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Fuzzy Logic Control in Air Temperature and Skin Temperature in the Infant Incubator

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Abstract

Premature birth is a worldwide problem. Thermoregulation is a major problem in premature infants. A novel control implementation of temperature control presented in this paper. The paper overview a model design of heat exchange between the newborn and its environment and a robust fuzzy control algorithm. The purpose of implementation is to improve the operation of controlling temperature inside incubator, two sensors required to control the incubator air temperature and skin temperature simultaneously. Fuzzy logic is used to incorporates incubator air temperature and skin temperature to control the heating. Simulation results prove that the design provides high level of output accuracy for a high dynamic input range.

Keywords: *Infant incubators, simulation, Sensors, FIS (Fuzzy inference system).*

1. Introduction

Infant Incubators are a very important technology that used to provide a health environment for case such as those born early. Incubators provide an easier control mechanism for doctors to monitor different parameters needed to keep infant baby safely[1].the development of control systems helps engineers and researchers to improve a lot of useful ideas to enhance the reliability on incubators. This paper proposed an advance design of temperature control inside the incubator. The main feature of the design is the use of two in the skin of child to sensors, one is used to monitor the air temperature around the child while the other fixed in the skin of child to monitor the temperature. Both sensors work together to control temperature ,the control system which control the operation of both sensors smoothly developed in fuzzy logic. Fuzzy techniques are Successfully because it has the ability to provides wide levels of control therefore it has been used in control in several fields. [2].

2. Methodology

Development of the Control system using Air Temperature is much easier when it used single sensor but in our case two sensors used to enhance the operation which unfortunately needed a complicated control process to organize the work procedures of the sensors. The fuzzy logic system was developed to incorporate both the skin temperature and the air temperature to control the flow of hot air into the incubator. The temperature was sensed and used as inputs to the fuzzy logic system. The fuzzy logic system as shown in Fig [1] consists of two input sensor (Air Temp and Skin Temp) parameters and one output parameter corresponding to the flow rate of hot air.

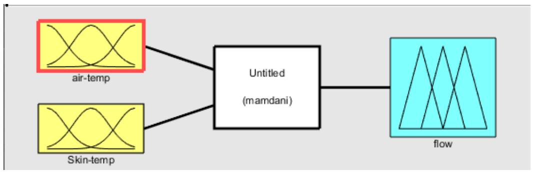

Figure [1] Naming the input variable (flow)

The temperature is usually obtained by measuring the temperature by a sensor placed in the incubator. These sensors can be hung at different positions in the air and skin.[4] In the present investigation, changed automatically in each time step, Flow rate was expressed as a fraction of maximum flow of hot air from the blower into the incubator. Therefore, the output varied from a minimum value of zero to a maximum of 1[5]

In the Classical logic, a parameter belongs to only one sub domain. However, in the fuzzy logic system, a parameter can partially belong to several overlapping subsets at the same time. Since there is an overlap on some parts of the fuzzy subsets, values in those parts belong partially to both the overlapping subsets. Fuzzy membership functions were first defined for both of the input parameters (Air temp and Skin temp) with five overlapping subsets. The output membership functions were also defined. A set of rules (shows the table [1]) were developed to map the input to output membership values

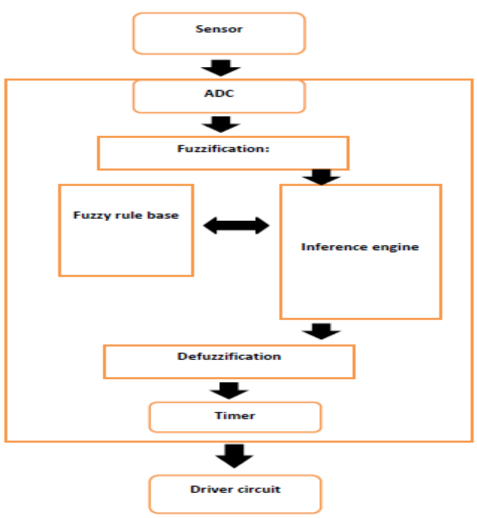

Figure [2]: Fuzzy logic controller

The dynamic input parameters (Air temp and Skin temp) were first fuzzified to obtain a set of membership values using the predefined membership functions. The membership values were then input to a rule based system .These rules decide the fuzzy output based on the fuzzy input variables. After the fuzzy output was computed, the centroid defuzzification technique was used to convert the fuzzy output into a crisp output.

