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JUDUL: SIMULATION COMPUTER CONTROLLED OVEN BY USING FUZZY LOGIC

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SIMULATION COMPUTER CONTROLLED OVEN BY USING FUZZY LOGIC

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“This thesis is submitted fulfillment of the requirement for the award of the Bachelor of
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“I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)”

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*Specially dedicated to my beloved parents
Che Wan Fadzal Bin Che Wan Abdullah, Raja Rahmah Binti Raja Sulong, brothers,
sister and all my fellow friends who have encouraged, guided and inspired me
throughout my journey of education*

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ABSTRACT

An oven is a kitchen appliance that cooks or heats food by using heat which has been converted from electric energy. By using oven, we must set the temperature for each types of food, time to finish cooking and also must always take a look to make sure the food is cook well. From this, I noticed that it will be a problem to someone who didn't know how to cook very well, busy with other works but want their food cook in the good condition. So, to overcome this situation, I propose this proposal that is simulation computer controlled oven using fuzzy logic. In this project there are three clearly different parts. First, the conceptual design of the oven and the mathematical modeling implemented in Matlab-Simulink®1, second, the application of fuzzy logic in constant the variables of temperature and relative humidity and last, the analyze of display the real graph output for temperature and relative humidity. Fuzzy logic will established the temperature control system model that focus on the fuzzy logic controller using Matlab and simulated it. It indicates that using the fuzzy logic control system can greatly control the variables of the temperature and stable it.

ABSTRAK

Oven ialah salah satu perkakas untuk memasak atau memanaskan makanan dengan menggunakan haba yang telah ditukarkan daripada tenaga elektrik. Dengan menggunakan oven, kita perlu menentukan suhu untuk setiap jenis makanan, masa untuk selesai memasak dan juga perlu sentiasa memerhatikan makanan yang dimasak untuk memastikan ia masak dalam keadaan yang dikehendaki. Berdasarkan ini, saya mengetahui bahawa ia akan mendatangkan masalah kepada seseorang yang tidak pandai memasak dengan baik dan sibuk dengan kerja lain, tetapi mahu makanan yang dimasak dalam keadaan baik. Jadi, untuk mengatasi situasi ini, saya memperkenalkan project ini, iaitu 'Simulation Computer Controlled Oven by Using Fuzzy Logic'. Didalam projek ini, ada 3 bahagian yang secara jelasnya diuraikan. Pertama, konsep merangka oven dan model matematik dalam Matlab-Simulink. Kedua, aplikasi untuk Logik Kabur dalam mengekalkan perubahan suhu dan kelembapan relatif dan akhir sekali, menganalisis graf yang keluar untuk suhu dan kelembapan relatif. Logik kabur akan mendirikan model sistem pengawalan suhu yang memfokuskan pada kawalan logik kabur dan simulasinya. Ia menentukan penggunaan sistem kawalan logik kabur boleh dengan bagusnya mengawal perubahan untuk suhu dan menstabilkannya.

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LIST OF SYMBOLS

SYMBOL	DESCRIPTION
oC	- degree Celsius
V	- volt
G	- gram
Kg	- kilogram
Cm	- Centimeter
A	- Ampere

CHAPTER 1

INTRODUCTION

1.1 Oven

As we all know, an oven has their own history. At first, it was introduced by settlement across the Indus Valley Civilization who's the first have an oven within each mud-brick house by 3200 BC [9].

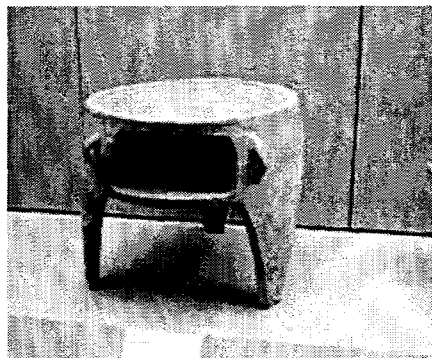


Figure 1.1.1: Ancient Greek portable oven

The above picture in figure 1 is the first oven introduced in the world. There are only a simple oven which can use to create a wide variety of dough, and styles of serving bread with other foods. After a long time, baking developed by developed many kind of oven.

Now, we have a modern oven which use used for roasting and heating. This oven has more function not only to cook bread, but also includes meat, cake and other desserts. Figure 2 is example one of a modern oven.

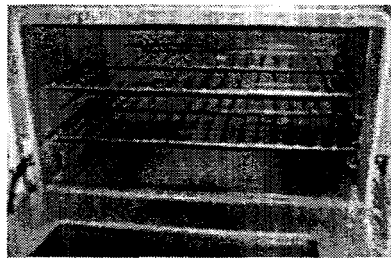


Figure 1.1.2: Modern oven

In cooking, oven will produce humidity from the food when interaction with the temperature. Humidity is the steam ovens which produce in form of water into the cooking chamber. The degree of humidity is usually selectable among at least several steps. Some steam ovens use water carried to the oven by the user in a container; others are permanently connected to the building plumbing. This situation can give the speed in cooking of certain types of food.

Actually, oven can come in varies way in the way that they are controlled. The simplest ovens such as AGA cooker [9] not have any control in cooking. it runs continuously at various temperature . Besides the simplest oven, there are conventional oven that better than the simplest oven. More conventional ovens have a simple thermostat which turns the oven on and off and the temperature will select which it will operate. A timer may allow the oven to be turned on and off automatically at pre-set times.

Compare with the above oven that I have introduced, there are also more sophisticated ovens which may have complex, with computer –based controls and allowing a wide variety of operating modes and special features including the use of a temperature probe to automatically shut the oven off when the food is completely cooked to the desired degree.

From the above information, we know that, almost all people have oven in their house because it is the common appliance in the kitchen. An oven is used for heating, baking or drying and commonly used in cooking and pottery. In the past, cooking ovens were fueled by wood or coal. Modern ovens are fueled by gas or electricity. When an oven is contained in a complete stove, the fuel used for the oven may be the same as or different from the fuel used for the burners on top of the stove [9]. So, the oven needs some improvement to make it give more advantages to people.

In control system, there are number of generic systems and method which encountered in all areas and technology. From the dozen ways to control any system, it turns out that fuzzy is often the best way which are faster and cheaper. There are most of the examples have ever seen of fuzzy logic control which being successfully applied fall into the category of things that humans do well [2]. Oven will be one of the successful applications that used fuzzy control.

Years ago, when we operated an oven, we had to give it precise settings or inputs. We had to put in the foods and clearly mention the temperature for each food and also time to finish. But in today's fully automatic machines, we just have to put the food inside the oven and stand back to watch it determine the types of food, automatically setting the temperature required

and such details. This ability of the oven to simulate the commonsense of human beings is a result of the usage of fuzzy logic.

Oven Fuzzy is an automatic oven which have ability to cook food in the suitable condition and time. This oven function using system fuzzy logic that controlled the temperature and timer that act as a brain for this oven. It can function depend on types of food, humidity in the oven, and also by the initial temperature that we have set. In order to sense the humidity, humidity sensor has been used that will sense the humidity in the oven that is the environment of the food, then system fuzzy logic will decide the timer based on the humidity in the oven and temperature setting.

Commonly, people use oven to cook almost all type of food like cakes, biscuits and others. Nevertheless, it gives people only to set the temperature and time for each cooking without help the people to overcome any problem in their cooking. At this time of year, everyone is always busy with their work and didn't have time to learn give some time in cooking. This situation will cause our food cook in not in the good condition like being harsh and others. So, when cooking, we might be concerned about our oven temperature .If it runs too hot, or too cold, our meals won't come out just right.

Usually, some food have been cook but not in the good condition because they set more time or at not suitable temperature for their cooking. This is the real situation always happened in the kitchen. So, my project will overcome this problem.

1.2 Objectives

- To develop simulation computer controlled oven by using fuzzy logic.

1.3 Scope of Project

In order to carry out my project successfully, I need to have a clear scope of study. This scope will make my study easier because this is my guideline to do my project. Below are my scopes of study:

1.3.1: Oven design.

- In order to achieve my objective, I need to identify the weakness of previous project in oven design. Especially in determine the time in cooking. Furthermore, this fuzzy logic will be applied as the new application in this oven called as Oven Fuzzy (OFZ).

1.3.2: Parameter in Oven Fuzzy (OFZ)

There are three parameters cover in this oven, which are temperature, timing, and relative humidity .The scope in this parameter is in making system do a better, more precise job and enable the computer to make human- like decisions

- The temperature for each time cooking is set at the initial suitable temperature for each food. In timing, we must also set how long the food finishes to cook. Although that, the time we set always refer to the changing of temperature and humidity to stop cooking at suitable time either to stop at the setting time or before that.
- Humidity in the oven is based on relative humidity that we have assumed at 50% for each food. The initial relative humidity in this oven we have assumed first about 10 %. Time is setting when we

have chosen types of food. The humidity in this oven will become stabilized after it reached 50%.

- Temperature is proportional increase with relative humidity and time. It starts at the initial temperatures, 27°C. The temperature will increase until it reached the setting temperature and become to constant control using system fuzzy logic
- Lastly, we go to the setting time. It functions to stop the cooking at the setting time or before the setting time. When all the criteria for the cooking is reaches before arrived at their setting time, the food will stop their time to cook meanwhile if it not full the criteria need, the cooking is still continuous until arrived at the setting time. So, the food will cook in the suitable condition and not burn.

1.4 Layout of Thesis

Basically this thesis discuss about the simulation of an oven by using system fuzzy logic. First chapter of this thesis will discuss on the introduction. Second chapter will discuss on the literature review while chapter three will focus on the methodology in this chapter, oven design, parameter design and program development. Result and discussion described in the chapter four. The conclusion and recommendation of this thesis will be discussed in the last chapter.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses about the existing systems that are already designed and its functionality are proven. There are a lot of research and articles have been found and discovered on doing this project. The information from these are summarized in this chapter.

2.1 Basics

An Oven Fuzzy (OFZ) is different from other more conventional, modern ovens in that it requires no timing for cooking and is able to cook well over a variety of types of food and humidity. It is also different in that the rate of development of the other oven which can cook more easily, faster and safely.

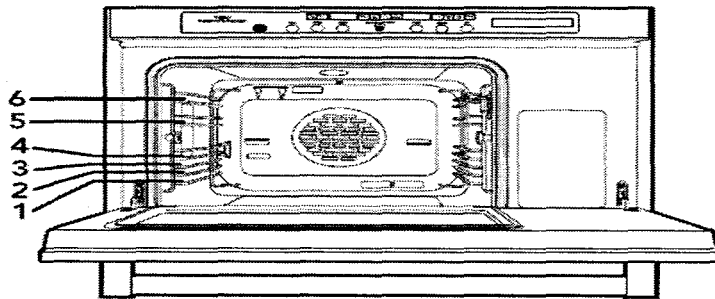


Figure 2.1 : General Parts of an Oven

2.2 History Types of Oven

2.2.1 Standard or Conventional Oven

This oven use natural convection and radiant heat to cook food product. These ovens in general do not mechanically circulate the air within the cavity. The burner or elements heat the air within the oven cavity walls, causing currents of hot air that transfer heat to the surface of the food. The arrangement of pans in the oven and the texture of the food can affect the circulation air, changing the cooking speed, and uniformity. It is the latest expensive to purchase and their production capacity is typically not as high as forced convection oven.

There are 2 types of standard oven, that is range oven and deck/pizza oven. The range oven is most familiar and can be used for nearly all types of food preparation such as breads, pies, meats, fish, and also baked potatoes. Range oven also known as the general-purpose oven, which heated with atmospheric gas burners located directly below the oven cavity. Energy input rate is between 35 kBtu/h to 45 kBtu/h for gas and 7 kW to 9 kW for

electric. It is specified for small operations because their exterior dimensions are typically 36 inches (900mm) wide by 30 inches (750mm) deep by 30 inches (750mm) high.

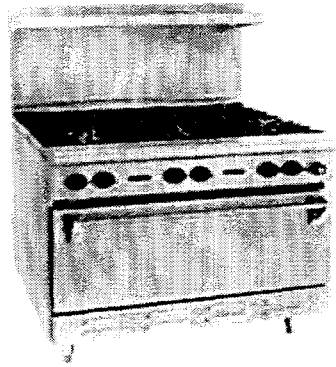


Figure 2.2.1(a): Six burner range with range oven

Deck oven are similar to conventional roast or bake ovens accepts the inside cavity has a low height, ranging from 6 to 10 inches (150-250 mm). The bottom of each compartment is called a deck and heat is typically supplied by burners or elements located beneath the deck. It is also can be used to cook a wide variety of other foods fairly such as meats and fish. The limiting factors is the height or thickness of the food product.

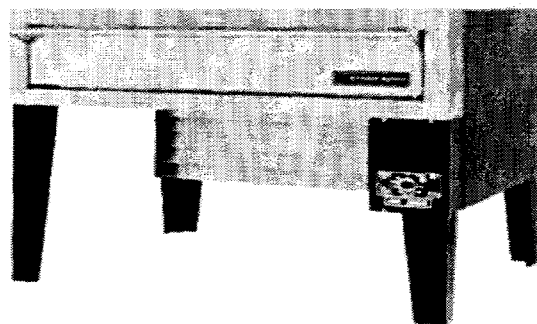


Figure 2.2.1(b): Deck Oven

2.2.2 Convection Oven

Almost all convection ovens are available in both gas and electric models. The concepts behind the forced- air convection oven is a simple one, when food is cooking inside an oven, it is surrounded by an insulating layer of air that is cooler than the overall oven cavity temperature. A motorized fan or blower forces the heated air to move through the oven's cavity, stripping away the layer of cooler air next to the food. The result is a faster, more even cooking process than that provided by standard, natural convection, radiant heat oven. Forced convection can reduced the cook time significantly on long to cook items such as potatoes and can allow more food to be cooked in a period of time.

