA, Singapore

Detailed Product Description | Case Studies

Description

The CommonKADS WorkBench is an integrated Case toolkit which supports the analysis, design and management of KBS applications.

The Workbench incorporates six models for guiding the KBS development cycle:

- **Organisation model**
  - A model of the organisational context in which the KBS will operate.
- **Task model**
  - A model of the local task environment
- **Agent model**
  - A model of the properties of agents which perform tasks identified in the Task model. The agents can include KBS, humans or conventional IT systems
- **Communication model**
  - A model of the interaction between agents involved in the problem solving process
- **Expertise Model**
  - A model of the problem solving capability of any of the agents involved in the problem solving process
- **Design model**
  - A model of the computational and representational techniques for building the final KBS artefact

Integral Solutions is a SPONSOR OF THE AI INFORMATION BANK

Platforms and Costs:

First Released: ???? 19??

PC PACK

Integral Solutions

Company Profile | News

HQ. Other outlets: **UK**, USA, Singapore

Detailed Product Description | Case Studies

Description

PC PACK, described as a "**requirements and knowledge analysis tool**", was developed by Epistemics Ltd under contract to the UK's Defence Research Agency under the technical direction of Prof. Nigel Shadbolt of Nottingham University. Integral Solutions is the distributor of the product.

Integral Solutions is a SPONSOR OF THE AI

PC PACK consists of **nine** integrated knowledge analysis/ knowledge elicitation

tools. Surprisingly, given the maturity of KBS technology, PC PACK is the only major European product to support these techniques.

BANK

Platforms and Costs:

First Released:
???? 19??

LPA

FLEX

Logic Programming Associates

HQ, Other outlets:
UK, USA



Description

Flex is an expressive and powerful expert system toolkit which supports frame-based reasoning with inheritance, rule-based programming and data-driven procedures fully integrated within a logic programming environment. To make these constructs accesible in an intuitive way, Flex contains its own dedicated English-like Knowledge Specification Language (KSL).

Flex goes beyond most expert system shells in that is employs an open architecture and allows you to access, augment and modify its behaviour through a layer of access functions. Because of this, flex is often referred to as an AI toookit. The combination of flex and Prolog, i.e. a hybrid expert system tookit with a powerful general-purpose AI programming language, results in a functionally rich and versatile expert system development environment where developers can fine tune and enhance the built-in behaviour mechanisms to suit their own specific requirements.

Platforms and Costs:
Windows, Macintosh, Dos, Unix

First Released: 1990

MultiLogic Inc.

EXSYS Professional

MultiLogic Inc.

HQ, Other outlets:
USA, Japan, Phillipines



Case Study

Description

A Knowledge-based development tool that features a rule editor and compiler, command language, automatic validation, backward and forward chaining, blackboarding, linear programming, SQL interface, frames, report generator, fuzzy logic, neural net, tree diagramming, security, 6 confidence modes, no-fee runtime license. Embeds and interfaces to other applications, databases and process control software. Applications are completely portable across platforms.

RuleBook - For any problem that involves a selection from among a definable group of choices, where the decision is based on logical steps that can be described as a set of tree diagrams. The trees can involve relative probabilities of a choice being correct, or derive information used in other trees.

Professional - Input is in English text, algebraic expression or menu selection. Developer interface has menus, prompts and help. A built-in automatic validation system detects errors in logic. Validation graphs provide a way to graphically examine data produced during system validation. The Command Language provides maximum control and flexibility using sub-sets, looping and conditional tests. "Point-and-click" design program for end user screen customization. The Report Generator provides many output alternatives. Applications built with Professional can be run on web sites using the EXSYS (WREN).

Platforms and Costs: MS-Windows, 95, NT, Solaris, Macintosh, SUN, DOS, VAX
MS-Windows - $2,900.
Contact vendor for pricing on other platforms.
50% university discount.

First Released: 1985

EXSYS Web Runtime Engine (WREN)

MultiLogic Inc.

HQ, Other outlets:
USA, Japan, Phillipines



Case Study

Description

Systems developed with EXSYS tools make decision-making knowledge available on the Web. Users are asked questions by the system which then makes recommendations to problems. Multiple users can simultaneously access expert knowledge, 24 hours a day, for tech support, product selection, help desks, etc. Secured knowledge from one site is accessed and shared by others via an Intranet.

Decision-making logic on web sites and intranets provides users with customized, expert consultations to answer their questions. Provides interaction with domain expert knowledge that can make recommendations and explain problem solutions. Links through HTML to other pages for a manual reference, specific product data or specialized support. Developed EXSYS expert systems can be moved to a web site in minutes and run with default settings, or customized to match the existing look and feel of a web site. Based entirely on HTML and automatically uses CGI forms to ask the user questions, present conclusions and explain its logic. WREN has a default format for the CGI forms and automatically calls the form and gets data back to EXSYS. Directories can be password protected. Rule displays to explain logic can optionally be switched off, preventing unauthorized examination of decision-making logic.

Platforms and Costs: Sun Unix, Intel Based Windows NT, HP-UX
Runtime only - $5,595
Development Software and Runtime, $7,995
Software, Runtime and Training Package - $9,995
50% educational discount.

First Released: 1996

EXSYS Linkable Object Modules

MultiLogic Inc.

HQ, Other outlets:
USA, Japan,
Phillipines

Case Study

Description

EXSYS Linkable Object Modules enable the user to develop highly customized EXSYS expert system programs. With this product you can:

- Add up to 100 user defined functions, which behave like internal EXSYS commands to perform special functions for data acquisition or display.
- Create custom windows or dialogs in a custom command and update from the event stream.
- Access custom commands from the custom Runtime or the custom Editor.
- Convert knowledge-based files to C code to compile and link with the inference engine to produce a single .EXE program.
- Embed the inference engine within another application.
- Reduce load time of external programs by linking them as internal routines.
- Directly access knowledge-base data structures.
- Access high level functions through C language API.
- Change default screens used to ask questions and modify dialog boxes used to ask questions or present data.
- Customize or enlarge the help system.
- Add DDE links to other programs.

Platforms and Costs:
Windows, NT, 95, Mac, OS/2, UNIX, VAX, others
Linkables only for MS-Windows - $5,000
Development/Runtime Package plus Linkables - $6,500
Call on other platforms and for site licensing.

First Released: 1991

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UPS Software Downloads

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Alta Vista Web Pages (1-20 of 321870)

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amazon.com Find Related Books

- Fuzzy Thinking (Technique) - **Fuzzy Thinking**. Western **thinking** is based on Aristotle ... around 2000 years old. So much of our logic and decision making depends on True/False or Yes/No.
  --http://www.ozemail.com.au/~caveman/Creative/Technique...

- Fuzzy Thinking : The New Science of Fuzzy Logic - Text-Only. **Fuzzy Thinking** : The New Science of **Fuzzy** Logic by Bart Kosko. List: $16.95 Our Price: $11.87 You Save: $5.08 (30%) Availability: This title...
  --http://www.amazon.com/exec/obidos/ISBN=0944993974/u/

- MEDIOTHEK: **Fuzzy thinking** : the new science of **fuzzy** logic / Bart Kosko - Katalog der Mediothek für Berufsbildung. Amt für Berufsbildung des Kantons Zürich. Titel. **Fuzzy thinking** : the new science of **fuzzy** logic /.
  --http://agora.unige.ch/berufsbildung/f/j532.html

- Bart Kosko -- Fuzzy Thinking - Bart Kosko. **Fuzzy Thinking**. 1993. Bart Kosko Home Page. Dynamic links: Alta Vista search. Bart Kosko. **Fuzzy Thinking**. Flamingo. 1993. **Fuzzy** logic deals...
  --http://public.logica.com/~stepneys/bib/nf/kosko.htm

- Who is thinking fuzzy? - Who is **thinking fuzzy**? [Follow Ups] [Post Followup] [Today's TMJ4 News Forum] Posted by Ed on July 27, 1997 at 21:55:29: In Reply to: Ed's **fuzzy**...
  --http://www.touchtmj4.com/newsforum/messages/286.htm

- Re: Who is thinking fuzzy? - Re: Who is **thinking fuzzy**? [Follow Ups] [Post Followup] [Today's TMJ4 News Forum] Posted by Hugh Briss on July 28, 1997 at 13:16:12: In Reply to:...
  --http://www.touchtmj4.com/newsforum/messages/287.htm

- Fuzzy Thinking - **Fuzzy Thinking**. **Fuzzy Thinking**. Data Mining. Helicopters and Bayesians. Previous slide. Next slide. Back to the first slide. View Graphic Version.
  --http://physics.www.media.mit.edu/~neilg/talks/predict...

- Fuzzy Thinking - **Fuzzy Thinking**. Data Mining. Helicopters and Bayesians. -->
  --http://physics.www.media.mit.edu/~neilg/talks/predict...

- Re: Who is thinking fuzzy? - Re: Who is **thinking fuzzy**? [Follow Ups] [Post Followup] [Today's TMJ4 News Forum] Posted by Ed on July 28, 1997 at 22:02:46: In Reply to: Re:

Who is.
--http://www.touchtmj4.com/newsforum/messages/288.htm

- Citizens Against Stupid People and **Fuzzy Thinking** - This is so amazingly arrogant it deserves preservation. From: tangle@iadfw.net (Tim of Angle) To: Patrick Farley. Subject: Re: So, WHY are liberals...
--http://www.abattoir.com/~prime8/Chronofile/1995/10199...

- **Fuzzy thinking** produces better anaesthesia - **Fuzzy thinking** produces better anaesthesia. By Anne Sarzin. Electrical Engineering student David Lin (pictured right) has designed a prizewinning...
--http://www.usyd.edu.au/su/exterel/news/961121News/21....

- DAVID SKLANSKY - Fighting **Fuzzy Thinking** - PLEASE READ THIS WEEK'S COLUMN IN CARD PLAYER. CARD PLAYER. RETURN TO COLUMNS.
--http://www.cardplayer.com/sklansky.htm

- **Fuzzy Thinking** - The New Science of Fuzzy Logic - KOSK93a], Kosko, B., **Fuzzy Thinking** - The New Science of **Fuzzy** Logic, Hyperion, New York, NY, 1993. Professor Bart Kosko is one of the most recognized...
--http://www.afit.af.mil/Schools/EN/graphics/annobib/ko...

- Ed's **fuzzy thinking** - Ed's **fuzzy thinking**. [Follow Ups] [Post Followup] [Today's TMJ4 News Forum] Posted by Hugh Briss on July 27, 1997 at 12:09:40: In Reply to: Re:...
--http://www.touchtmj4.com/newsforum/messages/284.htm

- ACCU Digest of Book Reviews - **Fuzzy Thinking** by Bart Kosko, Flamingo books, [s - border=0> **Fuzzy Thinking** by Bart Kosko, Flamingo books, [sterling]7.99. (other details not provided) Reviewed by Rob Henley (7-3) This book wasn't on the..
--http://brian.accu.org/bookreviews/public/digest/dbrf21.htm

- Poker, Gaming, and Life : Fighting **Fuzzy Thinking** - Poker, Gaming, and Life : Fighting **Fuzzy Thinking** by David Sklansky
--http://rf.rexl.boise.id.us/v/research.pl/rfrexlboise/...

- VJF Library Career Resources: **Fuzzy Thinking** - **Fuzzy Thinking**. By John Dinan. A Boston Globe article a few months ago told how a software house lost almost half its stock market value in one day...
*--http://www.careerexpo.com/pub/docs/**fuzzy**.html*

- **Fuzzy thinking** - Next: Food and fact Up: Food fads Previous: Food fads. **Fuzzy thinking**. First, a legitimate researcher publishes a study in the New England Journal of...
--http://www.fourmilab.ch/hackdiet/www/subsubsection1_2...

- **Fuzzy** archive: Re: Kosko's '**Fuzzy Thinking**' - Re: Kosko's '**Fuzzy Thinking**' ShankarS (shankars@aol.com) 13 Sep 1995 00:13:28 -0400. Messages sorted by: [date][thread][subject][author] Next...
*--http://www.dbai.tuwien.ac.at/marchives/**fuzzy**-m...*

- **Fuzzy** Critter Studios - Possibility **Thinking** - Possibility **Thinking**. Examples. 1. Discovering alternating current, for electric motors was a breakthrough after much experimentation by

many people. 2....
--http://fuzzycritter.com/fcs-tools/possibility_exmp.html

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Yellow Pages - People Search - City Maps - Get Local - Today's Web Events & Chats - **More Yahoos**

Copyright © 1994-98 Yahoo! All Rights Reserved. - Company Information - Help - Search Feedback

Timothy Masters, Practical Neural Network Recipes in C++, Academic Press
describe varias estrategias neurales, (con un disco) también la lóg. fuzzy y algoritmos genéticos.

David Goldberg, "Genetic Algorithms", Addison Wesley.

exige un poco de maths. pero no tanto. Explica como y porque trabajan los algoritmos genéticos

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From Kirkus Reviews , 05/01/93:
Aristotle is out and Buddha is in; the law of the excluded middle (either A or not-A) is repealed, and A and not-A together replaces it. No more black and white, right and wrong, true or false. In their place come shades of gray, more or less, maybe so, maybe not. Why? Because the new world of fuzzy logic more closely mirrors reality, has a rigor all its own, and is paying off in the marketplace. Kosko (Electrical Engineering/USC) has been called the ``St. Paul" of fuzziness, and for good reason: Not only has he contributed major theories and proofs in the development of fuzzy logic, but he's also been a major proselytizer and gadfly, organizing conferences and frequently going on the road (which usually leads to Japan). He's also young...which may account for the passion and posturing that color the text. Indeed, until Kosko gets down to chapter and verse on what FL is and how it works, reader will be put off by the constant put-down of Western logic and philosophy and opposing schools of computer science. But when Kosko is good, he's very, very good. One comes away from his text with a real understanding of the concepts of fuzzy sets, rules, and systems, and of how they're applied to make ``smart" machines, devices, trains, and planes. He's also good in extending these ideas to neural nets in hypothesizing how brains change, learn, get smart. But toward the end, he plunges big time

into metaphysical questions about life, death, cosmology, God (seen as the math- maker). Curious about the future, Kosko says that he'll opt for freezing at death. Still, for all the self-indulgence, probably the best primer around for learning what FL is all about, certainly cuts above Daniel McNeill and Paul Freiberger's Fuzzy Logic (p. 45). -- *Copyright ©1993, Kirkus Associates, LP. All rights reserved.*

Synopsis:
Fuzzy logic's leading proponent explains how "fuzzy thinking" can lead us out of the system of binary logic--and can challenge the very basis of our culture. 2 cassettes. *--This text refers to the cassette edition of this title.*

Synopsis:
brings readers up to speed on the ""smart"" products and computers that will change all of our lives in the future.

Midwest Book Review :
Fuzzy logic is a science and way of thinking which challenges ordinary mental habits and provides a changing, flowing world view which challenges cut and dry mental processes. Bart Kosko is a leader in the fuzzy logic way of thinking: his is an excellent and lively presentation which is even more compelling in audio form. *--This text refers to the cassette edition of this title.*

Customer Comments
Buddahed@MSN.com , 08/12/96, rating=10:
Life changing
Growing up in the U.S., never truly appreciated Eastern thought patterns of a non-binary nature. This book has changed the way I look at things and did it in a very clear and logical way without getting boring. Bart Kosko a someone who deserves the following he has. Fantastic reading. *--This text refers to the paperback (reprint) edition of this title.*

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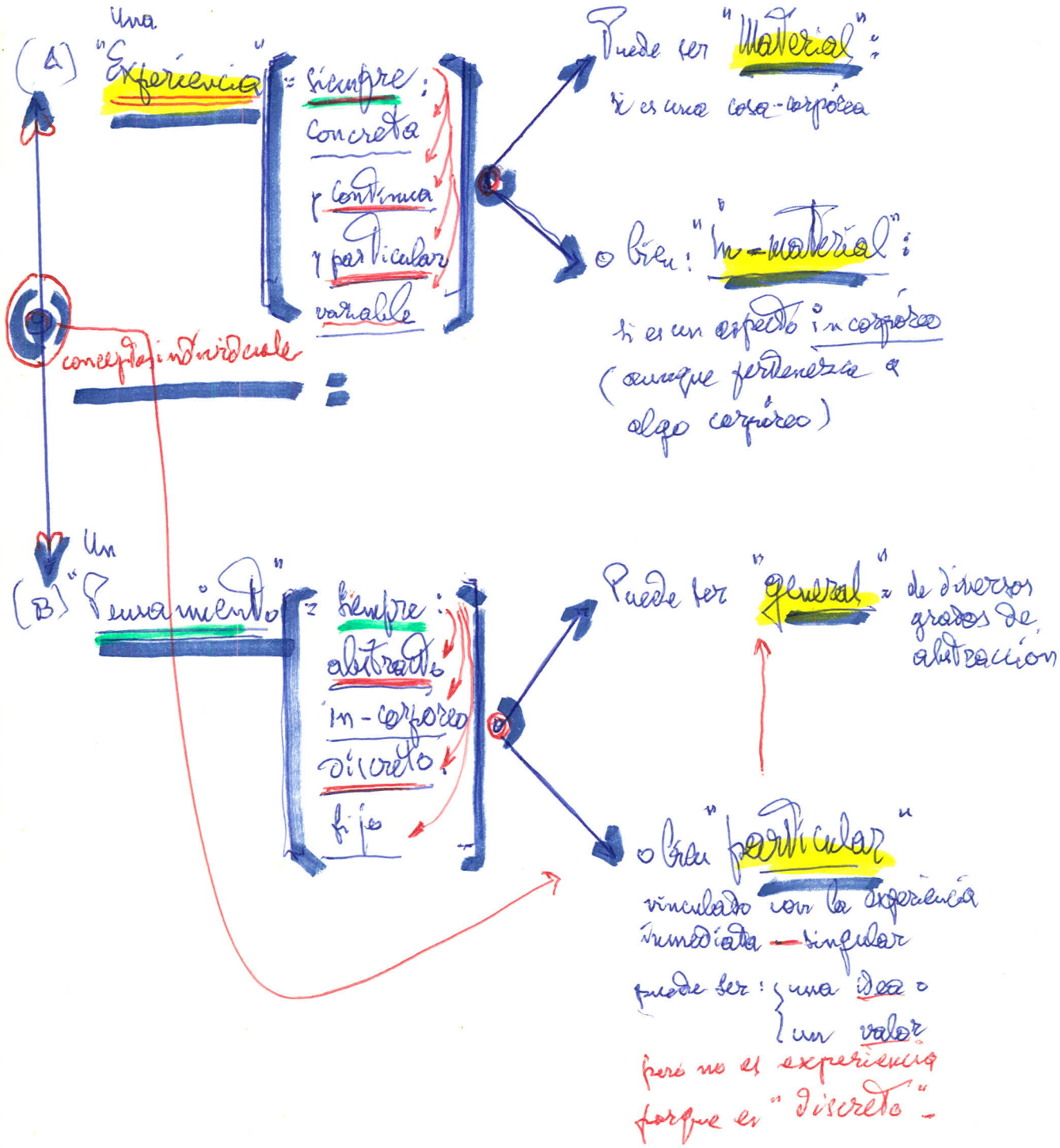
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Los "elementos básicos" que se manejan, son:



Fuzzy Logic

MAJ Atkinson

Definition

Fuzzy Logic:
In Fuzzy Logic, truth values are real values in the closed interval [0..1]. The definitions of the boolean operators are extended to fit this continuous domain. By avoiding discrete truth-values, Fuzzy Logic avoids some of the problems inherent in either-or judgments and yields natural interpretations of utterances like "very hot". Fuzzy Logic has applications in control theory.

