Industrial Applications of Intelligent Control at Samsung Electronics Co. - in the Home Appliance Division -

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ABSTRACT

Intelligent control technologies (fuzzy logic, neural network, chaos, and genetic algorithm) have been a great deal of influences and impact, especially in home appliances industry. As a result, products that utilize these technologies are pouring into the market from just about every companies. These products are getting good responses from the consumers, because they offer convenience and amenities through the intelligent self-control. In this article, the functionality of the intelligent control technologies will be explained, and how they are being applied to the consumer products developed in Samsung Electronics Co.

1. Introduction

The fuzzy theory, first introduced by Prof. Zadeh in 1965, started to be noticed by public since it was applied to control the nonlinear systems such as process and traffic control in 1980's. This control algorithm, generally called as the fuzzy logic control, has been proved to be easy to handle the nonlinear system, which is difficult to control with a mathematical model, because of taking the rule-type approach with "IF ... THEN ..." format, and excellent in the field familiarity and cost -performance, through lots of examples. The current Korea Fuzzy Logic and Intelligent Systems Society was founded in Dec. 1990 as Korea Fuzzy Mathematics and Systems Society, and the interest and research of home appliances industry were followed.

The Samsung Electronics Co., on the verge of being the world renowned maker of general home appliances, developed their first fuzzy module for wet/dry vacuum cleaner in 1991, and the concept of intelligent control was introduced to the home appliances. Some of the examples that use these new control concept are: the Neuro-fuzzy refrigerator keeping the stored food fresh while keeping the electricity low by estimating the food temperature ('91); the Fuzzy simulator for designing fuzzy control algorithm ('92); the Neuro-fuzzy rice cooker that cooks rice depending on the users' flavor as well as keeping the cooked rice longer without the discoloration and odor ('92); the Fuzzy inference chip, Samsung Fuzzy Logic Engine (SFLE), designed to implement the high speed fuzzy logic to carry out the optimum control depends on the input conditions ('93); the Inverter air conditioner which uses the neuro-fuzzy and chaos theory to achieve the optimum cooling by the natural wind and the predicted mean vote (PMV) ('93); the Chaos simulator ('94); the MoonDanSock refrigerator using GA-

fuzzy theory; and most recently the GA-fuzzy washing machine ('95). These intelligent control technology is being developed and applied for the various other home appliances. In this review, a few selected cases will be described briefly.

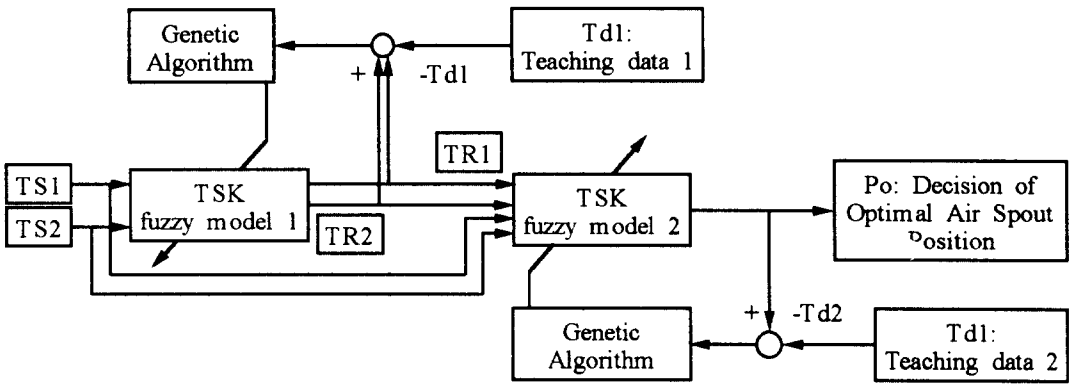
2. Fuzzy and GA-Fuzzy Theory Applied Refrigerator and Washing Machine

2.1 GA-Fuzzy Controller for MunDan-Sock Refrigerator

The Fuzzy theory applied refrigerator, developed in 1991, estimates the food temperature by the fuzzy inference from the sensor inputs about inside temperature, door open/closing time, and outside temperature, then feed them to fuzzy controller to adjust the fan and compressor to extend the food storage duration while saving electricity. In contrast to the conventional cold air supplying system that uses the natural convection, three rotating wings are embedded in the back of refrigerator room to actively send the cold air where it's needed and keep them from leaking out. This cold-air management system is named as V system, and the refrigerator with the V system was commercialized as "MoonDanSock", which means "leakage prevention from door" in Korean, in 1994. In " MoonDanSock" refrigerator, the V system is effectively controlled by TSK (Takagi-Sugeno-Kang) fuzzy model and genetic algorithm.

*** GA-Fuzzy Algorithm (Fig.1)**

Step 1: Inference of Refrigerator-room Temperature (T_R).