Example of this convection ovens are Rack Oven, Combination oven and also Cook –and-Hold Oven

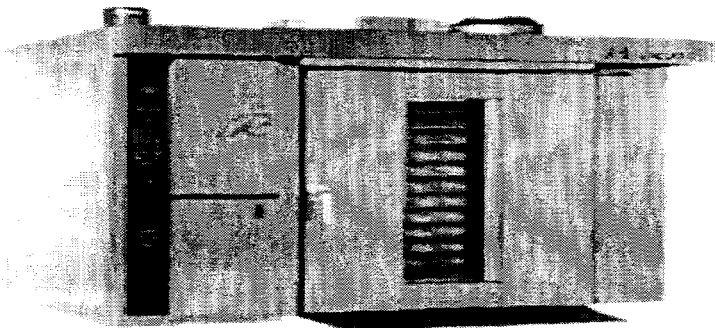


Figure 2.2.2: Double –rack Rack oven

2.2.3 Conveyor Oven

Conveyor Oven available using 4 different heating process that are infrared, natural convection with a ceramic baking hearth, forced convection or air impingement , or a combination of infrared and forced convection. The air impingement oven use a blower and baffles to intensity and focus the air movement within the oven cavity towards the food load. These high-velocity “fingers” of air impinge upon or blow away the layer of air and moisture that insulates the food, thus increasing the speed of the cooking process.

It is highly flexible and can be used to bake or roast a wide variety of products including pizza, meats and breads. One of the newer features included on some conveyor oven is the option to have independently controlled cooking zones. The temperatures within each zone may be independently adjusted. The first zone is very hot and as the product passes through it, it is quickly heated up to cooking temperature. Before it start to burn, the product is moved into the second zone, generally referred to as “the finishing “ zone. Here the temperature is even lower, cooking the product to the desired degree of “doneness”.

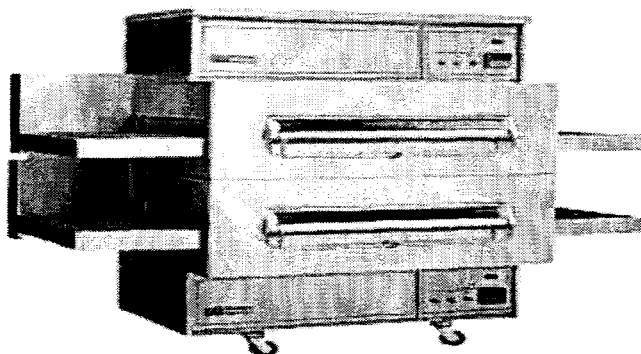


Figure 2.2.3: Doubled-stacked Conveyor Oven

2.3 Previous Work/Related Research

2.3.1 : Development of a Fuzzy Logic Control System in Matlab for an Air Impingement Oven

The main objective for this journal is to determine the optimal combination of cooking time, temperature, humidity and air flow to destroy the pathogenic organisms while maintaining desirable food quality characteristics and product yield[1].

A fuzzy logic control system is developed to maintain constant temperature and humidity values and quickly recover from disturbances to the oven. As a result, higher humidity values in the main oven chamber are achieved by adding steam to a smaller pre-chamber that is located to the right of the main oven chamber[1].

Besides that,air velocity is provided by a 2-foot fan located above the main oven chamber that is capable of providing 450 standard cubic feet per minute (scfm) of airflow. This fan is controlled by a potentiometer located on the front of the electrical panel, where a digital display for the fan speed is also located. The fuzzy logic controller able to maintain constant temperature and humidity values and recover from disturbances quickly

The knowledge and understanding of the behavior and characteristics of the plant acquired either directly or indirectly, provide enough information to create a fuzzy logic control system. Such knowledge allows input and output membership functions to be defined and rules to be created mapping the inputs to the outputs.

2.3.2: Fuzzy concepts applied to food product quality control

Fuzzy concepts applied to food product quality control have its own objectives that are to provide an overview of the application of fuzzy concepts to the control of the product quality in the food industry over the past 10 years [2].

This paper focuses on representation of the descriptive sensory evaluation performed by a quality team, an operator, or a consumer, indirect measurement of the properties of a food product; and also diagnosis, supervision, and control of food quality.

Compared with the other paper, it discusses more about how to control of food quality meanwhile the first journal is about how the fuzzy system function in constant any parameter. Actually, there are two specific approaches for extrusion cooking, drying, cheese making and others, that are data-driven approaches and expert knowledge driven approaches. Fuzzy PID implementations, developed a fuzzy neural network to control the temperature are used in data-driven approaches.

2.3.3: Method for controlling the humidity level in a cooking oven.

Maintaining the power to a predetermined value that is correlated to a choice made by the user among a plurality of predetermined values corresponding to different values of at least one cooking parameter, particularly the degree of browning of the food is the objective in this

paper[3]. The humidity level is controlled according to the following formula [3]:

$$\text{Humidity Level} = (k_1 - 1) * (\text{Power}) - (k_2 - 3 + k_3 - 4) * (\text{Voltage} - 2)$$

Power = the controlled power delivered to the steam generator

Voltage = the voltage of the current delivered to the fan motor

k_1 , k_3 and k_4 = experimental values

The humidity profile inside the cavity is automatically established by the oven control according to the food category selected by the user, or according to the weight of the food estimated by the oven or inputted by the user.

Controlled using a temperature sensor inside the cavity said sensor closing the loop on a desired cavity temperature and generating, through a control unit, the proper heating element actuation to maintain the desired set temperature. The right humidity level inside the cavity is typically dependent on the food category to be cooked. Other parameters that typically drive the humidity level to be maintained inside the cavity are also: recipes, quantity/mass of food, food types, final result of cooking etc.

2.3.4: Model-based temperature control in ovens

The objective of this paper is to improve an oven cavity by implementing more advanced control algorithms to the unit and also modified significantly through the implementation of a model-based tuned P.I.D. controller. It is almost same with my project but my oven did not used

PID controller. So, I can investigate about the controller of temperature in this oven.

The findings from this paper are the implementation of the developed controller only requires minor changes, which is important from a practical point of view. Besides that, the design of the new controller is based on the identification of a multiple model block, describing the main dynamics of the cavity, the tuning of a P.I.D. type controller in a numerical optimization framework, and the final implementation, taking into account practical considerations such as discretization[4].

Finally, it is shown that the performance of the oven cavity is improved considerably through the implementation of this modern model-based tuned P.I.D. controller for temperature control. The following conclusions about the controller performance can be stated, the temperature set point is reached better and faster, the temperature distribution is more homogeneous over the oven cavity, and the new control system has an excellent performance over a wide range of operating conditions

2.3.5: The relationship between outside air humidity and finished biscuit moisture

The objective for this journal is to check out the possibility that Finished Biscuit Moisture is higher when the humidity of the air is drawn into the Weet-Bix ovens is higher. From this journal, I find that the effect of air temperature and humidity on finished biscuit moisture as following [5]. First, the pair wise correlation coefficients were 0.141 and 0.154

respectively, which are not significant. Second, Finished Biscuit Moisture does not show any correlation with Air Temperature or Relative Humidity. Even taking all variables into account this data explains less than half of the variation in Finished Biscuit Moisture. Third, all variables explains less than half of the variation in Finished Biscuit Moisture. Fourth, other variables that have a large effect on Finished Biscuit Moisture, been obscured by the random data collection method and finally, finished biscuit moisture can be lowered to some extent by lower Moist Biscuit Weights, and Oven Speeds which relate with Packet Weight and production rate

2.3.6: Convection Automated Logic

In Convection automated logic, there have 2 stages involved in the system, that will cooks the food. The first stage is the sensing stage of the food's thermal load. In this stage, the oven program calculates the total time it takes to reach a threshold temperature determined by the program. This threshold temperature is determined by experimentation in the research and development (R&D) program and threshold point will changes from food group to food group[6]. When threshold is known, total cooking timer and temperature can be calculated.

Total time = time to threshold x X factor.

X factor = variable that determined by exp in R&D program and derived from knowing time to threshold and total time food need to cook.

The second stages or final stages is cooking stages. After X factor and control temperature calculated, the display is updated to show the remaining cook time and the thermostat temperature. Then, it gives the oven

the power needed to reach the control temperature (thermostat temperature) and cook the food. When the cooking program is complete, the control shuts off the oven.

2.3.7: The Role of Water in Food.

Water in food actually gives the important information in understanding the relation of humidity in each food. It was produced by Ken Morison, NZ Institute of Food Science and Technology, Dept of Chemical and Process Engineering, University [7]. The foods we eat actually contain different amounts of moisture depending on what we expect of the food. The amount of moisture required influences the manner in which the foods are packaged and stored. So, this paper give the result from the experiment in determines the percentages of humidity in each food.

2.3.8: Types of Cooking

This article is about types of cooking in an oven. It explains the temperature need in each types of cooking and examples of food can be cook. There are actually 7 types of cooking, which are baking, roasting, broiling and grilling, frying, boiling, simmering and also steaming. Table 2.3.8 below is the summary for each type.

Types of cooking	Temperature	Explanation
Baking	300 to 450 °F (149 to 232 °C).	Foods made from a batter or dough (Such

		foods include breads, cakes, cookies, and pastries).
Roasting	300 to 350 °F (149 to 177 °C).	Cooking food uncovered in hot air. Usually refers to the cooking of meat. For example, a turkey or a leg of lamb is roasted.
Broiling and Grilling	Cooking by the application of direct heat.	In broiling = food lies directly under a continuous heat source In grilling = food lies directly over the heat source.
Frying	About 350 °F (177 °C)	Cooking of food in fat, such as butter or vegetable oil.
Boiling	Food cooked in boiling water, which has a temperature of about 212°F (100 °C).	Air bubbles rise to the surface of the water and break. Potatoes and other vegetables are often boiled in a saucepan over a burner
Simmering	Food cooked in water that is just below the boiling point.	Such foods as eggs and meats should be simmered rather than boiled
Steaming	Food cooked in steam	Used mostly to cook vegetables.

Table 2.3.8 : Types of cooking in an oven

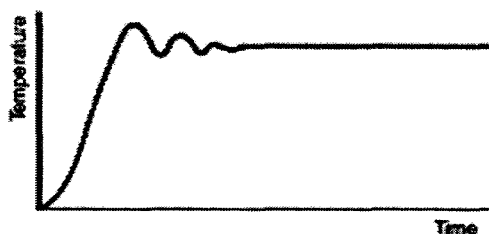
2.3.9: Conventional Oven and Modern Oven

From this, there are 5 way oven vary that explain in this articles. First, the oven which do not have any controls at all. That is the simplest oven and control manually by person. Second, the oven run continuously at various temperatures. Third, it have a simple thermostat which turns the oven on and off and selects the temperature at which it will operate. Then, the oven also may have the timer which allow it to be turned on and off automatically at pre-set times. Finally, the last way is more important to explain in this project because it is the way that my oven work. It is the more sophisticated oven,that is computer based controls allowing a wide variety of operating modes and special features. In this oven, the use of a temperature probe to automatically shut the oven off when the food is completely cooked to the desired dergee.

2.3.10: Configuration Example of Temperature Control

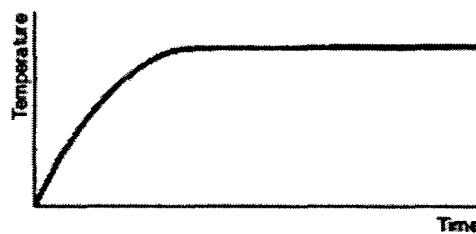
Configuration example of temperature control discuss characteristics of the controlled object, temperature sensor and the output include heating and cooling control. There are 3 graphs in control temperature versus time that show in this article. First, graph show the temperature stabilize after overshooting several times, second show the proper response, and the third show the response is slow in reaching the set point[10].

1. The temperature stabilizes after overshooting several times.



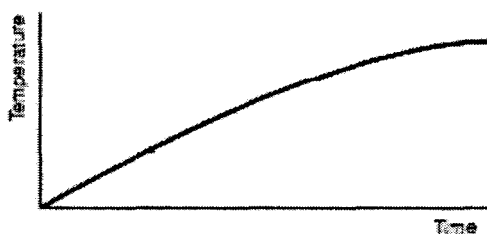
Graph 1

2. Proper response



Graph 2

3. The response is slow in reaching the set point.



Graph 3

Fuzzy logic uses some basic information about the system within a process controller which is input by the user, to emulate the way an expert's operator who was manually controlling the system would react to a process upset. Besides that, there also explain about the temperature sensor use, like thermocouple and thermistor.

2.4 Summary

Besides the related research reviewed above, there are numerous hobbyists and enthusiasts around the world who have make various kinds of research on oven to improve their performance and other model oven.

Listing all of the projects that have been reviewed throughout the course of this project would be impossible due to space constraints. In short, they can be the performance of oven, applications of fuzzy logic and PID and also the operation of oven. Each of them is unique in terms of their design and construction materials. However, it can be generally concluded that all of them operate using the same basic electrical principles. Thus, after assessing the techniques of oven construction, a wide range of methods are employed in the design and controller of temperature in oven.

