Fuzzy Rules Generation for a microkernel, integrated to a Motorola 68HC11 Operating System

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Introduction

The fuzzy logic approach for the decision-making process is frequently used for simplify and accelerate the operation of the modern microcontroller systems. The similarity of the fuzzy rules generation to the human reasoning enable designers to create an appropriate base of fuzzy rules in order to control dynamic systems with non-linear parameters.

The advantage of fuzzy logic is the opportunity to control sophisticated automation processes demanding high sensitivity and a detailed process programming. The process modeling with fuzzy rules don't require differential relation to describe the behavior of variables. Subject of description are only the final states of parameters under control. In this manner the designer don't need to define the regulation parameters, but have to establish fuzzy rules under which the system ought to obey.

One of the major functions of the embedded real-time operating systems is to provide a standardized environment for real-time coördination and communication. This environment includes functions such as interrupt handling and memory allocation. This presentation concerns the interrupt handling - especially the activation of tasks with dynamic priority determined by the membership function of controlled fuzzy variables.

Description of Fuzzy Rules Generation for a microkernel

Following the classical approach of fuzzy system control for a nonlinear dynamic application it will be necessarily to dispose firstly with:

- the problem description by state variables ($x_i \in X$) which change in function of the environment and the working conditions varies;

- the fragmentation of the change and its definition linguistic variables in {IF...THEN...ELSE} format;

- identification of the process dynamic and generation of a membership function covered the behavior of the application under control - on the base of the problem knowledge.

The rules are generated using the Mamdani type of fuzzy rule named FMSR :

IF x_1 is Start from the beginning
AND x_2 is Start from interrupt point RTI
AND x_n is start from interrupt point ANY_ONE *(antecedent part)*
....
THEN y is B_1 , y_2 is B_2 .....y_n is B_n *(consequent part)*

This type of rule were chosen because it considers a multi-input-multi-output fuzzy system(MIMOS). In the created microkernel for a real-time operating system the decision making process is based on the Zimmerman definitions for fuzzy decision [3]:

Lets $\mu_{S_i}(x), i = 1,\dots m$ $x \in X$ be the membership function of constraints defining the decision space and $\mu_{g_j}(x), j = 1,\dots n$ $x \in X$ - the membership function of objective(utility) function goals.

A decision is then defined by its membership function:

$$\mu_D(x) = \nabla_i \mu_{S_i}(x) * \nabla_j \mu_{g_j}(x), i = 1,\dots m, j = 1,\dots,n$$

where ∇ and * denote appropriate, possibly, context dependent "aggregators" (connectives).

If the objective function is crisp it will be necessary to determine an extremum of the crisp function over a fuzzy domain. Then the definition given by Orlovski [2] of the term "*decision*" in this case is more convenient. He suggest to compute for all α-level sets of the solution space , the corresponding optimal values of the objective function, and to consider as the fuzzy set "decision" the optimal values of the objective function with the degree of membership equal to the corresponding α-level of the solution space.

It is suitable to use two kind of decision making - Multiobjective decision making (MODM) and Multi Attribute Decision Making (MADM). For the first kind it is very important to concentrate on continuous decision spaces - the programming with several decision spaces. For the second kind - the most important are discrete decision spaces.

The construction of fuzzy control rules have been evaluated on the base of heuristic and deterministic approaches. In order to obtain time - effective control, it is proposed that the generation of fuzzy rules have to be done following two optimizing procedures:

- the first - for the parameters of input fuzzy variables in any shape of convex form(triangular, trapezoid, etc.)
- the second - for the parameters of output variables.

The real process have been modeled was the stand-alone power system control of a radio transceiver for weather forecast. The model was described by three components - status modification, model status and prediction function(fig. 1).

The power supply is the most critical part concerning the reliability of all the radio transceiver equipment. The time for switching between the principal and the stand-by source is critical and should be the shortest possible. The control of this switching is an operation provided by the real-time operating system for Motorola single chip microcontroller M68HC11. The decision is made by a microkernel with built-in membership function. Each control element is composed according to the consequence in fig. 2.

