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A Fuzzy-Based Chat-bot Messenger for Home Intelligent System with Multiple Sensors

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ABSTRACT

The integration of chatbot engines and home automation systems is an area that is seeing a lot of development and resources dedicated to in recent years. Many devices nowadays are constantly connected to the Internet (IoT) and this is a huge opportunity to create a software application that can manage an area of our everyday life. This paper was aimed at the design and implementation of a low-cost fuzzy-based system which converts fuzzy values to Crips values that uses weather conditions of a particular environment to function as an intelligent system in a smart home. The functions of this system is made possible with the integration of multiple sensors of Pewatron zirconia in a circuit in conjunction with fuzzy values in a chatbot messenger environment with the aid of the Telegram Bot service to control the state of electrical devices in the house based on atmospheric weather conditions. The commands to the control of electrical appliances was done by creating user interface that interfaces with the mobile devices that provides intelligent response programmed on to the Freescale S32K microcontroller with wireless fidelity. The main focus was to create a chat interface that allows the users to interact with their systems at home in their convenience(reaching the users where they already are, like Telegram, Facebook etc.), creating a system that not only allows you to control and manage your home electrical systems but also a networking system that gives you leverage of ease and faster network in terms of operation in controlling your home devices through decisions. The outcome of this fuzzy-based smart home intelligent system proved reliable and efficient more than the previously designed smart home systems based on relay and microcontroller. More so, the system reduces power consumption from electrical appliances as the application generally employed fuzzy Crips values based on the weather conditions.

Key words: Fuzzy Logic, Pewatron zirconia, Smart Home, Microcontrollers.

1.INTRODUCTION

When a home is typically automated to control virtually all domestic appliances such as lighting, refrigerator, washing machines and other electrical gadgets, then that home is a smart home.

The ultimate goal of a smart home is not only convenience in the operation of all in a single unit but also to reduce the consumption of resources such as power, gas, etc, [12]. Due to the current pricing of energy virtually over the world, resource conservation has become a part of a person's day-to-day life. Thus, if a person has the possibility to control his home automation remotely, then he can reduce the consumption of energy and consequently cutting down cost on expenses. Smart home can also be known as Automated Home or intelligent home which indicates the automation of daily tasks with electrical appliances used in homes [15].This could be the control of lights, fans, viewing of the interiors for surveillance purposes or indication in case of gas leakage. Automation is the use of control systems and information technology to control equipment, industrial machinery and processes, reducing the need for human intervention. Chat-bot systems started with programs like ELIZA named after Eliza Doolittle, a working-class character in Pygmalion who is taught to speak with an upper-class accent, it was an early natural language understanding program and was intended to demonstrate natural language conversation with a computer[6][8]. Natural language understanding (NLU) systems were required to pass the Turing Test in which a human interrogator was required to interact with the systems and to deem a computer "intelligent" enough to pass as a human[5][9]. The problem is not only constructing and implementing an automated system, the most important issue is getting a system that will be able to save the user operational cost of these electrical appliances by minimizing power consumption and also enhancing the efficiency of operation.

2.0 LITERATURE REVIEW

The quest for convenience in the operation of home appliances and reducing the stress of operating these electrical appliances has led to the development of smart homes, coupled with wireless access network. The American Association of House Builders in the year 1984 introduced the word "smart home" with the intention of inventing microcontrollers [11]. So many microcontrollers have been developed which can be classified as 8051, AVR and PIC, ZigBee technology is also employed in determining network topology and protocols to enhance smart home wireless devices[13]. The memory types are classified into embedded memory microcontrollers and external memory microcontrollers, while according to instruction set, it is classified as CISC (complex instruction set computer), RISC (reduced instruction set computer), and while as memory architecture is classified as Harvard memory architecture and Princeton memory architecture [10]. In building smart home, [2] employed Atmega as a microcontroller in implementing GSM based home automation system that can remotely control the house surveillance. In the design and implementation of a cost effective and yet flexible and powerful home security system, using GSM technology, [16][3] adopted 8021 microcontroller to detect burglary, leaking of harmful gas, smoke caused due to fire and after detecting suspicious activities it sends alarm message to the owner of the house. Atmega644p as a microcontroller was used in the design of security systems for smart home based on GSM technology and uses web camera to detect the intruder [7]. In all, these projects were geared towards switching off error detection byitself; hence the development of smart home based GSM system by embedding sensors into the Aduino microcontrollers, sensors and relays. This system makes it possible to detect error in the electrical appliances and switch off by itself without the owner operating it and allows for convenience in operation. All these reviews geared towards developing smart home system, did not take cognizance of the fact that electrical consumption is a powerful opposition in home smart systems, therefore, this research focuses on building fuzzy logic into the intelligent system of the smart home. This is to create an inference engine that can determine when the electrical appliances should be in operation or not considering the weather condition of that particular environment it is deployed. This is a recent development that will help reduce operational power consumption of some of the electrical appliances and thereby saving a lot for the user. Such appliances that are integrated into this system includes; the air-conditioners, heaters and dryers. Furthermore, this research work applies multiple sensors in building home intelligent systems which has not been applied in previous works with fuzzy logic.