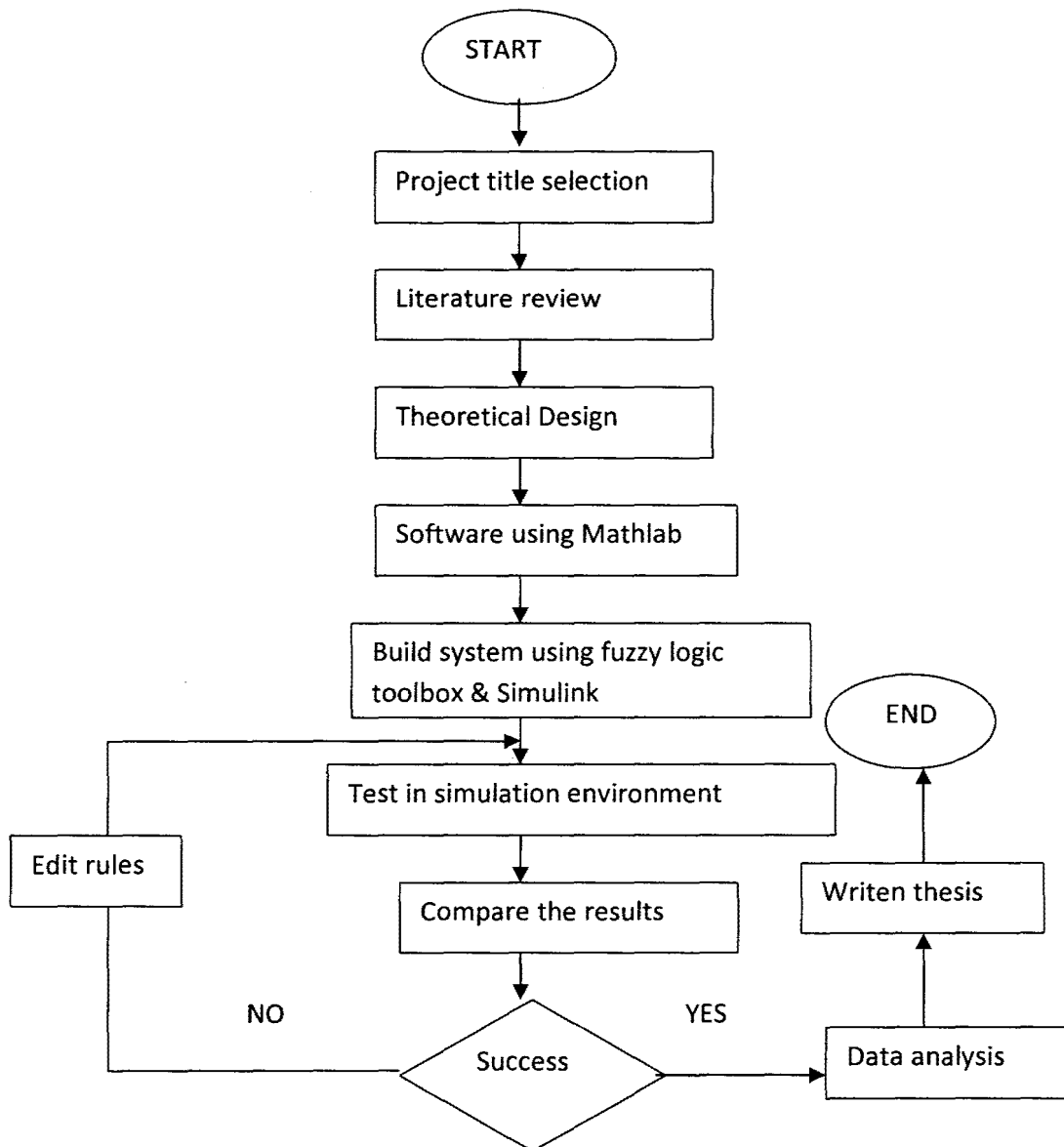
CHAPTER 3

METHODOLOGY

This chapter discusses in methodology involve in the design process of The Fzzy Oven. Generally, the design processes are divided into three phases, which are the Electrical Design, Circuit Design, and Software Development. Each phase is explained in details accordingly to method and material selection factors

3.1: Introduction

Project methodology is based on the flow chat 1, which explained how the flow of the project is planned and organized. Besides that, it also discuss the steps take in order to achieve the aim and objectives of the project.



Flow chart 1 : Flow chart whole project

The fuzzy logic system controlled oven, called 'Oven Fuzzy', was successfully constructed using research and items of various sources. The project met its objective of being a functional automatic oven based on application of fuzzy system. This project is to design and construct on of oven, control the oven with specified temperature accuracy and display a real time output graphically for temperature and humidity.

Oven fuzzy can successfully cook the various types of food with the specific controlled temperature, and this was determined after carrying out experiments which returned positive results. Temperatures and times for each types of food are determined from the research. From this, we can make the comparison with the calculated time of finishing cook which related with their changing humidity. The humidity actually we know from their weight which changes proportional with the time.

The Fuzzy Oven is automatically controlled by using Fuzzy Logic in software of MATLAB. The range for temperature and humidity were set first using this software and can be adjust to get the actual output or nearest output. Fuzzy Oven is able to use in baking or roasting, as well as how many parameter we put in the fuzzy to be control. It is responsive and relatively fast and easy in cooking considering its simple design with fuzzy application.

This Oven Fuzzy has equipped with some important device from some research to construct the prototype oven. In order to get smooth function of this oven, the sensor in Figure 5.1 and 5.2 is used to detect the temperature and the percent of relative humidity in this oven. With this sensor, the oven detects the temperature and humidity at the specified value we have set. Then it is no problem at all to discuss about the function of this because in this project we focus about the application of fuzzy logic in this oven and the control of the input we have setting.

Commonly, an oven uses an accurate thermometer to verify the actual temperature of the oven. Although that, the moist inexpensive dial thermometer are no more accurate than the oven's built in thermostat. To get the good reading, I use a glass-bulb thermometer. If the sensor does not

detect vapor properly, the oven will turn off, and the correct time of day will be displayed.

The humidity sensor allows for automated cooking to ensure the optimum mode of cooking whatever dish we are preparing or warming up. The sensor detects the degree of relative humidity present within the oven, adjusting the overall cooking time to perfect the dish being cooked or warmed up. In this project, I use 'Thermal Conductivity Humidity Sensors'. That's because this sensors perform well in corrosive environments and at high temperatures

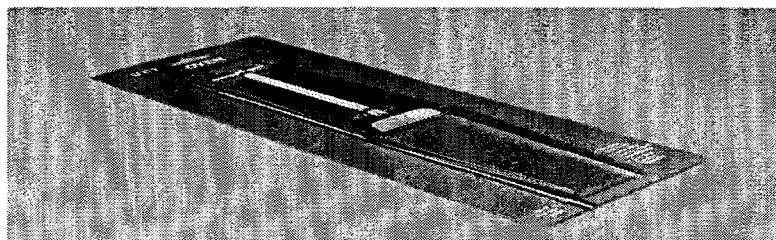


Figure 3.1(a): glass-bulb thermometer

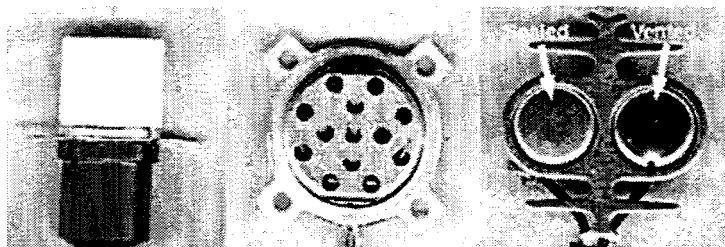
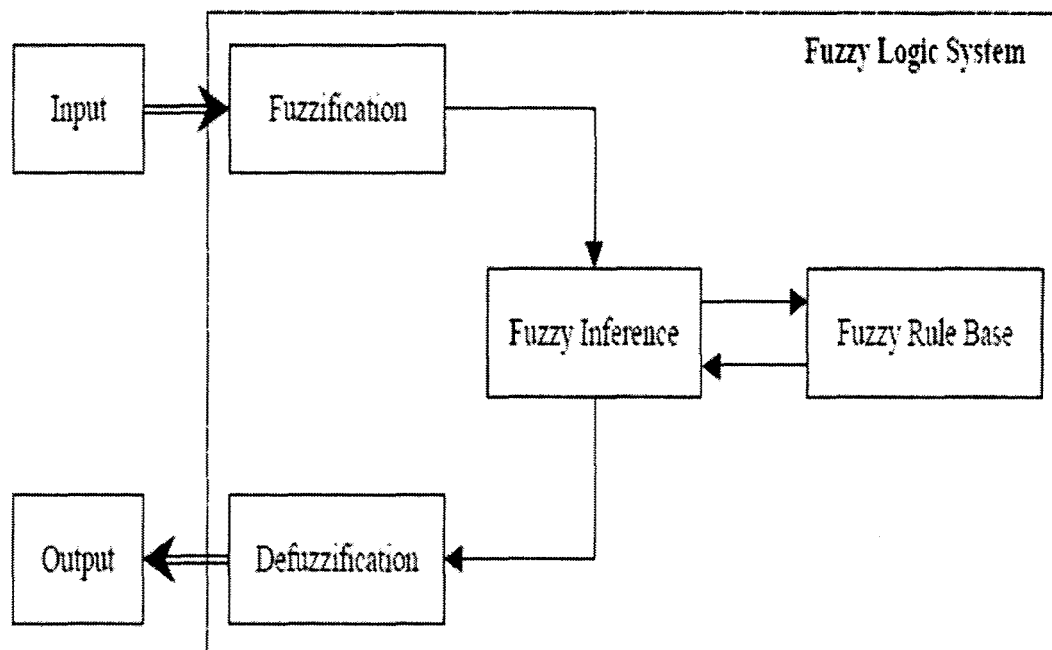


Figure 3.1(b): Thermal Conductivity Humidity Sensors'

Once the oven characteristics have been identified, the next step is to analysis and to identify the strengths and weaknesses of this oven. This oven is tested by the graph that have been produced either the fuzzy rules that insert in this system will function as assumption in giving good performance for cooking or there have some problem

In this project, explanation about the fuzzy logic is more to the Mamdani concept because that is the type used. The most commonly used inference mechanism is the “Mamdani” one. It represents a simplification of the more general mechanism based on “fuzzy implication” and the “generalized modus ponens”. In Mamdani inference mechanism for principle, it explains that a Mamdani fuzzy rule base contains linguistic rules using membership functions to describe the concepts used. The inference mechanism is made up of the following steps: Fuzzification, degree of activation, implication, degree of activation, Implication, Aggregation and also defuzzification.

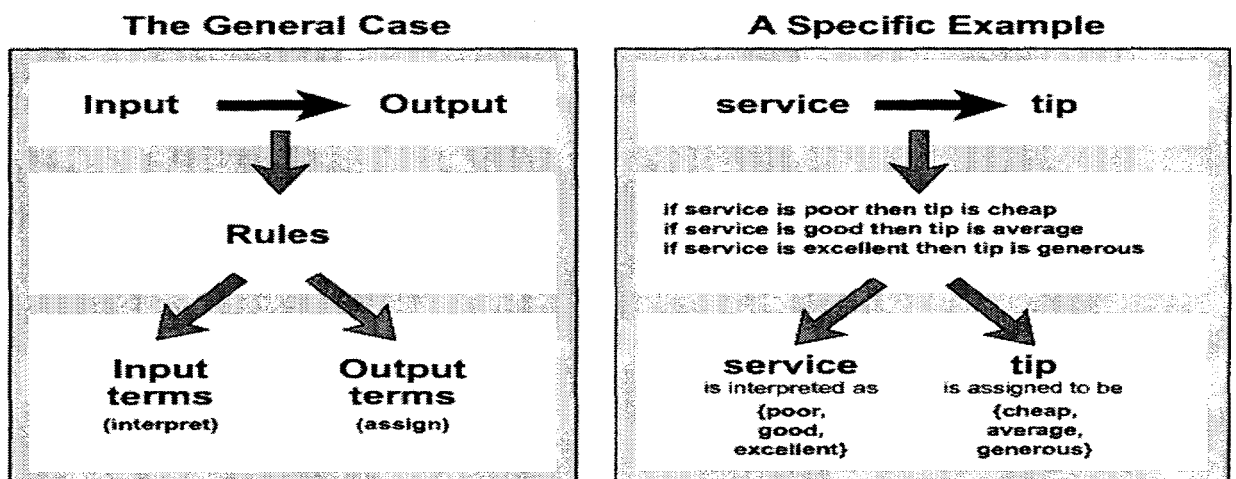
From the above flow chart, the most important process is in the build system using fuzzy logic toolbox & Simulink. Flow chart 2 showed the fuzzy logic system that will be discussed in this chapter.



Flow Chart 2: Block diagram of fuzzy logic system

3.2. Theoretical Design

The point of fuzzy logic is to map an input space to an output space, and the primary mechanism for doing this is a list of if-then statements called rules. All rules are evaluated in parallel, and the order of the rules is unimportant. The rules themselves are useful because they refer to variables and the adjectives that describe those variables. Before we can build a system that interprets rules, we must define all the terms we plan on using and the adjectives that describe them. To say that the oven is hot, we need to define the range that the heat's temperature can be expected. The following diagram provides a roadmap for the fuzzy inference process. It shows the general description of a fuzzy system on the left and a specific fuzzy system on the right.



Related with my project, two inputs involved, those are temperature and relative humidity and the output is speed of fan in the oven



From the input and output above, there are 9 rules developed:

1. If temperature Low and relative humidity Normal, Then Speed of fan is Slow
2. If temperature Low and relative humidity Normal, Then Speed of fan is Normal
3. If temperature Low and relative humidity High, Then Speed of fan is High
4. If temperature Normal and relative humidity Low, Then Speed of fan is Normal
5. If temperature Normal and relative humidity Normal, Then Speed of fan is Normal
6. If temperature Normal and relative humidity High, Then Speed of fan is Fast
7. If temperature High and relative humidity Low, Then Speed of fan is Fast
8. If temperature High and relative humidity Normal, Then Speed of fan is Fast
9. If temperature High and relative humidity High, Then Speed of fan is Fast.

Fuzzy logic process

Fuzzy logic has the process step by step. So, that is an introduction to the theory and practice of fuzzy logic implemented in this project. The first three sections of this section are the most important which they move from general to specific, first introducing underlying ideas and then discussing implementation details specific to the toolbox.

These three areas are as below:

1. Foundations of Fuzzy Logic, which is an introduction to the general concepts.
2. Fuzzy Inference Systems, which explains the specific methods of fuzzy inference used in the toolbox. Because the field of fuzzy logic uses many terms that do not yet have standard interpretations, this section is to become familiar with the fuzzy inference process as it is employed through the toolbox.
3. Building Systems with Fuzzy Logic Toolbox Software, this goes into detail about how we build and edit a fuzzy system using this toolbox. It provides a quick start orientation to the Fuzzy Logic Toolbox graphical
4. User interface tools and guides us through the construction of a complete fuzzy inference system from start to finish.

3.3. Software Using Matlab

MATLAB® is a high-level language and interactive environment that enables to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and FORTRAN.

It supports the entire data analysis process, from acquiring data from external devices and databases, through preprocessing, visualization, and numerical analysis, to producing presentation-quality output.

