Design of Fuzzy Logic Control for Automatic Switching OFF Electric Iron

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***Abstract*— Auto off switch iron is a product that acts like a circuit breaker to interrupt the flow of the electricity from the socket to the iron. Mostly the iron system in the current market still uses the classic switching system which means the output is just produced on and off to control the temperature of iron without permanently cut the current through to iron. Besides, decision making from the latest project only cuts the current if there is no motion and current in low without setting any range to switch the timer to off the iron system. The goal of this product is to develop the fuzzy logic controller (FLC) in the auto off switching iron. Rules of the fuzzy logic enable to control of the complex system to be more effectively compared classical method which operates on discrete value only. The design of the fuzzy logic controller (FLC) will implement in Arduino Nano to control the auto off switch iron. This study uses the current sensor and ultrasonic sensor as the input that will send the signal to the Arduino nano as the controller to set the output. The process of this entire product is to collect the signal from the input which is the sensor, analyze the input in fuzzy controller and obtain the right time to auto off the switch iron. All the rules of membership function will set in Mamdani Fuzzy Inference System in MATLAB software. This project can avoid human interruption to decide the output and make the controller more intelligent to represent the decision.**

Keywords*— *switch off iron, fuzzy logic controller, Mamdani Fuzzy Inference System, response surface of input and ouput relation, arduino UNO, current sensor, ultrasonic sensor

I. INTRODUCTION

Today, clothes iron is very important in a house. The main function is to remove wrinkles from the garments in order to make the wearing style tidy for the users at their workplace or school. The concept for auto off switch irons currently are constantly on and off without permanently cutting the current through to iron[1]. The condition of the on state and off state iron depends on the temperature of the iron plate[2], which means that it will automatically switch off the iron when iron at a maximum temperature which is 230ºC and when the iron temperature drops below the range, it will automatically switch on the current to iron to maintain the condition of the temperature on the iron plate[3].

The fuzzy logic controller is more convincing compared to the classical method based on the performance and decision making that will generate from this system[4]. In the classical method, the set logic for true is 1 (in general) and false is 0 and it is done with human access according to instant needs. But if so different in fuzzy logic because there is no concept of exactly true or exactly false[5].These rules for fuzzy logic depend on the given membership in the database. The rule in the membership function will be determined by the input range and the output decision will match the input setting[6]. Using the Fuzzy logic, the result for the switch iron to off will be more robust and intelligent[7]. Implementation fuzzy logic controller to replace the classical method iron switch off system is very important to make this electrical appliance more consumer-friendly since an iron use 800 to 2000 watts, with an average iron using 1100 watts when heated on high[3] that can affect the human safety especially for children under 3 years old[8][9]. Most of the contact injuries from hot cloth iron are triggered when they may touch the iron because they do not realize it is hot and they can pull on the electrical cord which allows the iron to topple on them[9].

From the various studies, the highest problem with the iron cloth system is the automatic switch off is still works according to the classical method which means that the output is only on and off to control the temperature of iron without permanently cutting the current through to iron. In addition, controller decision making from the latest project will only cut the current if there is no motion and current in low condition without setting any range to choose whether or not the switch is ON or OFF [6]. This concept is not suitable because the output is not too smarter and needs to be upgraded in line with technological change in the modern era to ensure their electrical appliances in a more flexible way and also safer to use.

The main objective of this project is to develop the intelligent controller for auto off switch iron. To achieve the objectives, this project will divide into two parts, namely the design of the fuzzy logic control and the hardware design for automatic power off switch iron. Besides, this project is to design and develop an automatic controller in the iron switching off the system using the fuzzy logic controller and to test the performance output of this design.

