Application of Fuzzy Logic Control in Design and Implementation of Digital Egg Incubator

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Abstract
This paper present a design and implementation of a digital egg incubator system based on Fuzzy Logic Technology. The input is obtained from LM35 which is an integrated circuit sensor that can be used to measure temperature (in °c). The output of the (LM35) is fed as an input to the Analog to Digital Converter whose major task is to convert the continuous quantity (Analog voltage from the LM35) to a discrete time digital representation / number proportional to the magnitude of the voltage, the 8 – bits binary output from the (ADC) are connected to (Port 2) of the AT89C52 microcontroller onboard the incubator, which analyses the data and provides the necessary control signal. The seven segment displays are used to display the temperature of the incubator. A Fuzzy Logic is used to control the heating element of the digital egg incubator. The problem of precision in temperature control and monitoring was analyzed and the AT89C52 microcontroller that was used to store all the assembly language of the digital egg incubator was programmed with the aid of (Top Universal Programmer).

Keywords
Digital egg incubator system, Fuzzy Logic, AT89C52 microcontroller, LM35

I. Introduction

Incubators are special warm enclosure for keeping fertilized eggs to ensure satisfactory development of embryos inside them into normal birds. Incubation of fowl eggs usually lasts for 21 days. Eggs incubation is the most delicate stage in poultry husbandry because the proper care of eggs at this stage of development has a decisive influence on the number of birds to be hatched and health condition of the Hatched birds. Fundamental elements of incubation are; the provision of heat, humidity, ventilation and turning of the eggs. The efficient combination of these factors determines the level of physiological and biological development and the mortality of the embryo. In attempt to formulate approaches that can handle real world uncertainty (lack of adequate information to make decision), researchers are frequently faced with the necessity of considering (exchange of compromise) between developing complex cognitive systems that are difficult to control, or adopting a host of assumptions that lead to simplified models which are not sufficiently representative of the system or the real world. The latter option is a popular one which often enables the formulation of viable control laws. However, these control laws are typically valid only for systems that comply with imposed assumptions. The option that involves complex systems has been less prevalent due to the lack of analytical methods that can adequately handle uncertainty and concisely represent knowledge in practical control system. Recent research and application employing non – analytical methods of computing such as Fuzzy Logic, Neural networks and evolutionary computation have demonstrated the utility and potential of these paradigms for intelligent control of complex systems. In particular, Fuzzy Logic has proven to be a convenient tool for handling real world uncertainty and knowledge representation.

A digital incubator is a modern improvement on ordinary electric incubator in which various discrete components are substituted for integrated circuit components which are fabricated for specific functions or task. The major components of the Digital Egg Incubator are; (ADC 0805), LM35, AT89C52 microcontroller, Seven segment display, Resistors, Capacitors, Crystal oscillator, etc. However the project seek to identify an alternative means of hatching eggs in mass for a lager / greater quantity in order to provide food for human populace. Thus, providing sufficient meat and food for mankind. It also tries to overcome the natural disasters incurred during natural incubation.

A. Classes of Incubator

1. Natural Incubator
2. Artificial Incubator.

1. Natural Incubator

Under natural conditions, a hen sits over her eggs until the chicks hatch (usually for 21 days). Also under this system a hen can take a maximum of 8-15 eggs for a set of hatching. Larger hens with good feathers can cover as many as 15eggs, but smaller local hens may be able to cover not more than 8 eggs well. However, the desire by the hen to incubate is under hormonal control. Heat is transferred from the hen's body to the eggs via the so-called brood patches. Down feathers are lost on the underside of the body and the skin here receives a high blood supply, providing local heat for incubation of the eggs. This position provides naturally the right temperature (37.5°C-38.8°C), humidity (59%-65%) and ventilation for eggs to develop as well.

2. Artificial Incubation

Artificial incubator simulates the conditions, which are obtained under the mother hen when she sits on eggs. Under modern poultry farming, incubation is carried out by artificial means in boxes known as incubator.

II. Concepts of Fuzzy Logic (FL)

In this context, FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster. Fuzzy Logic can also be simply seen as a new method of dealing with vague and imprecise information.

On a mathematical level, Fuzzy Logic abandons the strict bivalent logic of TRUE and FALSE, ONE and ZERO, ON and OFF. Fuzzy Logic allows for half – truths. Fuzzy Logic is a method of

ISSN : 0976-8491(Online) | ISSN : 2229-4333(Print)

characterizing knowledge in terms of Fuzzy sets and a rule base. Fuzzy Logic does not require precise inputs, is inherently robust, and can process any reasonable number of inputs but system complexity increases rapidly with more inputs and outputs. Consider the rule for the temperature sensor used in the design and implementation of digital egg incubator:
This rule uses the truth value of the “temperature” input, which is some truth value of “cold”, to generate a result in the fuzzy set for the “heater” output, which is some value of “high”.