To effectively design an embedded control system and accurately predict its performance, we must understand the behavior of the entire system in which the control system will reside. MATLAB and Simulink form the core environment for Model-Based Design for creating accurate, mathematical models of physical system behavior. The graphical, block-diagram paradigm of the Math Works environment lets us drag-and-drop predefined modeling elements, connect them together, and create models of dynamic systems.

3.4. Build system using fuzzy logic toolbox & Simulink

In built this system, we can use any software which has fuzzy logic toolboxes in that software. For this, I use MATHLAB 7.1 and below are the step in build this system.

- 1) From MATHLAB software, fuzzy logic toolboxes and choose the FIS editor viewer.

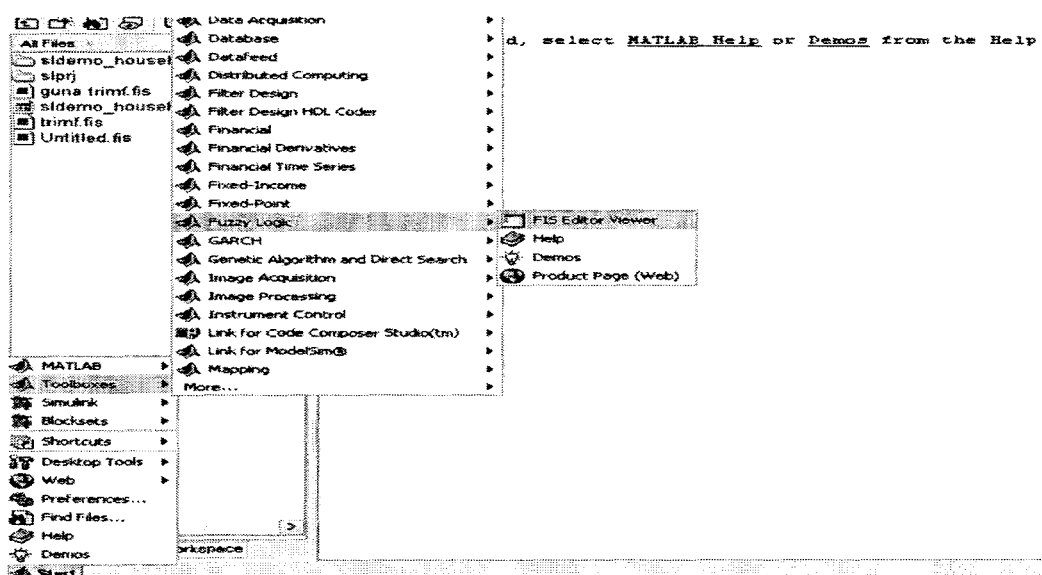


Figure 3.4(a): FIS editor Viewer in the fuzzy logic toolboxes

2) In the FIS editor viewer, the input and output must be decide first, the setting for method for each step. This project use centroid method in defuzzufication.

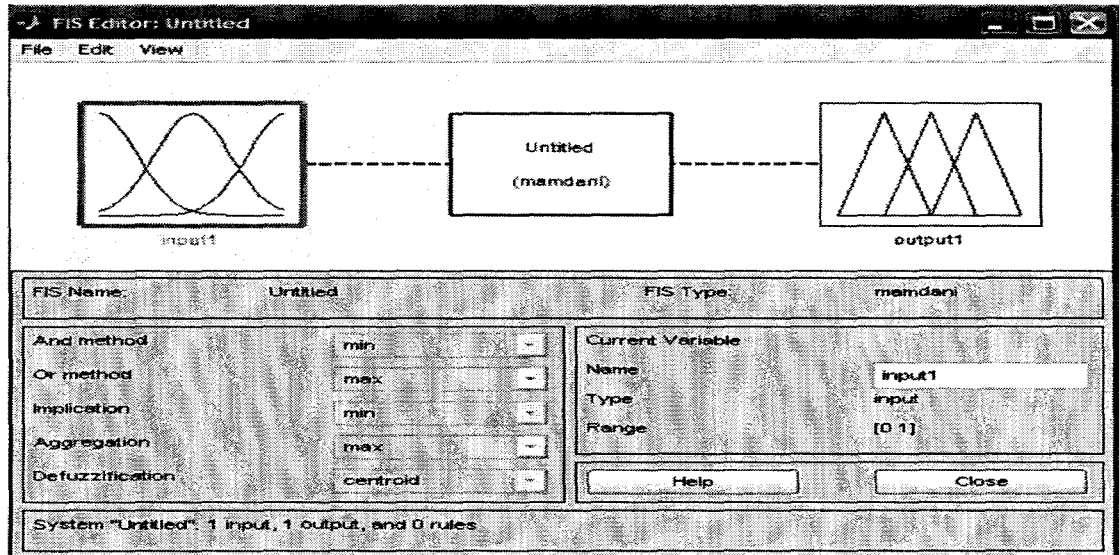


Figure 3.4(b): FIS Editor

3) Mamdani types for this fuzzy logic system have been choosing. Mamdani is the familiar type apply and I choose this types based on the output to display that is in fuzzy, and not specific like on, off or open and close.

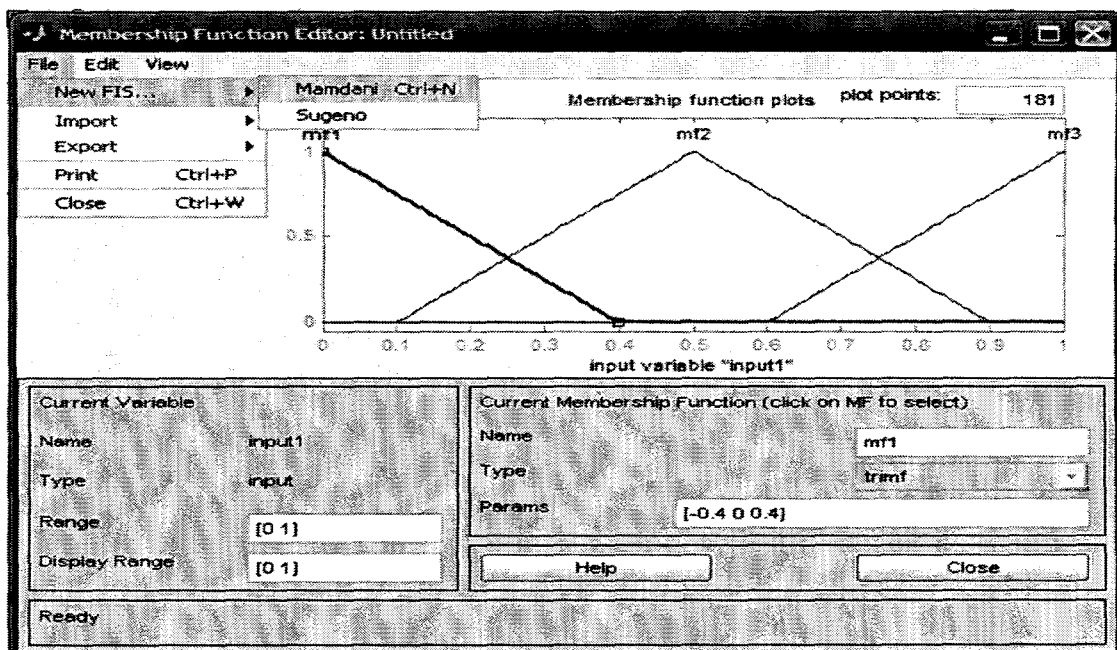


Figure 3.4(c):Mamdani Types

- 4) The input and output must be added if we use more than 1 input/output variable and save the name of the system

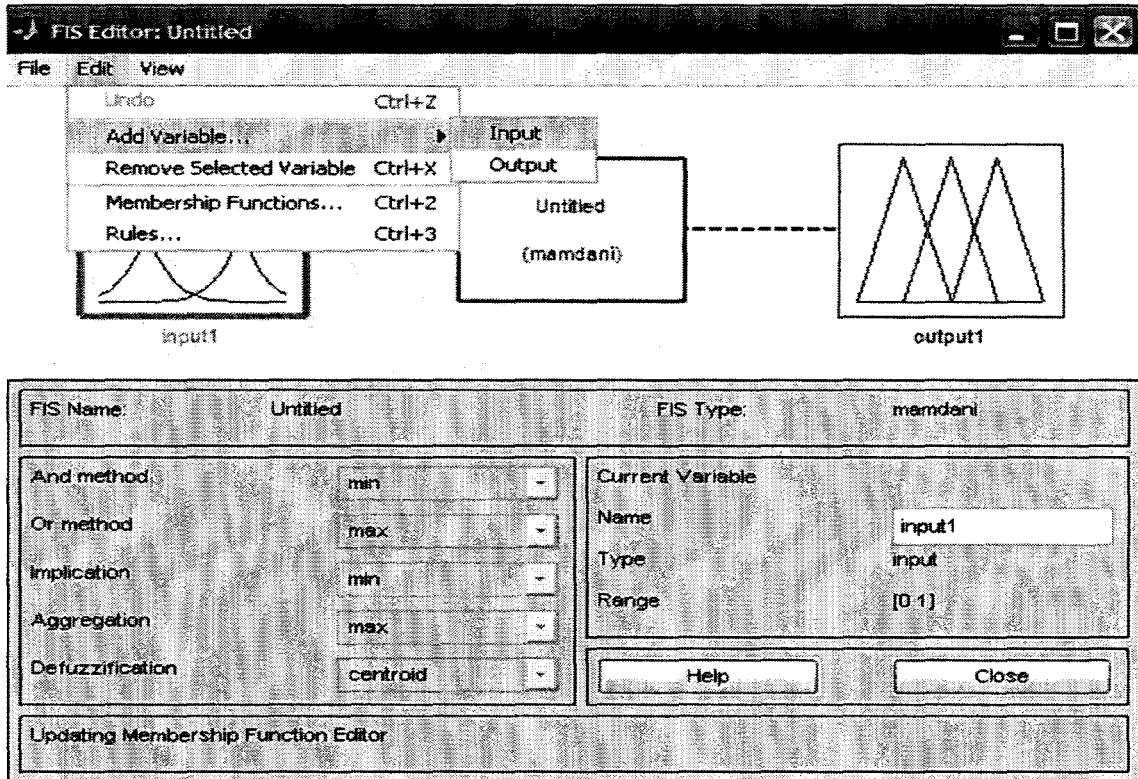


Figure 3.4(d): FIS Editor

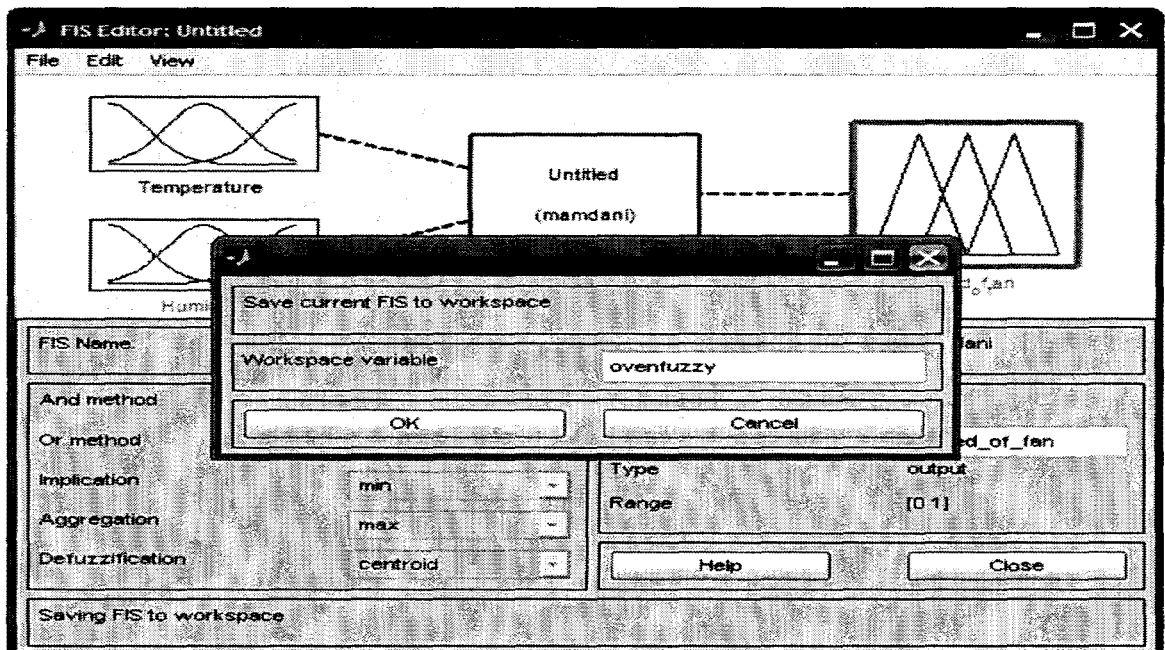


Figure 3.4(e): FIS Editor(name for the project)

5) After all the membership function for each variable are set, the tuning process have been done by adjusting their membership in input or output to produce the actual or near the desired output.