In this paper, the design of a fuzzy logic controller for auto off switch iron system is presented. This controller is designed with two inputs and one output system. The current and motion detection condition from a current sensor (ACS712) and the ultrasonic sensor are used to control the time to auto-off the switching iron. The output of this controller will be the countdown timer to auto-off

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the switch depending on the presented rule. The concept ' IF ' ' THEN ' is used to design the fuzzy logic rule and is implemented in the Arduino Nano Microcontroller[10][11]. The result shows that the time to auto-off switch is followed by the setting of the rule and the system runs efficiently with fast responses.

II. DESIGN METHODOLOGY

A. Schematic diagram

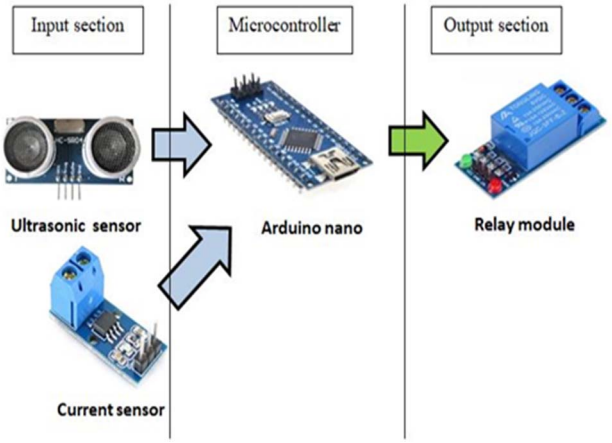

Figure 1: System architecture of the switch controller

For hardware design in Figure 1, this project uses two sensors as the input which is the ultrasonic sensor for motion detection in 4m of maximum range detection, and the current sensor to measure the current state[12]. Besides, Arduino Nano is used as a microcontroller to control the system for this project. Arduino Nano will send the actual output result to the relay module and take action to switch off the iron. The schematic diagram for this project can not be applied in proteus software because the ultrasonic sensor is not available in the library. The connection of the components in hardware design is referred to as the component datasheet.

B. System operation for hardware

In Figure 2, a flowchart is shown to describe the flow of this design operation. This project will be started when the switch to the cloth iron is ON and if not, the flow will loop back to start. After that, this flow will be running into the next step in which the current sensor and ultrasonic sensor will activate and sensing the current flow through socket to cloth iron and motion of user around the cloth iron area.

The signal detection from these two inputs will send to the Arduino Nano for fuzzyfication process to pact with the details of the fuzzy logic controller. Before Arduino Nano produces the output, it will check the human distance and current condition detection are in fuzzy logic rule or not. If the fuzzy logic rule is related to membership function in the fuzzy logic controller, this device will simulate the rule in the fuzzy arithmetic process and from this action, it will produce the real output of switch to automatically off in the setting range using defuzzyfication process. This device will constantly in the off state condition until it detects the new logic rule condition to turn on again.