Resources

- AI Center Papers
  - Fuzzy Logic Overwatch Paper
- WWW Pages
  - Fuzzy Logic Archvie
  - The World-Wide Web Virtual Library: Logic Programming
  - FuzzyCLIPS
- Gopher Servers
  - Fuzzy Logic News Answers *DIR*
  - fuzzy_logic.faq
  - Conference on Fuzzy logic May 26 and 27, 1995
  - >comp.ai.fuzzy
  - Journal of intelligent & fuzzy systems.
- Repositories
  - ntia.its.bldrdoc.gov
  - Ostfold Regional College, Norway
- Databases
  - BibTeX database addressing neuro-fuzzy issues via ftp
- Other Information
  - The Fuzzy FAQ

Pero = Frege se olvida que el "significado" pertenece a la mente y no al lenguaje!
Esta confusión genera muchos excesos! (se maleva un desarrollo lógico)

CAMPO DE APLICACIÓN -

La lógica-fuzzy solo opera entre "contrarios" que admiten infinitas posiciones intermedias y portando "medidas-parciales" = entre cosas concretas experimentales:

Pero si la oposición llega a valores "contradictorios" entonces (0-1); (Si-No); coincide con la lógica corriente = lógica y — aristotélica.

Oposición entre "discreto" ⟷ "continuo"! = [abstracto ⟷ y experimental.]

"Discretos" son los "conceptos" que "definen" una realidad! a nivel de pensamiento!
"Continua" a la "realidad" (que se conceptualiza) = se traslada al pensar.
y se capta. continua con la SENSACIÓN = ti es material

= La oposición entre discreto y continuo no es superable! Cada vez que se intenta superar la "separación - entre discretos"; se subdivide en tipo de "conceptos" - 1) con otro concepto, o bien, = nivel epistemológico.
- 2) con una "palabra" = nivel lingüístico.
- 3) con una fórmula-matemática = nivel simbólico.
- 4) con un "signo" cualquiera = semiótica.

- En todo caso el concepto permanece encerrado en el ámbito [especulativo conceptual semiótico] que en un ámbito de entidades discretas! {percepciones y conceptos.
- La "realidad" se encuentra en otro ambito y se nos da como: continua!

La "aproximación" entre {ámbito discreto! / ámbito - continuo.} ⟹ es un proceso que puede ser mejorado! = una "aproximación", en proceso, que nunca llega a "plenificarse" definitivamente! en el sentido de llegar a una plenitud - estática: inmóvil!

Index of Resources

Workshops and Conferences
Fuzzy Logic related Journals
Fuzzy Logic Researchers
Fuzzy Logic Tools and Companies
General Sources of Information
Back to main fuzzy page

Periódicos

(IFSA)

① = IEEE Transactions on Fuzzy Systems (Bruselas)

② = Fuzzy Sets and Systems.

③ = International Journal of Uncertainty - Fuzzy; and Knowledge Based Systems.

"Bob John" zij@dmu.ac.uk = zij@dmu.ac.uk

④ = "International journal - of "approximate Reasoning" >> publica de NAFIPS - 8 números al año $282 (72 miembros) NY. David Reilly. e-mail 71740.2606@compuserve.com

③ Tiene una Web: http://www.wspc.co.uk/wspc/journals/ijufks/ijufks.html

Adaptive-Logic.

« http://www.adaptivelogic.com/ »

FRIL = "fuzzy relational inference language"

31. Inia L. Rolesu (Ed.) Trevor Martin (Ed.):

"Fuzzy Logic in Artificial Intell.: Towards Intelligent Systems" — Lecture Notes in Artificial Intell. 1995

- Introduction
- [1] What is the purpose of this newsgroup?
- [2] What is fuzzy logic?
- [3] Where is fuzzy logic used?
- [4] What is a fuzzy expert system?
- [5] Where are fuzzy expert systems used?
- [6] What is fuzzy control?
- [7] What are fuzzy numbers and fuzzy arithmetic?
- [8] Isn't "fuzzy logic" an inherent contradiction? Why would anyone want to fuzzify logic?
- [9] How are membership values determined?
- [10] What is the relationship between fuzzy truth values and probabilities?
- [11] Are there fuzzy state machines?
- [12] What is possibility theory?
- [13] How can I get a copy of the proceedings for ?
- [14] Fuzzy BBS Systems, Mail-servers and FTP Repositories
- [15] Mailing Lists
- [16] Bibliography
- [17] Journals and Technical Newsletters
- [18] Professional Organizations
- [19] Companies Supplying Fuzzy Tools
- [20] Fuzzy Researchers
- [21] Elkan's "The Paradoxical Success of Fuzzy Logic" paper
- [22] Glossary
- [24] Where to send calls for papers (cfp) and calls for participation

NB:
Para llegar a esta página:
(1) "Internet" = allí ! click en "buscar páginas". (la última línea)
(2) en yahoo, poner: Sciences ! Computer Science: Artif. Intelig.
(3) En el cuadrito, escribir: Fuzzy Logic ; aparece esta lista.

San Borja
Residencia

Tool and Fox

Fuzzy Systems Development Tools

En = Fuzzy Logic and Neuro Fuzzy Tools (Software ScatterMap)

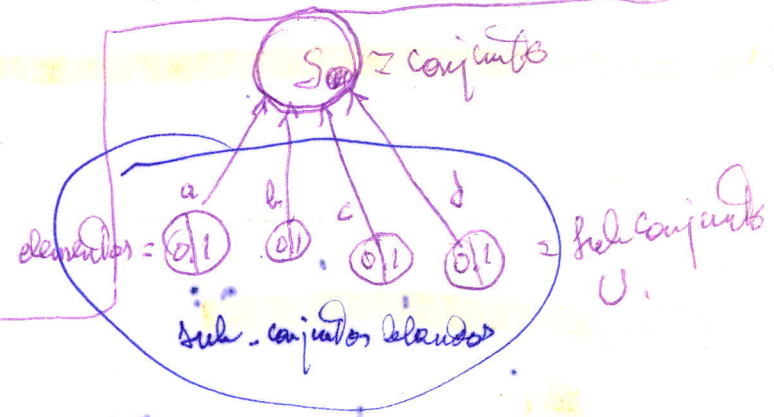
En Matlab En Fuzzy Inference

En: U. Toronto Department of Mechanical Engineering

En Fuzzy Logic Apli ....

Subir

H. Mf



(a c U) { 0 0
0 1

Los conjuntos blandos son todos sub-conjuntos.

No hay un sistema de conjuntos blandos = Un sistema de conjuntos incluye solo conjuntos duros - rígidos (definidos)

1 metro : 3,28 pie

1 pie = 0,30 m.

El sistema de conjuntos - rígidos = S.

incluye un subsistema de conj sub conjuntos - blandos

Conversión pies =

Apto.postal 39 C
Tel. directo: 3640523
Fax: 3640423
Tel URL: 3690691 ext. 515

[2] What is fuzzy logic?

Date: 15-APR-93

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth -- truth values between "completely true" and "completely false". It was introduced by Dr. Lotfi Zadeh of UC/Berkeley in the 1960's as a means to model the uncertainty of natural language. (Note: Lotfi, not Lofti, is the correct spelling of his name.)

Zadeh says that rather than regarding fuzzy theory as a single theory, we should regard the process of ``fuzzification'' as a methodology to generalize ANY specific theory from a crisp (discrete) to a continuous (fuzzy) form (see "extension principle" in [2]). Thus recently researchers have also introduced "fuzzy calculus", "fuzzy differential equations", and so on (see [7]).

Fuzzy Subsets:

Just as there is a strong relationship between Boolean logic and the concept of a subset, there is a similar strong relationship between fuzzy logic and fuzzy subset theory.

In classical set theory, a subset U of a set S can be defined as a mapping from the elements of S to the elements of the set {0, 1},

U: S --> {0, 1}

This mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of S. The first element of the ordered pair is an element of the set S, and the second element is an element of the set {0, 1}. The value zero is used to represent non-membership, and the value one is used to represent membership. The truth or falsity of the statement

x is in U

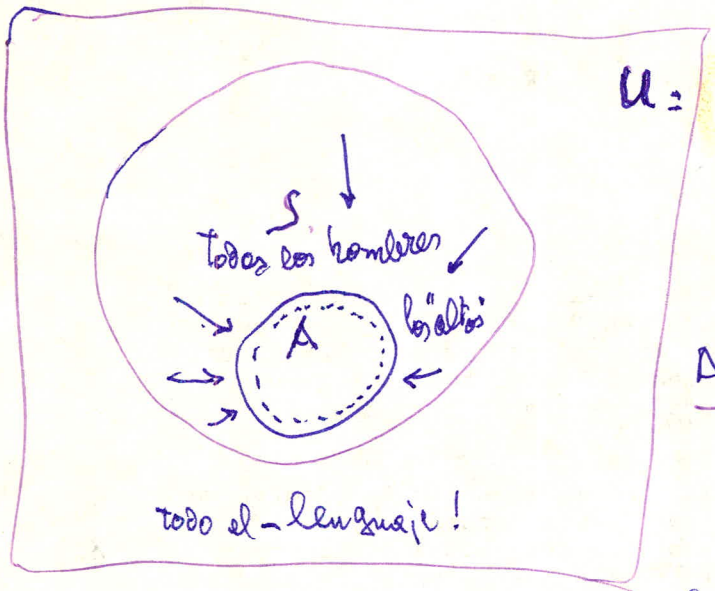
is determined by finding the ordered pair whose first element is x. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

Similarly, a fuzzy subset F of a set S can be defined as a set of ordered pairs, each with the first element from S, and the second element from the interval [0,1], with exactly one ordered pair present for each element of S. This defines a mapping between elements of the set S and values in the interval [0,1]. The value zero is used to represent complete non-membership, the value one is used to represent complete membership, and values in between are used to represent intermediate DEGREES OF MEMBERSHIP. The set S is referred to as the UNIVERSE OF DISCOURSE for the fuzzy subset F. Frequently, the mapping is described as a function, the MEMBERSHIP FUNCTION of F. The degree to which the statement

x is in F

is true is determined by finding the ordered pair whose first element is x. The DEGREE OF TRUTH of the statement is the second element of the ordered pair.

In practice, the terms "membership function" and fuzzy subset get used



U = universo del discurso

S = conjunto de todos los hombres

< 5 pies = 1.50

A(x) - 1.50 / 10 cm if 1.55 < 2.10 (Δx)

S() = el conjunto de todos los hombres. = conjunto - rígido

Alto = Subconjunto - blando !

Alto = una variable linguística = "A"

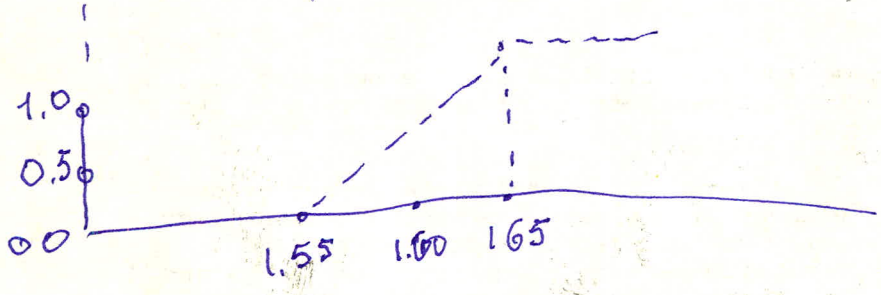
Es necesario definir la "función de membrecía" de los elementos de "A".

para eso encontrar el "grado de pertenencia" al subconjunto blando!

Alto : Ax = 0 si es < que 1.55 m Ax membrecía cero

Δx - 1.55 / 10 cm. Si 1.55 = - Δx <= 1.65

1 si es > de 1.65 Ax membrecía uno.



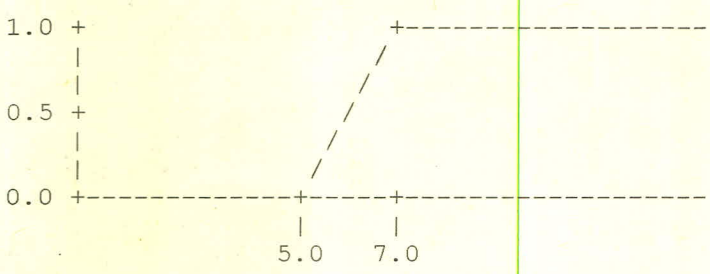
Relación de medidas - con bordes — grande = fuzzy
— para su edad = fuzzy

interchangeably.

That's a lot of mathematical baggage, so here's an example. Let's talk about people and "tallness". In this case the set S (the universe of discourse) is the set of people. Let's define a fuzzy subset TALL, which will answer the question "to what degree is person x tall?" Zadeh describes TALL as a LINGUISTIC VARIABLE, which represents our cognitive category of "tallness". To each person in the universe of discourse, we have to assign a degree of membership in the fuzzy subset TALL. The easiest way to do this is with a membership function based on the person's height.

```
tall(x) = { 0,                    if height(x) < 5 ft.,
          { (height(x)-5ft.)/2ft., if 5 ft. <= height (x) <= 7 ft.,
          { 1,                    if height(x) > 7 ft. }
```

A graph of this looks like:



Given this definition, here are some example values:

Person	Height	degree of tallness
Billy	3' 2"	0.00 [I think]
Yoke	5' 5"	0.21
Drew	5' 9"	0.38
Erik	5' 10"	0.42
Mark	6' 1"	0.54
Kareem	7' 2"	1.00 [depends on who you ask]

Expressions like "A is X" can be interpreted as degrees of truth, e.g., "Drew is TALL" = 0.38.

Note: Membership functions used in most applications almost never have as simple a shape as tall(x). At minimum, they tend to be triangles pointing up, and they can be much more complex than that. Also, the discussion characterizes membership functions as if they always are based on a single criterion, but this isn't always the case, although it is quite common. One could, for example, want to have the membership function for TALL depend on both a person's height and their age (he's tall for his age). This is perfectly legitimate, and occasionally used in practice. It's referred to as a two-dimensional membership function, or a "fuzzy relation". It's also possible to have even more criteria, or to have the membership function depend on elements from two completely different universes of discourse.

Logic Operations:

Now that we know what a statement like "X is LOW" means in fuzzy logic, how do we interpret a statement like

X is LOW and Y is HIGH or (not Z is MEDIUM)

The standard definitions in fuzzy logic are:

```
truth (not x)   = 1.0 - truth (x)
truth (x and y) = minimum (truth(x), truth(y))
truth (x or y)  = maximum (truth(x), truth(y))
```

Some researchers in fuzzy logic have explored the use of other interpretations of the AND and OR operations, but the definition for the NOT operation seems to be safe.

Note that if you plug just the values zero and one into these definitions, you get the same truth tables as you would expect from conventional Boolean logic. This is known as the EXTENSION PRINCIPLE, which states that the classical results of Boolean logic are recovered from fuzzy logic operations when all fuzzy membership grades are restricted to the traditional set {0, 1}. This effectively establishes fuzzy subsets and logic as a true generalization of classical set theory and logic. In fact, by this reasoning all crisp (traditional) subsets ARE fuzzy subsets of this very special type; and there is no conflict between fuzzy and crisp methods.

Some examples -- assume the same definition of TALL as above, and in addition, assume that we have a fuzzy subset OLD defined by the membership function:

```
old (x) = { 0,                        if age(x) < 18 yr.
            (age(x)-18 yr.)/42 yr., if 18 yr. <= age(x) <= 60 yr.
            1,                        if age(x) > 60 yr. }
```

And for compactness, let

```
a = X is TALL and X is OLD
b = X is TALL or X is OLD
c = not (X is TALL)
```

Then we can compute the following values.

height	age	X is TALL	X is OLD	a	b	c
3' 2"	65	0.00	1.00	0.00	1.00	1.00
5' 5"	30	0.21	0.29	0.21	0.29	0.79
5' 9"	27	0.38	0.21	0.21	0.38	0.62
5' 10"	32	0.42	0.33	0.33	0.42	0.58
6' 1"	31	0.54	0.31	0.31	0.54	0.46
7' 2"	45	1.00	0.64	0.64	1.00	0.00
3' 4"	4	0.00	0.00	0.00	0.00	1.00

For those of you who only grok the metric system, here's a dandy little conversion table:

Feet+Inches	Meters
3' 2"	0.9652
3' 4"	1.0160
5' 5"	1.6510
5' 9"	1.7526
5' 10"	1.7780
6' 1"	1.8542
7' 2"	2.1844

An excellent introductory article is:

Bezdek, James C, "Fuzzy Models --- What Are They, and Why?", IEEE Transactions on Fuzzy Systems, 1:1, pp. 1-6, 1993.

For more information on fuzzy logic operators, see:

- Bandler, W., and Kohout, L.J., "Fuzzy Power Sets and Fuzzy Implication Operators", Fuzzy Sets and Systems 4:13-30, 1980.

- Dubois, Didier, and Prade, H., "A Class of Fuzzy Measures Based on Triangle Inequalities", Int. J. Gen. Sys. 8.

The original papers on fuzzy logic include:

Zadeh, Lotfi, "Fuzzy Sets," Information and Control 8:338-353, 1965.

Zadeh, Lotfi, "Outline of a New Approach to the Analysis of Complex Systems", IEEE Trans. on Sys., Man and Cyb. 3, 1973.

Zadeh, Lotfi, "The Calculus of Fuzzy Restrictions", in Fuzzy Sets and Applications to Cognitive and Decision Making Processes, edited by L. A. Zadeh et. al., Academic Press, New York, 1975, pages 1-39.

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[4] What is a fuzzy expert system?

Date: 21-APR-93

A fuzzy expert system is an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. The rules in a fuzzy expert system are usually of a form similar to the following:

    if x is low and y is high then z = medium

where x and y are input variables (names for know data values), z is an output variable (a name for a data value to be computed), low is a membership function (fuzzy subset) defined on x, high is a membership function defined on y, and medium is a membership function defined on z. The antecedent (the rule's premise) describes to what degree the rule applies, while the conclusion (the rule's consequent) assigns a membership function to each of one or more output variables. Most tools for working with fuzzy expert systems allow more than one conclusion per rule. The set of rules in a fuzzy expert system is known as the rulebase or knowledge base.