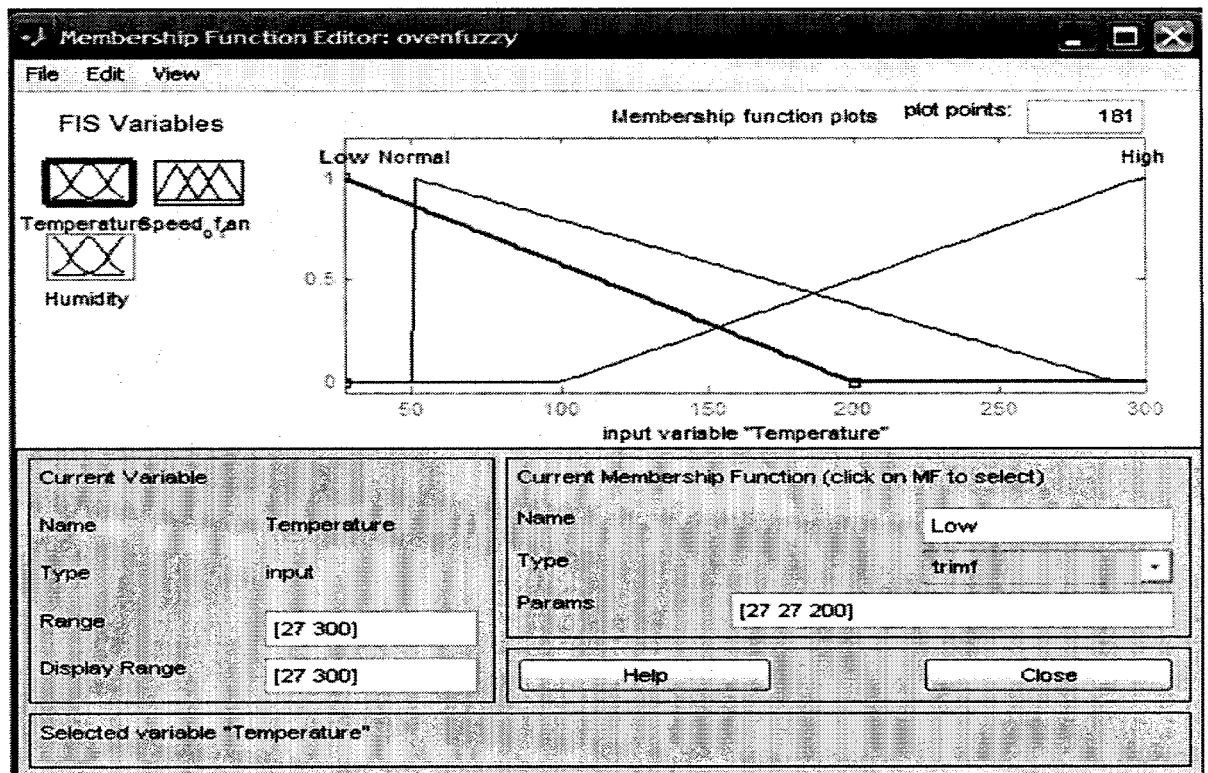


Figure 3.4(f): Membership Function Editor

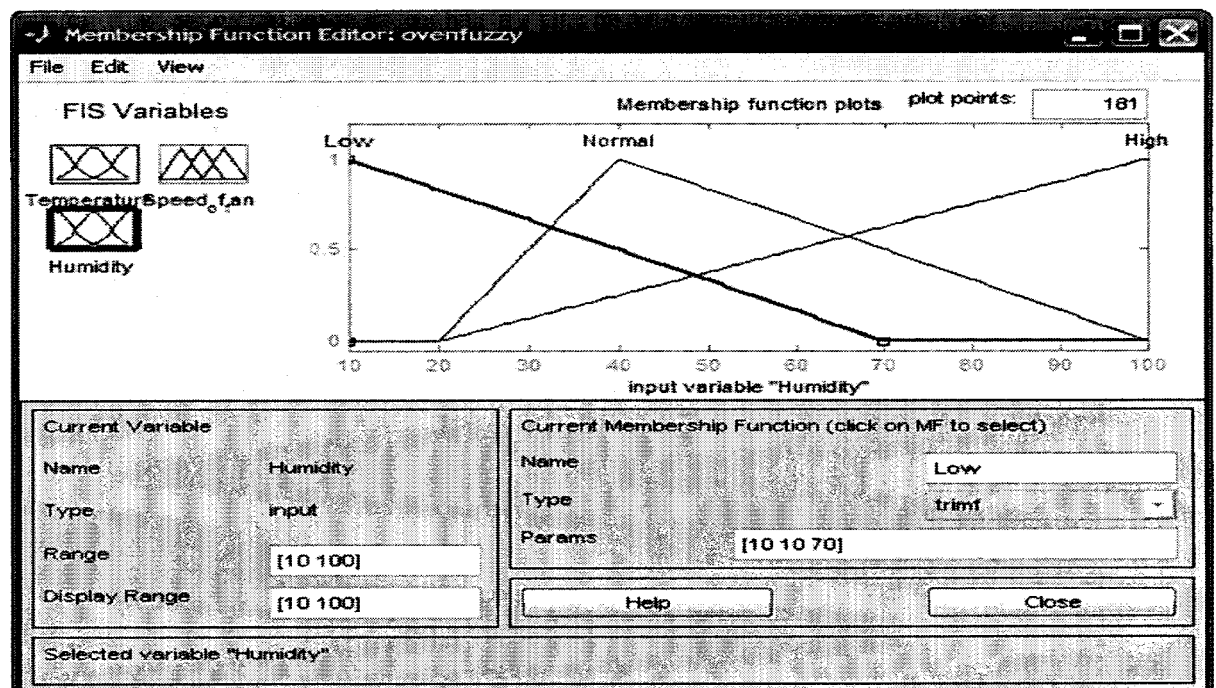
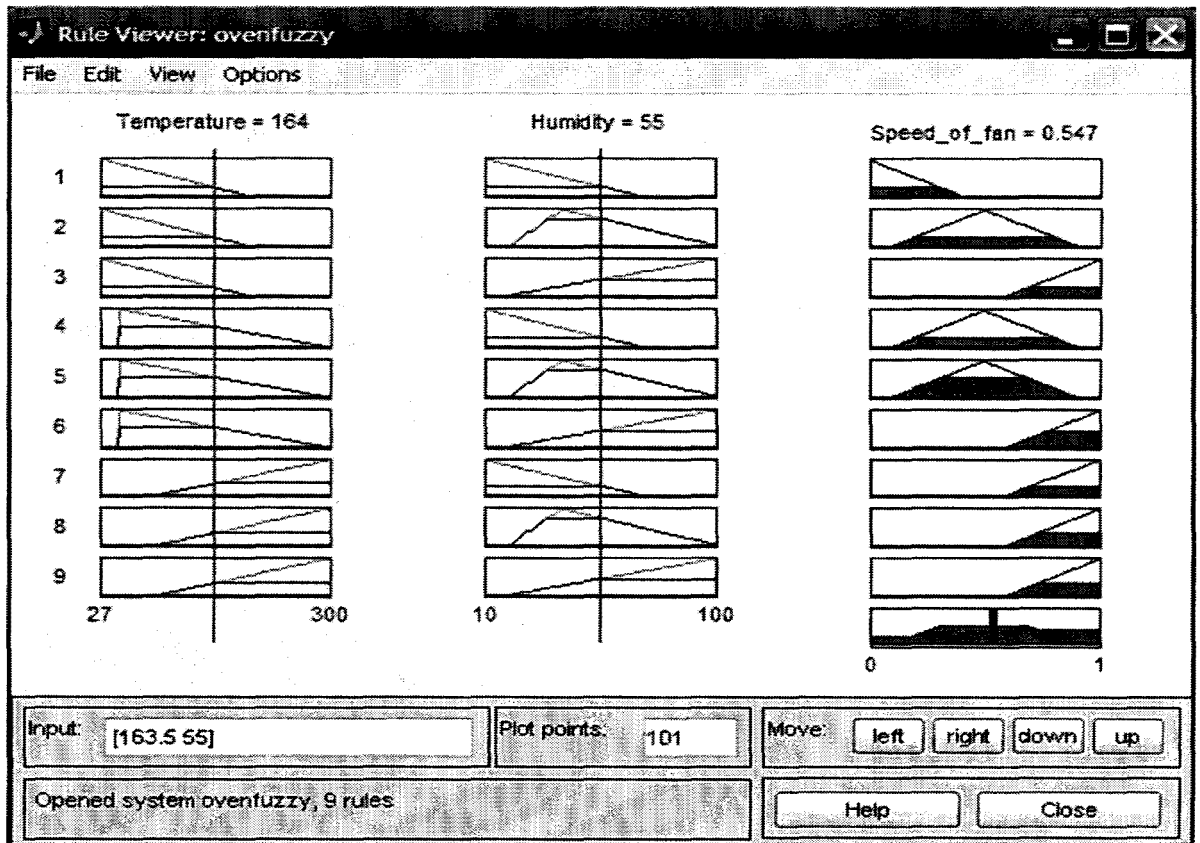


Figure 3.4(g): Setting for the humidity ranges

6) The last process to get output is defuzzification. Defuzzification is a mapping from a space of fuzzy control actions defined over an output universe of discourse into a space of nonfuzzy (crisp) control action. There are 4 method in this process, that are Max membership method, Center of gravity method, Weight average method and Mean-max membership method. This process, I used center of gravity method. Below is process in



defuzzification from combine the input to produce output.

Figure 3.4(h): Rule Viewer

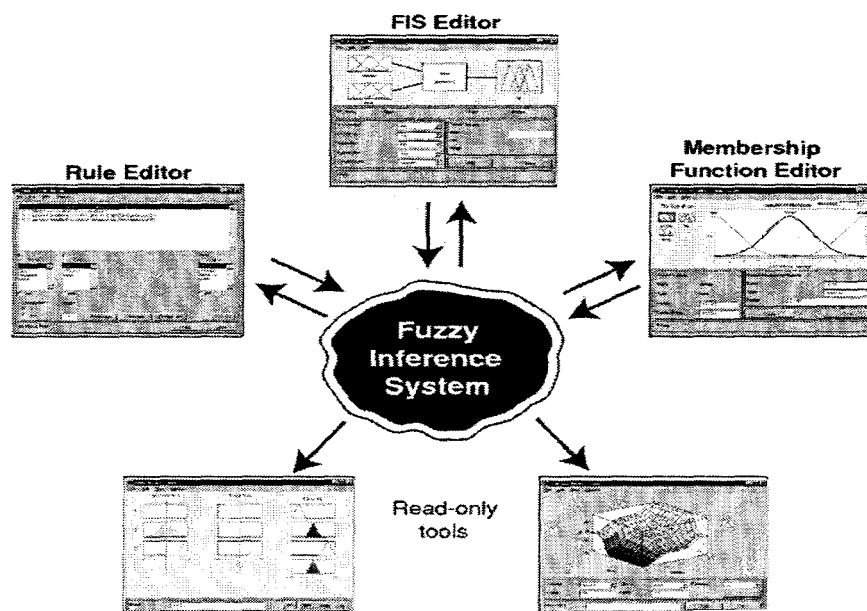
Interpreting if-then rules is a three-part process.

1. Fuzzify inputs: Resolve all fuzzy statements in the antecedent to a degree of membership between 0 and 1. If there is only one part to the antecedent, then this is the degree of support for the rule.
2. Apply fuzzy operator to multiple part antecedents: If there are multiple parts to the antecedent, apply fuzzy logic operators and resolve the antecedent to a single number between 0 and 1. This is the degree of support for the rule.
3. Apply implication method: Use the degree of support for the entire rule to shape the output fuzzy set. The consequent of a fuzzy rule assigns an entire fuzzy set to the output. This fuzzy set is represented by a membership function that is chosen to indicate the qualities of the consequent. If the antecedent is only partially true, (i.e., is assigned a value less than 1), then the output fuzzy set is truncated according to the implication method.

In general, one rule alone is not effective. Two or more rules that can play off one another are needed. The output of each rule is a fuzzy set. The output fuzzy sets for each rule are then aggregated into a single output fuzzy set. Finally the resulting set is defuzzified, or resolved to a single number.

3.5 Fuzzy Interferences

Fuzzy Inference Systems shows how the whole process works from



beginning to end for a particular type of fuzzy inference system called a *Mamdani type*.

1. The FIS Editor handles the high-level issues for the system: How many inputs and output variables and their names. Fuzzy Logic Toolbox software does not limit the number of inputs. However, the number of inputs may be limited by the available memory of the machine. If the number of inputs is too large, or the number of membership functions is too big, then it may also be difficult to analyze the FIS using the other GUI tools.
2. The Membership Function Editor is used to define the shapes of all the membership functions associated with each variable.
3. The Rule Editor is for editing the list of rules that defines the behavior of the system. The Rule Viewer and the Surface Viewer are used for looking at, as opposed to editing, the FIS. They are strictly read-only tools.

The Rule Viewer is a MATLAB technical computing environment based display of the fuzzy inference diagram shown at the end of the last section. Used as a diagnostic, it can show (for example) which rules are active, or how individual membership function shapes are influencing the results.

- The Surface Viewer is used to display the dependency of one of the outputs on any one or two of the inputs. That is, it generates and plots an output surface map for the system.

Mamdani-style inference

Mamdani method is the most commonly used in fuzzy inference technique. The first fuzzy system built by professor Ebrahim Mamdani of London University in 1975 is to control a steam engine and boiler combination. A set of fuzzy rules that has been apply supplied by experienced human operators.

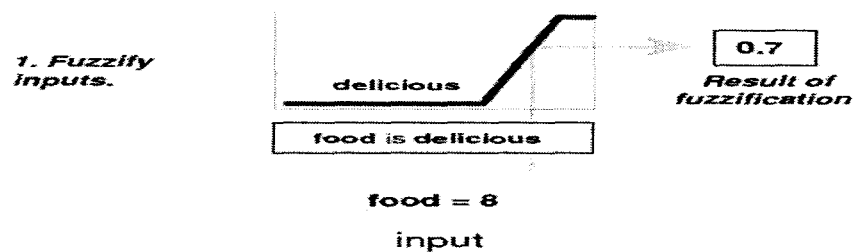
In Mamdani–style fuzzy inference process, it performed in four step as below:

- 1) Fuzzification of the input variables.
- 2) Rule evaluation
- 3) Aggregation of the rule outputs
- 4) Defuzzification

Step 1. Fuzzification of the input variables

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. In Fuzzy Logic Toolbox software, the input is always a crisp numerical value limited to the universe of discourse of the input variable (in this case the interval between 0 and 10) and the output is a fuzzy degree of membership in the qualifying linguistic set (always the interval between 0 and 1). Fuzzification of the input amounts to either a table lookup or a function evaluation.

This project is built on nine rules, and each of the rules depends on resolving the inputs into a number of different fuzzy linguistic sets: temperature is low, temperature is medium, temperature is high, and cooking is beginner and so on. Before the rules can be evaluated, the inputs must be fuzzified according to each of these linguistic sets. Various fuzzy systems use a variety of different crisp inputs. While some of the inputs can be measured directly as example height, weight, speed distance, temperature pressure and others. And some of them can be based only on expert estimate. As example the food delicious as an 8, which, given your graphical definition of delicious, corresponds to $\mu = 0.7$ for the delicious membership function.