The figure 1, shows a typical smart home electrical appliances system designed which is applied in this research paper which is controlled by the telegram bot intelligent system embedded with Crips values from fuzzy logic which depends on weather conditions of a particular location.

Figure 1: The Smart Home Electrical Appliances System

3.MATERIALS ANDMETHODS

This study will be carried out with the aid of many technologies and hardware components as well as software design, communication set up and electrical circuit design with fuzzy logic.

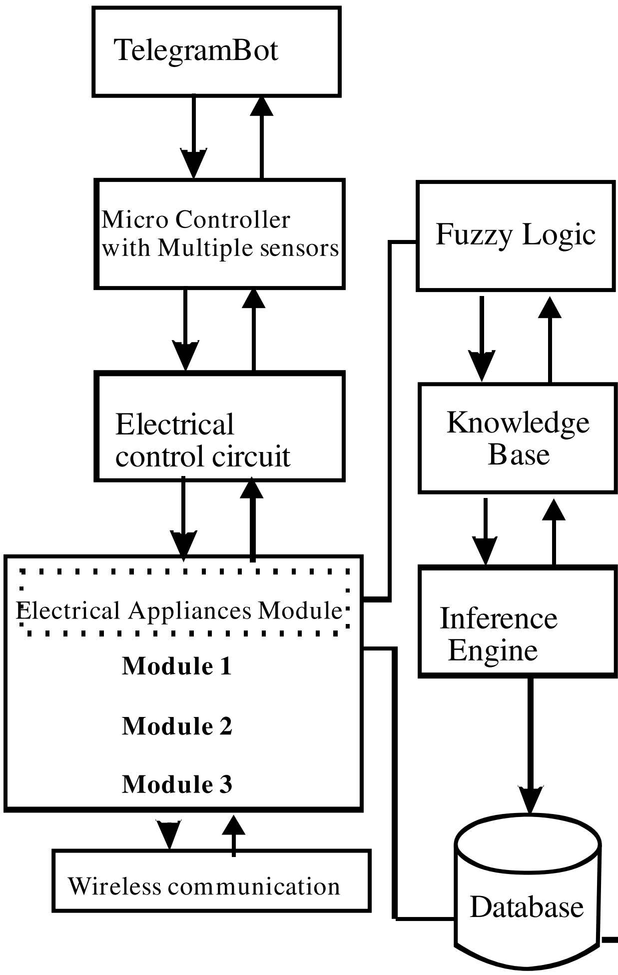
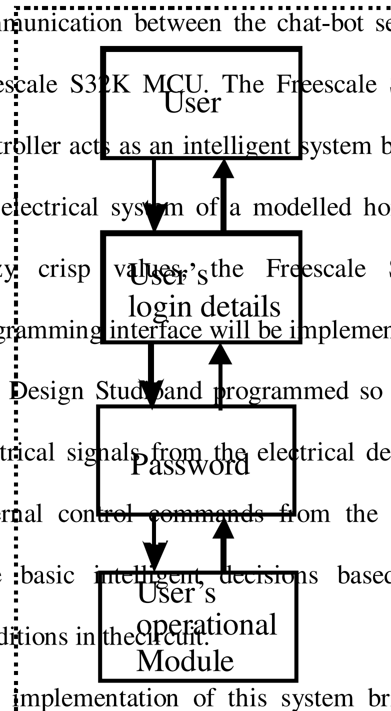


Figure2:Fuzzy-Based Chat-botIntelligent System flow diagram

The figure2 depicts the operational flow diagram of the fuzzy-based chat-botsystem for smart homes that comprises various components built for effective functioning of a weather based smart home.