The general inference process proceeds in three (or four) steps.

1. Under FUZZIFICATION, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise.

2. Under INFERENCE, the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule. Usually only MIN or PRODUCT are used as inference rules. In MIN inferencing, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth (fuzzy logic AND). In PRODUCT inferencing, the output membership function is scaled by the rule premise's computed degree of truth.

3. Under COMPOSITION, all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable. Again, usually MAX or SUM are used. In MAX composition, the combined output fuzzy subset is constructed by taking the pointwise maximum over all of the fuzzy subsets assigned tovariable by the inference rule (fuzzy logic OR). In SUM composition, the combined output fuzzy subset is constructed by taking the pointwise sum over all of the fuzzy subsets assigned to the output variable by the inference rule.

4. Finally is the (optional) DEFUZZIFICATION, which is used when it is useful to convert the fuzzy output set to a crisp number. There are more defuzzification methods than you can shake a stick at (at least 30). Two of the more common techniques are the CENTROID and MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable.

Extended Example:

Assume that the variables x, y, and z all take on values in the interval [0,10], and that the following membership functions and rules are defined:

```
low(t)  = 1 - ( t / 10 )
high(t) = t / 10

rule 1: if x is low and y is low then z is high
rule 2: if x is low and y is high then z is low
rule 3: if x is high and y is low then z is low
rule 4: if x is high and y is high then z is high
```

Notice that instead of assigning a single value to the output variable z, each rule assigns an entire fuzzy subset (low or high).

Notes:

1. In this example, low(t)+high(t)=1.0 for all t. This is not required, but it is fairly common.

2. The value of t at which low(t) is maximum is the same as the value of t at which high(t) is minimum, and vice-versa. This is also not required, but fairly common.

3. The same membership functions are used for all variables. This isn't required, and is also *not* common.

In the fuzzification subprocess, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise. The degree of truth for a rule's premise is sometimes referred to as its ALPHA. If a rule's premise has a nonzero degree of truth (if the rule applies at all...) then the rule is said to FIRE. For example,

x	y	low(x)	high(x)	low(y)	high(y)	alpha1	alpha2	alpha3	alpha4
0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
0.0	3.2	1.0	0.0	0.68	0.32	0.68	0.32	0.0	0.0
0.0	6.1	1.0	0.0	0.39	0.61	0.39	0.61	0.0	0.0
0.0	10.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0
3.2	0.0	0.68	0.32	1.0	0.0	0.68	0.0	0.32	0.0
6.1	0.0	0.39	0.61	1.0	0.0	0.39	0.0	0.61	0.0
10.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0
3.2	3.1	0.68	0.32	0.69	0.31	0.68	0.31	0.32	0.31
3.2	3.3	0.68	0.32	0.67	0.33	0.67	0.33	0.32	0.32
10.0	10.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0

In the inference subprocess, the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule.

MIN and PRODUCT are two INFERENCE METHODS or INFERENCE RULES. In MIN inferencing, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth. This corresponds to the traditional interpretation of the fuzzy logic AND operation. In PRODUCT inferencing, the output membership function is scaled by the rule premise's computed degree of truth.

For example, let's look at rule 1 for x = 0.0 and y = 3.2. As shown in the table above, the premise degree of truth works out to 0.68. For this rule, MIN inferencing will assign z the fuzzy subset defined by the membership function:

```
rule1(z) = { z / 10,  if z <= 6.8
             0.68,    if z >= 6.8 }
```

For the same conditions, PRODUCT inferencing will assign z the fuzzy subset defined by the membership function:

```
rule1(z) = 0.68 * high(z)
         = 0.068 * z
```

Note: The terminology used here is slightly nonstandard. In most texts, the term "inference method" is used to mean the combination of the things referred to separately here as "inference" and "composition." Thus you'll see such terms as "MAX-MIN inference" and "SUM-PRODUCT inference" in the literature. They are the combination of MAX composition and MIN inference, or SUM composition and PRODUCT inference, respectively. You'll also see the reverse terms "MIN-MAX" and "PRODUCT-SUM" -- these mean the same things as the reverse order. It seems clearer to describe the two processes separately.

In the composition subprocess, all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable.

MAX composition and SUM composition are two COMPOSITION RULES. In MAX composition, the combined output fuzzy subset is constructed by taking the pointwise maximum over all of the fuzzy subsets assigned to the output variable by the inference rule. In SUM composition, the combined output fuzzy subset is constructed by taking the pointwise sum over all of the fuzzy subsets assigned to the output variable by the inference rule. Note that this can result in truth values greater than one! For this reason, SUM composition is only used when it will be followed by a defuzzification method, such as the CENTROID method, that doesn't have a problem with this odd case. Otherwise SUM composition can be combined with normalization and is therefore a general purpose method again.

For example, assume x = 0.0 and y = 3.2. MIN inferencing would assign the following four fuzzy subsets to z:

```
rule1(z) = { z / 10,     if z <= 6.8
           { 0.68,       if z >= 6.8 }

rule2(z) = { 0.32,       if z <= 6.8
           { 1 - z / 10, if z >= 6.8 }

rule3(z) = 0.0

rule4(z) = 0.0
```

MAX composition would result in the fuzzy subset:

```
fuzzy(z) = { 0.32,  ------ if z <= 3.2
           { z / 10,       if 3.2 <= z <= 6.8
           { 0.68,  ------ if z >= 6.8 }
```

PRODUCT inferencing would assign the following four fuzzy subsets to z:

```
rule1(z) = 0.068 * z
rule2(z) = 0.32 - 0.032 * z
rule3(z) = 0.0
rule4(z) = 0.0
```

SUM composition would result in the fuzzy subset:

```
fuzzy(z) = 0.32 + 0.036 * z
```

Sometimes it is useful to just examine the fuzzy subsets that are the result of the composition process, but more often, this FUZZY VALUE needs to be converted to a single number -- a CRISP VALUE. This is what the defuzzification subprocess does.

There are more defuzzification methods than you can shake a stick at. A couple of years ago, Mizumoto did a short paper that compared about ten defuzzification methods. Two of the more common techniques are the CENTROID and MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable. There are several variations of the MAXIMUM method that differ only in what they do when there is more than one variable value at which this maximum truth value occurs. One of these, the AVERAGE-OF-MAXIMA method, returns the average of the variable values at which the maximum truth value occurs.

For example, go back to our previous examples. Using MAX-MIN inferencing and AVERAGE-OF-MAXIMA defuzzification results in a crisp value of 8.4 for z. Using PRODUCT-SUM inferencing and CENTROID defuzzification results in a crisp value of 5.6 for z, as follows.

Earlier on in the FAQ, we state that all variables (including z) take on values in the range [0, 10]. To compute the centroid of the function f(x), you divide the moment of the function by the area of the function. To compute the moment of f(x), you compute the integral of x*f(x) dx, and to compute the area of f(x), you compute the integral of f(x) dx. In this case, we would compute the area as integral from 0 to 10 of (0.32+0.036*z) dz, which is

```
(0.32 * 10 + 0.018*100) =
(3.2 + 1.8) =
5.0
```

and the moment as the integral from 0 to 10 of (0.32*z+0.036*z*z) dz, which is

```
(0.16 * 10 * 10 + 0.012 * 10 * 10 * 10) =
(16 + 12) =
28
```

Finally, the centroid is 28/5 or 5.6.

Note: Sometimes the composition and defuzzification processes are combined, taking advantage of mathematical relationships that simplify the process of computing the final output variable values.

The Mizumoto reference is probably "Improvement Methods of Fuzzy Controls", in Proceedings of the 3rd IFSA Congress, pages 60-62, 1989.

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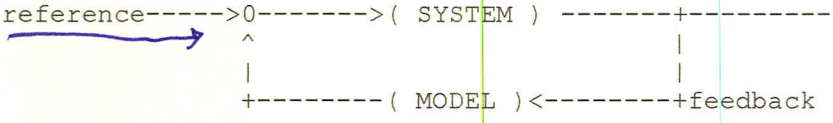
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[6] What is fuzzy control?

Date: 17-MAR-95

The purpose of control is to influence the behavior of a system by changing an input or inputs to that system according to a rule or set of rules that model how the system operates. The system being controlled may be mechanical, electrical, chemical or any combination of these.

Classic control theory uses a mathematical model to define a relationship that transforms the desired state (requested) and observed state (measured) of the system into an input or inputs that will alter the future state of that system.



The most common example of a control model is the PID (proportional-integral-derivative) controller. This takes the output of the system and compares it with the desired state of the system. It adjusts the input value based on the difference between the two values according to the following equation.

$$output = A.e + B.INT(e)dt + C.de/dt$$

Where, A, B and C are constants, e is the error term, INT(e)dt is the integral of the error over time and de/dt is the change in the error term.

The major drawback of this system is that it usually assumes that the system being modelled in linear or at least behaves in some fashion that is a monotonic function. As the complexity of the system increases it becomes more difficult to formulate that mathematical model.

Fuzzy control replaces, in the picture above, the role of the mathematical model and replaces it with another that is build from a number of smaller rules that in general only describe a small section of the whole system. The process of inference binding them together to produce the desired outputs.

That is, a fuzzy model has replaced the mathematical one. The inputs and outputs of the system have remained unchanged.

The Sendai subway is the prototypical example application of fuzzy control.

References:

Yager, R.R., and Zadeh, L. A., "An Introduction to Fuzzy Logic Applications in Intelligent Systems", Kluwer Academic Publishers, 1991.

Dimiter Driankov, Hans Hellendoorn, and Michael Reinfrank, "An Introduction to Fuzzy Control", Springer-Verlag, New York, 1993. 316 pages, ISBN 0-387-56362-8. [Discusses fuzzy control from a theoretical point of view as a form of nonlinear control.]

C.J. Harris, C.G. Moore, M. Brown, "Intelligent Control, Aspects of Fuzzy Logic and Neural Nets", World Scientific. ISBN 981-02-1042-6.

T. Terano, K. Asai, M. Sugeno, editors, "Applied Fuzzy Systems",

translated by C. Ascchmann, AP Professional. ISBN 0-12-685242-1.

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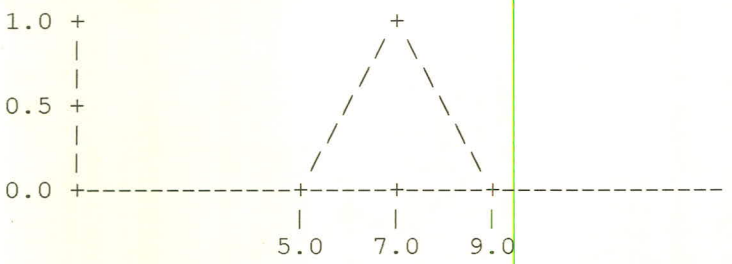
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[7] What are fuzzy numbers and fuzzy arithmetic?

Date: 15-APR-93

Fuzzy numbers are fuzzy subsets of the real line. They have a peak or plateau with membership grade 1, over which the members of the universe are completely in the set. The membership function is increasing towards the peak and decreasing away from it.

Fuzzy numbers are used very widely in fuzzy control applications. A typical case is the triangular fuzzy number



which is one form of the fuzzy number 7. Slope and trapezoidal functions are also used, as are exponential curves similar to Gaussian probability densities.

For more information, see:

Dubois, Didier, and Prade, Henri, "Fuzzy Numbers: An Overview", in Analysis of Fuzzy Information 1:3-39, CRC Press, Boca Raton, 1987.

Dubois, Didier, and Prade, Henri, "Mean Value of a Fuzzy Number", Fuzzy Sets and Systems 24(3):279-300, 1987.

Kaufmann, A., and Gupta, M.M., "Introduction to Fuzzy Arithmetic", Reinhold, New York, 1985.

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[8] Isn't "fuzzy logic" an inherent contradiction? Why would anyone want to fuzzify logic?

Date: 15-APR-93

Fuzzy sets and logic must be viewed as a formal mathematical theory for the representation of uncertainty. Uncertainty is crucial for the management of real systems: if you had to park your car PRECISELY in one place, it would not be possible. Instead, you work within, say, 10 cm tolerances. The presence of uncertainty is the price you pay for handling a complex system.

Nevertheless, fuzzy logic is a mathematical formalism, and a membership grade is a precise number. What's crucial to realize is that fuzzy logic is a logic OF fuzziness, not a logic which is ITSELF fuzzy. But that's OK: just as the laws of probability are not random, so the laws of fuzziness are not vague.

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[10] What is the relationship between fuzzy truth values and probabilities?

Date: 21-NOV-94

This question has to be answered in two ways: first, how does fuzzy theory differ from probability theory mathematically, and second, how does it differ in interpretation and application.

At the mathematical level, fuzzy values are commonly misunderstood to be probabilities, or fuzzy logic is interpreted as some new way of handling probabilities. But this is not the case. A minimum requirement of probabilities is ADDITIVITY, that is that they must add together to one, or the integral of their density curves must be one.

But this does not hold in general with membership grades. And while membership grades can be determined with probability densities in mind (see [11]), there are other methods as well which have nothing to do with frequencies or probabilities.

Because of this, fuzzy researchers have gone to great pains to distance themselves from probability. But in so doing, many of them have lost track of another point, which is that the converse DOES hold: all probability distributions are fuzzy sets! As fuzzy sets and logic generalize Boolean sets and logic, they also generalize probability.

In fact, from a mathematical perspective, fuzzy sets and probability exist as parts of a greater Generalized Information Theory which includes many formalisms for representing uncertainty (including random sets, Demster-Shafer evidence theory, probability intervals, possibility theory, general fuzzy measures, interval analysis, etc.). Furthermore, one can also talk about random fuzzy events and fuzzy random events. This whole issue is beyond the scope of this FAQ, so please refer to the following articles, or the textbook by Klir and Folger (see [16]).

Semantically, the distinction between fuzzy logic and probability theory has to do with the difference between the notions of probability and a degree of membership. Probability statements are about the likelihoods of outcomes: an event either occurs or does not, and you can bet on it. But with fuzziness, one cannot say unequivocally whether an event occured or not, and instead you are trying to model the EXTENT to which an event occured. This issue is treated well in the swamp water example used by James Bezdek of the University of West Florida (Bezdek, James C, "Fuzzy Models --- What Are They, and Why?", IEEE Transactions on Fuzzy Systems, 1:1, pp. 1-6).

Delgado, M., and Moral, S., "On the Concept of Possibility-Probability Consistency", Fuzzy Sets and Systems 21:311-318, 1987.

Dempster, A.P., "Upper and Lower Probabilities Induced by a Multivalued Mapping", Annals of Math. Stat. 38:325-339, 1967.

Henkind, Steven J., and Harrison, Malcolm C., "Analysis of Four Uncertainty Calculi", IEEE Trans. Man Sys. Cyb. 18(5)700-714, 1988.

Kamp`e de, F'eriet J., "Interpretation of Membership Functions of Fuzzy Sets in Terms of Plausibility and Belief", in Fuzzy Information and Decision Process, M.M. Gupta and E. Sanchez (editors), pages 93-98,

North-Holland, Amsterdam, 1982.

Klir, George, "Is There More to Uncertainty than Some Probability Theorists Would Have Us Believe?", Int. J. Gen. Sys. 15(4):347-378, 1989.

Klir, George, "Generalized Information Theory", Fuzzy Sets and Systems 40:127-142, 1991.

Klir, George, "Probabilistic vs. Possibilistic Conceptualization of Uncertainty", in Analysis and Management of Uncertainty, B.M. Ayyub et. al. (editors), pages 13-25, Elsevier, 1992.

Klir, George, and Parviz, Behvad, "Probability-Possibility Transformations: A Comparison", Int. J. Gen. Sys. 21(1):291-310, 1992.

Kosko, B., "Fuzziness vs. Probability", Int. J. Gen. Sys. 17(2-3):211-240, 1990.

Puri, M.L., and Ralescu, D.A., "Fuzzy Random Variables", J. Math. Analysis and Applications, 114:409-422, 1986.

Shafer, Glen, "A Mathematical Theory of Evidence", Princeton University, Princeton, 1976.

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[12] What is possibility theory?

Date: 15-APR-93

Possibility theory is a new form of information theory which is related to but independent of both fuzzy sets and probability theory. Technically, a possibility distribution is a normal fuzzy set (at least one membership grade equals 1). For example, all fuzzy numbers are possibility distributions. However, possibility theory can also be derived without reference to fuzzy sets.

The rules of possibility theory are similar to probability theory, but use either MAX/MIN or MAX/TIMES calculus, rather than the PLUS/TIMES calculus of probability theory. Also, possibilistic NONSPECIFICITY is available as a measure of information similar to the stochastic ENTROPY.

Possibility theory has a methodological advantage over probability theory as a representation of nondeterminism in systems, because the PLUS/TIMES calculus does not validly generalize nondeterministic processes, while MAX/MIN and MAX/TIMES do.

For further information, see:

Dubois, Didier, and Prade, Henri, "Possibility Theory", Plenum Press, New York, 1988.

Joslyn, Cliff, "Possibilistic Measurement and Set Statistics", in Proceedings of the 1992 NAFIPS Conference 2:458-467, NASA, 1992.

Joslyn, Cliff, "Possibilistic Semantics and Measurement Methods in Complex Systems", in Proceedings of the 2nd International Symposium on Uncertainty Modeling and Analysis, Bilal Ayyub (editor), IEEE Computer Society 1993.

Wang, Zhenyuan, and Klir, George J., "Fuzzy Measure Theory", Plenum Press, New York, 1991.

Zadeh, Lotfi, "Fuzzy Sets as the Basis for a Theory of Possibility", Fuzzy Sets and Systems 1:3-28, 1978.

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[19] Companies Supplying Fuzzy Tools

Date: 15-APR-93

*** Note: Inclusion in this list is not an endorsement for the product. ***

Accel Infotech Spore Pte Ltd:

Accel Infotech is a distributor for FUZZ-C from Byte Craft.

FUZZ-C generates C code that may be cross-compiled to the 6805, Z8C and COP8C microprocessors using separate compilers.
FUZZ-C was reviewed in the March 1993 issue of AI Expert.

For more information, send email to accel@solomon.technet.sg, call +65-7446863 (Richard) or fax +65-7492467.

Adaptive Informations Systems:

This is a new company that specializes in fuzzy information systems.