III. System Design

IF (room temperature is “cold”) THEN (heater is “high”)

A. System Analysis

The first step in implementing Fuzzy Logic is to decide exactly what is to be controlled and how. Here we are considering (Design and Implementation of Digital Egg Incubator) and our purpose is to design a simple proportional temperature controller with an electric heating element (electric bulb).
A schematic representation of Fuzzy system control is shown in fig. 1 While a simple block diagram of the control system is shown in fig. 2

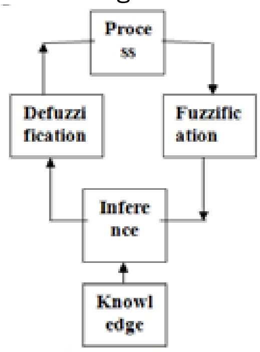

Fig. 1: A Schematic Representation of Fuzzy System Control

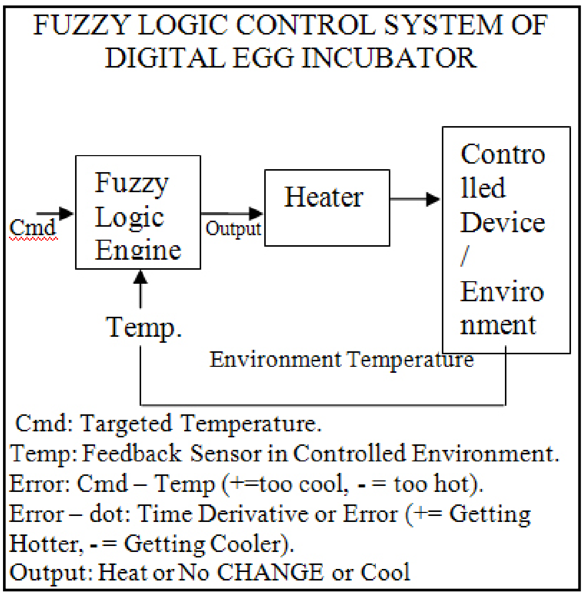

Fig. 2: A Simple Block Diagram of the Control System

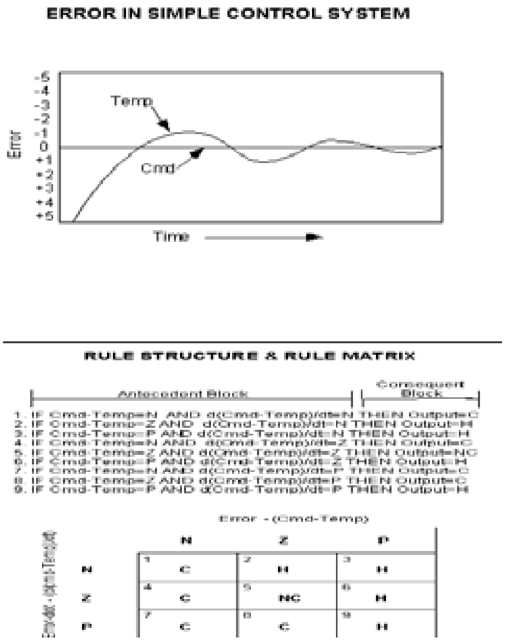

Fig. 3: Typical control system response

Fig. 3 above shows what command and error look like in a typical control system relative to the command set point as the system hunts for stability. Definitions are also shown for this example.

DEFINITIONS

INPUT#1: (“Error”, positive (P), zero (Z), negative (N))
INPUT#2: (“Error-dot”, positive (P), zero (Z), negative (N))
CONCLUSION: (“Output”, Heat (H), No Change (-), Cool (C))
INPUT#1 System Status
Error = Command-Feedback
P=Too cold, Z=Just right, N=Too hot
INPUT#2 System Status
Error-dot = d(Error)/dt
P=Getting hotter Z=Not changing N=Getting colder
OUTPUT Conclusion & System Response
Output H = Call for heating - = don’t change anything C = Call for cooling

B. System Operating Rules

Linguistic rules describing the control system consist of two parts; an antecedent block (between the IF and THEN) and a consequent block (following THEN). Depending on the system, it may not be necessary to evaluate every possible input combination (for 5-by-5 & up matrices) since some may rarely or never occur. By making this type of evaluation, usually done by an experienced operator, fewer rules can be evaluated, thus simplifying the processing logic and perhaps even improving the FL system performance.
After transferring the conclusions from the nine rules to the matrix there is a noticeable symmetry to the matrix. This suggests (but doesn’t guarantee) a reasonably well-behaved (linear) system. This implementation may prove to be too simplistic for some control problems; however it does illustrate the process. Additional degrees of error and error-dot may be included if the desired system response calls for this. This will increase the rule base size and complexity but may also increase the quality of the control.

