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Realization of Fuzzy Logic Temperature Controller

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ABSTRACT

Fuzzy logic technique is an innovative technology used in designing solutions for multi-parameter and non-linear control models for the definition of a control strategy. As a result, it delivers solutions faster than the conventional control design techniques. This paper thus presents a fuzzy logic based-temperature control system, which consists of a microcontroller, temperature sensor, and operational amplifier, Analogue to Digital Converter, display interface circuit and output interface circuit. It contains a design approach that uses fuzzy logic technique to achieve a controlled temperature output function.

Keywords: Fuzzy logic; microcontroller; temperature sensor; Analogue to Digital Converter (ADC).

1. INTRODUCTION

Fuzzy logic is a mathematical system that analyzes analog input values in terms of fuzzy variables that takes continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 0 or 1. Fuzzy logic was first proposed by Lotfi A, Zadeh of the University of California at Barkley in 1965 paper and the idea was elaborated in 1973 paper that introduced the concept of Fuzzy set. Fuzzy Logic Toolbox, also known as Graphical User Interface (GUI) tools are used to build and edit Fuzzy Interface System (FIS).

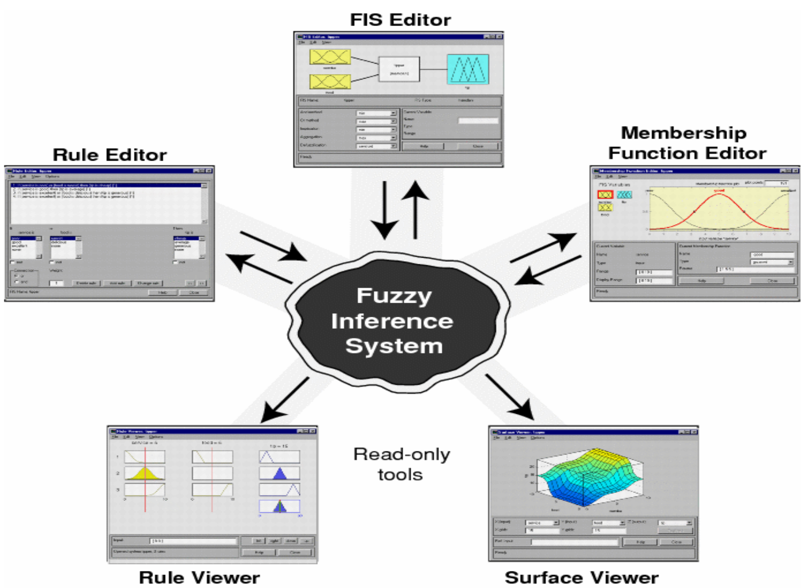

Fig 1

A control system is a device or a set of devices to manage, command, direct or regulate the behavior of other devices or systems. There are two common classes of control systems, with many variations and combinations: logic or sequential controls and feedback or linear controls. There is also fuzzy logic which attempts to combine some of the design simplicity of logic with the utility of linear control. There are two types of Fuzzy Logic Controller-

1) **Mamdani type controller:-**

Mamdani introduced the fuzzification/inference/de-fuzzification scheme and used an inference strategy that is generally mentioned as max-min method. This inference type is a way of linking input linguistic variables to output ones in accordance with the generalized modus ponens, using only the MIN and MAX functions. It allows achieving approximate reasoning. One important aspect of Mamdani's method is that it is essentially heuristic and it can sometimes be very difficult to express an operators or engineering knowledge in terms of fuzzy sets and implications. More over such knowledge is often incomplete and episodic rather than systematic. There is in no specific methodology for clearly driving and analyzing a rule base of a fuzzy inference system. Here, some problems may occur when the rules have to describe a process that is too complex or to deal with a high number of variables. It can be then very difficult to define a sufficient set of coherent rules and the danger of having not enough or conflicting rules occurs. This method is currently and effectively applied to process control, robotics and other expert systems. It is especially well appropriated to execute an operators control or command action.

2) Takagi-Sugenos type controller

This type controller differs from the previous one in the nature of inference rules that only deal with linguistic variables. Takagi-Sugeno controller directly leads to real values that are not membership functions but deterministic crisp values. This method only used fuzzy sets for the input variables and there is no need of any de-fuzzification stage. Whereas the antecedents still consist in logical function of linguistic variables, the output values are resulting from standard functions of input variables. In most of the cases, only linear functions are used.

2. ANALYSIS

In this paper, microcontroller was used to implement a fuzzy logic-based temperature control system. The system is aimed at controlling the temperature of an environment by regulating a heater and the speed of a fan. The Microcontroller has to make decisions based on external temperature condition. The variable "temperature" which is inputted on the system can be divided into a range of states such as "Cold", "Cool", "Moderate", "Warm", "Hot", "Very hot". Defining the bounds of these states is a bit tricky.