Main products of AIS:

- Consultancy and application development in fuzzy information retrieval and flexible querying systems

- Development of a fuzzy querying application for value added network services

- A fuzzy solution for utilization of a large (lexicon based) terminological knowledge base for NL query evaluation

Adaptive Informations Systems
Hoestvej 8 B
DK-2800 Lyngby
Denmark
Phone: 45-4587-3217
Email: hll@dat.ruc.dk

Adaptive Logic (formerly American NeuraLogix):

Products:

AL220	8 bit fuzzy microcontroller(18 pin DIP or 20 pin SOIC) with A/D & D/A(4I/O).
NLX221	4-8 bit digital I/O single chip fuzzy microcontroller with EEPROM memory.
NLX222	4-8 bit analog and digital I/O single chip fuzzy microcontroller.
NLX230	8 bit microcontroller utilizing fuzzy logic at 30 million rules per second.
NLX110	Fuzzy Pattern Comparator.
NLX112/113	Fuzzy Data Correlators.
INSiGHT IIe	Real time emulator, programmer and development software for AL220.
INSiGHT	Development software for NLX22X family.
INStANT	Programmer for NLX22X family.
ADS230	Development System for NLX230.
ADS110	Development System for NLX110

Note: The AL220 was named Innovation Of the Year '94 by EDN

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Tel. directo: 3640523
Fax: 3640423
Tel URL: 3690691 ext. 515

Magazine in the microprocessor category. Data sheets and application notes are available on the products plus local application assistance.

Adaptive Logic Inc.
800 Charcot Ave., Suite 112
San Jose, CA 95131
Phone: 408-383-7200
Fax: 408-383-7201
Email: 75471.2025@compuserve.com

Europe:
Applied Marketing & Technology Ltd.
Saville Court, Saville Place, Clifton
Bristol BS8 4EJ
Phone: 117-9237594
Fax: 117-9237598
Email: 100435.1630@compuserve.com

Japan:
Nippon Precision Device
Nichibei Time 24 Bldg.
35 Tansu-cho
Shinjuki-ku, Tokyo 162
Phone: 332601411
Fax: 332607100

Adaptive Logic Inc.-R&D facility
411 Central Park Drive
Sanford, Fl 32771
Phone: 407-322-5608
Fax: 407-322-5609
Email: 75471.2032@compuserve.com or info@adaptivelogic.com
URL: http://www.adaptivelogic.com/

Aptronix:

Products:
Fide — A MS Windows-hosted graphical development environment for fuzzy expert systems. Code generators for Motorola's 6805, 68HC05, and 68HC11, and Omron's FP-3000 are available. A demonstration version of Fide is available.

Aptronix, Inc.
2150 North First Street, Suite 300
San Jose, Ca. 95131 USA
Phone: 408-261-1888
Fax: 408-261-1897
Fuzzy Net BBS: 408-261-1883, 8/n/1

Aria Ltd.:

Products:
DB-fuzzy — A library of fuzzy information retrieval for CA-Clipper. See ftp.cs.cmu.edu:/user/ai/areas/fuzzy/com/aria/ for more information.

Aria Ltd.
Dubravska 3
842 21 Bratislava
SLOVAKIA
Phone: (+42 7) 3709 286
Fax: (+42 7) 3709 232
Email: aria@softec.sk

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ClippArt Ltd. is the exclusive distributor of DB-fuzzy.
Any additional information about DB-fuzzy you can obtain
from this company.

ClippArt Ltd. Polianky 15 Tel. (+42 7) 786 160
841 02 Bratislava Fax (+42 7) 786 160
Slovakia

ByteCraft, Ltd.:

Products:
Fuzz-C "A C preprocessor for fuzzy logic" according to the cover of its manual. Translates an extended C language to C source code.

Byte Craft Limited
421 King Street North
Waterloo, Ontario
Canada N2J 4E4
Phone: 519-888-6911
Fax: 519-746-6751
Support BBS: 519-888-7626

Fril Systems Ltd:

FRIL (Fuzzy Relational Inference Language) is a logic-programming language that incorporates a consistent method for handling uncertainty, based on Baldwin's theories of support logic, mass assignments, and evidential reasoning. Mass assignments give a consistent way of manipulating fuzzy and probabilistic uncertainties, enabling different forms of uncertainty to be integrated within a single framework. Fril has a list-based syntax, similar to the early micro-Prolog from LPA. Prolog is a special case of Fril, in which programs involve no uncertainty. Fril runs on Unix, Macintosh, MS-DOS, and Windows 3.1 platforms.

For further information, write to

Dr B.W. Pilsworth
Fril Systems Ltd
Bristol Business Centre,
Maggs House,
78 Queens Rd,
Bristol BS8 1QX, UK.

A longer description is available as
ftp.cs.cmu.edu:/user/ai/areas/fuzzy/com/fril/fril.txt

Fujitsu:

Products:
MB94100 Single-chip 4-bit (?) fuzzy controller.

FuziWare:

Products:
FuziCalc An MS-Windows-based fuzzy development system based on a spreadsheet view of fuzzy systems.

FuziWare, Inc.
316 Nancy Kynn Lane, Suite 10

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Tel. directo: 3640523
Fax: 3640423
Tel URL: 3690691 ext. 515

Knoxville, Tn. 37919 USA
Phone: 800-472-6183, 615-588-4144
Fax: 615-588-9487

FuzzySoft AG:

Product:

FuzzySoft	Fuzzy Logic Operating System runs under MS-Windows, generates C-code, extended simulation capabalities.

Selling office for Germany, Switzerland and Austria (all product inquiries should be directed here)

GTS Trautzl GmbbH
Gottlieb-Daimler-Str. 9
W-2358 Kaltenkirchen/Hamburg
Germany
Phone: (49) 4191 8711
Fax: (49) 4191 88665

Fuzzy Systems Engineering:

Products:

Manifold Editor	?
Manifold Graphics Editor	?

[These seem to be membership function & rulebase editors.]

Fuzzy Systems Engineering
P. O. Box 27390
San Diego, CA 92198 USA
Phone: 619-748-7384
Fax: 619-748-7384 (?)

HyperLogic Corporation:

Products:

CubiCalc	Windows-based Fuzzy Logic Shell. Includes fuzzy and plant simulation, plots, file I/O, DDE.
CubiCalc RTC	Windows-based Fuzzy Logic Development Environment. Superset of CubiCalc includes run-time generator, code libraries, DLL for Windows Applications (incl Visual Basic).
CubiCard	Superset of CubiCalc RTC with data acquisition capabilties via hardware interface board.
CubiQuick	Inexpensive version of CubiCalc with limited capabilties for classroom and small projects. Academic discounts available.
Rule Maker	Add-on to CubiCalc and higher products for automatic rulebase generation. Provides four different generation strategies.

HyperLogic Corporation
P.O. Box 300010
Escondido, CA 92030-0010
Tel: 619-746-2765
Fax: 619-746-4089
Email: prodinfo@hyperlogic.com

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The URL for their home page is http://www.hyperlogic.com/hl. It includes product descriptions, pricing information, their Tech Notes on various subjects, and several downloadable demonstration programs.

Inform:

Products:

fuzzyTECH 3.0	A graphical fuzzy development environment. Versions are available that generate either C source code or Intel MCS-96 assembly source code as output. A demonstration version is available. Runs under MS-DOS.

Inform Software Corp
1840 Oak Street, Suite 324
Evanston, Il. 60201 USA
Phone: 708-866-1838

INFORM GmbH
Geschaeftsbereich Fuzzy--Technologien
Pascalstraese 23
W-5100 Aachen
Tel: (02408) 6091
Fax: (02408) 6090

IIS:

IIS specializes in offering short courses on soft computing. They also perform research and development in fuzzy logic, fuzzy control, neural networks, adaptive fuzzy systems, and genetic algorithms.

Intelligent Inference Systems Corp.
P.O. Box 2908
Sunnyvale, CA 94087
Phone: (408) 730-8345
Fax: (408) 730-8550
email: iiscorp@netcom.com

LPA, Ltd.:

FLINT, a Fuzzy Logic INferencing Toolkit, is a versatile fuzzy logic inferencing system that makes fuzzy logic technology and fuzzy rules available within a sophisticated programming environment. FLINT supports standard and user-defined membership functions, linear and curved membership lines, automatic propagation of fuzzy values, range of and/or/not combinators, configurable linguistic hedges, standard and user-defined defuzzification algorithms. FLINT is available as a versatile programming toolkit for LPA Prolog running Windows 95/3.1/NT or Macintosh and as an extension to LPA's popular expert system toolkit, Flex.

For further information contact:
Logic Programming Associates Ltd.,
Studio 4, R.V.P.B., Trinity Road,
London, SW18 3SX, UK.

Web: http://www.lpa.co.uk
US Toll Free: 1-800-949-7567
Tel: +44 181 871 2016
Fax: +44 181 874 0449
Email: lpa@cix.compulink.co.uk

Metus Systems Group:

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Apto.postal 39 C
Tel. directo: 3640523
Fax: 3640423
Tel URL: 3690691 ext. 515

Products:
Metus Fuzzy Library — A library of fuzzy processing routines for C or C++. Source code is available.

The Metus Systems Group
1 Griggs Lane
Chappaqua, Ny. 10514 USA
Phone: 914-238-0647

Modico:

Products:
Fuzzle 1.8 — A fuzzy development shell that generates either ANSI FORTRAN or C source code.

Modico, Inc.
P. O. Box 8485
Knoxville, Tn. 37996 USA
Phone: 615-531-7008

National Semiconductor, Santa Clara CA, USA
http://www.commerce.net/directories/participants/ns/home.html

NeuFuz is aimed at low end controls applications in automotive, industrial, and appliance areas. NeuFuz is a neural-fuzzy technology which uses backpropagation techniques to initially select fuzzy rules and membership functions. Initial stages of design using NeuFuz technology are performed using training data and backpropagation. The result is a fuzzy associative memory (FAM) which implements an approximation of the training data. By implementing a FAM, rather than a multi-layer perceptron, the designer has a solution which can be understood and tuned to a particular application using Fuzzy Logic design techniques.

NeuFuz4 Learning Kit, Product ordering code (NSID): NF2-C8A-KIT
- NeuFuz2 Neural Network Learning Software
- Up to 2 inputs, 1 output
- 50 training patterns
- Up to 3 membership functions
- COP8 Code Generator (COP8 is National's family of 8-bit microcontrollers)

NeuFuz4 Software Package, Product ordering code (NSID): NF4-C8A
- NeuFuz4 Software
- Neural Network Learning Software - Up to 4 inputs, 1 output and 1200 training patterns
- Up to 7 membership functions
- COP8 Code Generator

The NeuFuz4 Development System, Product ordering code: (NSID): NF4-C8A-SYS.
- Neural Network Learning Software - Up to 4 inputs, 1 output and 1200 training patterns
- Up to 7 membership functions
- COP8 Code Generator
- COP8 In-Circuit Emulator "Debug Module"
  - Real-Time Emulation Microcontroller EPROM Programming
  - Real-Time Trace
  - Complete Source/Symbolic Debug
- One-Day Training on Customer Request
- Access to Factory Expert via Telephone (Maximum 16 hrs.)

NeuFuz4-C Learning Kit, Product ordering code (NSID): NF2-C-KIT
- Up to 2 inputs, 1 output 50 training patterns

- Up to 3 membership functions
- ANSI Standard C Language Code Generator
- Tutorial Examples for Neural Network Learning and Fuzzy Rule Generation

NeuFuz4-C Software Package, Product ordering code (NSID): NF4-C
- Up to 4 inputs, 1 output and 1200 training patterns
- Up to 7 membership functions
- ANSI Standard C Language Code Generator
- One-Day Training on Customer Request
- Access to Factory Expert via Telephone (Maximum 16 hrs.)

Oki Electric:

Products:

MSM91U111	A single-chip 8-bit fuzzy controller.

Europe:

Oki Electric Europe GmbH.
Hellersbergstrasse 2
D-4040 Neuss, Germany
Phone: 49-2131-15960
Fax: 49-2131-103539

Hong Kong:

Oki Electronics (Hong Kong) Ltd.
Suite 1810-4, Tower 1
China Hong Kong City
33 Canton Road, Tsim Sha Tsui
Kowloon, Hong Kong
Phone: 3-7362336
Fax: 3-7362395

Japan:

Oki Electric Industry Co., Ltd.
Head Office Annex
7-5-25 Nishishinjuku
Shinjuku-ku Tokyo 160 JAPAN
Phone: 81-3-5386-8100
Fax: 81-3-5386-8110

USA:

Oki Semiconductor
785 North Mary Avenue
Sunnyvale, Ca. 94086 USA
Phone: 408-720-1900
Fax: 408-720-1918

OMRON Corporation:

Products:

C500-FZ001	Fuzzy logic processor module for Omron C-series PLCs.
E5AF	Fuzzy process temperature controller.
FB-30AT	FP-3000 based PC AT fuzzy inference board.
FP-1000	Digital fuzzy controller.
FP-3000	Single-chip 12-bit digital fuzzy controller.
FP-5000	Analog fuzzy controller.
FS-10AT	PC-based software development environment for the FP-3000.

Japan

Kazuaki Urasaki
Fuzzy Technology Business Promotion Center
OMRON Corporation
20 Igadera, Shimokaiinji
Nagaokakyo Shi, Kyoto 617 Japan
Phone: 81-075-951-5117
Fax: 81-075-952-0411

USA Sales (all product inquiries should be directed here)

Pat Murphy
OMRON Electronics, Inc.
One East Commerce Drive
Schaumburg, IL 60173 USA
Phone: 708-843-7900
Fax: 708-843-7787/8568

USA Research

Satoru Isaka
OMRON Advanced Systems, Inc.
3945 Freedom Circle, Suite 410
Santa Clara, CA 95054
Phone: 408-727-6644
Fax: 408-727-5540
Email: isaka@oas.omron.com

Togai InfraLogic, Inc.:

Togai InfraLogic (TIL for short) supplies software development tools, board-, chip- and core-level fuzzy hardware, and engineering services. Contact info@til.com for more detailed information.

Products:

FC110	(the FC110(tm) Digital Fuzzy Processor (DFP-tm)). An 8-bit microprocessor/coprocessor with fuzzy acceleration.
FC110DS	(the FC110 Development System) A software development package for the FC110 DFP, including an assembler, linker and Fuzzy Programming Language (FPL-tm) compiler.
FCA	VLSI Cores based on Fuzzy Computational Acceleration (FCA-tm).
FCA10AT	FC110-based fuzzy accelerator board for PC/AT-compatibles.
FCA10VME	FC110-based four-processor VME fuzzy accelerator.
FCD10SA	FC110-based fuzzy processing module.
FCD10SBFC	FC110-based single board fuzzy controller module.
FCD10SBus	FC110-based two-processor SBus fuzzy accelerator.
FCDS	(the Fuzzy-C Development System) An FPL compiler that emits K&R or ANSI C source to implement the specified fuzzy system.
MicroFPL	An FPL compiler and runtime module that support using fuzzy techniques on small microcontrollers by several companies.
TILGen	A tool for automatically constructing fuzzy expert systems from sampled data.
TILShell+	A graphical development and simulation environment for fuzzy systems.

USA

Togai InfraLogic, Inc.
5 Vanderbilt
Irvine, CA 92718 USA
Phone: 714-975-8522
Fax: 714-975-8524
Email: info@til.com

Toshiba:

Products:

T/FC150	10-bit fuzzy inference processor.
LFZY1	FC150-based NEC PC fuzzy logic board.
T/FT	Fuzzy system development tool.

TransferTech GmbH:

Products:

Fuzzy Control Manager (FMC)	Fuzzy shell, runs under MS-Windows

TransferTech GmbH
Cyriaksring 9A
D-38118 Braunschweig
Germany
Tel: +49 531 890255
Fax: +49 531 890355
Email: info@transfertech.de
URL: http://www.transfertech.de

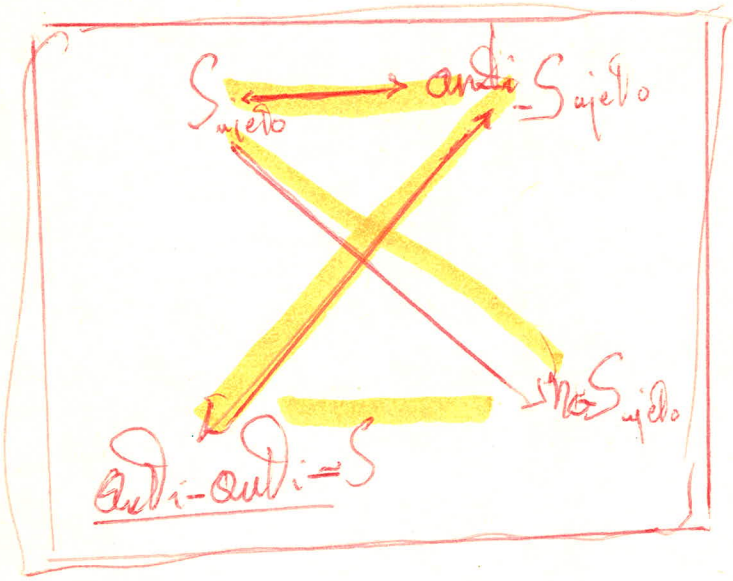
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El cuadrado de Greimas.



[20] Fuzzy Researchers

Date: 23-AUG-94

A list of "Who's Who in Fuzzy Logic" (researchers and research organizations in the field of fuzzy logic and fuzzy expert systems) may be obtained by sending a message to
  listproc@vexpert.dbai.tuwien.ac.at
with
  GET LISTPROC WHOISWHOINFUZZY
in the message body. New entries and corrections should be sent to Robert Fuller <rfuller@finabo.abo.fi>.

A copy of this list is also available by anonymous ftp from —
  mira.dbai.tuwien.ac.at:/pub/mlowner/whoiswhoinfuzzy
or
  ftp.cs.cmu.edu:/user/ai/areas/fuzzy/doc/whos_who/whos_who.txt

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— Revistas: —

1) IEEE Transactions on Fuzzy Systems. (Bruselas)

2) Fuzzy Sets and Systems.

3) International journal of Uncertainity. Fuzzy and Knowledge based Systems.

4) International journal of aproximate reasoning...
(una publicación de NAFIPS. 8 numeros al año ($282)
N.Y. David Reiss.
e-mail « 74740.2600@compuserve.com »

Adaptive Logic: « http://www.adaptivelogic.com/ »

P. [?] cuál es el fundamento de la lógica "fuzzy"? R/ Es una aplicación!

R/ = { Es la oposición entre dos extremos "contrarios"
Los contrarios: blanco-negro, grande-pequeño, etc.. | admiten infinitas medidas-intermedias

S anti-S

La "fuzzy-logic", te "aplica" a estas medidas intermedias.

— Kelkan afirma que "para un particular conjunto de axiomáticas de lógica fuzzy, la lógica fuzzy decae a una lógica-de dos-valores" —

"CONTROVERSIA:"

— Cuando una medida "Fuzzy" se extiende, no solo a "2 polos contrarios," — sino a 2 términos contradictorios; viene a coincidir con la lógica tradicional del [Si-y-no] y del [0 y 1]. - Ej. [S ∨ ~S] (+1 ∨ -1)

- se eleva a nivel abstracto,

- Lo que sucede es que: entre "2 [oraciones] contradictorias" no existe ninguna "medida parcial".

