Fuzzy Logic Control System and its Applications

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***Abstract*:- The concept of fuzzy logic is based near the human thinking and natural activities. It presents predicates which are present in nature and similar to those either big or small. This theory mimics human psychology as to how a person makes the decision faster. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth values between completely true and completely false. It can be implemented in hardware, software, or a combination of both. It can be built into anything from small, hand-held products to large computerized process control systems. In the present competitive scenario the fuzzy logic system are being adopted by the automotive manufacturers for the improvement of quality and reduction of development time and the cost as well. Fuzzy logic was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications.**

Keyword: Fuzzy logic, control system, subset, application, technology.

1. INTRODUCTION

There are many misconceptions about fuzzy logic. To begin with, fuzzy logic is not fuzzy. In large measure, fuzzy logic is precise. Another source of confusion is the duality of meaning of fuzzy logic. In a narrow sense, fuzzy logic is a logical system. But in much broader sense which is in dominant use today, fuzzy logic, or FL for short, is much more than a logical system. Fuzzy Logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. It is a type of logic that recognizes more than simple true and false values. With fuzzy logic, propositions can be represented with degrees of truthfulness and falsehood. For example, the statement, *today is sunny*, might be 100% true if there are no clouds, 80% true if there are a few clouds, 50% true if it's hazy and 0% true if it rains all day. Fuzzy logic has proved to be particularly useful in expert system and other artificial intelligence applications. It is also used in some spell checkers to suggest a list of probable words to replace a misspelled one.

It was introduced by Dr. Lotfi Zadeh of a professor at the University of California at Berkley in the 1960's as a means to model the uncertainty of natural language. He 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. Thus recently researchers have also introduced "fuzzy calculus", "fuzzy differential equations" and so on. In fuzzy process control, the expertise of a skilled operator may be encapsulated into a system in terms of linguistic descriptions of knowledge about human operating criteria, and knowledge about the process states and input ± output relationships. An ever increasingly number of contributions is appearing in the technical literatures, which are focused on applications of fuzzy control techniques to monitoring and control of unmanned machining systems. Fuzzy adaptive control is particularly attractive because practical heuristic approaches may be designed and engineered. This control philosophy is focused on the possibility of self-adapting the control system in order to maintain given closed-loop performance, by learning about modifications that may affect the process behavior.

2. LITERATURE REVIEW

The birth and the evolution of fuzzy logic is narrated by the pioneer Zadeh, and the state of the art after a quarter century of fuzzy systems can be found in a collective work edited by Klir. General treatments of fuzzy set theory, fuzzy logic, and fuzzy systems can be found in several handbooks.

Wang et al. (1995) propose a model to investigate the safety of engineering systems which integrates the fuzzy sets theory with evidential reasoning. Their approach allows the analyst to represent the safety of the system by separately analyzing the behavior of its components in terms of failure likelihood, consequence severity and failure consequence probability. The authors stated how the integration of the fuzzy sets theory (Zadeh, 1965) in risk assessment models is a good way to deal with uncertainty issues. Moreover, fuzzy sets allow the introduction of verbal judgments, instead of numerical ones, which are more human interpretable, thus involving more understanding in the evaluation of large numbers of hazardous activities**.** Fuzzy logic has been employed in handling inexact and vague information because of its ability to utilize natural language in terms of linguistic variables.

Sugeno (1974) presented the theory of fuzzy measures and fuzzy integrals as means to express fuzzy systems and further proposed to use his theory in modeling subjective human evaluation process. Hence, subjective human ratings can be better approximated using fuzzy measures than using the additive ones. Applications of fuzzy sets within the field of decision-making have, for the most part, consisted of extensions or fuzzifications of the classical theories of decision-making. While decision-making under conditions of risk and uncertainty have been modeled by probabilistic decision theories and by game theories, fuzzy decision theories attempt to deal with the vagueness or fuzziness inherent in subjective or imprecise determinations of preferences, constraints, and goals [4].

3. FUZZY EXPERT SYSTEMS

A fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. 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.

3.1 How does Fuzzy Logic Works

Fuzzy Logic 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 [2].