An arbitrary threshold might be used to separate "warm" from "hot", but this would result in a discontinuous change when the input value passes over that threshold. The way to make the states "fuzzy" is to allow them change gradually from one state to the next. The input variables in a fuzzy control system are mapped by sets of membership functions, known as "fuzzy sets". The process of connecting a crisp input value to a fuzzy value is called fuzzification. A fuzzy-based control system can also incorporate the analog inputs of 0, 1 into its fuzzy functions that are either one value or another [5].

Given "mappings" of inputs variable into membership functions and truth values, the microcontroller then makes decision of what action to take based on a set of "rules" for each of the form. For instance, if the external temperature is warm, then the fan speed is not very fast, but heater is low. In this example, the input variable temperature has values defined by fuzzy set. The output variables which are the speed of fan and heater temperature are also defined by a fuzzy set that can take values like "static", "slightly increased", "slightly decreased", and so on.

3. FUZZY-BASED PROCESS USING "IF – THEN": STATEMENT/RULE:

Fuzzy-based control process consists of an input stage, processing stage and an output stage. The input stage maps sensor or other inputs such as switches, thumbwheels and so on, to an appropriate rule and generates a result for each. The processing stage then combines the results of the rules; and finally the output stage converts the combined result back to a specific control output value.

The processing stage is based on a collection of logic rules in the form of If-Then statements, where the IF part is called the "antecedent" and the THEN part is called the "consequent". Typical fuzzy control systems have dozens of rules [6].
Consider a rule for a thermostat, IF (temperature is "cold") Then (heater is "high").

This rule uses the truth value of the "temperature" input which has truth value of "cold" to generate a result in a fuzzy set for the "heater" output, which has truth value of "high". This result is used with the results of other rules to finally generate the crisp composite output. Obviously, the greater the truth value of "cold", the higher the truth value of "high", though this does not necessarily mean that the output itself will be set to "high" since this is only one rule among many.

In some cases the membership functions can be modified by “hedges” using “about”, “near”, “close to”, “approximately”, “very”, “slightly”, “too”, “extremely” and “somewhat”. The operations of these may have precise definitions, though the definitions can vary considerably between different implementations.

4: MICROCONTROLLER-BASED FUZZY LOGIC;

A microcontroller-based fuzzy logic control system has a fuzzy inference kernel and a knowledge-base. The fuzzy inference kernel is executed periodically to determine system output based on current system input. The knowledge-base contains membership functions and rules.

A programmer who does not know how the application system works can write a fuzzy inference kernel. One “execution pass” through a fuzzy inference kernel generates system output signals in response to current system input conditions

Fuzzification: The current input values are compared against stored input membership functions, usually in a program loop structure to determine the degree to which each linguistic variable of each system is true.

Rule Evaluation: Processes a list of rules from the knowledge-based using current fuzzy input values to produce a list of fuzzy output linguistic variable.

Fuzzy Output: Considers raw suggestions for what the system output should be in response to the current input conditions.

CONCLUSION

The development of a fuzzy logic control system is a way forward to the improvement of industrial automation. This area of control will also improve and advance the study of control engineering in modern systems.

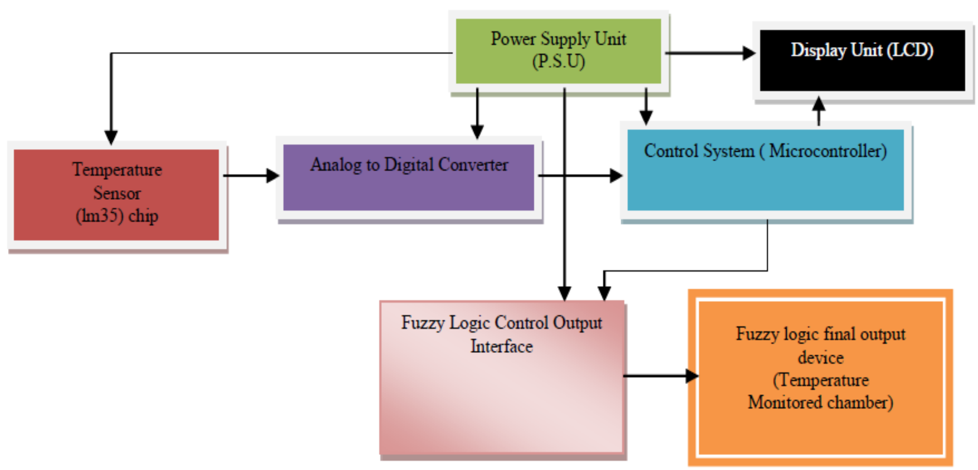

Fig 2: The Block diagram of the fuzzy logic control system

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