Específicamente: entre una afirmación A y su contradictoria: [∃a ∈ -A]

[(a) (a ∉ A)] - mismo.

Solo hay un cero!

Ej: ¿cómo representar "2 contrarios"?

1 000 000 habitantes
1 000 casas
30 mas
Otras
"Todos los papeles"
= Ninguno papeles
1000 papeles
"infinitos algunos"

Ej: Infinidad "Todos"

250
15
2
30
7

- cómo representar "2 contradictorios"

Todos vuelan
Todos
Todos
alguno no

ha varios Todos

Con uno que sea diferente contradice al todo

[21] Elkan's "The Paradoxical Success of Fuzzy Logic" paper

The presentation of Elkan's AAAI-93 paper

> Charles Elkan, "The Paradoxical Success of Fuzzy Logic", in Proceedings of the Eleventh National Conference on Artificial Intelligence, 698-703, 1993.

has generated much controversy. The fuzzy logic community claims that the paper is based on some common misunderstandings about fuzzy logic, but Elkan still maintains the correctness of his proof. (See, for instance, AI Magazine 15(1):6-8, Spring 1994.)

Elkan proves that for a particular set of axiomatizations of fuzzy logic, fuzzy logic collapses to two-valued logic. The proof is correct in the sense that the conclusion follows from the premises. The disagreement concerns the relevance of the premises to fuzzy logic. At issue are the logical equivalence axioms. Elkan has shown that if you include any of several plausible equivalences, such as

> not(A and not B) == (not A and not B) or B

with the min, max, and 1- axioms of fuzzy logic, then fuzzy logic reduces to binary logic. The fuzzy logic community states that these logical equivalence axioms are not required in fuzzy logic, and that Elkan's proof requires the excluded middle law, a law that is commonly rejected in fuzzy logic. Fuzzy logic researchers must simply take care to avoid using any of these equivalences in their work.

It is difficult to do justice to the issues in so short a summary. Readers of this FAQ should not assume that this summary is the last word on this topic, but should read Elkan's paper and some of the other correspondence on this topic (some of which has appeared in the comp.ai.fuzzy newsgroup).

Two responses to Elkan's paper, one by Enrique Ruspini and the other by Didier Dubois and Henri Prade, may be found as

> ftp.cs.cmu.edu:/user/ai/areas/fuzzy/doc/elkan/response.txt

A final version of Elkan's paper, together with responses from members of the fuzzy logic community, will appear in an issue of IEEE Expert sometime in 1994. A paper by Dubois and Prade will be presented at AAAI-94.

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NB. Esta polea continúa también en documentos de 1997 y 1998.
En esencia, el problema consiste en una "mala-traducción" de la palabra
FUZZY { = que en inglés significa: borra, pelusa que se corta, = dispersa
= pero no significa "borrota" = confusa, nublada indefinida!!!
Sino: fragmentada, difusa, desbilachada.

La "aporía" de los universales !!! y Términos generales del lenguaje.

El "problema" surge en la "comparación" entre: extremos opuestos:

como:

A "Experiencia-empírica" = { continua ≡ totalidad sin límites pero no extrema
concreta; = vida-sensible { fluida = se "mueve" en el espacio y el tiempo =
[permanencia — variable]!



Domicio de la ... continuidad — cambio ... = es una única experiencia

- La sensación material también es continua y fluida pero capta las diferencias
- La percepción psicológica crea imágenes { - singulares y - discontinuas } singulares y universales (3)

B El "pensamiento-perfecto" es { (1) discreto = unidades separadas!
abstracto = epistema { (2) entático = subdivisibles pero no variables!
"permanencia invariable"

→ se fragmenta en unidades "diferentes" = la "diferencia" marca el límite

Niveles de "pensamiento":

(a) Nivel primario: experiencia actuante, presente: "este" árbol, "este" pero, "este" manteniendo, "este" gesto ... ⟹ SINGULARES { CONCEPTOS PERCEPTUALES

efecto = CONCEPTOS = modelos, universales abstractos!

(b) Niveles secundarios { (1) concepto universal discreto { un pájaro, un árbol, una casa, un perro = conceptos genéricos
(2) conceptos específicos y

C - Niveles de lenguaje:

El lenguaje pertenece al Nivel (B.b) = abstracto discreto − { + general
con sus respectivas fals

Su estructura del lenguaje corresponde a los niveles secundarios de abstracción! Ej →

- regla norma
- barra
rod = vara
= disciplina
= medida

« Fuzzy Logic »

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discreta

reducida a continua. = con bordes - esfumados.

Fuzzy logic is discrete (rod) logic that has undergone fuzzification. Anything mathematical structure that is discrete can be fuzzified to allow continuous values. Just there is fuzzy logic, there are fuzzy differential equations. Fuzzy logic is an extension of rod logic, not an alternative. Fuzzy logic differs from discrete logic in that it allows range of membership within a set. For example, a truth value needs to be made about the statement, "The kiln is cold." Under a discrete system, only two values are possible, false or true, represented by binary as 0 or 1. A fuzzy logic system allows for a continous range in the degree to which the kiln belongs in the set of cold things. There is a value of cold, a value for not cold, and a range in between. If the kiln is equal to or below the temperature of 100 degrees, then it has a maximum coldness value of 1. If it is above 250 degrees, it has a completely false cold value of 0. Any temperature falling in between would have a partial value. If the temperature was 150 degrees, the kiln would belong to the set of cold things to a degree of .667. In a fuzzy algorithm, this value is plugged in as a variable in an equation, frequently with other fuzzily determined membership values for other variables, and at the end a fuzzy output appears.

« What Good is It? »

Fuzzy logic is very useful when dealing with the ordinary language, where lack of precision is standard. Fuzzy systems can take a qualititative term such as 'very' and convert it into something a computer can use, namely that the object that is 'very' has a membership value of .87. This generally isn't directly useful, but fuzzy logic is used in expert systems that are. A fuzzy expert system is adept at handling rules of thumb. These rules of thumb are presented in ordinary language with many qualifiers (if oil pressure is high and rising and the RPM is high, change to one higher gear). The expert system juggles all of these rules and through fuzzy response has a literally infinite number of possible reactions to choose from. If rules are contradictory, the fuzzy system can plug the 0-1 membership values of each rule's truth (relative applicability) to the situation at hand into an algorithm come to a balanced conclusion. Response can be partial instead of severe, allowing a feather touch when that is all that is needed. Sometimes output is defuzzified (by too many methods to explore)so that a crisp response can be made.

Fuzzy systems have found practical application in many ways. Fuzzy logic is a near necesity for any program that aspires to understand the nonprecision of human language. It also has use in many industrial applications. Some Japanese trains are controlled by fuzzy systems. The possibility of a continous change of states has resulted in smoother acceleration.and reduced wear and tear on parts, freed from the discrete jolts from one system state to another.

For such a simple idea, fuzzy logic is a relatively recent phenomenon. It was introduced by Prof. Lotfi Zedah of Berkeley in 1965. Unfortunately, he was mostly ignored for a number of years, and actually treated with some disdain as an imprecise thinker. In recent years, fuzzy systems have rapidly become much more respected. This is primarily because fuzzy logic was used extensively in Japan during the late 80s, and was obviously of considerable practical use. The rest of the world has been playing catch up since then, but now there are many resources and companies dedicated to making fuzzy logic work. Given the simplicity of the improvement over rod

Sin embargo: en lo "continuo" de la realidad hay "diferencias" o mejor dicho "cualidades" que pueden virtualizar límites (aproximados) e individualizar - objetos = seres que tienen "propiedades" y relaciones !!! a nivel de operaciones superiores!

A nivel de percepciones bio-psicológicas ⇒ - Esto es suficiente para que la TOTALIDAD-"continua" se transforme, en la experiencia: en TOTALIDAD-DISCRETA
→ por tanto individualizada - separada en unidades - únicas -
y como tal conceptualizable ! = } perceptible a unidades
discretas a nivel de la mente
pero ya no las diferencias

- la mera "situación - material - no es discreta.
perceptiva → bio-psicológica

Nuestra experiencia + captación } cualidades = peso, dureza, color, sabor ,,,,
pero no las separa → } diferencias = límites, contrastes, paralelos
y através de estas propiedades S → individualiza ! → conceptualiza ! = decir expresa IDEAS
mientras la epidemo-pensamiento

Estas ideas { a) a nivel inmediato de experiencia son "individuales"
b) a nivel secundario de reflexiones y comparaciones
poseen varios grado de abstracción. = UNIVERSALES

No hay un salto entre la captación de lo continuo y la de lo discontinuo
ni entre lo individual y lo universal. !-

Lo individual no se contradice con lo universal. todo es asumido = incluido
Lo universal { es un "superconjunto" de lo individual = (= no es conjunto porque no definido)
es una extensión conceptual del concepto singular
Esta operación es "mediada" por el (yo) ! El yo asegura la continuidad entre esos dos extremos.

Lo individual (idea - percepción) es "unificado" con lo general - universal por la "continuidad" del (yo) = el yo - trascendental! el yo es capaz de reconocer lo individual dentro de lo general por su misma potencia a ambos!

logic, I see little reason why not to add it to a nanocomputer design.

Darrell Parfitt

Links

Fuzzy Logic Page - This site has links to a wide variety of Fuzzy papers and Fuzzy system vendors.

Fuzzy Logic Hypertext Tutorial - A nice hypertext tutorial with lots of illustrations for the non-verbal.

Fuzzy Logic FAQ A (theoretically) regularly updated site providing Fuzzy logic information and resources.

La razón de "ente-pluralidad" es la "condividad del yo material-y-plurante.
Entre los dos términos-extremos, hay grados de inteligibilidad, medianos y mediadores

F. = Estructura racional ⟷ = globalización conceptual
E. = Dinamismo conceptual-analizador ⟷ = dinamismo generalizador comparativo
D. = Dualidad de representación → = representac. generalizada-categorial
= representac. individual abstracta individualizadora
C = "percepción" sentible-psicológica = imagen sentible-discontinua
B = contacto sentible ⟷ = captación con=diferenciación !!?
A = contacto material ⟷ = fluido y continuo-y concreto. material fluido-continuo

El yo media entre los niveles = trascende entre pluripolaridades

= Experiencia y Conocimiento ????

No podemos reflexionar, enfocar, discutir, delimitar el conocimiento y ni siquiera una pregunta sobre el conocimiento si no empezamos con la "experiencia" →
lo dado lo pre-dado. lo pre-predicativo = "el ser desnudo"

= "Extremo Mental" (= consciente - reflexivo - especulativo)

globalización discursiva: actividad especulativa relacional = abstractos universales

globalización conceptual = conceptos jerarquizados: géneros y especies

generalización conceptual = conceptos generalizados: abstractos universales

dinamismo comparativo-creativo: relaciones entre representaciones individuales y generales = abstractos

representación conceptual = obra del entendimiento especulativo de varios niveles abstractos: → conceptos generalizables → conceptos individuales y valores

representación fundadora - imagen individual - discretas - o percepciones
imágenes caracterizadas por diferencias fijas - ordenadas!

Sensaciones materializadas → fluidas - continuas
→ diferenciadoras de intensidades y cualidades

Valores intermedios entre dos valores extremos - contrarios!!!

"Experiencia inmediata" = [fluida continua reactiva! previa - pre consciente - pre predicativa]

= "Extremo material" → [pre consciente - pre predicativa]

o no-material ... va a las cosas. Estas cosas pueden ser fenomenos de tipo material o bien inmaterial.

Ej:

(yo) veo (una persona) encuentro

material:
- tocar -
- ver -
- oler -
- oír -
- tender el peso ...

inmaterial:
- percibir armonía
- violencia
- desequilibrio
- belleza
- agrado
- repulsión

Todo ello es experiencia:
- es concreta
- es fluida
- es continua
- es particular
- es individual
- es pre-dada
- es pre-predicativa
- es variable (no fijas)

Fuzzy Logic, Applications and Related Areas

- Åbo Akademi University, Institute for Advanced Management Systems Research
  - Approximate Reasoning, Fuzzy Logic
  - Neural Networks for Intelligent Decision Support
  - Who is Who in Fuzzy by Robert Fullér
- Aston University, Department of Computer Science and Applied Mathematics
  - Neural Computing Research Group
- Binghamton University, Department of Systems Science and Industrial Engineering
  - Center for Intelligent Systems
  - George Klir
- Bogazici University, Department of Industrial Engineering
  - Taner Bilgiç
- Brunel University, Department of Computer Science and Information Systems
  - Centre for Neural and Evolutionary Systems (CNES)
  - MSc in Neural and Evolutionary Systems
- Chinese University of Hong Kong, Department of Computer Science and Engineering
  - Soft Computing
- COST-MVL : European Cooperation in the field of Many Valued Logics
- De Montfort University, Department of Mathematical Sciences
  - Robert John
- Georgia State University, College of Business Administration
  - Decisions Sciences Department: Decision Sciences Laboratory
- German National Research Center for Information Technology, Institute for System Design Technology
  - Innovative Application Design: Fuzzy Group
- Iona College, Hagan School of Business
  - Machine Intelligence Institute

- Johannes Kepler University Linz, Institut für Mathematik
  - Fuzzy Logic Laboratorium : Projects
  - Erich Peter Klement
- Korea Advanced Institute of Science and Technology, Department of Computer Science
  - Artificial Intelligence Laboratory : Fuzzy Logic Group
- Kyushu Institute of Technology, Department of Control Engineering & Science
  - Yamakawa & Uchino's Laboratory : Research Projects
- National University of Singapore, Department of Information Systems and Computer Science
  - Neural Networks and Fuzzy Logic Research
- Otto-von-Guericke-Universität Magdeburg, Computer Science Department
  - Neuro-Fuzzy Systems
- Philadelphia College of Textiles and Science, Computer Science Department
  - Les M. Sztandera
- Politecnico di Milano, Dipartimento di Elettronica e Informazione / Artificial Intelligence and Robotics Project
  - Learning and Optimization of Fuzzy Controllers
  - Fuzzy and Qualitative Simulation
  - Fuzzy Logic and Expert Systems
- Swiss Federal Institute of Technology, Automatic Control Laboratory
  - Intelligent Fuzzy Control of Elevators
  - Analogical Gates: an Operator Approach to Fuzzy Control
  - Analysis of the Applicability of Fuzzy Control to Hydroelectric Power Plants
- Technische Universität Wien, Institute of Information Systems
  - Database and Expert Systems Group: Wolfgang Slany
- Texas A&M University, Department of Computer Science
  - Center for Fuzzy Logic, Robotics, and Intelligent Systems (CFL) : Research Projects
- University of Arkansas at Little Rock, Chemistry Department
  - Center for Theoretical Studies of Molecular and Biomolecular Systems
- Università degli Studi di Bologna, Physics Department
  - VLSI & Fuzzy Logic Research Group
- Université Libre de Bruxelles, IRIDIA

- Fuzzy and Neuro Control
- Implementation of Uncertain Reasoning
- Using Fuzzy Logic in Autonomous Robot Navigation

- University of California at Berkeley, Computer Science Division
  - Berkeley Institute for Soft Computing (BISC)
  - Lotfi Zadeh

- University of Erlangen-Nuremberg and Bavarian Research Center for Knowledge-Based Systems
  - Neural Networks and Fuzzy Logic Group : Projects

- University of Granada, Department of Computer Sciences and Artificial Intelligence
  - Approximate Reasoning and Artificial Intelligence Group

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  - Advanced Process Control and Intelligent Systems

- University of New Mexico, The Center for Autonomous Control Engineering - ACE
  - Fuzzy Logic

- University of Pittsburgh, Laboratory for Computational Neuroscience
  - Bogdan R. Kosanovic

- University of Reading, Department of Cybernetics
  - Neural Networks

- University of Sheffield, Department of Automatic Control and Systems Engineering
  - Intelligent and Adaptive Systems

- University of Southampton, Department of Electronics and Computer Science
  - Image, Speech and Intelligent Systems (ISIS) Research Group: Research in Neural Networks and Neurofuzzy Systems

- University of Southern California, Signal and Image Processing Institute
  - Bart Kosko

- University of Toronto, Department of Industrial Engineering
  - Intelligent Fuzzy Systems Laboratory

NB: FUZZY = atribuido a una persona = quisquillosa
se refiere al carácter → complicada
llena de problemas

from (Fuzzy) = aplicada a la lógica
es: indagante
llena de detalles
particularística.

Active Decision Support

There is no universally accepted definition of DSS, as the substance of a support system is geared to the context for which it has been developed, to available data, information and knowledge, and to the users - intended and actual - using the system. There are, however, some elements and some characteristics commonly accepted and recognized as being parts of a DSS :

A DSS is in most cases, * an interactive, computer-based system, which has * functions for giving a user modelling and data support, which is * flexible and adaptable to varying needs in changing environments, with * a supportive and easy to use interface, and which * has been built to represent the necessary and sufficient problem and knowledge elements of the context it should support.

The meaning and functionality of these elements have varied with the changing generations of software technology introduced since the early years of DSS in the late 1970'es. The ideal DSS [Turban]

- deals with semi-structured decisions;
- is in-tended for managers of various levels of an organisation;
- is adapted to both group and individual needs;
- supports both interdependent and sequential decisions;
- supports all three phases of the Simon problem solving process: intelligence, design and choice;
- supports a variety of decision styles and processes which could occur among a group of managers;
- is adaptable and flexible to changes in both the or-ganisation and its environment;
- is easy to use and modify;
- improves the ef-fectiveness of decison making and problem solving, not only the efficiency;
- allows humans to control the computer support and does not try to control the human problem solving and decision making;
- supports an evolutionary usage and adapts easily to changing requirements;
- is easy to construct if the logic of the context can be formulated;
- supports modelling, and
- allows the use of knowledge.

The standard DSS appears to be a passive support system:

- it is built to respond with a series of pre-programmed routines to standardized and well-defined commands;

- it finds and presents data in a standard form in response to predefined data re-quests,
- it analyzes changes in its context with predesigned routines, and
- it computes the consequences of input data on the basis of well-defined model structures.

It appears that this approach actually reduces non-structured problems to well-defined and unambiguous tasks, i.e. to well-structured problems. In this sense standard DSS has failed to live up to the expectations formulated in the early years of DSS develop-ment.

Then it is not surprising that the expected synergy of human decision makers and com-puter-based support systems tackling complex problems in interaction has not material-ized. One of the reasons for that is that senior managers - the intended users - are not active DSS users; they are replaced by junior analysts and staff who are responsible for preparing routine data for senior decision makers, and these people do not have the knowledge, experience and overview to fully utilize the potential of a DSS.