In this manner, each input is fuzzified over all the qualifying membership functions required by the rules.

Step 2. Rule Evaluation

a) Apply Fuzzy Operator

After the inputs are fuzzified, you know the degree to which each part of the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number is then

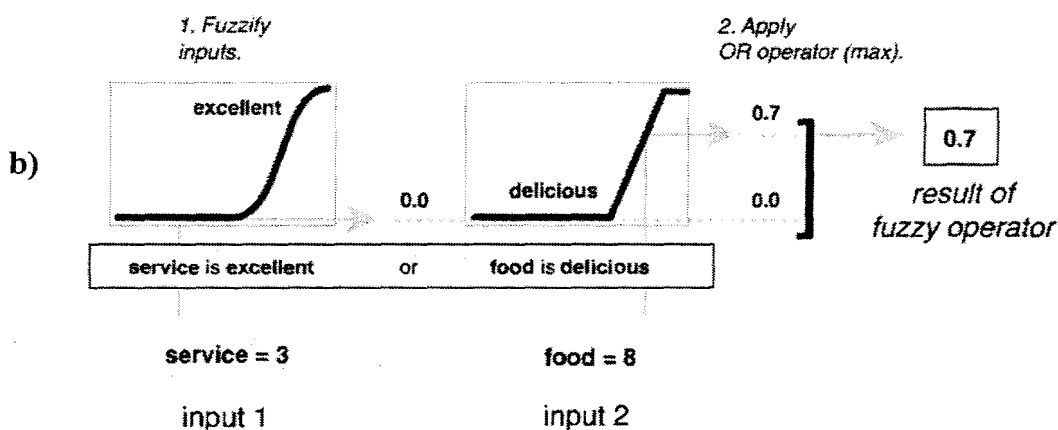
applied to the output function. The input to the fuzzy operator is two or more membership values from fuzzified input variables. The output is a single truth value.

As is described in Logical Operations section, any number of well-defined methods can fill in for the AND operation or the OR operation. In the toolbox, two built-in AND methods are supported: *min* (minimum) and *prod* (product). Two built-in OR methods are also supported: *max* (maximum), and the probabilistic OR method *probor*. The probabilistic OR method (also known as the algebraic sum) is calculated according to the equation

$$\text{probor}(a,b) = a + b - ab$$

In addition to these built-in methods, you can create your own methods for 'AND' and 'OR' by writing any function and setting that to be your method of choice.

The following figure shows the OR operator *max* at work, evaluating the antecedent of the rule 3 for the tipping calculation. The two different pieces of the antecedent (service is excellent and food is delicious) yielded the fuzzy membership values 0.0 and 0.7 respectively. The fuzzy OR operator simply selects the maximum of the two values, 0.7, and the fuzzy operation for rule 3 is complete. The probabilistic OR method would still result in 0.7.



Apply Implication Method

Before applying the implication method, you must determine the rule's weight. Every rule has a *weight* (a number between 0 and 1), which is

applied to the number given by the antecedent. Generally, this weight is 1 (as it is for this example) and thus has no effect at all on the implication process. From time to time you may want to weight one rule relative to the others by changing its weight value to something other than 1.

After proper weighting has been assigned to each rule, the implication method is implemented. A consequent is a fuzzy set represented by a membership function, which weights appropriately the linguistic characteristics that are attributed to it. The consequent is reshaped using a function associated with the antecedent (a single number). The input for the implication process is a single number given by the antecedent, and the output is a fuzzy set. Implication is implemented for each rule. Two built-in methods are supported, and they are the same functions that are used by the AND method: *min* (minimum), which truncates the output fuzzy set, and *prod* (product), which scales the output fuzzy set.

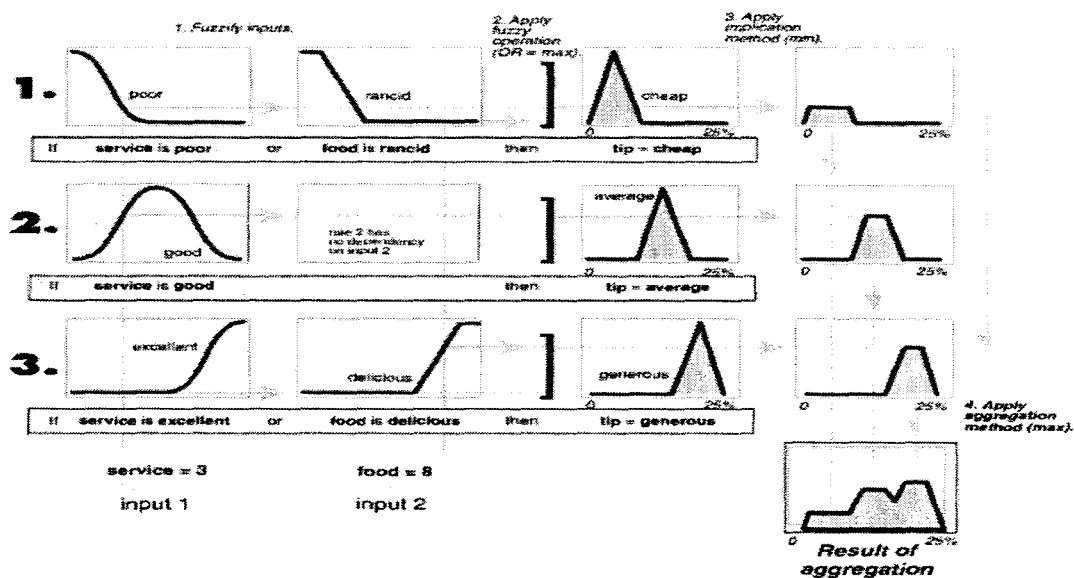
Step 3: Aggregate All Outputs

Because decisions are based on the testing of all of the rules in a FIS, the rules must be combined in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. Aggregation only occurs once for each output variable, just prior to the fifth and final step, defuzzification. The input of the aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable.

As long as the aggregation method is commutative (which it always should be), then the order in which the rules are executed is unimportant. Three built-in methods are supported:

- max (maximum)
- probor (probabilistic OR)
- sum (simply the sum of each rule's output set)

In the following diagram, all three rules have been placed together to show how the output of each rule is combined, or aggregated, into a



single fuzzy set whose membership function assigns a weighting for every output (tip) value.

Step 4: Defuzzify

The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. As much as fuzziness helps the rule evaluation during the intermediate steps, the final desired output for each variable is generally a single number. However, the aggregate of a

fuzzy set encompasses a range of output values, and so must be defuzzified in order to resolve a single output value from the set.

The most popular defuzzification method is the centroid calculation, which returns the center of area under the curve. There are five built-in methods supported: centroid, bisector, middle of maximum (the average of the maximum value of the output set), largest of maximum, and smallest of maximum.

CHAPTER 4

RESULT AND ANALYSIS

This chapter discusses on the result, findings and the assessment from the analysis conducted in this project. After the development of the “Oven Fuzzy”, this oven will be analyzed to measure the effectiveness and to ensure the objectives successfully achieved. Throughout the analysis stage, strengths and weaknesses of the oven were identified. Generally, below are the aspects stressed in the analysis, which are Simulation from fuzzy toolboxes, analysis of graph, and GUI design with the coding.

Fuzzy Logic Toolboxes Simulation Results

This section will discuss on the results of simulation oven using fuzzy logic toolboxes. It involved FIS editor viewer, and also rule viewer.

4.1.1 Surface Viewer

The result of using fuzzy logic toolboxes has been discussed in term of membership function editor, rules, and types have been used. The simulation results of the membership function editor are shown in figure 4.1. The range of each input that is temperature and humidity has been setting and can be seen by observing the input in the membership functions.

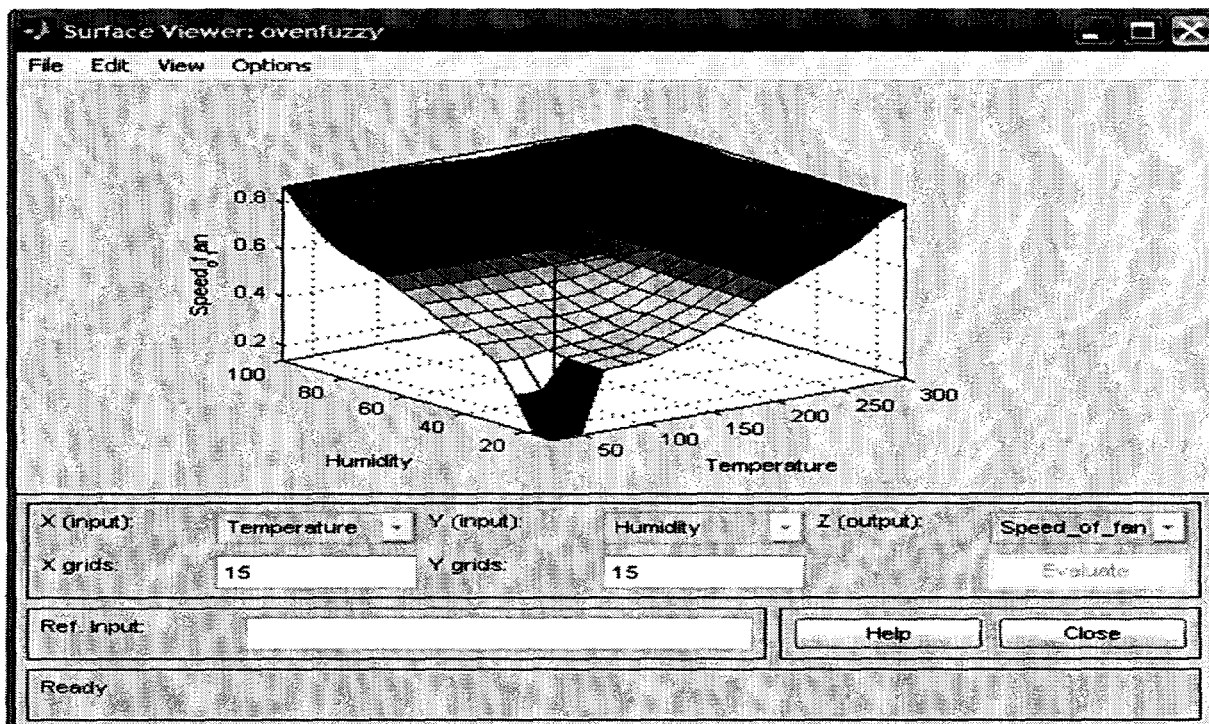


Figure 4.1(a): Surface Viewer

Figure 4.1(a) above is the surface for my system. It has 2 inputs and 1 output. All the process for fuzzy logic has been done and inserts to produce this. As example, the type of fuzzy must be choose, range of input and output, and also the other specifications.

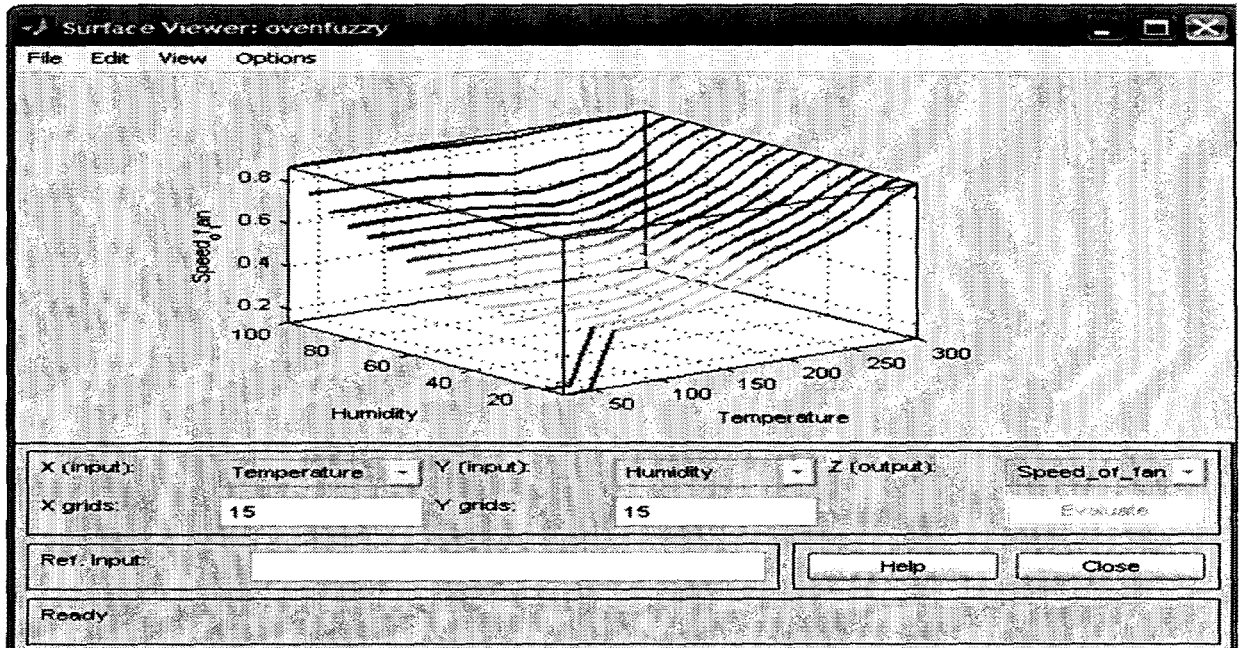


Figure 4.1 (b): X mesh Surface viewer (Temperature)

