Application of Fuzzy Logic to Smart Decision of Smart Sensor System

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Abstract

This paper considers the application of Fuzzy Logic to Smart Decision process of Smart Sensor system that interprets and response to the change of environmental parameters. The considered system consists of three sensors: temperature sensor, humidity sensor and pressure sensor. The smartness of system is constituted by the applying of Fuzzy Logic. The paper discusses the technical details of the application of Fuzzy Logic for making the system to be smarter.

Keywords

Smart Sensor, Smart Space, Fuzzy Logic

Ⅰ. Introduction

Smart Space [1], which is a typical multi-modal system, typically involves distributed computation and perception modules. These modules are usually not developed for centrally running together.

Recently, Smart Space has been an important research domain for the foreseeable future [2]. The existing systems are mainly restricted to laboratory prototypes. Smart Space is becoming the convergence point of many researchgroup's topic. It is also topic that has been strongly supported in many countries'research. Although we already have sufficient technologies to produce powerful and effective systems, lots of works should be done to make all the resources together intoa coherent and more effective system.

Smart Spaces incorporate embedded computing devices with sensors technology to provide automatic response to environmental changes. Thus we would like the sensors to operate in a coordinated manner.

Moreover, the requirement not to load to the host system is the golden rule of Smart Sensor design.

The basic elements of a Smart Sensor are: primary sensing, data conversion, and information processing, communication, and display information and excitation control. However, in this work we concentrate only on the information-processing block. The others are assumed to be sufficiently developed. Then on top of them the algorithms will be considered for information processing block. In this light, we have developed and implemented Fuzzy Decision on improving the smartness of system.

For the remainder, we review Fuzzy Logic in section II. In Section III we present briefly the hardware structure of developed system. The detail discussion of Fuzzy Logic application to Smart Decision is given in Section IV. Our conclusions and future works will be discussed in Section V and VI

Ⅱ. An overview of Fuzzy Logic

Fuzzy Logic and Fuzzy Sets [3] are powerful mathematical tools for modeling: uncertain systems, nature and humanity; and facilitators for common sense reasoning in decision making in the absence of complete and precise information. Fuzzy Logic and Fuzzy Sets have a very wide range of applications such as control theory, signal processing, robotics, decision making.

A Fuzzy Set F, on a collection of objects, X, is a mapping:

$$\mu_F(x): X \rightarrow [0, \alpha] \qquad (1)$$

Here $\mu F(x)$ indicates the extent to which x has attribute F, and is called the membership function.

On top of Fuzzy Sets, Logical Operators and Algebraic ones have been defined.

To implement a Fuzzy control strategy we usually use the following three steps

- *Fuzzification:* This step translates the crisp input into linguistic term and assigns a degree of membership to each input value. Linguistic variables are fuzzy sets that contain linguisticterms as members of the set.
- Fuzzy Rule Inference: Based on the IF-THEN rule defined the relationship between linguistic variables, this step determine the source of actions or decisions the system must follow.
- De-fuzzification: In this step, the result of Fuzzy Inference is converted from linguistic concept into a crisp output. There are some operators that help us to do this step, however the center of gravity (COG) is the most commonly used

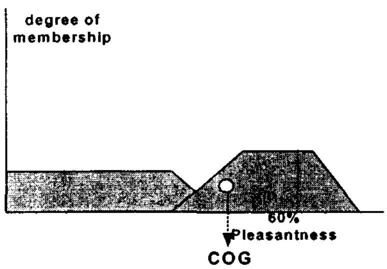

Figure 1: Example of usage COG for de-fuzzifying

III. System structure of Smart Sensor System

In general, the model of a Smart Sensor system can be separated into three fundamental stages as shown in Fig.2.

- An acquisition stage which normalizes the signal delivered from the perceptron, then makes them compatible with sampling and converting tasks
- A processing stage which performs various tasks of signal processing
- A high level interpretation stage which based on numerical data yielding and then executes the feedback control and interprets signal into human' sense such as picture, sound.

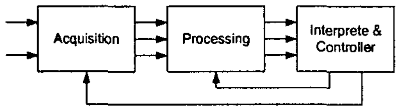

Figure 2: Model of a Smart Sensor system

Based on top of the model, we have develop a Smart Sensor system which has a block diagram as shown in Fig.3

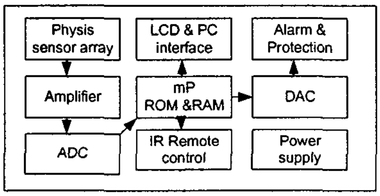

Figure 3: Block diagram of developed Smart Sensor system

IV. Smart Decision Application

The execution of a task must be carefully considered in order to take into account unexpected changes of environmental parameters.

The application of Fuzzy logic engine developed in the system is given in Fig.4

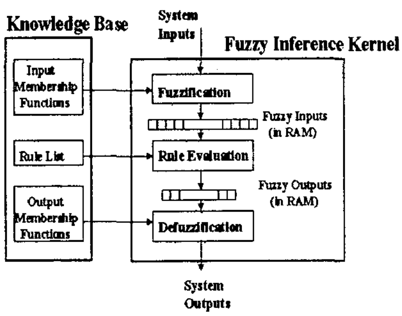

Figure 4: Diagram of Fuzzy Logic engine developed in system.

The Knowledge Base contains a number of Rules by which the input environmental parameters are interpreted into human sense indication. The rules also help system primarily make decision to react the change of environment. The responses to environmental changes include remote control the peripheral device to try to keep balance and warn user if serious case may happen.

On our system we has just only exampled with two environmental parameters: temperature and humidity (Fig.5).

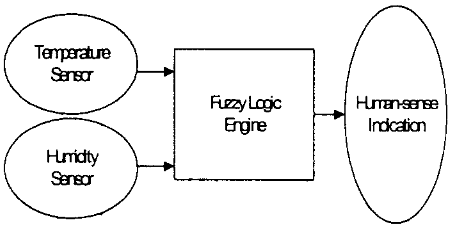

Figure 5: Example of Fuzzy Logic Engine for Intelligent indication

In addition, we improve the flexibility of the fuzzy inference engine for interpreting environmental parameters by applying Adaptive Neural-Fuzzy System [4]. The diagram of this system is presented in Fig.6.

This is one combination of Neural Network and Fuzzy Logic.Besides the pre-defined IF-THEN rules in Knowledge base, the IF-THEN rules can be defined by reality data training via the Neural network. Consequently Adaptive Neural-Fuzzy system is more flexible than Static pre-defined IF-THEN system.

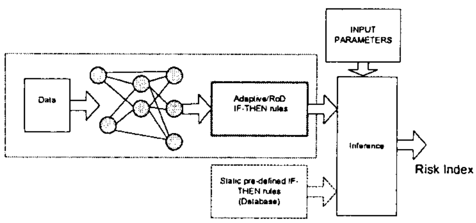

Figure 6: Application of Neural-Fuzzy for improving smartness of system

V. Future works

In order to meet the market demand, the implement of system will have to be reduction in number of components, size and costs, while continuing to improve evolving abilities. The approaches can solve this requirements are:

- Using standard FPGA to implement complete solution.
- Using a system on chip (SoC) device that contains dedicated functions.

With these approaches, the smartness of system can be increased by implementing a combination some well-known algorithms such as ones related to Neural Network and Belief Network.

VI. Conclusions

In this paper, we have presented a methodology of development and application of Fuzzy Logic to make smart decision of the Smart Sensor System.

VII. Reference

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