A) **Telegram Bot**

For the Chat-bot design the Telegram based design environment will be used to implement the chat-bot messenger and then the Freescale S32K Microcontroller was programmed using the S32 Design Studio and Telegram Chat-bot API (BotFather)[14] token created to allow communication between the chat-bot server and the Freescale S32K MCU. The Freescale S32K micro-controller acts as an intelligent system by controlling the electrical system of a modelled home based on fuzzy crisp values, the Freescale S32K MCU programming interface will be implemented using the S32 Design Studio and programmed so as to receive electrical signals from the electrical devices, enable external control commands from the chat-bot and take basic intelligent decisions based on certain conditions in thecircuit.



The implementation of this system brings about a simple cost- effective system where a user is faced with decision making from the fuzzy logic system to accept or not to accept switching of a particular appliance.

B) Multiple Sensors

Multiple sensors of Pewatron Zirconia were used in the implementation of fuzzy-based home intelligent system. The multiple sensors send signals of every weather condition to the micro controller circuit of all the electrical appliances in the home. The service port is the port number from the pewatron zirconia code (Service port: 80):

C) Freescale S32K MCU

The Freescale S32K MCU as shown in figure 2, is a micro-controller board designed by Espressif Systems based on the Wi-Fi ESP-12E which enables wireless connection through the use of the ESP8266 library enabled on the pewatron zirconia for programming. The S32 Design itself is a self-contained Wi-Fi networking solution offering as a bridge from existing micro controller to Wi-Fi and is also capable of running programs onto it to control various devices and sensors. With a built-in micro USB cable, you can connect Freescale S32K MCU development kit to your laptop and flash it without any trouble, just like an pewatron zirconia device [4][1].

D) The Home Electrical Control System

The home electrical control system is designed by modeling a home and creating an electric circuit to depict the basic electrical system of a home by deploying electrical controls that houses every other electrical appliances in a home. It contains the main circuitry system of the entire design, which collaborates with the wireless network provided in mobile devices.

E) Electrical Appliances Module

The electrical appliances module is divided into three categories since their operations varies based on fuzzy logic arrangement. The modules are;

i. Module 1: This module is intended to control all the lighting points in the house
ii. Module 2: Module 2 controls the electrical appliances such as fans, air conditioners and heaters
iii. Module 3: This module comprise of the refrigerator.

F) A Wireless Communication

A wireless communication will be implemented with the aid of the S32 Design Studio Wi-Fi library by creating a Wi-Fi enabled access so as to allow connections over wireless networks and the S32 Design library supports 802.11b/g/n. A simple wireless hotspot is created for the purpose of this work in order to allow the wireless communication between the Telegram chat-bot server and the Freescale S32K MCU. Communication occurs on both ends of the device enabling the microcontroller access to communicate with the server with the use of the token key so as to ensure secure communication. This is in tandem with the API of the TelegramBot to communicate with the TelegramBot library by sending and receiving bot updates which are read into the Freescale S32K MCU for implementation [9].

3.1. The Design of the Fuzzy Logic

The fuzzy logic is designed to generate Crisp values and decision rules that the module 1, the lighting points, module 2, the refrigerator, and module 3, the heaters and air conditioners will base their principle operations via the weather conditions.

3.2**Algorithm for the Fuzzy logic of Home intelligent system**

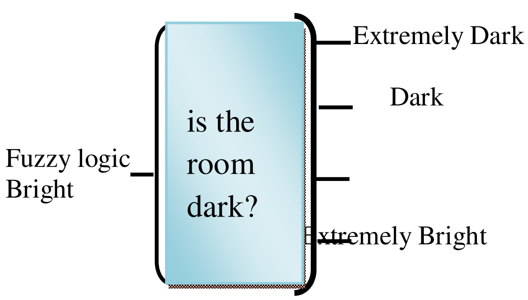
1. Define the linguistic variables and terms
2. Construct membership functions for them
3. Construct knowledge base of rules
4. Evaluate rules in the rule base – interfacengine
5. Combine results from each rule – interfaceengine
6. Convert output data into non-fuzzy values – defuzzification

Module 1 which is for lightings in the homes uses four membership functions using equation 1

$$A = n_1, n_2, n_3, \ldots, n_k$$

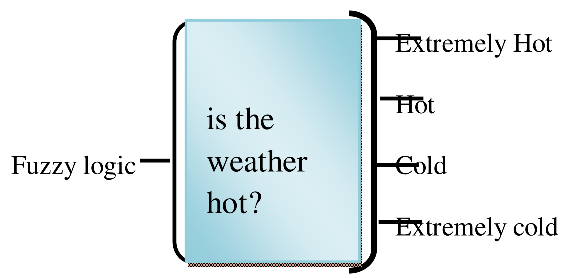
(1)