There are a couple of fallacies which have occurred in the field over the years:

- it is counter-productive to give executives tools to carry out tasks they normally do not perform at all;
- the people we think of as decision makers in an organisation are those not using computer-based systems - the DSSs are something used by the people charged with getting answers for the decision makers.

Apparently something has gone rather wrong with the standard DSS approach, and the promised more effective and productive way to deal with non-structured problems has not become a reality.

With some loose categorization we will describe an alternative approach as Active DSS and understand with this a way to build computer-based support which is meaningful, relevant, effective and productive for a variety of contexts and users.

The term active DSS has been used by a number of authors. An active DSS should "take the initiative without getting specific orders" and "respond to nonstandard re-quests and commands" [Manheim] when dealing with tasks in problem solving which are ambiguous and complex. An active DSS should be useful for

- understanding the domain (to provide explanations),
- problem formulation (to determine assump-tions and abstract reality),
- relating a problem to solver (to assist with proper problem-solver interaction, to advise on proper procedures),
- interpreting results and
- explaining results and decisions [Mili].

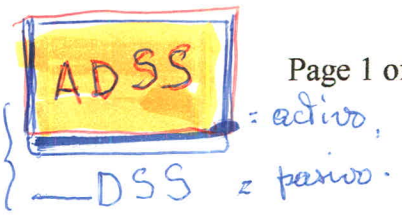
An active DSS could be a conversa-tional, agent-based approach to DSS in order to "enhance creativity in collaborative human-computer problem solving" [Anghern].

The Active DSS technology will be developed in joint research and development pro-grams by the industrial partners and co-operating research institutions.

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Cognitive Maps and Hyperknowledge

A Blueprint for Active Decision Support Systems

Experience from the design and implementation of a knowledge based support system for strategic management

Strategic Management is defined as a system of action programs which form sustainable competitive advantages for a corporation, its divisions and its business units for a chosen strategic planning period

in a number of strategic business units in the Finnish forest industry shows that there are good alternatives to the standard, passive DSS technology. Especially for handling the complex issues of strategic management we need adaptive, effective and productive support tools.

The classical definitions of Decision Support Systems stress the use of interactive computer-based systems to solve unstructured or semi-structured problems with the help of data and models. Standard DSS constructs appear to produce only passive support for decision makers. The introduction of new software technologies with significantly improved capabilities has created a platform for developing new generations of decision support systems with more advanced features for problem-solving and decision support. With the introduction of hyperknowledge and fuzzy logic it has become possible to create a new category of decision support systems we have decided to call Active DSS.

In the Woodstrat project we developed and implemented a support systems technology for strategic management in two major Finnish forest industry corporations in 1992-94. The development work was done interactively with management teams and involved more than 60 managers in 14 strategic business units (SBUs). The total amount of resources used for developing the system was about 20 man-years.

The Woodstrat offers an intuitive and effective strategic planning support with object-oriented expert systems elements and a hyperknowledge user interface. The effectiveness and usefulness found with this hyperknowledge support system can be extended and enhanced with fuzzy logic and approximate reasoning. We will show that this enhanced decision support systems technology represents the beginning of the new generation of Active DSS technology.

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Soft Decision Analysis

BISC -SIG on Decision Analysis

The *Special Interest Group on Decision Analysis* will focus on several different aspects of decision analysis:

- single criterion decision making under certainty, randomness and uncertainty;
- linear programming modelling (including variants for transportation, scheduling, networks, goal programming, etc.) and optimal decisions;
- multiple objective linear programming (including variants for utility function trade off, reference points, interactive bargaining among nondominated points, interdependence, etc.), multiple criteria decision making (mcdm) multiple criteria decision aid (mcda) and optimal decisions;
- decision support systems (DSS) and intelligent systems for decision support as means for building optimal decision processes;

In all these approaches attempts have been made at fuzzyfying the standard modelling techniques, which is easy to do in a technical sense, but which does not make much sense otherwise, as the modelling substance is missing and it is not clear - from the perspective of a decision maker - why we need the fuzzy set theory.

The SIG on DA will work on a new theory base for decision analysis to anchor it in a real life decision making context and work out a conceptual modelling framework for better decision making with the help of soft computing technology.

The theory base is partly to be found in the literature. The base will probably evolve in several stages:

1. state of the art surveys,
2. identifying sound key contributions to serve as cornerstones,
3. picking out obvious shortcomings missing parts of the theory base,
4. proposing and validating new elements and theory segments, and
5. writing a proposed new theory base.

He elements and problems we will have to tackle include:

- some consistent conceptual framework(s) for tackling real life decision problems

using fuzzy modelling and approximate reasoning;

- modify, unify and expand fuzzy DA theory;
- develop a conceptual basis for fuzzy lp, molp, mcdm and mcda;
- work out a conceptual framework for using fuzzy logic in decision support technology;

When the theoretical issues have been solved or resolved, the next step will be to work out specifications for soft computing software which should be designed to be instrumental for implementing the new DA approach in real world decision making.

In order to get the methods and the software launched sets of good test cases for each one of the areas listed above should be worked out and offered as a way to both demonstrate the new methods and to offer easy ways of questioning their substance and testing the new algorithms. Cases could also be used to encourage people to find alternative methods and modelling techniques, which would both initiate debate and create a bandwagon effect. Finally, cases would help spread the new DA approach by offering good teaching material for undergraduate programs.

Cases are not enough. Fairly early on the challenge of making sense to corporate decision makers should be undertaken. This could be done by tackling either classical $-saving problems in a new, more effective ways or by working on problems for which classical optimisation techniques do not make sense, but for which soft computing techniques would produce more effective and more productive results than plain experience and intuition. The problem is, of course, that the problems need to be worthwhile in $ terms and that these problems are not readily accessible for research people wanting to test and prove a new theory and an improved technology.

The problems we want to tackle and the goals we want to attain thus include:

1. to find a soft computing paradigm for DA;
2. to create a consistent theory for **soft decision analysis**;
3. to develop a methodology for optimal decision making with the help of soft computing;
4. to create a recommended implementation program for soft DA and to develop a taxonomy for successful implementation to be used for follow up studies of implementation programs;

The SIG on DA will be formed as a network of task forces with a minimum of 3-5 members per task force. A task form will be formed for each of the following areas:

- traditional single criterion decision making;

- linear programming modelling and optimal decisions;
- multiple objective linear, multiple criteria decision making (mcdm) multiple criteria decision aid (mcda) and optimal decisions;
- decision support systems (DSS) and intelligent systems for decision support;

Each task force will,

1. do an initial state-of-the-art report of its assigned area;
2. collect 3-5 obvious shortcomings or areas of potential improvement with standard DA approaches;
3. work out a proposal for how these improvement could/should be carried out;
4. work out solutions in detail with theory, models, solutions cases and follow up taxonomy;

The task forces will report their results on a Web-site, at BISC workshops, through invited sessions at international meetings or through IFORS SPC:s.

The SIG on DA will collect reports in edited books on Kluwer (or corresponding) and will work out implementation programs for the results in co-operation with ERUDIT and kindred groups.

When preliminary results are at hand funding for large scale research programs will be applied for through the ESPRIT V or corresponding programs.

Interdependent MCDM

One of the main goal of BISC-SIG on DA is to develop a conceptual framework for tackling real life decision problems with interdependences.

In their classical text *Theory of Games and Economic Behavior* John von Neumann and Oskar Morgenstern (1947) described the problem with *interdependence*; in their outline of a social exchange economy they discussed the case of two or more persons exchanging goods with each others (page 11):

"then the results for each one will depend in general not merely upon his own actions but on those of others as well. Thus each participant attempts to maximize a function ... of which he does not control all variables.

This is certainly no maximum problem, but a peculiar and disconcerting mixture of several conflicting maximum problems. Every participant is guided by another principle and neither determines all variables which affects his interest.

This kind of problem is nowhere dealt with in classical mathematics. We emphasize at the risk of being pedantic that this is no conditional maximum problem, no problem of the calculus of variations, of functional analysis, etc.

It arises in full clarity, even in the most "elementary" situations, e.g., when all variables can assume only a finite number of values."

The interdependence is part of the economic theory and all market economies, but in most modelling approaches in multiple criteria decision making there seems to be an implicit assumption that objectives should be independent. This appears to be the case, if not earlier than at least at the moment when we have to select some optimal compromise among the set of nondominated decision alternatives. Milan Zeleny [*Multiple Criteria Decision Making}, McGraw-Hill, New-York, 1982*] recognizes one part of the interdependence (page 1),

"multiple and conflicting objectives, for example, "minimize cost" and "maximize the quality of service" are the real stuff of the decision maker's or manager's daily concerns.

Such problems are more complicated than the convenient assumptions of economics indicate. Improving achievement with respect to one objective can be accomplished only at the expense of another."

but not the other part: objectives could support each others. We explore the consequences of allowing objectives to be interdependent.

Situations with multiple interdependent objectives are not only derived from some axiomatic framework as logical conclusions, or built as illustrations of complex decision problems in classical text books, there are real life situations which, if we ponder them systematically, reveal themselves to have interdependent objectives.

The Buyer/Seller dilemma

A well-known negotiation problem is the *Buyer/Seller* dilemma, in which it is unclear for both parties at which price they are going to settle when they start the negotiation process:

Their objectives are clearly conflicting:

the **Buyer** wants the price to be as low as possible;
the **Seller** tries to keep the price as high as possible.

There are two points, the reservation prices, beyond which the negotiations break down.

The Buyer will not discuss a price higher than the (Buyer)-point; the Seller will find a price lower than the (Seller)-point insulting.

If both parties compromise they can eventually settle on a price somewhere at the mid-point of the interval.

The problem becomes interesting and challenging when none of the parties can be sure of the other party's reservation price, but the setup is simple in the sense that the objectives are conflicting, and the problem can be solved with standard methods.

Let us now assume that there is a third party, the *Government*, involved and that the Government reacts to the negotiation process by working out consequences of both the reservation prices and the offers made during the negotiations. Let us also assume that the Government wants to intervent in the process in order to promote its own objectives.

In this way the negotiation problem becomes much more complex as there are a number of new objectives involved over which the primary parties have no control.

The Buyer and the Seller influence two different objectives of the Government respectively (Obj 1 and Obj 2):

- a low Seller reservation price will support Obj 1, but a high Seller reservation price will be in conflict with Obj 1 after some point G1 ;
- a high Buyer reservation price will support Obj 2, but a low Buyer reservation price will be in conflict with Obj 2 after some point G2 ,
- Obj 1 and Obj 2 are conflicting (as often is the case with political objectives).

The negotiation process ((1), (2), (3)) influences Obj 3 of the Government:

- short steps and a small interval both support the attainment of Obj 3, but
- large, oscillating steps and a large interval are hinders for the attainment.

There are a number of cases of labor market negotiations in which these types of interdependences are present. Because Obj 1-3 are influenced by the Buyer-Seller negotiations the Government can not remain passive, but will influence the objectives of the primary negotiators.

Then we get a set of decision problems for all parties involved, in which we have multiple interdependent objectives; these problems are not easy to cope with and to resolve.

In some labor market negotiations in the spring 1996 the Finnish government managed to both define such levels of its own objectives and to push the reservation prices of the primary negotiators to levels which were unattainable.

When the government finally agreed to face-saving compromises the country was 12 hours from a general strike.

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Fuzzy Logic

Welcome, you are visitor number 2 1 4 6 3 since Monday, April 1, 1996.

This software has been produced by students in Prof. Timothy J. Ross's semester course, Fuzzy Logic with Engineering Applications, at UNM over the past five years. Prof. Ross is the author of a textbook, by the same title, used in his class. For more information on how to place and order for the book, please click here.

Click here to download a copy of academic fuzzy logic software.

Click here to download a copy of fuzzy calculator.

These two programs are compressed in "zip" format. Both programs are DOS applications.

You will need utilities such as " pkunzip " or 

to decompress the archives.

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"Lógica Borrosa" = (peluda !) = medidas - borrosas !

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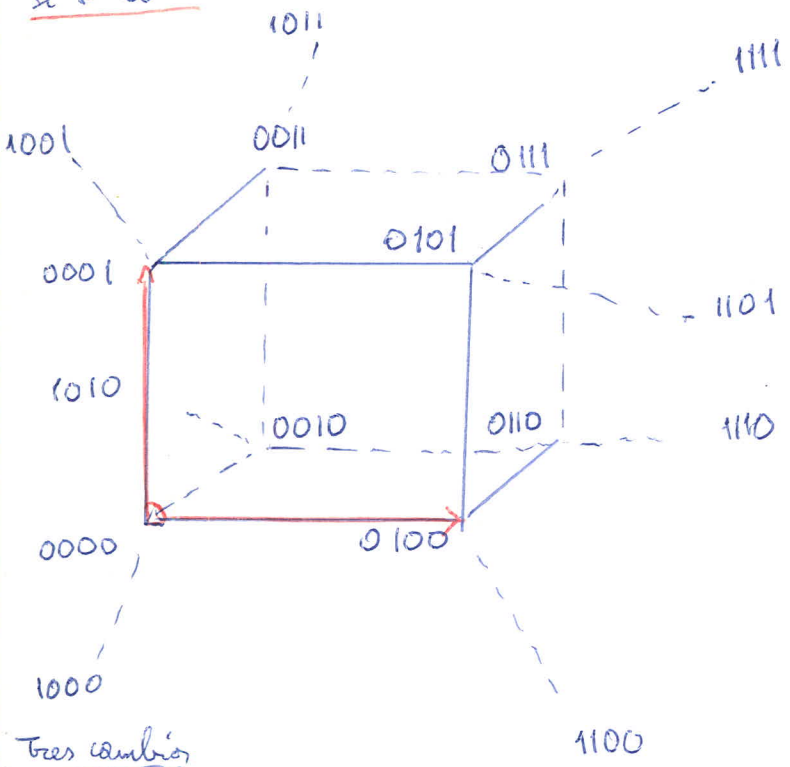
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p. 10/
(p. 11.) continuación)

Si se calculara un espacio con 4 dimensiones, se obtendría



Tres cambios

1) 0000
2) 0001
3) 0010
4) 0110
5) 0100
6) 0101
7) 0011
8) 0111

Cuatro cambios

1 0000
2 1001
3 1010
4 1011
5 1100
6 1110
7 1001
8 1111

un espacio
con 4 dimensiones tendría 16 esquinas

1a	2a	3a	4a
1	1	1	1
1	1	1	0
1	1	0	1
1	1	0	0
1	0	1	1
1	0	1	0
1	0	0	1
1	0	0	0
0	1	1	1
0	1	1	0
0	1	0	1
0	1	0	0
0	0	1	1
0	0	1	0
0	0	0	1
0	0	0	0

16 esquinas

12 - caras.

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(diferente = de una simple imágen → física = del cerebro
→ psíquica = de la fantasía !

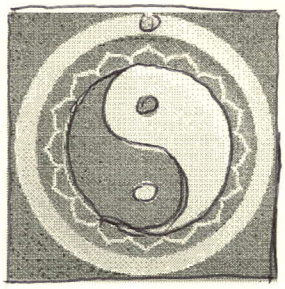
Concepto = Sistema de "conceptos" = Discontinuo + lineal y multidireccional
general - abstracta. plurivalente !

palabra = Sistema Linguístico = Discontinuo : lineal - solo !
general - simbólica.

cosa = La realidad es "a-sistemática", "continua" = "multidireccional
concreta - particular = existente. "pluri-valente."

Pero la conceptúamos sistemáticamente
Para que haya sistema (= orden) debe haber divisiones y medidas

You *fuzzyin'* with me ?



"So far as the laws of mathematics refer to reality, they are not certain. And so far as they are certain, they do not refer to reality."(-Albert Einstein, Geometry and Experience -)

[Abstract]

[Fuzzy *what* ??!!] [Boolean vs. Fuzzy] [Fuzzy Subset Theory] [Fuzzy Operations]

Abstract

In the movie *2001:A Space Odyssey*, Stanley Kubrick predicted how fast the computer technology would grow, by introducing the mainframe HAL, a "smart" computer with the ability to think and learn. Though, it is highly unlikely, that 5 years from now, man would have created HAL, one thing is for sure, it will eventually come from Japan. Why? Because of a very simple little thing in which the Japanese have adapted for decades; the Americans sweating to catch up;- fuzzy logic. This article introduces fuzzy logic, from a mathematics perspective, tracing its origins, stating its characteristics and finally illustrating with examples, its set theories and logic operations.

Fuzzy *what* ??!!

Fuzzy logic is a superset of conventional(Boolean) logic that has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature.

Boolean vs. Fuzzy

300 years B.C., the Greek philosopher, Aristotle came up with binary logic(0,1), which is now the principle foundation of Mathematics. It came down to one law: A or not-A, either this or not this. For example, a typical rose is either red *or* not red. It cannot be red *and* not red. Every statement or sentence is true or false or has the truth value 1 or 0. This is Aristotle's law of bivalence and was philosophically correct for over two thousand years.

Two centuries before Aristotle, Buddha, had the belief which contradicted the black-and-white world of worlds, which went beyond the bivalent cocoon and see the world as it is, filled with contradictions, with things *and* not things. He stated that a rose, could be to a certain degree completely red, but at the same time could also be at a certain degree not red. Meaning that it can be red *and* not red at the same time. Conventional(Boolean) logic states that a glass can be full *or* not full of water. However, suppose one were to fill the glass only halfway. Then the glass can be half-full *and* half-not-full. Clearly, this disprove's Aristotle's law of bivalence. This concept of *certain degree* or multivalence is the fundamental concept which propelled Zader Lofti of University Berkely in the

1960's to introduce fuzzy logic. The essential characteristics of fuzzy logic founded by him are as follows.

- In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
- In fuzzy logic everything is a matter of degree.
- Any logical system can be fuzzified
- In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently , fuzzy constraint on a collection of variables
- Inference is viewed as a process of propagation of elastic constraints.

The third statement hence, define Boolean logic as a subset of Fuzzy logic.

Fuzzy Subset Theory

There is a strong relationship between Boolean logic and the concept of a subset. Similarly there is a strong relationship between fuzzy logic and fuzzy subset theory.

A subset U of a set S can be defined as a set of ordered pairs, each with a first element that is an element of the set S, and a second element that is an element of the set { 0, 1 }, with exactly one ordered pair present for each element of S. This defines a mapping between elements of S and elements of the set { 0, 1 }. The value zero is used to represent non-membership, and the value one is used to represent membership. The truth or falsity of the statement

x is in U

is determined by finding the ordered pair whose first element is x. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

Similarly, a fuzzy subset F of a set S can be defined as a set of ordered pairs, each with a first element that is an element of the set S, and a second element that is a value in the interval [0, 1], with exactly one ordered pair present for each element of S. This defines a mapping between elements of the set S and values in the interval [0, 1]. The value zero is used to represent complete non-membership, the value one is used to represent complete membership, and values in between are used to represent intermediate *degrees of membership*. The set S is referred to as the *universe of discourse* for the fuzzy subset F. Frequently, the mapping is described as a function, the *membership function* of F. The degree to which the statement

x is in F

is true is determined by finding the ordered pair whose first element is x. The *degree of truth* of the statement is the second element of the ordered pair.

