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Review of Fuzzy Logic Control

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Abstract-Expert system is a computer system that emulated the decision making ability of a human expert. That is it acts in all respected like a human experts. It uses human knowledge to solved problems that would require human intelligence. The expert system represents expertise knowledge as data or rules within the computer. These rules and data can be called upon when need to solve problems. Expert systems have been developed in such diverse areas as science, engineering, business, and medicine. In these areas, they have increased the quality, efficiency, and competitive leverage of the organizations employed the technology. The scientists and engineers have used this technology to search for oil, diagnose medical problems, and explore space. This paper provided an overview of this technology and highlights the majors characteristics of expert systems with fuzzy logic along with an overview of various expert systems based on fuzzy logic.

Index Terms- Fuzzy Logic, Neurofuzzy, Expert System, Fuzzification, Defuzzification

1. INTRODUCTION

Fuzzy logic is a method of rules based decision making used for expert systems and process control. Fuzzy logic different from traditional Boolean logic in that fuzzy logic allows for partial membership in a set. Traditional Boolean logic is two-valued in the sense that a members either belongs to a set or does not. Values of one and zero represent the membership of a members to the set with one representing absolute membership and zero representing no membership. Fuzzy logic allows for partial membership, or a degree of membership, which might be any value along the continuum of zero to one. A fuzzy system is a system of variables that are associated using fuzzy logic.

A fuzzy controller uses define rule to control a fuzzy system based on the current values of input variables. You can use the Fuzzy System Designer and the Fuzzy Logic to design and control fuzzy systems.

Conventional controllers such as microprocessors or micro-controllers are suitable for parameter measurements such as pressure, temperature, liquid flow, motor speed, etc. Such controller are reliable only when the measuring parameters are linear and time invariant and when the mathematical models of this parameters are available, because conventional controllers work only on mathematical models of the parameters. If the system is complex and the associated parameters are ill-defined, imprecise, or time variant, then the mathematical model of such complex parameters are difficult to formulate, and hence conventional controllers failed to control such systems effectively.

The Fuzzy Logic Controller (FLC) is a controller which can control the said systems and associated parameters because the design and development of FLC is relatively very easy and less time consuming, and it is robust, flexible and adaptive. To control the processing parameters, the designers need not be experts on the system or sub-system.

The most important feature of FLC is that the mathematical model of the controlling parameters is not required at all. Moreover, the parameters can be described by linguistic variables (like warm, fast, medium, etc.) which can be controlled using simple IF-THEN rules.

2. Designing a Fuzzy System

A fuzzy system consists of three main parts are linguistic variables, membership functions, and rules. This chapter describes the general process of designing a fuzzy system. For information about designing a fuzzy system in the Lab VIEW PID and Fuzzy Logic Toolkit.

3. Functions

The linguistic variables current temperature and desired temperature each might include the linguistic terms cold, moderate, and hot. The linguistic variable heater setting might include the linguistic terms off, low, and high. Membership functions are numerical functions corresponding to linguistic terms. A membership function represents the degree of membership of linguistic variables within their linguistic terms. The degree of membership is continuous between 0 and 1, where 0 is equal to 0% membership and 1 is equal to 100% membership. For example, the linguistic variable current temperature might have full membership (1) within the linguistic term hot at 100 degrees, no membership (0) within that term at 70 degrees or less, and partial membership at all temperatures between 70 and 100 degrees.

4. Rules

Rules describe, in words, the relationships between input and output linguistic variables based on their linguistic terms. For example, you might define the following rule:

IF current temperature is cold AND desired temperature is moderate, THEN heater setting is low.

The clauses "current temperature is cold" and "desired temperature is moderate" are the antecedents of this rule. The AND connective specifies how the fuzzy logic controller relates the two antecedents to determine the truth value for the aggregated rule antecedent. The clause "heater setting is low" is the consequent of this rule. A rule base is the set of rules for a fuzzy system. The rule base is equivalent to the control strategy of the controller.

5. Fuzzy Controllers

You can use fuzzy controllers to control fuzzy systems. Most traditional control algorithms require a mathematical model of the system you want to control. However, many physical systems are difficult or impossible to model mathematically. In addition, many processes are either nonlinear or too complex for you to control with traditional strategies. However, if you can describe a control strategy qualitatively, you can use fuzzy logic to create a fuzzy controller that emulates a heuristic rule-of-thumb strategy.

6. Fuzzification

Fuzzification is the process of associating crisp, or numerical, input values with the linguistic terms of the corresponding input linguistic variables.

For example, a fuzzy controller might associate the temperature reading from a thermometer with the linguistic terms cold, moderate, and hot for the current temperature linguistic variable. Depending on the membership functions for the linguistic terms, the temperature value might correspond to one or more of the linguistic terms**.**

7. Defuzzification

Defuzzification is the process of converting the degrees of membership of output linguistic variables within their linguistic terms into crisp numerical values. A fuzzy controller can use one of several mathematical methods to perform defuzzification. The most accurate defuzzification method for a fuzzy controller varies based on the control application.

8. Architecture of Fuzzy Logic

There are five attributes associated with fuzzy expert systems:

1) Input variables,

2) Output variables,

3) Subsets of the inputs and the outputs and the membership functions corresponding to the various subsets leading to fuzzy set,

4) Rules connecting the input fuzzy subsets and the output fuzzy subset,

5) Procedure (or methodology) for de-fuzzification of the output.

9. Methods

(1) IF Vehicle Position x is Center (degree of membership = 0.8)

AND (Minimum)

Vehicle Orientation β is Left Up (degree of membership = 1.0) = 0.8

THEN Steering Angle ϕ is Negative Small

(2) IF Vehicle Position x is Right Center (degree of membership = 0.1)

AND (Minimum)

Vehicle Orientation β is Left Up (degree of membership = 1.0) = 0.1

THEN Steering Angle ϕ is Negative Medium

These two rules specify two non-zero values for the Steering Angle ϕ output linguistic variable:

Negative Medium to a degree of 0.1
Negative Small to a degree of 0.8

A fuzzy controller performs defuzzification to evaluate these two linguistic values and convert them into a single numerical output value.

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