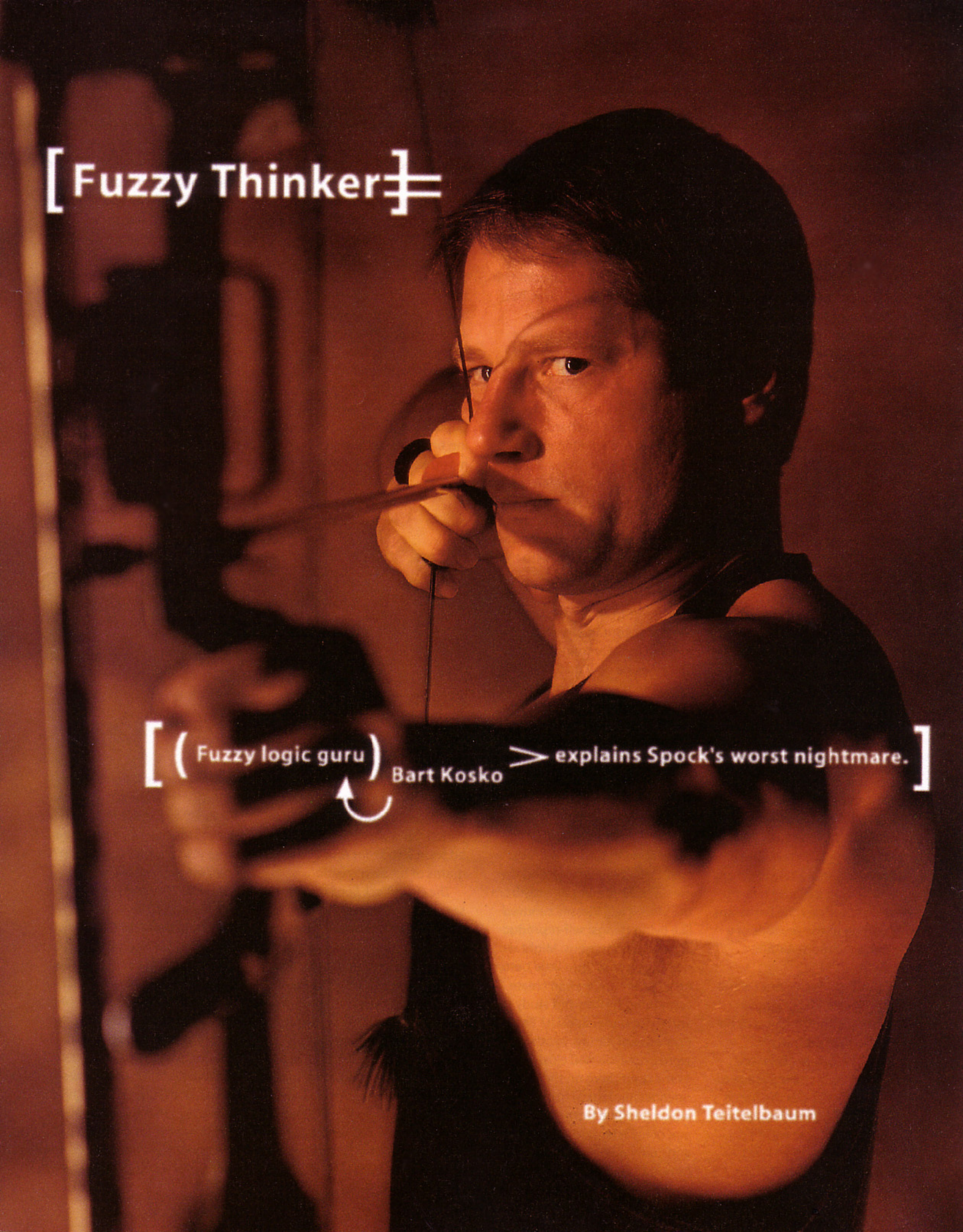
[Fuzzy Thinker]
[(Fuzzy logic guru) Bart Kosko > explains Spock's worst nightmare.]
By Sheldon Teitelbaum

Wired: What is fuzzy logic and why do critics call it "the cocaine of science?"

Kosko: Fuzzy logic is Spock's worst nightmare – a way of doing science without math. It's a new branch of machine intelligence that tries to make computers think the way people think and not the other way around. You don't write equations for how to wash clothes. Instead you load a chip with vague rules like "if the wash water is dirty, add more soap," and "if very dirty, add a lot more." All wash water is dirty and not dirty – to some degree. It's just common sense. But it breaks the old either/or logic of Aristotle. That offends some scientists, who would like us to think and talk like off/on switches. But they still haven't produced a statement of fact like "the sky is blue" or "$E=mc^2$" that is 100 percent true or 100 percent false. Fact ain't math. You can never get the science right to more than a few decimal places. That's one reason we find chaos when we look at things up close.