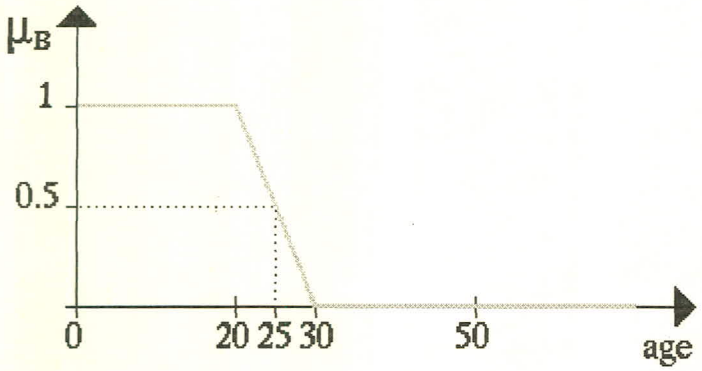
This can be illustrated with an example. Let's talk about people and "youthness". In this case the set S (the universe of discourse) is the set of people. A fuzzy subset YOUNG is also defined, which answers the question "to what degree is person x young?" To each person in the universe of discourse, we have to assign a degree of membership in the fuzzy subset YOUNG. The easiest way to do this is with a membership function based on the person's age.

young(x) = { 1, if age(x) <= 20.,

(30-age(x))/10, if 20 < age(x) <= 30,

0, if age(x) > 30 }

A graph of this looks like:



Given this definition, here are some example values:

Person	Age	degree of youth
Johan	10	1.00
Edwin	21	0.90
Parthiban	25	0.50
Arosha	26	0.40
Chin Wei	28	0.20
Rajkumar	83	0.00

So given this definition, we'd say that the degree of truth of the statement "Parthiban is YOUNG" is 0.50.

Note: Membership functions almost never have as simple a shape as age(x). They will at least tend to be triangles pointing up, and they can be much more complex than that. Furthermore, membership functions so far is discussed as if they always are based on a single criterion, but this isn't always the case, although it is the most common case. One could, for example, want to have the membership function for YOUNG depend on both a person's age and their height (Arosha's short for his age). This is perfectly legitimate, and occasionally used in practice. It's referred to as a two-dimensional membership function. It's also possible to have even more criteria, or to have the membership function depend on elements from two completely different universes of discourse.

Fuzzy Logic Operations

It is clear what the statement *X is LOW* means in fuzzy logic. But, how do we interpret a statement like

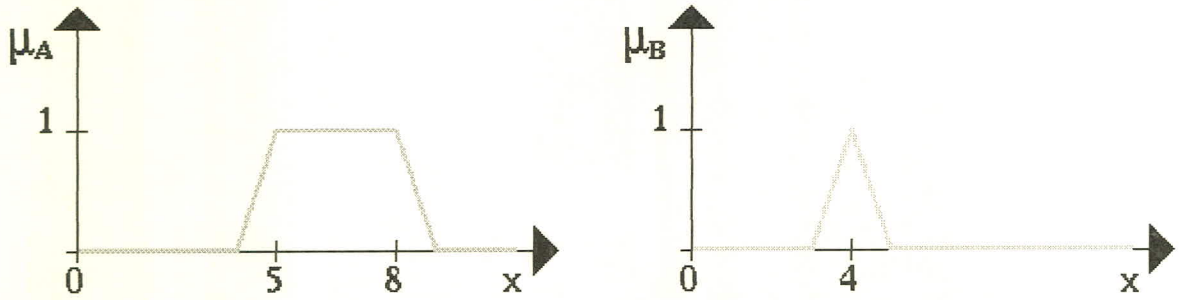
X is LOW and Y is HIGH or (not Z is MEDIUM)

The standard definitions in fuzzy logic as suggested by Lotfi are:

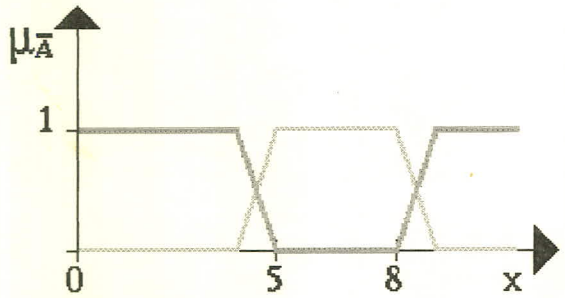
1) Negate(negation criterion) : truth (not x) = 1.0 - truth (x)
2) Intersection(minimum criterion): truth (x and y) = minimum (truth(x), truth(y))
3) Union(maximum criterion): truth (x or y) = maximum (truth(x), truth(y))

In order to clarify this, a few examples are given. Let *A* be a fuzzy interval *between* 5 *and* 8 and *B* be

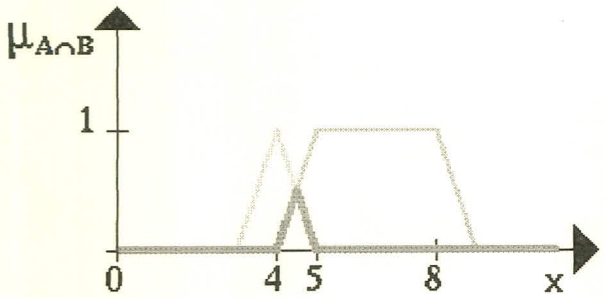
a fuzzy number *about* 4. The corresponding figures are shown below.



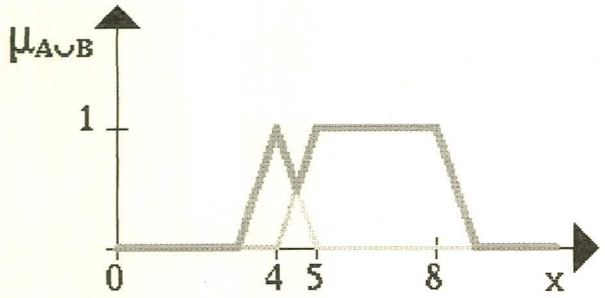
The figure below gives an example for a negation. The blue line is the **NEGATION** of the fuzzy set *A*. Note that the *negation* criterion is used.



The following figure shows the fuzzy set *between* 5 *and* 8 **AND** *about* 4 (blue line). This time the *minimum* criterion is used.



Finally, the Fuzzy set *between* 5 *and* 8 **OR** *about* 4 is shown in the next figure (blue line). This time the *maximum* criterion is used.



These basic operations, provide guidelines to construct more complex ones which in turn can be used to create fuzzy machines.

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Author: Zader Lofti

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Part I: Introduction to Fuzzy Logic

Thinking back to school mathematics the following task might be remembered. Figure 1 shows a car driving with speed v and mass M toward a wall at distance l. The brake-force can be calculated exactly in terms of M, v, l.

V : velocidad
M = masa
l = distancia
K = fuerza del freno

En teoría:



$$K = \frac{1}{2} \cdot M \cdot \frac{v^2}{l}$$

Figure 1. The values of M, v and l are well known. If loss of friction is negligated, we can compute the break force exactly.

But school is not life. In reality the situation is that an obstacle is recognized. The reaction is: " I am too fast and the wall is too close so I have to brake hard". Figure 2 tries to illustrate the problem.

En realidad:

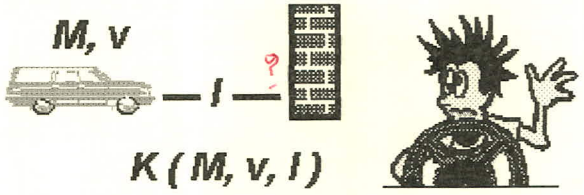


Figure 2. Unfortunately in a real situation, the driver dreamed about the landsscape and let god be a good man.
When the acknowlege is recommended, the exakt valus are not availivble for this time.
Also there is not enough time for solving a physical problem. Our decision for an reaction becomes fuzzy.

In this example typical aspects of fuzzy methods can be seen.

1st: Describing a situation with fuzzy terms:
"too fast", "too close"

2nd: Fuzzy decision making: If "A" and "B" then "C".

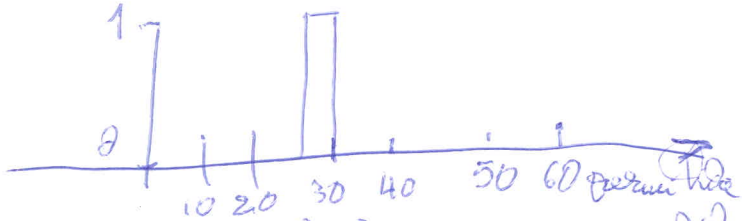
As can be seen in this example in fuzzy logic usually neither crisp sets, nor crisp numbers, nor crisp operators are used. A classical crisp set defined by its characteristic function.

$$\mu(a) = \begin{cases} 1 \text{ if } a \in A \\ 0 \text{ if } a \notin A \end{cases}$$

μ = miembro

Crisp = Terso, apelmazado

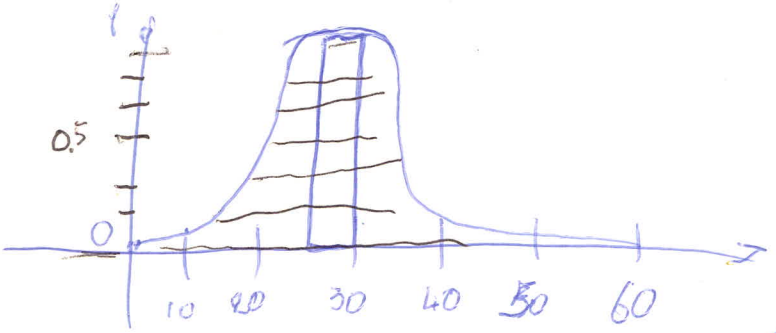
esquema representativo con lógica lógica de la "recepción de grasa - ingerida"
de el punto de vista de un educador - nutricional inexperto



Solo una ingestión de 25-30% de energía es concedida - en todo la membrecía 1 existe por el área permitida - el resto tiene 0 de membrecía,

Como se define el subconjunto Alto? Es definido por la función de Membrecía $\mu(a)$ que se extiende entre 0 y 1

Ej.



La línea curva representa la recepción de ingestión desde el punto de vista de un dietista - experimentado

Esta ~~curva~~ gráfica es considerada característica de la curva de la función de membrecía característica de la lógica Alanda

One further example is shown in figure 3. The acceptance of fat intake from the point of view of an inexperienced nutrition educator (before MSc) is crisp.

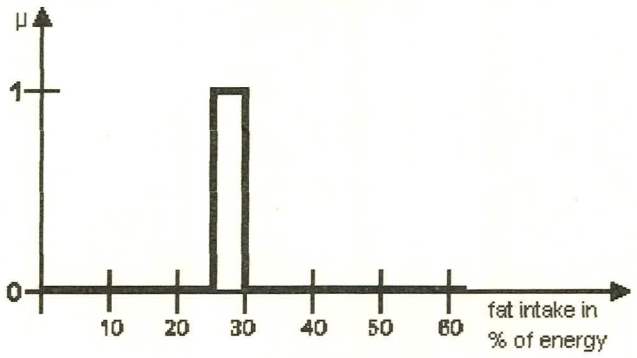


Figure 3. The peak illustrates the accpetance of fat intake from the point of view of a nutrition educator.

Only a fat intake of 25 to 30% of energy is allowed. So only the membership 1 exists for the allowed area and the rest has membership 0. Classic logic is a bivalent logic, membership - no membership, true - false, guilty - not guilty etc.

How is a fuzzy set defined? It is defined by the membership function μ(a) which ranges between 0 and 1.

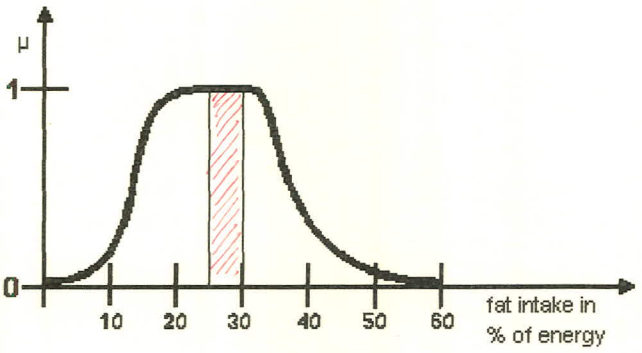


Figure 4. The smoothly curve illustrates the accpetance of fat intake from the point of view of a experienced nutrition educator (NE). Such a graph is known as the characteristic curve of the membership function of type I fuzzy set.

One example produced in figure 4 (after some years of experience in nutrition education): Now a fat intake of 25 to 30% of energy is optimal, but there exist areas close to the optimum which are still acceptable. The acceptance (= membership function) decreases the further the distance to the optimum is.

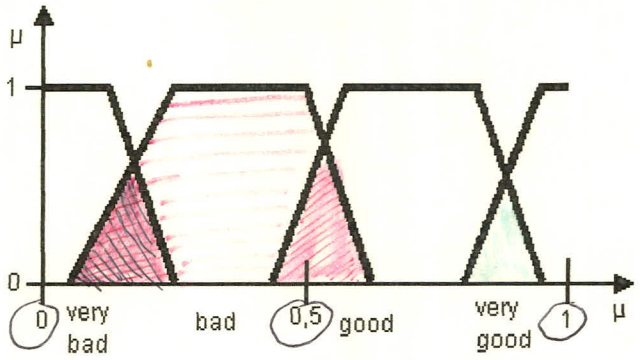


Figure 5. Fuzzy set type II for the interpretation of linguistic terms.

Fuzzy logic is a multivalent logic. There exists a degree of membership, more or less true, more or less false. The membership function can be interpreted verbally by type II fuzzy sets (fig. 5) in contrast to the previously explained type I fuzzy sets.

Even numbers are usually not crisp in fuzzy logic. A crisp number is, for example, 60 mg vitamin C. In reality this number does not exist. In fuzzy logic a number is described by a fuzzy set. The characteristic curve is shown by figure 6.

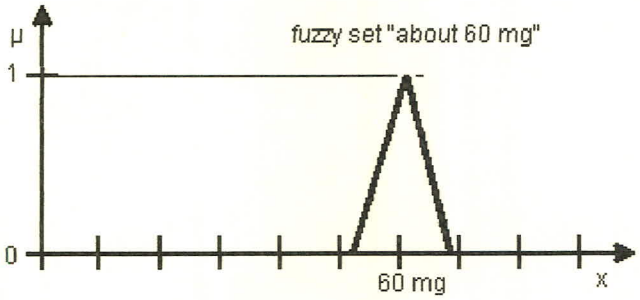
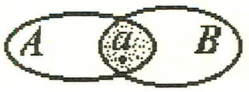


Figure 6. A more realistic description of the sharp value "60 mg", cause it takes care of the error of devation.

Besides sets and numbers, operators are used in fuzzy logic. In classic set theory intersection and logic "and" are defined as follows:



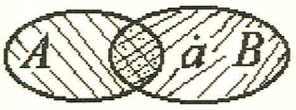
$$A \cap B$$
$$a \in A \text{ "and" } a \in B$$

characteristic function for $A \cap B$

$$\mu_{A\cap B}(a) = \begin{cases} 0 \text{ if } a \notin A \text{ and } a \notin B \\ 0 \text{ if } a \notin A \text{ and } a \in B \\ 0 \text{ if } a \in A \text{ and } a \notin B \\ 1 \text{ if } a \in A \text{ and } a \in B \end{cases}$$

$$\mu_{A\cap B}(a) = \min(\mu_A(a), \mu_B(a))$$

Union and logic "or" are defined in classic set theory as follows:



$A \cup B$

$a \in A$ "or" $a \in B$ o a los dos,

characteristic function for $A \cup B$

$$\mu_{A \cup B}(a) = \max\left(\mu_{A(a)}, \mu_{B(a)}\right)$$

In fuzzy logic min- and max- operators can be used to describe intersection and logic "and" or union and logic "or" respectively:

intersection and logic "and" = ∩

$$\mu_{\tilde{A} \cap \tilde{B}}(a) = \min(\mu_{\tilde{A}}(a), \mu_{\tilde{B}}(a))$$

union and logic "or" = ∪

$$\mu_{\tilde{A} \cup \tilde{B}}(a) = \max(\mu_{\tilde{A}}(a), \mu_{\tilde{B}}(a))$$

To demonstrate the intersection between acceptable intake of fat from the point of view of an experienced nutrition educator (NE) and acceptable intake of fat from the point of view of a beefeater (BE, fig 7.), the fuzzy set of the fat intake of the beefeater needs to be introduced.

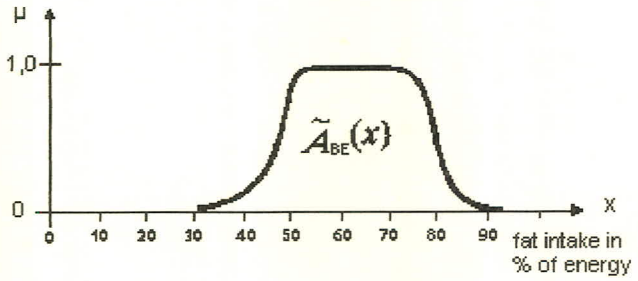


Figure 7. The accpetance of fat intake from the point of view of a beefeater.

It may be that his optimum is a nutrition with more than 50% fat, his acceptance decreases if there is less fat.

If one tries to find an acceptable intake for the beefeater and the nutrition educator one has to represent the logic "and" by intersection.

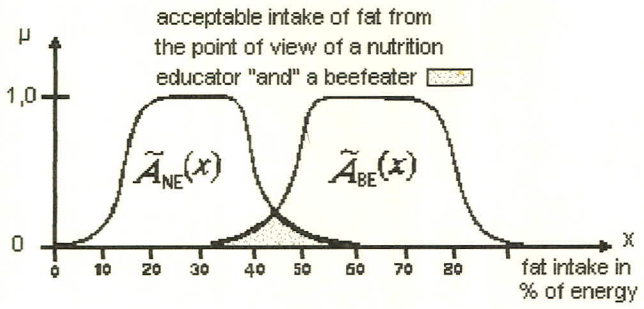


Figure 8. Enjoy that fuzzy theorie allows the marriage between a beefeater and an advanced nutrition educator.

So, acceptable for NE "and" BE is

Formular (5)

It can be seen that there exists an area of poor acceptance for both, as shown in figure 7.

We come now to the area of fuzzy decision making. This is identical to optimization of membership functions and identical to finding compromises. In our example maximizing the membership function for the intersection gives a compromise of about 45% fat.