Where the n's are the various membership functions of the fuzzy logic



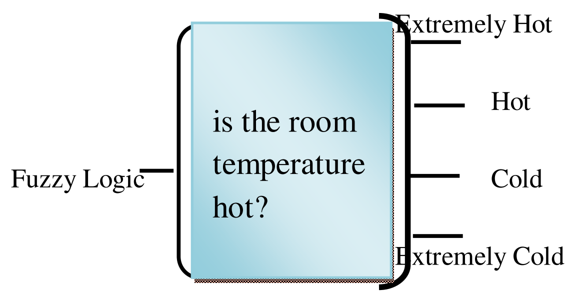
The associated membership functions are extremely dark 0.9, dark 0.7, bright 0.5 and extremely bright 0.3 Therefore, A = (0.9, 0.7, 0.5. 0.3)

For **Module 2**, it uses weather conditions in terms of measuring the temperature of the immediate environment to act.



The membership function values are A = (0.9, 0.7, 0.5, 0.3)

Module 3: Modu0le 3 considers the room temperature of the host electrical appliances



The associated membership function values are A = (0.9, 0.7, 0.5, 0.3)

$$\tilde{A} = \left\{\left(y, \mu_{\tilde{A}}\ {}^{(y)}/_{y} \in \mu\right)\right\} \qquad (2)$$

Where $\mu_{\tilde{A}}(y)$ is the membership of y in $\tilde{A}$, $\mu_{\tilde{A}}(y)$ € [0,1]

Equation 2 is used to associate membership function Boolean functions.

Equation (2) can be expanded into equation 3 to give the individual association of membership function into the operations in terms of time for module 1 and temperature for modules 2 and 3. Tables 1, 2 and 3 show the fuzzy membership function for electrical appliances modules.

$$\tilde{A} = \left\{ \frac{(\mu\tilde{A}(y_1))}{(y_1)}, \frac{(\mu\tilde{A}(y_2))}{(y_2)}, \frac{(\mu\tilde{A}(y_3))}{(y_3)}, \ldots \frac{(\mu\tilde{A}(yn))}{(yn)} \right\} \quad (3)$$

Table 1: Fuzzy Membership Function of Module 1 in Matrix Form

Membership function	Time (Hours)					
	0-4	5-8	9-12	13-16	17-20	21-24
0.9	M11	M12	M13	M14	M15	M16
0.7	M21	M22	M23	M24	M25	M26
0.5	M31	M32	M33	M34	M35	M36
0.3	M41	M42	M43	M44	M45	M46

Table 2: Fuzzy Membership Function of Module 2 in Matrix Form

Membership function	Temperature(^{0}C)								
	10	20	30	40	50	-10	-20	-30	-40
0.9	M11	M12	M13	M14	M15	M16	M17	M18	M19
0.7	M21	M22	M23	M24	M25	M26	M27	M28	M29
0.5	M31	M32	M33	M34	M35	M36	M37	M38	M39
0.3	M41	M42	M43	M44	M45	M46	M47	M48	M49

Table 3: Fuzzy Membership Function of Module 3 in Matrix Form

Membership function	Temperature(^{0}C)								
	10	20	-10	-20	-30	-40	-50	-60	-70
0.9	M11	M12	M13	M14	M15	M16	M17	M18	M19
0.7	M21	M22	M23	M24	M25	M26	M27	M28	M29
0.5	M31	M32	M33	M34	M35	M36	M37	M38	M39
0.3	M41	M42	M43	M44	M45	M46	M47	M48	M49

Table 4: Knowledge base rule for Module 1(Lightings)

Sr	Condition	Action
1	If weather = DarkORExtremelyDark and target =LightUp	ON
2	If weather = BrightORExtremelyBright and target = SwitchOff	OFF

Table 5: Knowledge base rule for Module 2(Fans, Heaters and Air conditioners)

Sr	Condition	Action
1	If Temperature = Hot OR Extremely Hot AND target = Cold THEN	Cool
2	If Temperature = Cold OR Extremely Cold AND target = Warn THEN	Heat
3	If Temperature = Warm AND Target = Warm THEN	No_ Change

Table 6: Knowledge base rule for Module 3(Refrigerator)

Sr	Condition	Action
1	If Room Temperature = Hot OR Extremely Hot AND target = Cool	ON
2	If Room Temperature = Cold OR Extremely Cold and target = SwitchOff	OFF

Table 4 shows the knowledge base rule constructed for module 1 which comprises of lightings such as bulbs in the house.Table 5 shows the knowledge base rule constructed for module 2 which comprises of electrical appliances such as heaters. Fans and Air Conditioners.