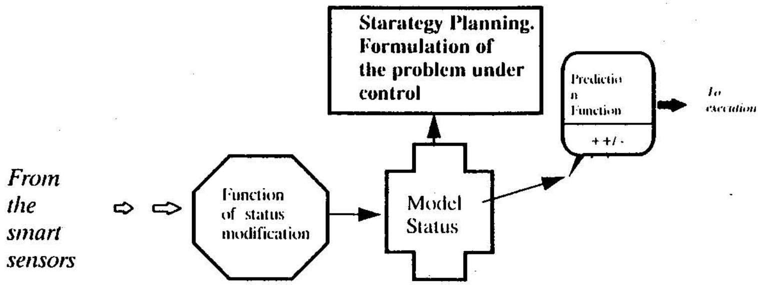

Fig. 1 Model of a real process, described by three components

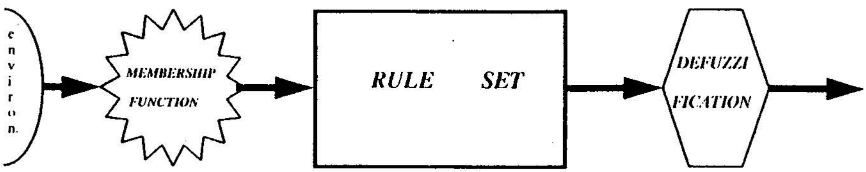

Fig. 2 The structure of a control element composed by a Fuzzy Logic Controller.

In order to create a small enough kernel for embedded operation in limited memory space of the microcontroller the fuzzy set of rules was made very concise, but effective - only seven input rules and two output rules.

The tuning of the membership function was not easy, because of the time- and event-depending load of the power supply. It was necessary to adjust the universes of discourse and the control resolution. The form of the membership function for rechargeable mode is trapezoidal and for all the others related to the load control functions - triangular. The restriction of Mamdani fuzzy model containing only one fuzzy set in the consequent of each rule is taken into account for this application.

The microkernel with fuzzy rules is written on assembler language in order to minimize the execution time of operations. This purely software implementation of fuzzy decision making process is related to the fuzzy controller in fig. 3 only in highlighted blocks. The estimation of each membership function in the operating system is performed as a task and their values are kept in table.

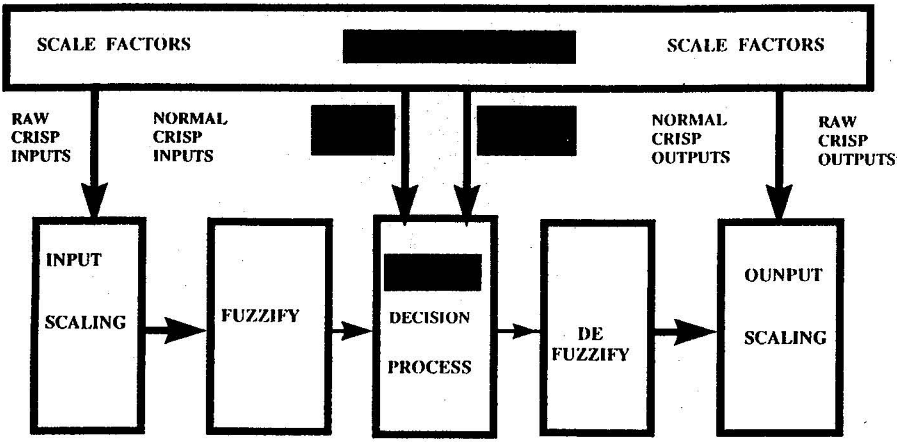

FIG.3 FUZZY LOGIC CONTROLLER

As an illustration the decision on the base of membership function can be composed as:

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        ; make decision in  ACCB
                ldab            Num_Activ_task
                incb
                cmpb            #Num_task+1
                bne             Start_Task
                clrb
Start_task: stab            Num_Activ_task  ;  end of decision
```

Conclusion:

The fuzzy logic implementation don't means a replacement of the classical approach of regulation and control, but to facilitate the modeling of the complicated control processes. The fuzzy approach together with the traditional one can create a good symbiosis in one and the same real-time control system. The integration of the fuzzy decision in a microkernel system provides more flexibility and a quick access to the low level of the system.

REFERENCES:

[1] Беллман,Р., Л.Заде-Принятие решений в разплавчатых условиях, сборник "Вопроси анализа и процедури принятия решений", ред.И.Шахнов, изд."Мир",Москва, 1976,с.172-215.

[2] Орловский, С. Проблемы принятия решений при нечеткой исходной информации, изд."Наука", Москва, 1982 г.

[3] Fuzzy sets theory and applications, edited by Andre Jones, Arnold Kaufmann, and Hans-Jurgen Zimmermann - D. Reidel Pub.Co. 1986.

[4] Dubois D., H. Prade - Fuzzy sets and systems - Academic Press, New York, 1980.

[5] Odeberg,H. - Distance measure for fuzzy sensor options - " Meas. Sci. Technology", 1993, v.4, No 8, pp. 808-815.