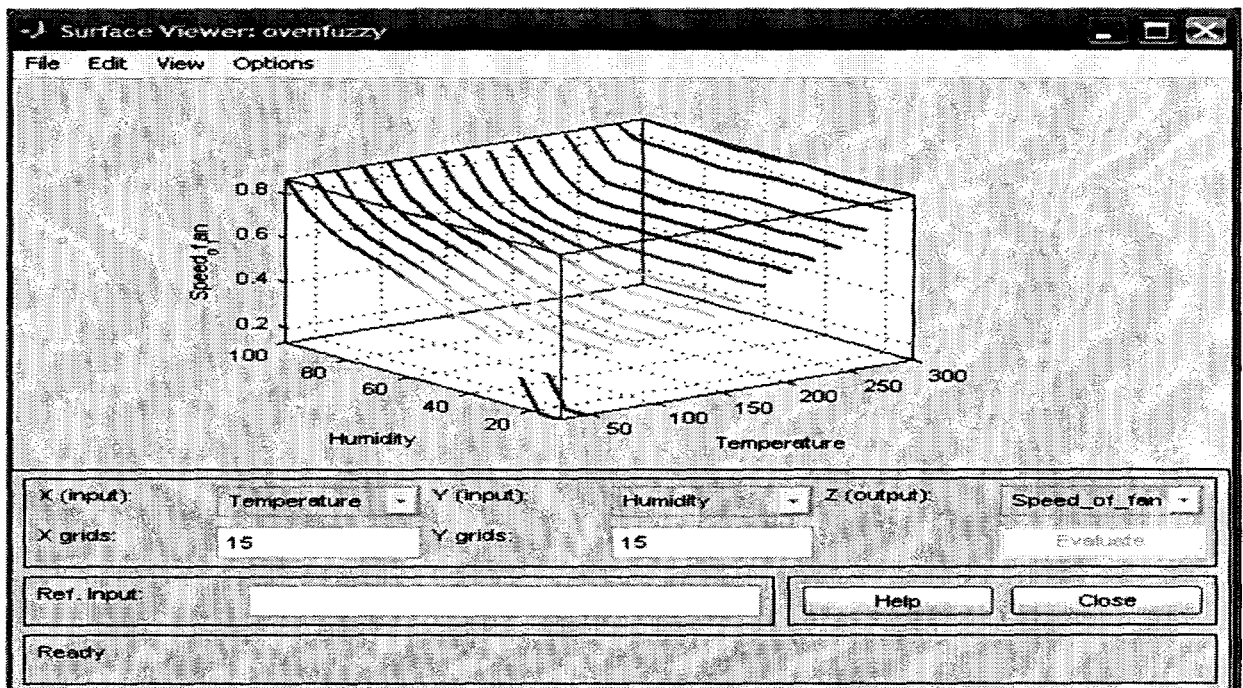


Figure 4.1(c): Y mesh Surface viewer (Humidity)

Figure 4.1(a) and 4.1(b) shown the output for temperature and relative humidity. Both of them prove the theory that the speed will increase with increasing both of that inputs.

Graph above come out from the membership for each input and output in the system. Membership rule was able to change based on the system that how we want it function. However, difficulties occurred when the system is not as we design. For this, we must try and error in change the range in membership editor. The graph of oven was still able to produce, but the condition will be different and the speed is not as desire. Figure 4.1 (d) and figure 4.1 (e) shows the xy graph for temperature and humidity versus speed of fan to make we more clear the changes of this variable

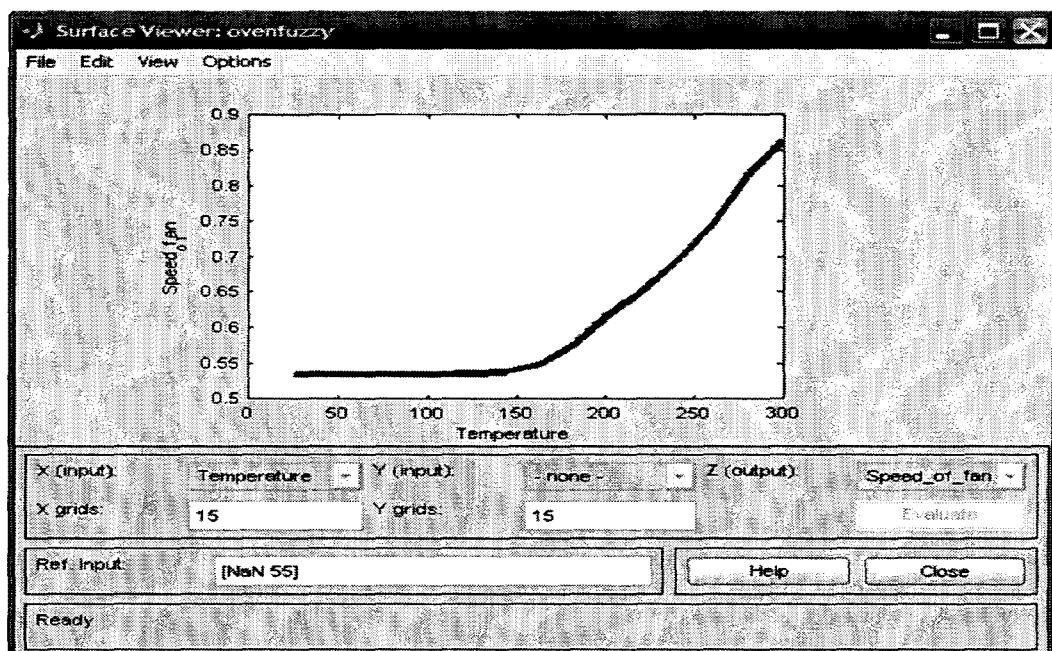


Figure 4.1(d): Graph speed of fan versus temperature

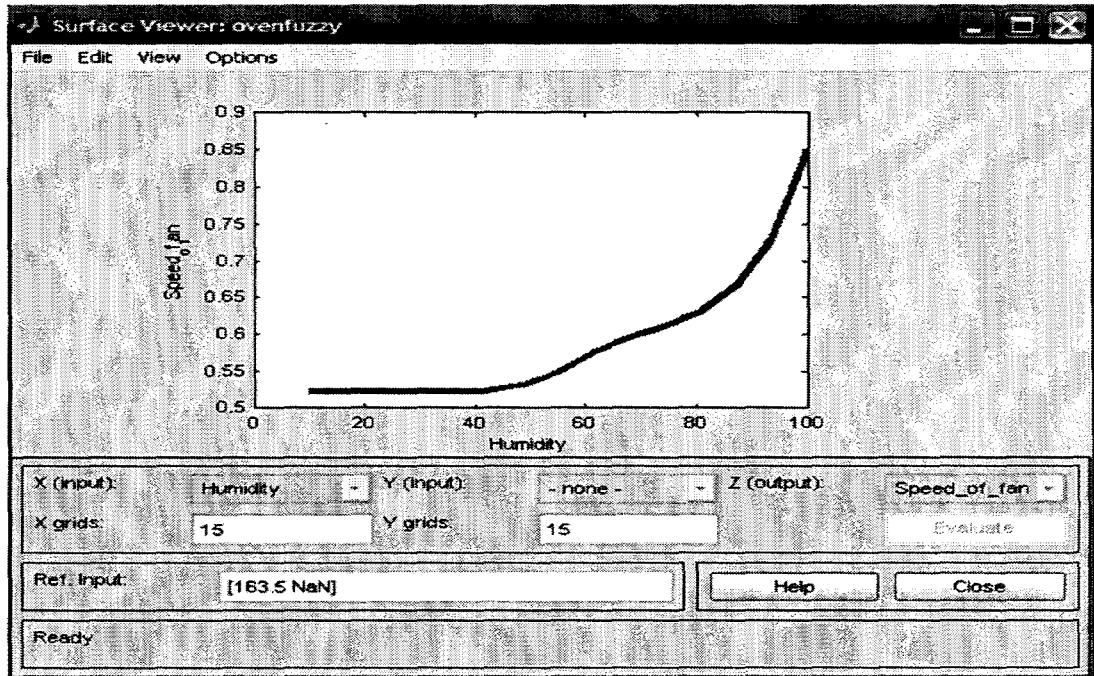


Figure 4.1(e): Graph speed of fan versus humidity

Graph speed of fan versus temperature and humidity as in figure above shown that it is start with the initial value that we have set and the change is constant at first and then increase with increasing the relative humidity until it reached at the specified value and begin to constant the value again.

A set of algorithm for every types of food actually need to be set first. The subroutine for the program is wrote base on the algorithm. In appendix, there are various subroutines in the program and each of it is labeled with its specific function.

When the programming is finished, it is found that the changes of temperature and humidity can be control at the value that has been setting. The movement of two graphs for temperature and humidity in the same direction moved the speed of fan's oven function slow, normal or fast

depends on the changes of temperature and humidity which changes in increasing of time.

The initial value for temperature is 27⁰ C and humidity is 10% .The 27⁰ C is the oven temperature when empty and I assume it from the room temperature meanwhile for relative humidity actually we assume 10% at the normal atmosphere. The researches have been made to know the temperatures which need to cook all types of the food. Then, I can get the ranges to give for this oven.

4.2 Rule Viewer.

In this section the rules of the system has been create from the membership above. From 2 inputs which each has 3 memberships and the output with 3 memberships too, I get 9 rules my system as in figure 4.2 (a) and 4.2(b) below.

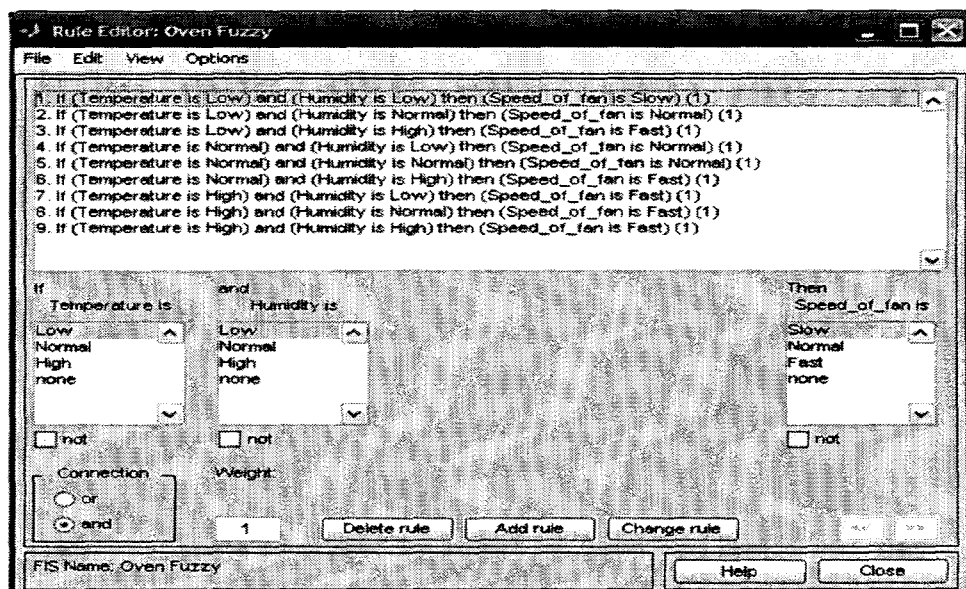


Figure 4.2(a): Rule Editor of Oven Fuzzy

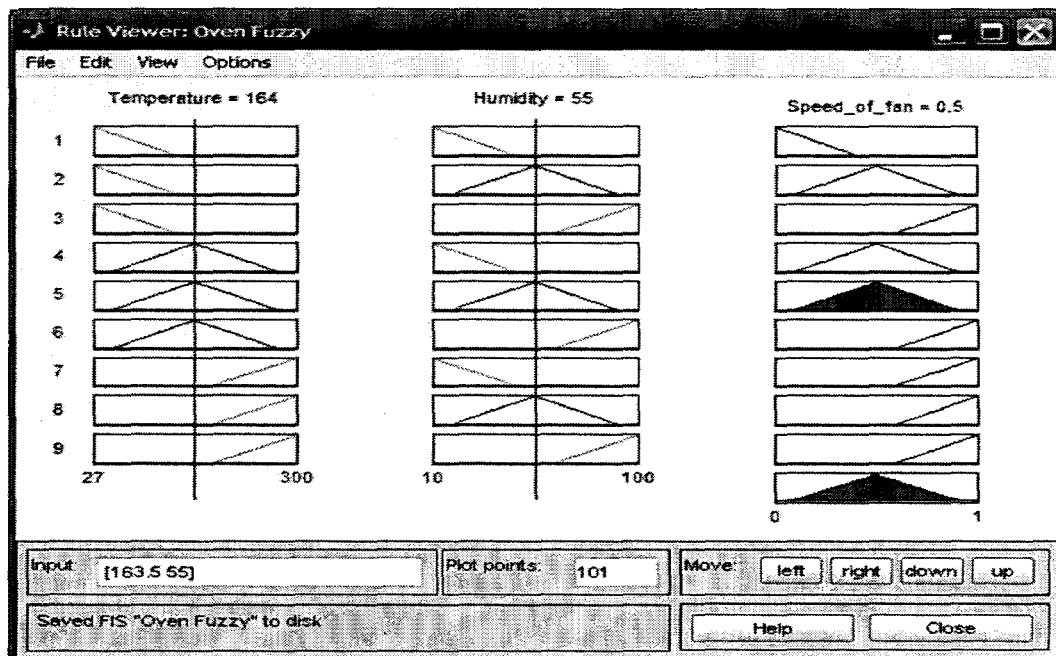


Figure 4.2 (b): Rule viewer for the oven function

The rules above are the most important because it is the result for my system. When temperature is about normal, and humidity also normal, then the speed of fan we can see function normal too. From this, the graph is produced in figure 4.2(b)

4.3 Project's Evaluation in GUI design

Based on the programming and system fuzzy that have been created, the result shows through the GUI's design. The important parameter insert to this GUI like the value of initial and final temperature and humidity, and also the plot of graph produced.