The Japanese and Koreans produce billions of dollars each year in fuzzy washing machines, microwave ovens, and carburetors. Is fuzzy logic just another gadget technology?

No. Fuzzy systems are universal computers. I proved that as a theorem – the fuzzy approximation theorem. In theory, you can replace every book on physics or economics with equivalent books that have fuzzy systems where the equations used to be. Fuzzy systems are "model-free" estimators. You don't have to guess at equations to build a bridge from inputs to outputs. Fuzzy rules build that bridge for you. There is math behind the rules, but you don't need to know it to program a fuzzy system. You can program it in English. "If the air is cool, turn the AC down a little." But the math is not fuzzy. That's why you can capture fuzzy logic in a digital chip.

Most of the first fuzzy systems were in control – as in adjusting a camera lens or backing up a trailer truck to a loading dock. Now we're applying fuzzy systems to wireless communications and multimedia. The fuzzy rules can "randomly" spread signals over a wide bandwidth or teach an intelligent agent the kind of houses or sunsets you prefer. The math says we can apply them anywhere. In practice, it may not be so easy.

How can a fuzzy system screw up?

The rules. The first problem is, where do you get them? Dumb rules give dumb systems. The bigger problem is rule explosion. You want to add more variables to capture more causes and to make the system more realistic. You might add humidity and light intensity to temperature in the air conditioner. The catch is that the number of rules grows exponentially as you add new variables. So you try to find optimal rules. The math tells us they cover the turning points of the system – they patch the bumps.

Where do neural networks come in?

At the front end. They tune the fuzzy rules by tuning the fuzzy concepts or sets. I may draw cool air as a triangle centered at 65 degrees Fahrenheit. The air is 100 percent cool at 65 but only 80 percent cool at 63 or 67. You may draw a fatter or a thinner triangle. Or you may center it at 70. This reminds us that we don't all mean the same thing for even the most basic sensory terms. And that's OK. You get user friendliness by finding your own niche in the conceptual anarchy.

You once consulted on the Tomahawk cruise missile. What joys will fuzziness deliver in the way of ballistic buggery?

The Smart War – all of our smart weapons against all of theirs. Right now, you have to store 50,000 to 100,000 images of a tank in a cruise missile's chip brain for a neural net to match against. Then it can tell a tank from a tree at all angles and resolutions. As chips continue to shrink, you can store more and more of these fuzzy patterns and allow the missile to reason with more and more fuzzy rules.

You are a well-published libertarian. Is there a political tie to fuzz?

For me there are two. First, I am pro-choice on all issues. Tyranny is one choice. Binary is next with two choices. Fuzz gives a whole spectrum of choices – and thus freedom of response. The pro-life zealot who wants to draw a hard line between life and death at conception or the first trimester is a binary tyrant of sorts. There is no hard line between life and death. It's a curve, or fuzzy set.

Second, I think someday we will see what I call a fuzzy tax form. As it works today, all your tax dollars go to general revenues. But suppose only half did, and the other half goes to social categories of your choice. Maybe 30 percent for AIDS research, 40 percent for debt relief, and 30 percent for environmental cleanup. That way you could set up real research bounties. Our binary tax forms deny us such a choice.

Taxes and death. You oppose them both.

Yes. It's a hell of a thing to live in a machine that has no backup. I am one of 500 or so who has a cryonic bracelet and hopes to see if future nanotech can rebuild those cells and synapses. That, too, is a form of backup. The better thing is just to upload in a chip. The brain stores about a billion billion bits of information and runs at about 10 million billion bits per second. Today you would need a chip the size of a house. But if Moore's Law keeps doubling the circuit density of chips every two years or so, by around 2020, your brain should fit to the last bit on a chip the size of a sugar cube. You could last until your last chip fell into a black hole or star.

On chip time, that may be as close to eternity as we can come in a universe made of matter and energy. Heaven or hell in a chip. Until then, it's burn, bury, or freeze. I wouldn't bet my life on cryonics, but I am happy to bet my death on it.

Bart Kosko holds degrees in philosophy, economics, math, and engineering. He chaired the first international conference on neural networks when he was 27. At 34, he is a tenured professor in electrical engineering at the University of Southern California. Kosko came to USC from the farmlands of Kansas on a full music scholarship – he wrote his first symphony when he was 18. Now he directs the prestigious Signal and Image Processing Institute, where he works on HDTV, brain scanning, and future effects for "digital film."

Kosko has written three textbooks and the best-selling *Fuzzy Thinking*. Today, you can find him pumping iron, scuba diving against the downward currents off the coast of Cozumel, or, armed with a bow-and-arrow, hunting wild boar. He recently shared a cigar with Sheldon Teitelbaum, filling a room with fuzzy ruminations.

Sheldon (Sheli) Teitelbaum is a Los Angeles-based senior writer for the Jerusalem Report *and a contributor to* Sci Fi Universe *and the* Los Angeles Times.