This crisp output was used to control the flow rate of hot air into the incubator. The block diagram of the procedure is shown in Fig [2]
The main challenge of this design is to make balance of temperature inside the incubator by comparing the reading results of both sensors, the idle case accrued when the ambient temperature Ta equal the skin temperature Ts as illustrated in equation(1):

$$T_A = T_s \qquad (1)$$

2.1 Membership Functions

The input variables of fuzzy subsets were divided into two input variables representing two sensors: the first one involved to temperature of incubator air space while the other input of the fuzzy subset defined the skin temperature of infant's skin, and there is only single output variable defining the flow rate of hot air into the incubator. There are five levels for each input parameter was divided into five subsets: very low (VL), Low (L), medium (M), High (H), Very high (VH) and correspondingly five membership functions were formed (Fig. 4). Similarly the output domain was divided into five sub-domains: very slow (VS), slow (S), medium (M), Fast (F), and very Fast (VF).the system consists of five Triangular membership functions for all inputs and ten triangular membership functions were used for all outputs subdomains [6].

3. Results and Discussion:

The present investigation represents the first application of fuzzy logic to the control of infant incubators. Current incubator devices use either air servo control or skin servo control to control the incubator temperature. Air servo control uses the incubator air temperature and the skin servo control uses infant's skin temperature to control the hot air flow into the incubator. The present study demonstrated the application of fuzzy logic expert systems to control the incubator heating using both the infant skin temperature and the incubator air temperature. The application of fuzzy logic control reduced the temperature fluctuations and provided a comparatively smooth response.
The main objective of the present system is to maintain a specific core temperature without

significant fluctuations in the air temperature, and without reaching the steady state too fast or too slow.

The accuracy of the fuzzy model is very reasonable as shown in MATLAB FIS Editor . these result demonstrate that the fuzzy logic is very useful method for assessing and not enforced to evaluate with a crisp number.

The shape of the membership functions used in this fuzzy logic control system was straight lines which form triangular shapes. Fig (4)shows the membership functions for the input variable Air temp, and Fig (5) shows the membership functions for the input variable Skin temp. Fig [6] shows the Fuzzy Mamdani-Rule Editor and Fig [7] shows the Rule View and Fig(8) shows the membership functions for the output variable flow rate. Each of the membership values for both input and output parameters varies from 0 to 1 and indicates the degree of membership to the corresponding subdomain. and Figure [9] shows the Fuzzy Rule.

Table [1]

No	Input Range	Fuzzy Variable Name
1	27 – 29.5	VL
2	28 – 32	L
3	31 – 34	M
4	33 – 36	H
5	35 – 37	VH

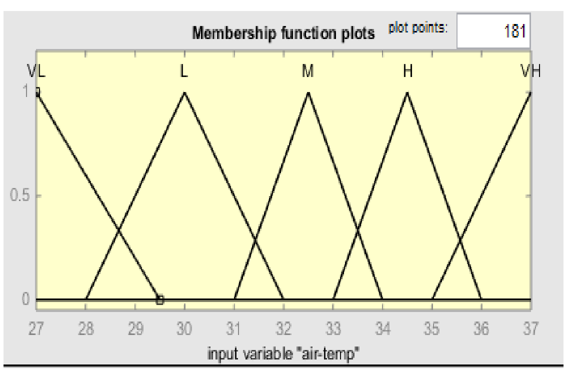

Figure [4]: Membership Functions of the Air temperature

An important case can be observed from figure (4, 7) and table (1) of results, when one of the two inputs either air temp or skin temp is reading different results such as:

Air temp = 31.4

And

Skin temp =34

The system is stable in the medium domain and the output flow rate is medium.