Table 6 shows the knowledge base rule constructed for module 3 which comprise of Refrigerator.

4. RESULTS AND DISCUSSIONS

The Telegram chat-bot is developed by creating an account with the Telegram application after the necessary account creation setup. After the setting up of the account has been concluded and the messenger environment, the creation of a chat-bot engine is initiated by searching for the BotFatherChat-bot engine which enables creation of an API key.

The API key will enable communication between the Telegram Chat-bot server. After creating the Chat-bot and acquiring the Key, then all the necessary libraries are downloaded to enable communication between the chat-bot server and the Freescale S32K MCU through the TCP web protocol running on the Freescale S32K MCU.

Applying equation (4), table 7 was derived as fuzzy values used in the intelligent system. The derived values are got as follows with total number of membership values as 4 for the first column while the rest of the calculations follows the same pattern.

$$\tilde{A} = \left(\frac{(0.9 \cdot 4)}{4} \; \frac{(0.9 \cdot 4)}{8} \; \frac{(0.9 \cdot 4)}{12} \; \frac{(0.9 \cdot 4)}{16} \; \frac{(0.9 \cdot 4)}{20} \; \frac{(0.9 \cdot 4)}{24} \right)$$

Table 7: Generated Fuzzy Logic Values for Module 1

Membership Values	**Time (Hours)**					
	0-4	**5-8**	**9-12**	**13-16**	**17-20**	**21-24**
0.9	0.90	0.45	0.30	0.23	0.18	0.15
0.7	0.70	0.35	0.23	0.18	0.14	0.12
0.5	0.50	0.25	0.17	0.13	0.10	0.08
0.3	0.30	0.15	0.10	0.08	0.06	0.05

Table 8: Generated Crisp Values Module 2

Membership Values	**Temperature (θ^0)**								
	10	20	30	40	50	-10	-20	-30	-40
0.9	0.36	0.18	0.12	0.09	0.07	-0.36	-0.18	-0.12	-0.09
0.7	0.28	0.14	0.09	0.07	0.06	-0.28	-0.14	-0.09	-0.07
0.5	0.20	0.10	0.07	0.05	0.04	-0.20	-0.10	-0.07	-0.05
0.3	0.12	0.06	0.04	0.03	0.02	-0.12	-0.06	-0.04	-0.03

Also applying equation (4), table 8 was derived as fuzzy values. The first column is derived as shown below while the other calculations follow the same pattern.

$$\tilde{A} = \left(\frac{(0.9 \cdot 4)}{10} \frac{(0.9 \cdot 4)}{20} \frac{(0.9 \cdot 4)}{30} \frac{(0.9 \cdot 4)}{40} \frac{(0.9 \cdot 4)}{50} \frac{(0.9 \cdot 4)}{(-10)} \frac{(0.9 \cdot 4)}{(-20)} \frac{(0.9 \cdot 4)}{(-30)} \frac{(0.9}{(-4} \right.$$

Applying equation (4), table 9 was derived as fuzzy values used in the intelligent system. The derived values are got as follows with total number of membership values as 4 for the first column while the column calculations follow the same pattern.

$$\tilde{A} = \left(\frac{(0.9 \cdot 4)}{10} \frac{(0.9 \cdot 4)}{20} \frac{(0.9 \cdot 4)}{(-10)} \frac{(0.9 \cdot 4)}{(-20)} \frac{(0.9 \cdot 4)}{(-30)} \frac{(0.9 \cdot 4)}{(-40)} \frac{(0.9 \cdot 4)}{(-50)} \frac{(0.9 \cdot 4)}{(-60)} \frac{(0.9 \cdot 4)}{(-70)} \right)$$

Table 9: Generated Fuzzy Logic Values for Module 3

Membership Values	**Time (Hours)**								
	10	20	-10	-20	-30	-40	-50	-60	-70
0.9	0.36	0.18	-0.36	-0.18	-0.01	-0.09	-0.07	-0.06	-0.05
0.7	0.28	0.14	-2.8	-0.14	-0.09	-0.07	-0.06	-0.05	-0.04
0.5	0.20	0.10	-0.20	-0.10	-0.07	-0.05	-0.04	-0.03	-0.03
0.3	0.12	0.06	-0.12	-0.06	-0.04	-0.03	-0.02	-0.02	-0.02