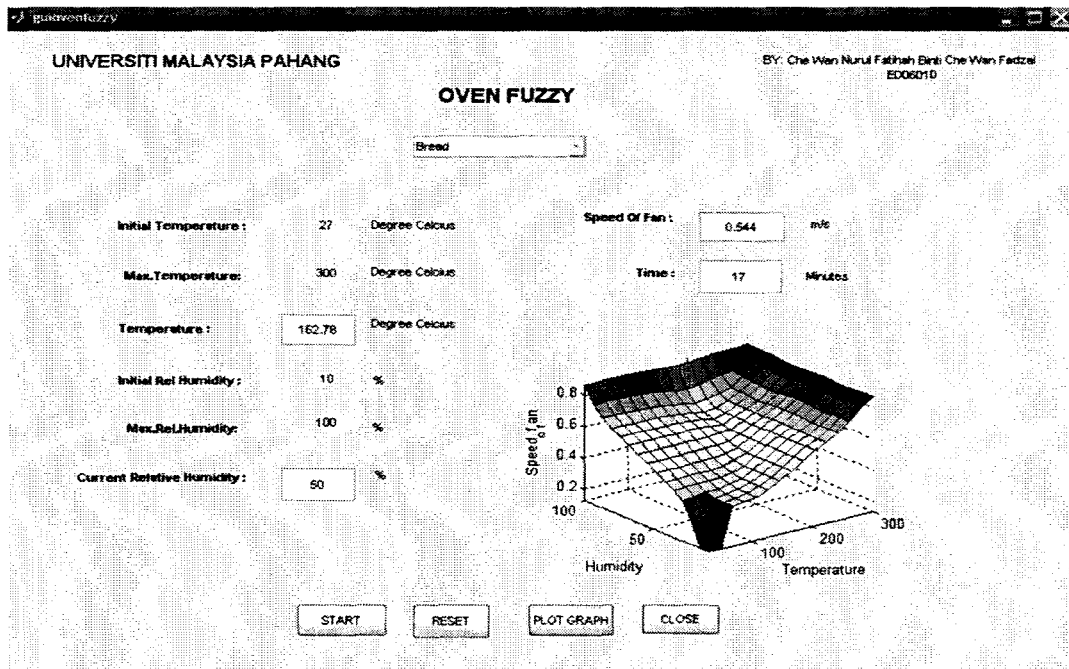


Figure 4.4: GUI design for 'Oven Fuzzy'

The parameter for types of food I have chose based on the common food that always cook in an oven. Six types of food with their own temperature, and times are list below:

Types of food	Temperature (oC)	Time(minutes)
Bread	162.78	17
Cookies	148.89	12
Cakes	125.00	30
Chicken	176.76	30
Fish	176.67	15
Beef	148.89	90

Table 4.3 : Temperature and time for each types of food.

Through out the development of this 'Oven Fuzzy', some problems and obstacles are encountered involving software, input and output, and functional of the system. The problems are:

1. Determine the input and output

The problem here is when the function of fuzzy logic did not understand clearly. For the first, I put the temperature and humidity as input and heater as output which then will determined the time of cooking based on the changes of humidity in the food. Unfortunately, the information or the real changes of the humidity in the food cannot get clearly. From my research, I need another value for temperature called dew point to continue the system and I have try to find it but did not know how get that ,I suggest to changes the input and output after discuss with my SV. The humidity in the food for input became the relative humidity in the oven and then the output is the speed of fan.

2. Functional of the system

It is difficult due to short time to implement the high function of this oven.. Although those speed of fan applied were the basic function which control the temperature and humidity but the understanding about the function or how the oven working is very important. So, I need to make research and understand it before I can implement system fuzzy logic for this oven. Beside that the relative humidity and temperature changes also have their own formula to calculate the value based on time.

2. Programming Language

It took a long time to choose the suitable programming language and make the coding in the Matlab because I'm not very expert with the programming. It actually takes long time too to edit and run the system. Luckily, I found one lecturer who expert with the matlab, Dr. Arun Gupta. I got some information how to run my system from him and finally the coding produced insert into GUI design .

4.4 Summary

In this chapter, it is obvious that the ability of the 'Oven Fuzzy' can be added by do some modifications. Even the project was completed successfully and the objective achieved, there are several problems which should be improved in the future. The improvement needed to make sure the weaknesses can be overcome.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This chapter discusses the conclusion of this project and the findings of 'Oven Fuzzy'. This chapter also discusses modifications that can be made for future research.

5.1 Conclusion

The purpose of this project is to develop simulation computer controlled oven by using fuzzy logic. IN this system, the focus is to control the oven with specified temperature accuracy, and also to analyze and display a real time output graphically for temperature and relative humidity.

The operation begins with determines the input and output for the system and put it into MATLAB by complete its membership function in the fuzzy logic toolboxes. The point of fuzzy logic is to map an input space to an output space, and the primary mechanism for doing this is a list of if-then statements called rules. The rules themselves are useful because they refer to variables and the adjectives that describe those variables. All the terms that have been plan on using and the adjectives that describe them must be defined before can build the system that interprets rules. The ranges of input also have been defined to vary as well as what is mean by each input.

Finally, before building the software about of MATLAB, a study on fuzzy logic system has to be done. Fuzzy logic includes type of fuzzy, how to make the rules, and so on .So that it could be used to explain the outcomes of the programming.

Finally, the expected results are achieved successfully using Fuzzy Logic Toolboxes. Fuzzy Logic is the best way to control the good performance of any application of system.

5.2 Recommendation

Although an oven called 'Oven Fuzzy' was successfully developed and met the objectives, however it is found that this oven is still can be improved by implementing some modifications.

Actually, this oven can be made more interesting but I don't have enough time to produce it. In this oven, the time for cooking is automatically set after we choose types of food to be cook. Actually, the time finished cooking based on the changed of humidity inside the food. When there are insert more quantity of food, the time finished will increased [3]. More research can be done on how to determine the changes on humidity in the food based on changing time. There are a lot of calculation can be done like calculate the absolute humidity, relative humidity and dew temperature.

The other aspect that can be taken into consideration is using weight sensor as a sensor for the oven changes with the humidity sensor. That's because humidity sensor is more sensitive and can react if any disturbance occur. The weight for each food will decrease with increasing time because the process of cooking that produce heat to the food always happened [12]. From the weight, formula to calculate the humidity inside each food can be inserting in the system.

Thermal food also can be applied to calculated time. Actually, the process in the oven has two stages [6]. The first stage is the sensing stage of the food's thermal load. In this first stage, the oven program calculates the total time it takes to reach a threshold temperature determined by the program. This threshold temperature is determined by experimentation in the research and

development (R&D) program. This threshold point changes from one food group to another food group. Once this time to threshold is known, we can calculate the total cooking time and temperature using the following formula:

Total time = Time to Threshold Factor

Currently, the controller use human eyes as the feedback to the system, to determines whether the colors of the food reach what we want. So, to give more advantages, camera on the position of the oven can be use. This system actually involved image processing which can detect whether the food really cooks or not. Thus, the efficiently of the system can be enhanced.

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APPENDIX A

SOURCE CODE

```

=====
;
=====
; PROGRAMMING FOR OVEN APPLY FUZZY LOGIC SYSTEM
;
=====

clc
clear all
aa=10
for loop1=90:100 % temperatureinitial:temperatureconstant
    tic
    for loop2=5:10 % humidity:humidityconstant
        tic
        for loop3=12:20 % timestartconstant:timefinish

aa=aa+1;

p=loop1;
%q=loop2;
x(aa)=loop1;
y(aa)=loop2;
t(aa)=loop3;
% p = get(handles.boxtem,'Value');
% q = get(handles.boxlight,'Value');
q=50;

a=newfis('ovenfuzzy');
a = addvar(a,'input','x',[27 300]);
a = addmf(a,'input',1,'Low','trimf',[27 27 200]);
a = addmf(a,'input',1,'Normal','trimf',[50 50 290]);
a = addmf(a,'input',1,'High','trimf',[100 300 350]);

a = addvar(a,'input','y',[10 100]);
a = addmf(a,'input',2,'Low','trimf',[10 10 70]);
a = addmf(a,'input',2,'Normal','trimf',[20 40 100]);

```

```
a = addmf(a,'input',2,'High','trimf',[20 100 150]);

a = addvar(a,'output','z',[0 1]);
a = addmf(a,'output',1,'Slow','trimf],[-0.4 0 0.4]);
a = addmf(a,'output',1,'Normal','trimf',[0.1 0.5 0.9]);
a = addmf(a,'output',1,'Fast','trimf',[0.6 1 1.4]);

rulelist =[ ...
1 1 1 1 1
1 2 2 1 1
1 3 3 1 1
2 1 2 1 1
2 2 2 1 1
2 3 3 1 1
3 1 3 1 1
3 2 3 1 1
3 3 3 1 1];

a=addrule(a,rulelist);

z(aa) = evalfis([p q], a);

% pause(0.5)
end
end
toc
end
%plot(y,z)
%plot(x,z)
%plot(x,y)
plot(t,y)
```

PROGRAMMING FOR OVEN CONVENTIONAL SYSTEM

%% information for the oven

% Initialisation of coding

clc

Cookies=100

Bread=200

Cakes=300

Beef=400

Chicken=500

Fish=600

Typesoffood=100

Temperature=100 % temperture that have been setting

Relativehumidity=10 %

%finalrelativehumidity=50 %

%RelativeHumidity = 50

LowSpeedoffan=500 % rpm

NormalSpeedOfFan=1000 % rpm

HighSpeedofFan=1500 % rpm

```
%-----  
% control relativehumidity  
%-----  
%if Relativehumidity<=40  
%Speedoffan =LowSpeedoffan  
  
%elseif Relativehumidity >41<=60  
    %Speedoffan = NormalSpeedOfFan  
  
%else  
    %Relativehumidity>61<=100  
    %Speedoffan = HighSpeedofFan  
  
%end %this one for big loop  
  
%-----  
%This is for Cookies  
%-----  
if Typesoffood==100  
    Time=12 % Time=12 min  
    temperature=148.89 %final temperature 148.89  
  
for Time = 1:12 % 12 is the time to bake cookies  
  
if Temperature<148.89  
    Speedoffan =LowSpeedoffan
```

```

elseif Temperature==148.9
    Speedoffan = NormalSpeedOfFan

else
    Temperature>148.9
    Speedoffan = HighSpeedofFan

end %this one for big loop

%-----
% To control temperature
%-----

if Temperature<148.9

    Temperatuer= Temperature+ ((Speedoffan*Time)/1000) %Empirical
    formula for temperature

else

    Temperatuer= Temperature- ((Speedoffan*Time)/1000) %Empirical
    formula for temperature

end

%if Relativehumidity<50

%Finalrelativehumidity = Relativehumidity +((Speedoffan*Time)/1000)

%else

```

```

%Finalrelativehumidity = Relativehumidity -((Speedoffan*Time)/1000)
%end
end
%p(Time)= Time
%q(Time)= Relativehumidity
x(Time)= Time
y(Time)=Temperatuer
%-----
% This is for Bread
%-----

elseif Typesoffood==200
    Time=17 % Time=17 min
    finaltemperature=162.78 %final temperature 148.89

for Time = 1:17 % 12 is the time to bake cookies

if Temperature<162.78
    Speedoffan =LowSpeedoffan

elseif Temperature ==162.78
    Speedoffan = NormalSpeedOfFan

else
    Temperature>162.78
    Speedoffan = HighSpeedofFan

```

```

end %this one for big loop

%-----

% To control temperature

%-----

if Temperature<162.78

Temperatuer= Temperature+ ((Speedoffan*Time)/1000) %Empirical
formula for temperature

else

    Temperatuer= Temperature- ((Speedoffan*Time)/1000) %Empirical
    formula for temperature

end

end

x(Time)= Time

y(Time)= Temperatuer

%-----

% This is for Cakes

%-----

elseif Typesoffood==300

    Time=30 % Time=30 min

    finaltemperature=125 %final temperature 148.89

for Time = 1:30 % 12 is the time to bake cookies

if Temperature<125

    Speedoffan =LowSpeedoffan

elseif Temperature==125

    Speedoffan = NormalSpeedOfFan

```



```

else
    Temperature>125
    Speedoffan = HighSpeedofFan

end %this one for big loop
%-----
% To control temperature
%-----
if Temperature<125
    Temperatuer= Temperature+ ((Speedoffan*Time)/1000) %Empirical
    formula for temperature
else
    Temperatuer= Temperature- ((Speedoffan*Time)/1000) %Empirical
    formula for temperature
end
end

x(Time)= Time
y(Time)= Temperatuer
%-----
% This is for Beef
%-----
elseif Typesoffood==400
    Time=90 % Time=90 min
    finaltemperature=148.89 %final temperature 148.89

for Time = 1:90 % 90 is the time to bake cookies

```

```

if Temperature<148.89
Speedoffan =LowSpeedoffan

elseif Temperature==148.9
    Speedoffan = NormalSpeedOfFan

else
    Temperature>148.89
    Speedoffan = HighSpeedoffan

end %this one for big loop
%-----
% To control temperature
%-----
if Temperature<148.89
Temperatuer= Temperature+ ((Speedoffan*Time)/1000) %Empirical
formula for temperature
else
    Temperatuer= Temperature- ((Speedoffan*Time)/1000) %Empirical
formula for temperature
end
end
x(Time)= Time
y(Time)= Temperatuer
%-----
% This is for Chicken
%-----

```

```

elseif Typesoffood==500
    Time=30 % Time=30 min
    finaltemperature=176.67 %final temperature 148.89

for Time = 1:30 % 30 is the time to bake cookies

if Temperature<176.67
    Speedoffan =LowSpeedoffan

elseif Temperature==176.67
    Speedoffan = NormalSpeedOfFan

else
    Temperature>176.67
    Speedoffan = HighSpeedofFan

end %this one for big loop
%-----
% To control temperature
%-----
if Temperature<176.67

Temperatuer== Temperature+ ((Speedoffan*Time)/1000) %Empirical
formula for temperature

else
    Temperatuer== Temperature- ((Speedoffan*Time)/1000) %Empirical
formula for temperature

```

```

end

end

x(Time)= Time
y(Time)= Temperatuer

%-----
% This is for Fish
%-----

else Typesoffood==600
    Time=15 % Time=12 min
    finaltemperature=176.67 %final temperature 148.89

for Time = 1:15 % 12 is the time to bake cookies
if Temperature<176.67
Speedoffan =LowSpeedoffan

elseif Temperature==176.67
    Speedoffan = NormalSpeedOfFan

else
    Temperature>176.67
    Speedoffan = HighSpeedofFan

end %this one for big loop

%-----
% To control temperature
%-----

```

```
if Temperature<176.67

    Temperatuer= Temperature+ ((Speedoffan*Time)/1000) %Empirical
    formula for temperature

else

    Temperatuer= Temperature- ((Speedoffan*Time)/1000) %Empirical
    formula for temperature

end

end

%-----

x(Time)= Time

y(Time)= Temperatuer
end

plot(x,y)
%plot(p,q)
```