4. BASIC PRINCIPLES OF FUZZY CONTROL SYSTEM

The principal aim of fuzzy logic based systems is to emulate human behavior in managing and solving problems that cannot entirely be formalized by use of mathematical models and treated by use of system theory approaches.

In fuzzy process control, expertise is encapsulated into a system in terms of linguistic descriptions of knowledge about human operating criteria, and knowledge about the process states and input- output relationships. The control actions are encoded by means of fuzzy inference rules [3].

5. TWO APPROCHES OF CONTROL SYSTEM

There are two approaches in international research and control can be divided into two main branches:

Algorithmic Optimization Approaches: Which stem from mathematics, classical computer science and operations research can find and the global optimum with respect to the goal function chosen.

Heuristic Approaches: Which try to find good (not necessarily optimal) solutions fast by employing AI methods and expert knowledge;

These approaches are not necessarily mutually exclusive but can be combined in a useful manner [5].

6. FUZZY REASONING OR LOGIC OPERATIONS

Fuzzy Set Theory defines Fuzzy Operators on Fuzzy Sets. The problem in applying this is that the appropriate Fuzzy Operator may not be known. For this reason, Fuzzy logic usually uses IF-THEN rules, or constructs that are equivalent, such as fuzzy associative matrices [6].

For example, an extremely simple temperature regulator that uses a fan might look like this:

IF temperature IS very cold THEN stop fan IF temperature IS cold THEN turn down fan

IF temperature IS normal THEN maintain level IF temperature IS hot THEN speed up fan

Notice there is no "ELSE". All of the rules are evaluated, because the temperature might be "cold" and "normal" at the same time to different degrees.

The AND, OR, and NOT operators of Boolean logic exist in fuzzy logic, usually defined as the minimum, maximum, and complement; when they are defined this way, they are called the *Zadeh operators*, because they were first defined as such in Zadeh's original papers. So for the fuzzy variables x and y:

NOT x = (1 - truth(x))

x AND y = minimum (truth(x), truth(y)) x OR

y = maximum (truth(x), truth(y))

There are also other operators, more linguistic in nature, called *hedges* that can be applied. These are generally adverbs such as "very", or "somewhat", which modify the meaning of a set using a mathematical formula.

7. WHY WE USE FOZZY LOGIC SYSTEM?

- Fuzzy logic is conceptually easy to understand.
- Fuzzy logic is flexible.
- Fuzzy logic is tolerant of imprecise data.
- Fuzzy logic can model nonlinear functions of arbitrary complexity.
- Fuzzy logic can be built on top of the experience of experts.
- Fuzzy logic can be blended with conventional control techniques.
- Fuzzy logic is based on natural language.

8. APPLICATION OF FUZZY LOGIC

There are several fields where fuzzy logic system uses as given below [1]:

- Automobile and other vehicle subsystems, such as automatic transmissions, ABS and cruise control (e.g. Tokyo monorail);
- Air conditioners;
- The Massive engine used in the Lord of the Rings films, which helped huge scale armies create random, yet orderly movements;
- Cameras;
- Digital image processing, such as edge detection;
- Rice cookers;
- Dishwashers;
- Elevators;
- Washing machines and other home appliances;
- Video game artificial intelligence;
- Language filters on message boards and chat

rooms for filtering out offensive text;

- Pattern recognition in Remote Sensing;
- Hydrometeor classification algorithms for polarimetric weather radar;
- Fuzzy logic has also been incorporated into some microcontrollers and microprocessors;
- Mineral Deposit estimation.

9. CONCLUSIONS

The term "fuzzy logic" emerged as a consequence of the development of the theory of fuzzy sets by Lotfi Zadeh. Fuzzy Logic provides a completely different, unorthodox way to approach a control problem. This method focuses on what the system should do rather than trying to understand how it works. 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. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. This almost invariably leads to quicker, cheaper solutions. Fuzzy logic represents hence a valuable tool which can lead to innovation in research and industrialization with applications to the area of materials and processing technologies. Once understood, this technology is not difficult to apply and the results are usually quite surprising and pleasing.

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

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