Output flow= 0.55

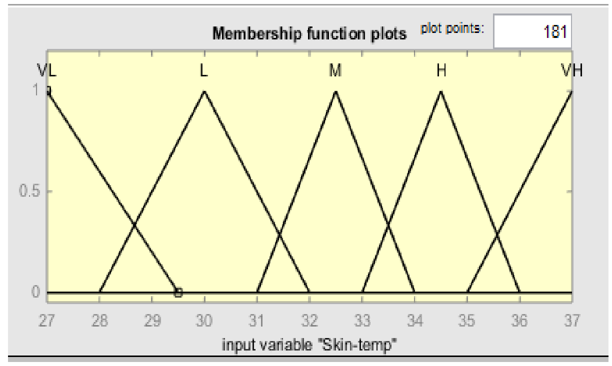

Figure [5]: Membership Functions of Skin temperature

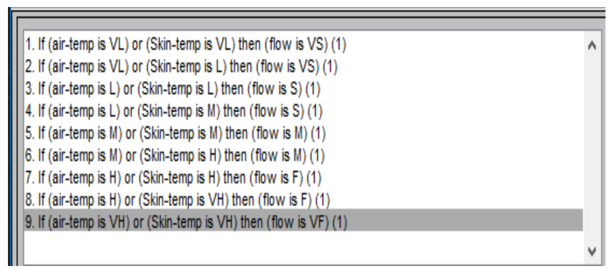

Figure [6]: Fuzzy Mamdani-Rule Editor

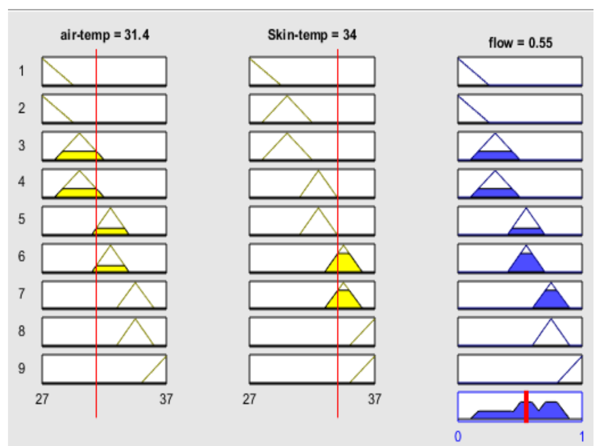

Figure [7]: Rule View

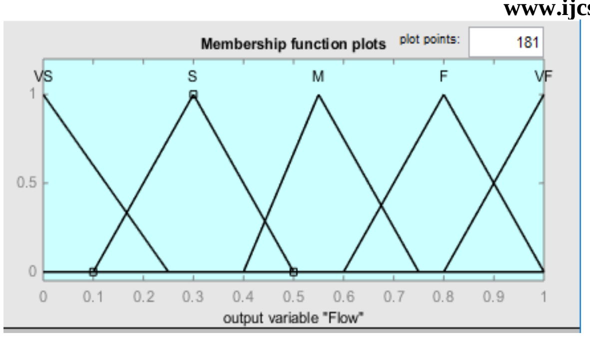

Figure [8] Output Flow Membership Function

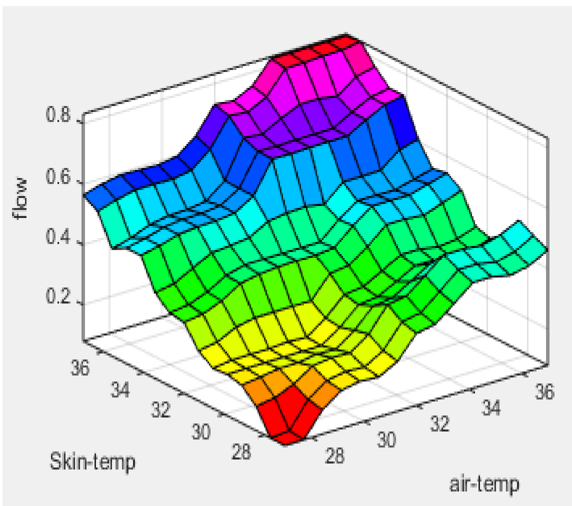

Figure [9]: Fuzzy Rule Viewer-3D Surface

4. Conclusions

A fuzzy logic control system was developed success fully in order to control the incubator air temperature. A control system was evaluated using of two sensor temperature model. .The advantage of this paper come the use of skin temperature sensor beside that one which often used to control the air temperature also using fuzzy logic provides a smooth control. The results show that the system with two Different sensor to measure temperature is more reliable and gives more accuracy.

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