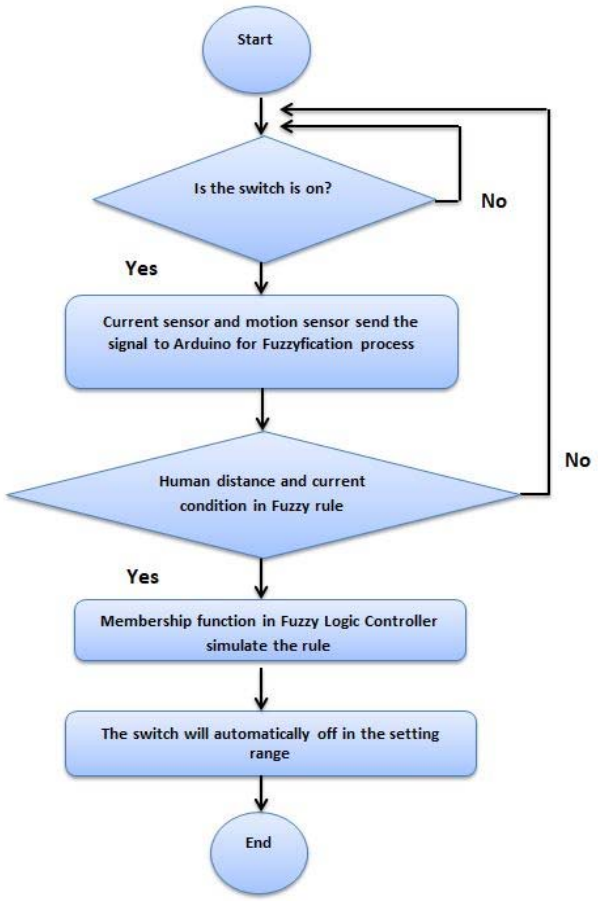

Figure 2: Operation system of the controller

C. Analysis of iron behavior

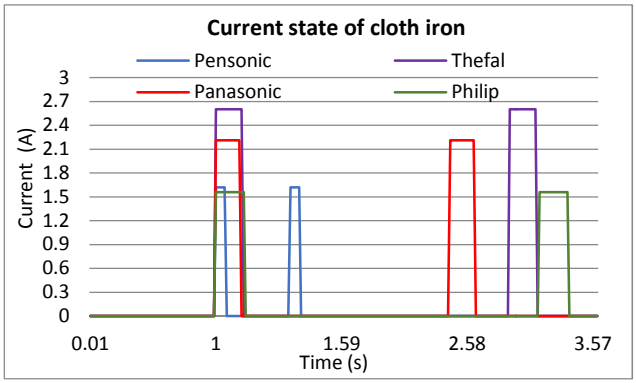

Figure 3: graph for current behavior of iron

To understand the system switching of cloth iron, an analysis is taken using Arduino software and current sensor to investigate the behavior of cloth iron in the current market. All the analyses were recorded in a graph in Figure 3. In Figure 3, the cloth iron behavior is defined with the range time for cloth iron in on-state and off-state is different and the value for current (A) is also different. The range time for on-state Tefal iron, Panasonic iron, and Philip iron are 11s - 14s and off-state is 97s - 138s with current reading being 1.59A up to 2.62A. This range is quite long because the range setting in the iron system depends on temperature control that already installed in the cloth iron operation. Besides, the duration time for Pensonic iron in the on-state condition is 4s and off-state

is 30s. From this analysis, the results show mostly an off-state iron range below that of the 90s and on state is 13s.

This condition is quite different when the cloth iron is on the usage situation which is, the time period at off state condition will be more shorter compared with the idle condition. Changes occur when the fabric absorbs the heat from the iron plate, which causes the temperature on the iron plate quicker to decrease. All this specification is required to build this device to produce the best system to control the iron cloth process without interrupting the existing iron cloth system.

D. Fuzzy inference system design

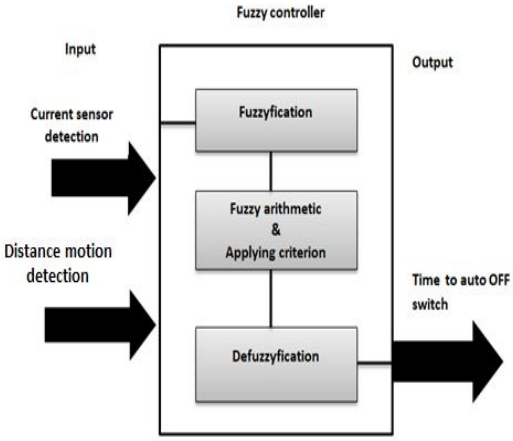

Figure 4: FLC for auto off switch iron

The design Fuzzy logic Controller for auto off switch iron consists of two Linguistic inputs which is.

1. Current sensor detection
2. Distance of motion detection

These two Linguistic Inputs will control the one Linguistic output, i.e. time to auto off switch. For the fuzzy controller, it consists of three main blocks which are, Fuzzyfication, fuzzy arithmetic with applying criterion, and Defuzzyfication by refer Figure 4.

