Computer control of manufacturing processes has usually been based on the binary logic of on/off, in/out of spec, etc. Human-like thinking, even with an artificial-intelligence program, has come slowly into this precision-based world. But this "soft computing" is coming. For manufacturers, fuzzy logic applications are growing in number, visibility, and variety. Lotfi Zadeh, "the father" of fuzzy logic, speaks out on this gray area of control technology.

SECTION

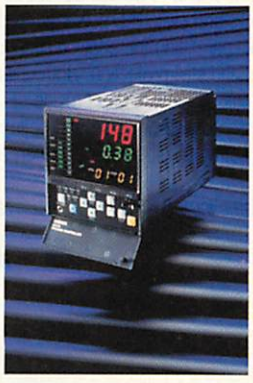
CONTROLS

A Focus on Fuzzy Logic: The Gray Area of Controls

BY MARTY WEIL

An old Welsh proverb states says that reason is the wise man's guide. With fuzzy logic, a recent form of computer logic, even the most common household appliance has the ability to reason—somewhat. When applied correctly, fuzzy logic provides increased efficiency, streamlined production, and economic advantage.

Although it was developed more than 25 years ago, applications of fuzzy logic are only now growing in number, visibility, and variety. "Up until the early 1980s most applications were concerned with expert or knowledge-based systems," says Lotfi A. Zadeh, professor emeritus of the computer science division at the University of California at Berkeley and the director of Berkeley's Initiative in Soft Computing (BISC). "But today, applications in controls are becoming much more important."



Omron's fuzzy logic co-processor module provides fuzzy logic processing capabilities.

Zadeh, who is regarded as the "father of fuzzy logic" for his groundbreaking work in the field, defines fuzzy logic as "a means for exploiting the tolerances for imprecision and uncertainty." Simply put, this technique transforms vague concepts like "a little cold" or "almost perfect" into a mathematical form used by machines to perform problem-solving actions.

MACHINE IQ. One advantage of fuzzy logic is its ability to increase machine IQ (MIQ), thereby improving machine performance and robustness. For example, fuzzy logic is used to achieve image stabilization to counteract the effect of shaking in camcorders or autofocusing of still cameras.

There are many factors which underlie the marked increase in MIQ. "The most important among them is the use of what might be referred to as soft computing—and, in particular, fuzzy logic—to mimic the ability of the human mind to employ so effectively [those] modes of reasoning which are approximate rather than exact," he says.

According to Zadeh, an important factor underlying the increase of MIQ is the rapidly growing use of soft computing in the conception and design of intelligent systems. The principal aim of soft computing is to achieve traceability, robustness, low solution cost, and high MIQ through an exploitation of the tolerance for uncertainty and imprecision. "After all, the model for fuzzy logic is the human mind," says Zadeh.

"The use of fuzzy logic makes it possible to design products which have higher MIQ," he continues. "There is no visible end to the level of machine IQ that might be reached. There are already applications where the machine can outperform a human."

In both consumer and industrial control applications, fuzzy logic does not require the same level of preciseness about how the logic is designed. It allows the control designer to deal with the ambiguity that is very different from traditional control logic, says Ron Ellis, manager of factory automation marketing for Omron Electronics Inc. (Schaumburg, IL), which markets fuzzy-logic-based controllers.

"Conventional control systems express control contents by using control expressions. This necessitates a massive amount of information, and some kinds of control are either very difficult or impossible to express using this method," continues Ellis. "Fuzzy control does not have this problem. In most instances, fuzzy logic requires a lot less information than is required by conventional algorithm controllers. This reduces the development time proportionally. In addition, an increase in processing speed is possible depending on the complexity of the application."

"When fuzzy logic is applied to complex control logic, it simplifies the design process," he adds. "Instead of having to measure things and make presumptions, fuzzy logic enables the designer to describe things in a more human-like fashion."

Fuzzy logic increases reliability, because unlike conventional control systems which process equations in a series, a fuzzy controller's processes operate in parallel; therefore, an individual equation's effect on the final result is minimal. As a result, the fuzzy control system

PEOPLE

THE FATHER OF FUZZY LOGIC

Lotfi A. Zadeh joined the Department of Electrical Engineering at the University of California at Berkeley in 1959 and went on to serve as its chairman from 1963 to 1968. In addition, he has held a number of visiting professorships in electrical engineering; a visiting scientist appointment at IBM Research Laboratory; and visiting scholar appointments at the AI Center of SRI International.

Until 1965, Zadeh's work had been centered on system theory and decision analysis. Since then, his research interests have shifted to the theory of fuzzy sets and its applications to artificial intelligence, linguistics, logic, decision analysis, expert systems, and neural networks.

Photos courtesy: Omron Electronics Inc.