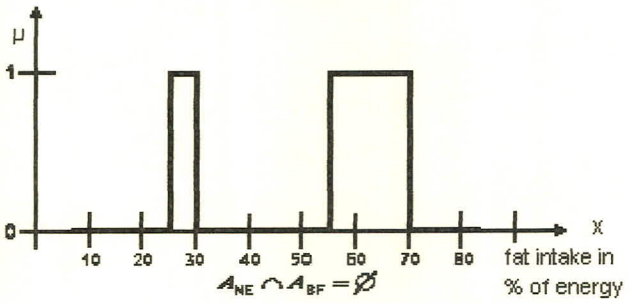


Figure 9. The worlds of an inexperiencend nutrition educator and a convinced beefeater are disjunct.

In comparison with classic set theory, we found a compromise in fuzzy theory, which was impossible in the former.

Typical for fuzzy logic are further operators. Especially mean operators are very often used to make compromises. The context decides which operator is best.

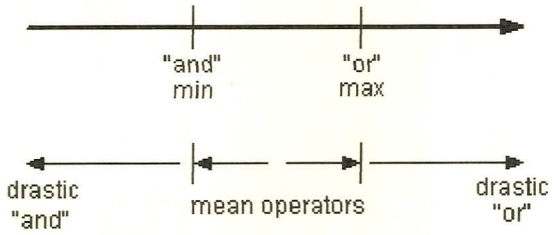


Table 1 compares the characteristics of classic and fuzzy logic.

classic logic	fuzzy logic

Bival. Multiv.

logic	bivalent	multivaltent
sets	crisp	fuzzy
membership	0 or 1	between 0 and 1 verbal interpretation by linguistic variables
numbers	crisp	fuzzy
Operators	crisp	fuzzy
compromises	often not possible	always possible

For fuzzy decision making the following steps are used. método:

- Describing the separated problem with fuzzy sets
- Identifying the conflicts
- Formulation of a compromise
- Application of an appropriate operator
- Optimization

There are a lot of institutions in Germany working in the field of fuzzy theory and its application to a wide spectrum (e.g. pattern recognition, production planning, financial engineering). In the field of nutrition fuzzy methods are used to make decisions in sensory analysis and to define the degree of risk for nutrition related diseases. In our company we use fuzzy logic in nutrition education.

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Aquí hay una falacia!

"bivalente" = se mide por 2 términos o valores no se opuesta solo es diferente como: "unidad - teoría"

a "multivalente" = también se mide por 2 valores a la vez!

La lógica multivalente no es mas que una "aplicación - repetida" de las operaciones bi-valente: le toma la unidad (bivalente) repetidas veces, seguido.

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Part II: Fuzzy Logic in Nutrition Education

In Truswell's book "ABC of Nutrition" a diagram (fig. 10) is to be found, which shows the degree of health when varying the intake of one nutrient and the rest of the diet is held constant.

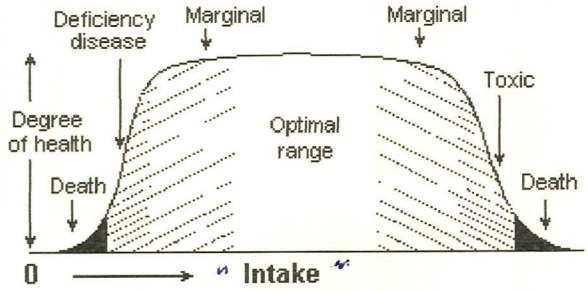


Figure 10. Degree of health when varying the intake of one nutrient and holding the rest of the diet constant.

There exists a very dangerous area of low intake, an area of deficiency diseases, a marginal area and a large optimal range. Here the health does not improve or deteriorate as the intake is changed. For most nutrients this is quite a long range. There is therefore no single optimal intake figure. The recommended dietary intake or reference nutrient intake is intended to be at the top of the left hand slope in the diagram. On the other hand there exists a marginal area of high intake, a toxic area and at the end again a very dangerous area. This diagram (fig. 10) can also be interpreted as a curve describing the "optimal intake". It can be used to define a fuzzy set.

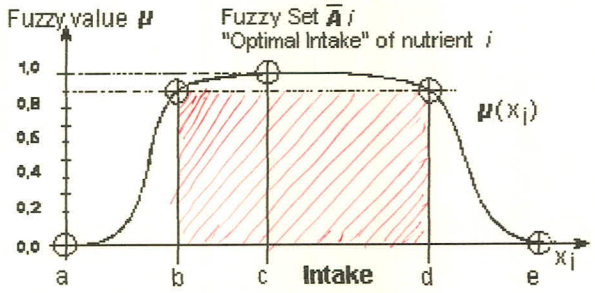


Figure 11. The fuzzy set "optimal intake" of a nutrient.

In the case of the fuzzy set "optimal intake" μ(xi) is now called the membership function or grade of membership of the intake xi in the fuzzy set Ai. The membership function (fig 11) can vary between 0 (=non membership) and 1 (=classical membership in a crisp set).

All values between 0 and 1 can be described verbally. In fuzzy logic linguistic variables can be used for this purpose. These are variables whose values are not numbers but words or sentences in a natural language.

Las figuras 13. 14. 15. 16, hay que abrirlas a parte

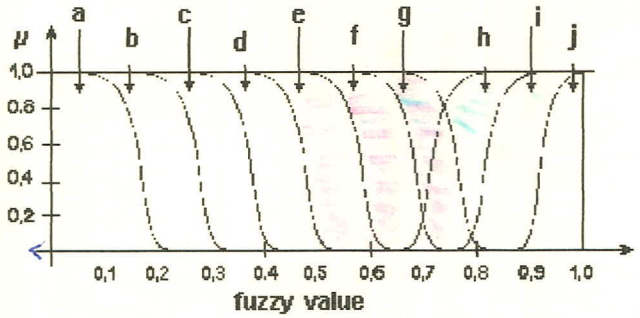


Figure 12. The membership function μ for some linguistic variables.

The membership function for several linguistic terms can be chosen as shown in figure 12.

On the basis of these verbal interpretations some nutrition scientists and ourselves developed the following fuzzy sets for the nutrients consistent with the German nutrition recommendations.

Characteristic curves for the fuzzy sets engerie, main nutrients dietary fibre and water.

Figure 13.

Figure 13. Characteristic curve for the fuzzy set dietary fibre.

Dietary fibre (fig. 13) is not an essential nutrient. Therefore the membership function does not start at the zero point. As there are beneficial effects when taking certain amounts of dietary fibre the curve starts at 0.7 and inclines to a value of one at optimal intake. With such kinds of curves semiessential nutrients are described.

Characteristic curves for the fuzzy sets water soluble vitamins.

Figure 14.

Figure 14. Characteristic curve for the fuzzy set vitamin C.

Clearly one can see in the case of water soluble vitamins (fig. 14) quite a long range for optimal intake. The recommended dietary intake is defined at the top of the left hand slope in the diagrams.

Characteristic curves for the fuzzy sets lipid soluble vitamins.

For the lipid soluble vitamins A and E again there is quite a long range for optimal intake, but not so for vitamin D. The fuzzy sets for minerals and trace elements differ from one substance to the other.

Characteristic curves for the fuzzy sets macro minerals.

As in the case of dietary fibre, fluoride is described as a semiessential nutrient.

Characteristic curves for the fuzzy sets micro minerals.

Beside the fuzzy sets for essential nutrients one can define fuzzy sets for some other substances too e.g. cholesterol, alcohol (fig. 15), sucrose. As they are not essential the membership function does not start at the zero point.

Characteristic curves for the fuzzy sets further substances.

Figure 15.

Figure 15. Characteristic curve for the fuzzy set alcohol.

For economic applications we are able to include these types of fuzzy sets even for costs, defining where problems with the costs start.

Characteristic curves for the fuzzy sets hamming distance and costs.

Figure 16.

Figure 16. Characteristic curve for the fuzzy set hamming distance.

In nutrition education it is always important to start with the actual nutrition situation and recommend only such nutrition changes that are not too great. For this purpose we define the Hamming distance, which measures the distance between 2 nutrition situations in kitchen units. The fuzzy set (fig. 16) defined on the basis of these units describes the degree of acceptance of these changes.

In real situations in nutrition education one does not optimize single nutrients but one always has to weigh up between several nutrients. For example if there is too little dietary fibre but too much energy in the diet: adding wholemeal bread gives more dietary fibre - but on the other hand more energy too. So there is a conflict.

To solve this conflict and to represent the logic "and" (because one wants to reach good results for dietary fibre and energy) one has to make compromises.

In fuzzy logic this is often done with mean operators.

After a lot of discussion we picked out a combination between the minimum operator and the harmonic mean operator. Its application to the fuzzy sets of all nutrients for which German nutrition recommendations exist and for which data is to be found in the German nutrient data bank, gives what we call the Prerow value.

The Prerow Value

$$PV := \min \cdot \frac{1}{\frac{1}{n}\sum_{i \neq \min}^{n} \frac{1}{\mu_{\tilde{A}_i}(x_i)}}$$

- A measure how close the German nutrition recommendations are reached on average.
- In relation to means (arithmetic, geometric, harmonic mean) the Prerow value is closest to the minimum, which represents the logical "and".
- If membership $\mu_{\tilde{A}_i}(x_i) = 0$, the Prerow value itself is 0.
- In large models one nutrient with a low value has the strongest influence when using the Prerow value.
- In the approximation used, the Prerow value is convex and therefore easily optimized.

The Prerow value so defined is now a measure for how close one comes on average to the recommendations - or how healthy our food is.

With the Prerow value one can decide whether a certain nutrition situation is better or worse than another.

Within a certain nutrition situation one can also get answers to questions like "what happens if less or more of one foodstuff is eaten while the rest are fixed?"

Starting with the actual intake of an average German woman one can calculate what happens if this woman eats less or more sausage for example (better: less sausage), less or more vegetables (better: more).

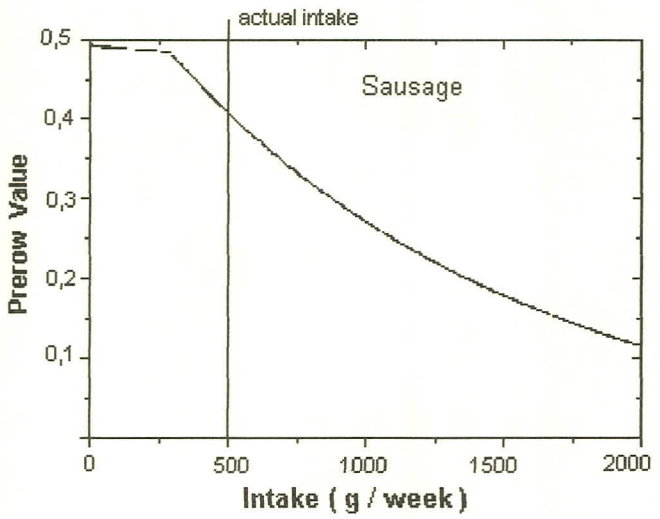


Figure 17. The curve shows the Prerow value in dependece of the intake of sausage in gramme per week.

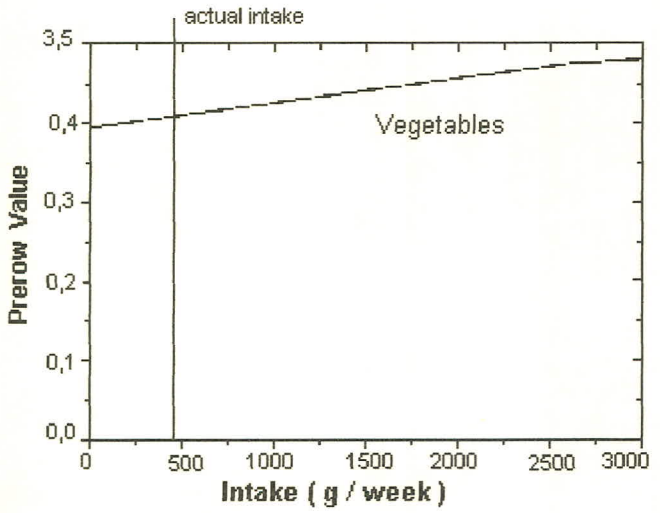


Figure 18. The curve shows the Prerow value in dependece of the intake of vegatables in gramme per week.

If one changes two foodstuffs one does not get a curve but a landscape. Clearly one can see which is the shortest way to come closer to the recommendations.

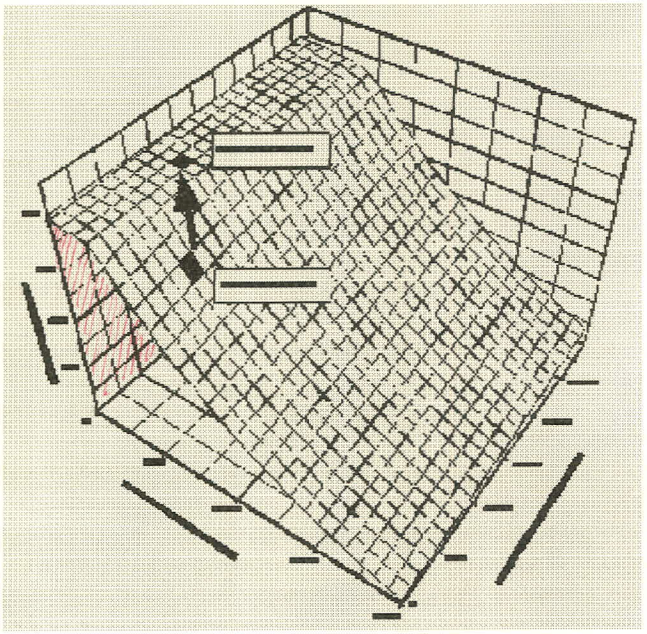


Figure 19. Variation of the Prerow value when varying two foodstuffs.

In reality, of course, this will be an n-dimensional decision space. It cannot be plotted, but we can develop a PC programme which calculates the gradient and which finds points in the nutrition landscape near to the starting point but in good agreement with the recommendations.

We have made the experience in our own nutrition education that the acceptance of such recommendations is good because this method tries to make only small changes in nutrition behaviour.

If the methods discussed are applied to a real nutrition situation keeping a food record for some days is necessary.

Analysis and optimization of such a record is shown in these slides. Here the analysis for the nutrients can be seen before and after optimization.

Here we miss the slide show and the example output from FOODOPT I.

The recommended changes in food consumption are shown in this slide. When a healthy person goes for consultation generally very small changes are sufficient to get good results. For persons at risks of nutrition related diseases in general bigger changes have to be made.

In this slide the interpretation of the importance of deviations from the official recommendations or other goals is shown.

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La PARTE III Se refiere a la absorción de Zinc en el organismo.

rústicas

(*) Las medidas Fuzzy pueden ser muy "groseras" (por ej: usar pulgadas para medir una hoja de papel (en lugar de centímetros) — y milímetros o usar galones para medir el agua de un cubo (en lugar de litros)
Cuanto el margen entre una medida y la otra es más amplio!

Esta "amplitud del margen" (imprecisión) da a la "medición" el carácter fuzzy a pesar de que la medida no sea fuzzy — sino fija! y definida.

Cuanto más rústicas las medidas tanto mayor es el "margen-fuzzy" que separa una medida de la otra

Ej: Tengo este lapicero y necesito medirlo: con qué precisión?



a) Lo puedo medir en pulgadas: = cinco pulgadas y margen: 6/8 de pulg.
b) o bien en centímetros = 14 cm + 6 mm (18 mm)
c) o bien en milímetros = 148 mm. + 1/2 m = este es el margen

La medida en mm es la más precisa! Solo hay un margen "no medible" de 1/2 milímetro - lo cual es extraordinario!

MA Archives

Topics in Mathematics

Logic & Set Theory

- The Alonzo Church Archive [G-P]
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- AMS's Materials Organized by Mathematical Subject Classification [Lnks]
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- Association for Symbolic Logic [G-P]
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- The Beginnings of Set Theory [UD]
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- A home page for THE AXIOM OF CHOICE [UD] [Lnks]
  ADD. KEYWORDS: Books, Formal Logic, Automatic Theorem-proving
- Institute for Logic, Language and Computation, University of Amsterdam [G-P]
  ADD. KEYWORDS: Newsletter, Preprints
- Introduction to Logic for Liberal Arts and Business Majors [LD]
  ADD. KEYWORDS: Tutorial, Proposition, Truth Value, Logical Equivalence, Tautologies and Contradictions, Conditional and the Biconditional, Rules of Inference, Arguments and Proofs, Propositional Calculus
- Johan Mårtensson's On-Line Logic Book [UD] [Int]
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- Journal of Logic and Computation [G-P]
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- Linear Logic [G-P] [Lnks]
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- New Foundations [G-P]
  ADD. KEYWORDS: Russell's theory of types, W. V. O. Quine, Set Theory, Consistent subsystems,

La lógica no es parte de la matemática -!

sino, la estructura lógica de la mente

La matemática: { axiomática / o constructivista } → ambas se fundan en la lógica.

Teleological Argument (St. Thomas Aquinas): All things in the world act towards an end. They could not do this without their being an intelligence that directs them. This intelligence is God.

Ontological Argument (St. Anselm): God is a being than which none greater can be thought. A being thought of as existing is greater than one thought of as not existing. Therefore, one cannot think of God as not existing, so God must exist.

Are these arguments valid?

Logic is the underpinning of all reasoned argument. The Greeks recognized its role in mathematics and philosophy, and studied it extensively. Aristotle, in his *Organon*, wrote the first systematic treatise on logic. His work in particular had a heavy influence on philosophy, science and religion through the Middle Ages.

But Aristotle's logic was logic expressed in ordinary language, so was still subject to the ambiguities of natural languages. Philosophers began to want to express logic more formally and symbolically, in the way that mathematics is written (Leibniz, in the 17th century, was probably the first to envision and call for such a formalism). It was with the publication in 1847 of G. Boole's *The Mathematical Analysis of Logic* and A. DeMorgan's *Formal Logic* that symbolic logic came into being, and logic became recognized as part of mathematics. This also marked the recognition that mathematics is not just about numbers (arithmetic) and shapes (geometry), but encompasses any subject that can be expressed symbolically with precise rules of manipulation of those symbols. It is symbolic logic that we shall study in this chapter.

Since Boole and DeMorgan, logic and mathematics have been inextricably intertwined. Logic is part of mathematics, but at the same time it is the language of mathematics. In the late 19th and early 20th century it was believed that all of mathematics could be reduced to symbolic logic and made purely formal. This belief, though still held in modified form today, was shaken by K. Gödel in the 1930's, when he showed that there would always remain truths that could not be derived in any such formal system. We'll mention more about this as we go along.

The study of symbolic logic is usually broken into several parts. The first and most fundamental is the **propositional calculus**, and this is the subject of most of this web text. Built on top of this is the **predicate calculus**, which is the language of mathematics, but goes beyond the scope of this web text.

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We would welcome comments and suggestions for improving this resource. Mail us at:
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