Fuzzification is the process of transforming responding values from the input into the degree of membership in linguistic terms of fuzzy sets as shown in Figure 5 until Figure 7. This membership will be built by pursuing a logical human judgment by controlling the willingness of the sensor to comply to produce the best results.

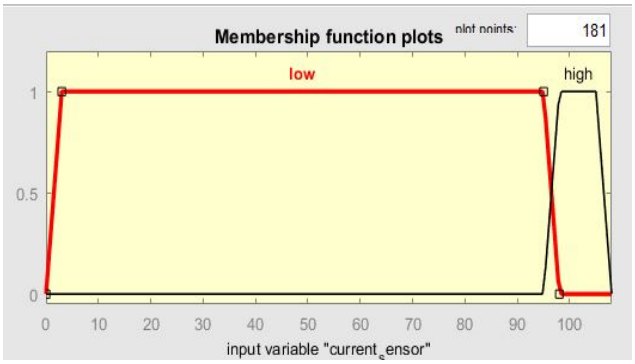

Figure 5: Input variable current sensor

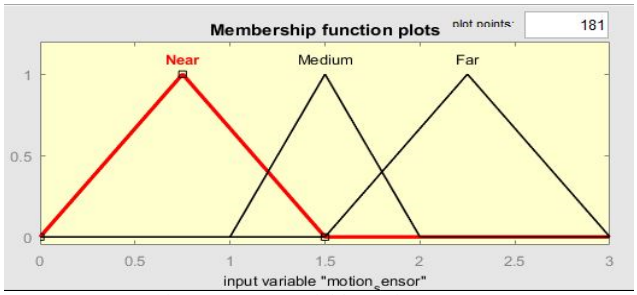

Figure 6: Input variable motion sensor

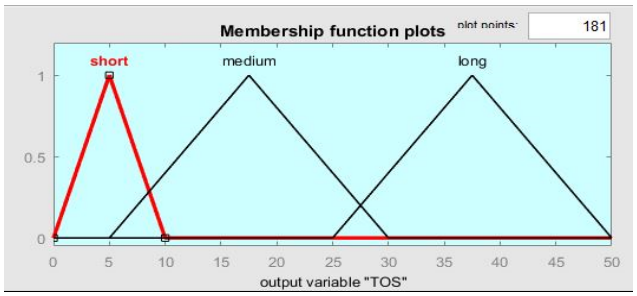

Figure 7: Output variable time off switch

Table 1: Range for input

	Low	**High**	
Current state (s)	0 - 98s	98s - 108s	
	Near	**Medium**	**Far**
Distance of motion detection (m)	0 - 1.5m	1m - 2m	1.5m - 3m

Table 2: Range for output

	Short	**Medium**	**Long**
Time to auto off switch iron (s)	0 -10s	5s - 30s	25s - 50s

Since the cloth iron system already uses the temperature sensor to control the auto-off switch, it has little effect on the current sensor setting range, which means that the range of current sensor detection time for the high and low state must follow the reading of the temperature sensor. The setting time for the current sensor in this design is designed to ensure that this device is comfortable to use for any kind of cloth iron. Besides, the setting range for motion detection is accompanied by the common area of the iron cloth room in the house[13]. Table 1 and Table 2 show the setting range for input for current state and distance of motion detection and output which time to auto off switch iron in fuzzy design using Mamdani.

Table 3: Fuzzy rule for auto off switch iron

Rule number	**Linguistic Input**		**Linguistic Output**
	Current state	**Distance of motion**	**Time auto off switch**
1	Low	Near	Long
2	Low	Medium	Medium
3	Low	Far	Short
4	High	Near	Long
5	High	Medium	Medium
6	High	Far	Short

Defuzzyfication is to obtain the result of the fuzzy inference technique[14]and processed to produce a specific number as the output of time to automatically switch off the iron. The set fuzzy rule for auto-off switch is shown in Table 3 and the rule obtained in the table can be read in terms of IF and THEN statements as shown below[11].