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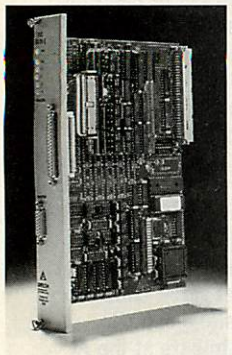
NEW PRODUCTS

CONTROLS

Motion Control Module Provides Precise Control

The TMC 188/40-Q four-axis motion control module has been enhanced to incorporate quadrature feedback for high-resolution positioning. It also provides precise and coordinated position control. The module also interfaces with a quadrature encoder, closed-loop servo system, and comes with DCSMON software, which assists in setup and tuning. This software is PC-based and displays dynamic and station axis information.



Delta Computer Systems Inc., 11719 NE 95th St., Suite D, Vancouver, WA 98682-2444 (206) 254-8688

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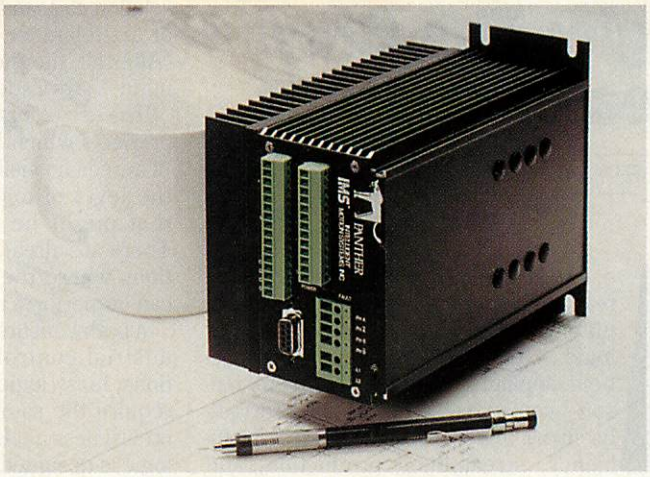

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Intelligent Motion Systems Inc., 511 Norwich Ave., Taftville, CT 06380 (203) 889-8353

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as a whole is resistant to errors.

Fuzzy logic has proven to be very suitable for embedded control applications. Several manufacturers in the automotive industry are using this technology to improve quality and reduce development time. In aerospace—which tends to require levels of exactness far beyond other types of manufacturing—such "inexact" logic actually enables very complex, real-time problems to be tackled using a simple approach. In consumer electronics, it improves time to market and helps reduce costs. In many types of manufacturing, fuzzy logic has proven to be invaluable in increasing equipment efficiency and diagnosing malfunctions.

EMBEDDED CONTROL. Fuzzy control can best be applied to production jobs that rely heavily on human experience and intuition. Omron's Ellis sights the example of swing prevention control as a prime example: the load of a walking crane, commonly found in factories and warehouses, will swing when the crane's forward motion is started and stopped; the greater the speed, the wider the swing.

Fuzzy control enables high-speed travel with minimal crane swing. Remember, conventional PID methods can't maintain control if the controlled object's variables change. High-level control algorithms, such as adaptive control, are needed. Unfortunately, developing high-level control algorithms means large system costs, time commitments, and maintenance difficulties. By using fuzzy control, a high-precision system can be created easily by determining several localized rules, and focusing on travel speed and swing angle of the crane.

"With fuzzy logic, we can take operator observations and put it into program language," explains Ellis. "In the crane example, for instance, the operator's own experiences with manually controlling sway can be incorporated into the fuzzy logic solution. The ability to draw from user experiences is a significant benefit of fuzzy logic."

These same principles can also be applied in situations such as tension control, temperature control, and speed adjustment control.

In contrast to conventional control methods, fuzzy logic operates more along the lines of human reasoning. But that doesn't mean that fuzzy logic deviates from the basis of conventional methods. On the contrary, it operates very much the same way, only it takes such methods a step further by incorporating the human ability to understand and deal with changing circumstances. Fuzzy is not in conflict with conventional methods, but rather it's their perfect companion.

"Fuzzy logic is a new addition to the designer's toolkit," according to Glenn Anderson, engineering services manager at Omron Electronics Inc. "As the number and breadth of fuzzy logic applications continue to grow, the rules of thumb will also increase. Fuzzy logic can offer significant savings in engineering development time, and the increase in intelligence to our machines and process will carry us well beyond the year 2000."

"In many of its future applications, fuzzy logic is likely to be used in combination with neural network theory under the label of neurofuzzy systems," according to Zadeh. "In such systems, neural network techniques are used to calibrate fuzzy rules and to learn from experience. The use of neurofuzzy concepts and techniques opens the door to the conception and design of systems with a far higher MIQ than those we have today."

Fuzzy logic control is a wise machines' guide. MA