· TSK fuzzy model : A model consisted with a number of "IF ... THEN ..." rules. It can describe the nonlinear system better even with a small number of rules, because the decision part below "THEN" is a linear function of input variables.
· Identification of parameters for TSK fuzzy model using genetic algorithm : Genetic algorithm is utilized to optimize IF-part parameters

Fig1. The Structure of GA-Fuzzy Controller for Refrigerator

- Temperature Distribution is estimated by the GA-Fuzzy Inference method based on the data collected from sensors attached to the refrigerator-room.

Step 2: Decision of Optimal Cold Air Spout Postion (Po)

- The optimal cold-air spout position is selected on the cold air control panel based on the GA-fuzzy theory from the inferred refrigerator-room temperature distribution and its change rate.

2.2 GA-fuzzy Controller for Agipul Washing Machine "SonPallae"

Newly developed Agipul washing machine, commercialized under the name of "SonPallae", provides low-speed swirled water through the single phase induction motor for the sensitive garments like wool and/or lingeries. In order to optimize this system, a controller utillizing fuzzy logic is developed to control the speed of a moter in a washing machine by choosing an appropriate phase, and 1st and 2nd genetic algorithm is used to optimize the parameters of I/O membership function, see Fig. 2.

3. Samsung Fuzzy Logic Engine (SFLE)

SFLE which is designed to use the VLSI related technologies of Samsung Electronics Co., can replace the functions performed by the traditional micro-controller or the controller systems which are sensitive in pricing. In order to obtain the optimal output value according to the input conditions, SFLE carry out fuzzy logic arithmetics in high speed. In the process, input values are evaluated by the degree of fitness for a set of membership functions defined by user.

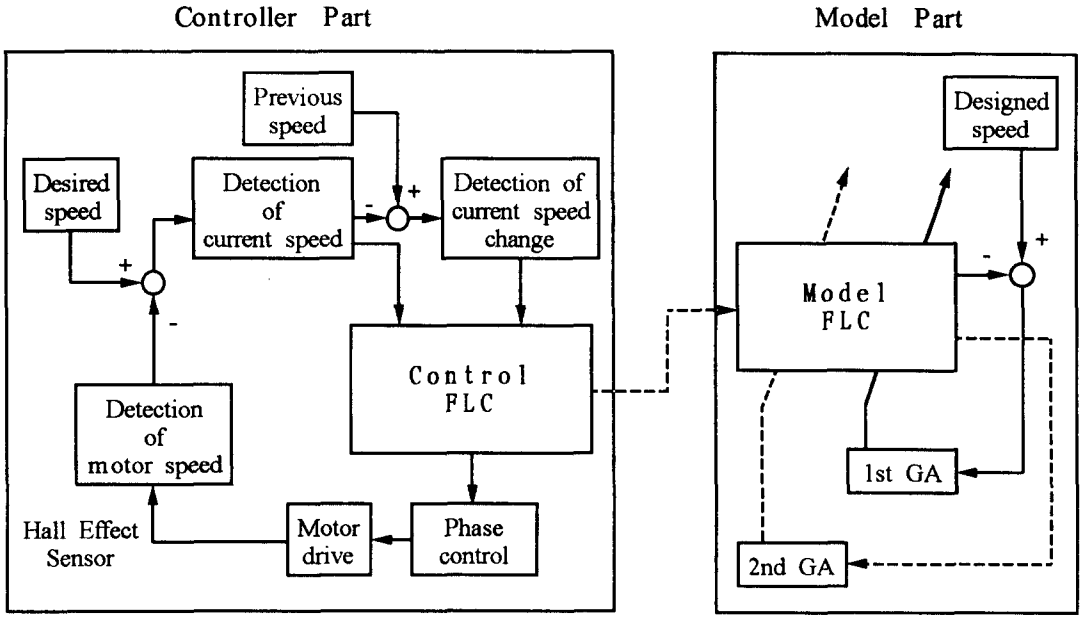


Fig2. The Structure of Proposed GA-Fuzzy System for Washing Machine

SFLE uses the triangular type membership functions and min/max inference method for the effective digital processing. The fuzzy rules used in this engine are consisted with a set of conditions in its input stage, and each rule can be designed to include maximum of 16 input terms and an action value. These terms can be defined or modified by user according to the output value. The input and rule implementations are performed concurrently for all input and output.

Maximum of 64 rules can be stored in the rule memory with 24 bit length. These rules can be utilized for all outputs variably, therfore, any necessary number of rules, up to its maximum number of 64, for each output can be defined by the user. The number of rules that can be used for an output are determined by the number of rules left out by the other outputs. Finally, the digital circuit based on this fuzzy logic is designed and fabricated to carry out the high speed processing as fast as 20 million rules/sec, efficiently.

4. Conclusion

Examples discussed in this review are a part of the products applying the intelligent control technology into consumer products by Samsung Electronics Co. It is not enough to study the technology itself to maximize the advantages of intelligent technology, but is important to develop the other related technologies like sensing, micro-computing, and man/machine interfacing at the same time.

Another critical area in the application of intelligent contorl technology is the study of consumer's feeling and habit on using products. The products based on the consumers' feeling as much as technology will be welcomed by the customers and called as "Human Electronics".

References

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