Rule 1 :

IF the current state is low and distance of motion is near THEN time to auto off switch iron is long.

Rule 6:

IF the current state is high and distance of motion is far Then time to auto off switch iron is short.

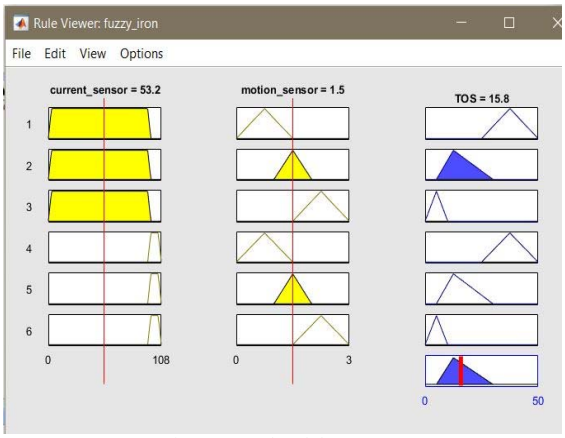

Figure 8: Rule of the system

III. RESULT AND DISCUSSION

By applying fuzzy logic control, it was able to set the real time to auto-off the switch iron for different current state and different motion detection range. The calculation of output time of this project is using Mamdani FES in MATLAB software. By using this method, it can avoid human interruption to decide the output and make the controller more intelligent to represent the decision.

Figure 9 until Figure 11 shows the response surface between the two inputs to produce the actual output as determined by using fuzzy interface units. As an example by referring Figure 8, if the current sensor at low state = 53.2s and distance motion at medium = 1.5m, the time to auto off the switch is in medium range = 15.8s. The real time shown in the fuzzy interface unit is compared with the simulation of hardware using Arduino as a microcontroller.

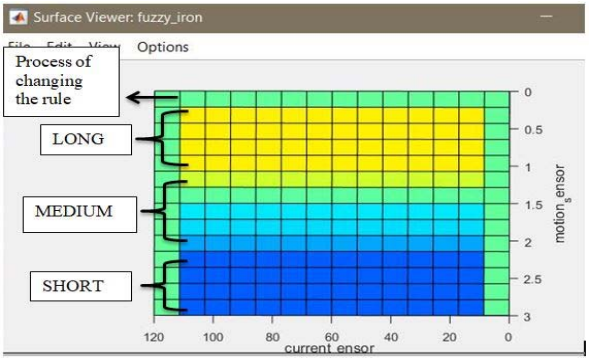

Figure 9: Response surface of the two inputs

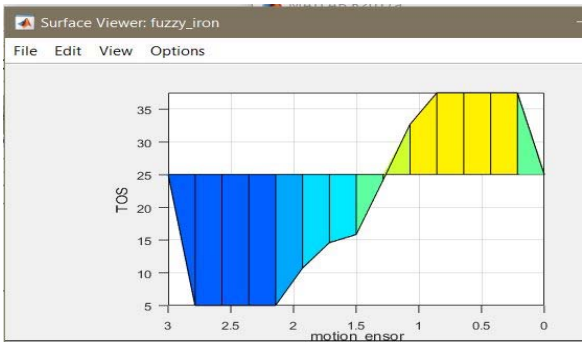

Figure 10: Response of the distance of the motion and time to auto off the switch