IV. System Implementation

A. Hardware Implementation

Fig. 5 below shows the complete hardware implementation of the proposed system. The processing unit is made of AT89C52 Microcontroller and it is the brain of the entire system. It controls and coordinates all the activities of other sub – units connected to it. It is also used to store all the assembly language of the system. The Seven Segment Display unit consists of (four seven segment displays) which are used to display the temperature of the incubator. Set temperature Unit consists of three micro – switch use to set the desired temperature of the incubator. Electromechanical Relay consists of one 12v relay which is used to control the heating element (100 – 200 watts electric bulb). Analog to Digital Converter (ADC 0805) is used to convert the continuous signals from the output of the temperature sensor to discrete digital numbers which are fed to the (Port 2) of the AT59C52 for further analysis and control. Incubator Heater consists of the heating element (100 - 200 watts) and a framed box for putting the fertilized eggs to be hatched. Temperature Sensor (LM35) measures the incubator temperature and gives an output voltage that is proportional to the Celsius temperature to the (ADC) for further conversion and processing. The system makes use of 12v, 1000MA step down transformer. The transformer steps down (220 – 240v) from main source to (12acv). The (12acv) present at the secondary side of the transformer is latter regulated to (+5Vdc) with the help of; Diode, Capacitor and 7805V Regulator.

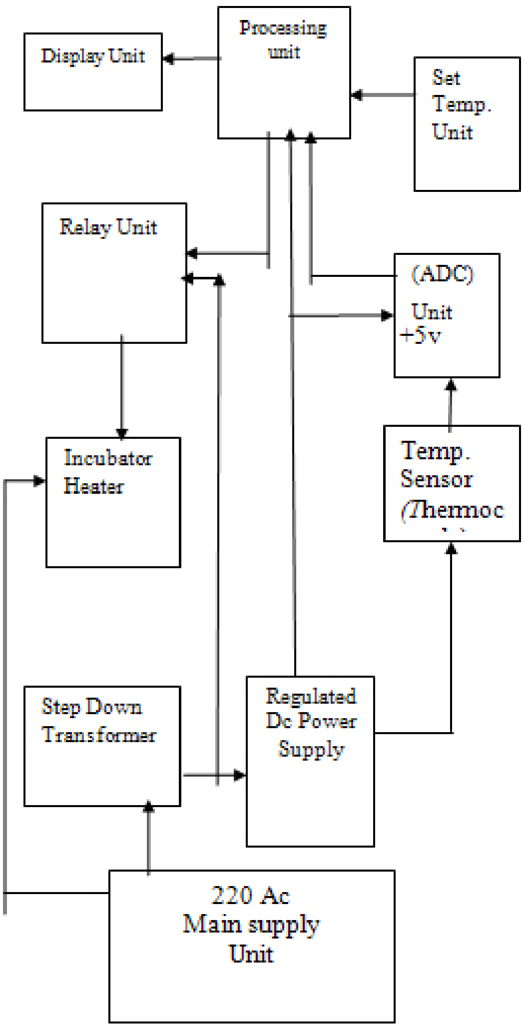

Fig. 4: The rule structure

B. Software Development

The steps taken in assembling the program is summarized as follows:

1. Type the program in notepad.
2. Save it as "Incubator.asm" in drive C: /
   Ensure that drive C: / has the 3 applications (A51, OHS51 and L51) required to assembly the program
3. Launch the "run" command from the start menu and type the commands

a51.Incubator.asm
l51.Incubator.obj
ohs51.Incubator.obj

And then click OK; In case of syntax error in program code, program will not be compiled and HEX file will not be generated. Errors need to be corrected in the original program file (the one typed in Notepad) and then the source file may be compiled again. The best approach is to write and test small, logical parts of the program to make debugging easier.
The PM-51 Macro Assembler was used for this project. The term PM-51 belongs to an entire family of single-chip microcomputers, all of which have the same processor design. They use the same instruction set, but differ slightly in Memory mapped special function registers and on-chip ROM and RAM. The assembler is a software tool- a program-designed to simply the task of writing computer programs. It performs the clerical task of translating symbolic code into executable object code. This object code may then be programmed into one of the PM-51 processor to which the 8051 belongs.

V. Testing and Results

The test was done by powering the incubator. When powered it first displayed "digital egg incubator" before flashing "set temperature". The required temperature was entered using the increment button. Then the incubator attained the required temperature.
Also the work was tested and found to meet our specified requirement with efficiency of 80%.
No of fertile eggs used are: 100
No of chicks hatched are: 80

VI. Conclusion

Fuzzy Logic represents a tremendous advancement in digital egg incubator control system. It was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. It is imperative to know that this project is portable. The monitoring of the device requires not the presence of the operator physically, saving time and cost. Its efficiency is optimum which guarantees production of poultry birds at its peak. .

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 ISSN : 0976-8491(Online) | ISSN : 2229-4333(Print)

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