Figure 11: Response of the current state and time to auto off the switch

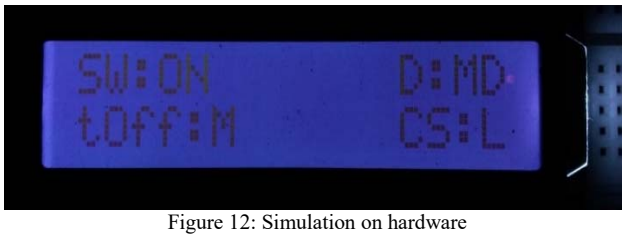

Figure 12: Simulation on hardware

For hardware, as shown in Figure 13, this prototype will operate between the main power source and the iron cloth. From this concept, this prototype will be more flexible to use for any type of iron because this product only controls the current flow from source to iron and does not interfere with the iron system. The position of the ultrasonic sensor will be installed in front of this device that makes it easier to detect the solid movement around the iron cloth area. A liquid crystal display is mounted on this system as a reference indicator for humans to recognize the state of this device whether it is on or off. Figure 14 shown the setup of this device with the mains socket and cloth iron. Usage of this device on the main socket is comfortable since the size is not too large and high safety to conduct the current to the cloth iron

The program for hardware has still used a rule base using the concept ‘if ‘ ‘ else’ rule to produce the range of the output that similar to the Mamdani response surface unit like shown in Figure 12. The condition of the input and output displayed on the LCD will be followed by the software design in Mamdani. Unfortunately, the simulation hardware still cannot read the formula that Mamdani uses to calculate the exact value that Mamdani produces. Changing the rule base on changes in input is quite fast to produce the new crisp value output. The range output that produces by this device is quite

convincing to ensure that this device can reduce electrical consumption cost and create a new safety feature in daily life.

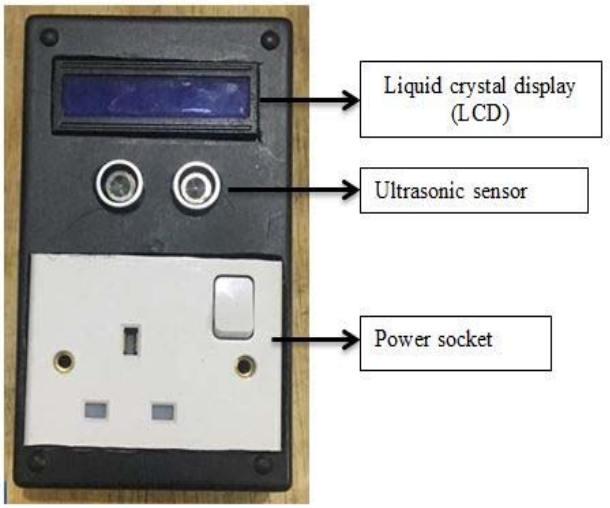

Figure 13: Hardware design

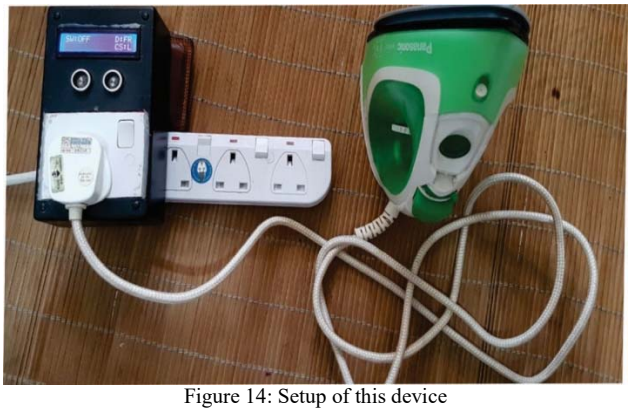

Figure 14: Setup of this device

IV. CONCLUSION

Fuzzy logic controller is very robust and convinces to control the time from the output to auto-off the switch iron. This system is very robust since it does not need precise, noise-free inputs and degrade gradually when system components fail as if a feedback sensor quits is destroyed. Implementation of this controller can upgrade the electrical appliance today to be more technological to make sure consumers are more comfortable and sure to use their electrical appliances at home. This auto off switch can be developed with more sensors to provide a new lifestyle requirement depending on human activity and other lifestyle functions[15] such as control the time for rice cooker operation or controlling the phone charge system.

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