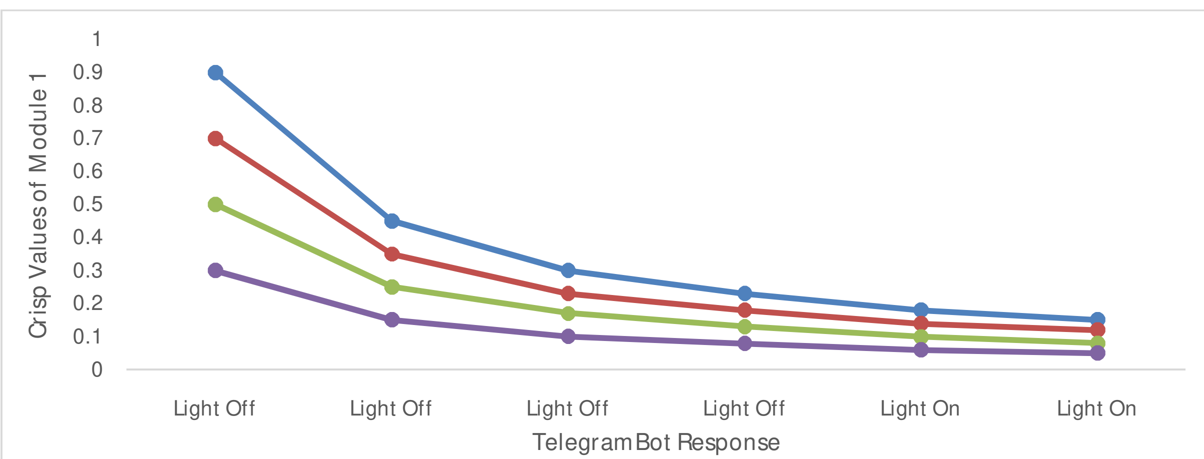


Figure 3: BOT response to Crips Values in Module 1(Lighting points)

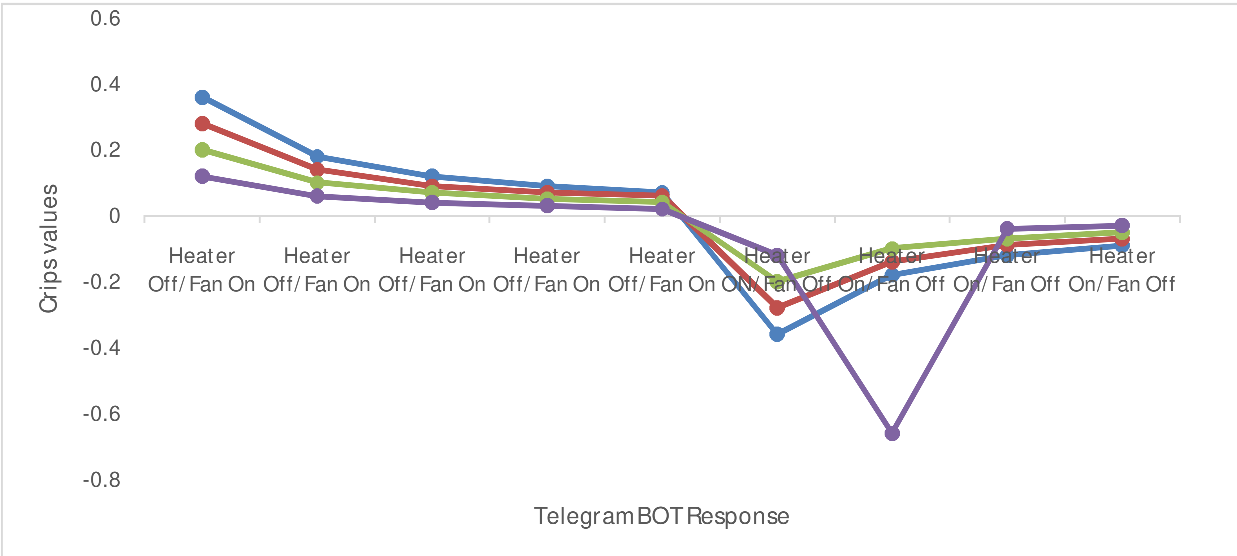


Figure 4: BOT response to Crips Values in Module 2(Fans and heater)

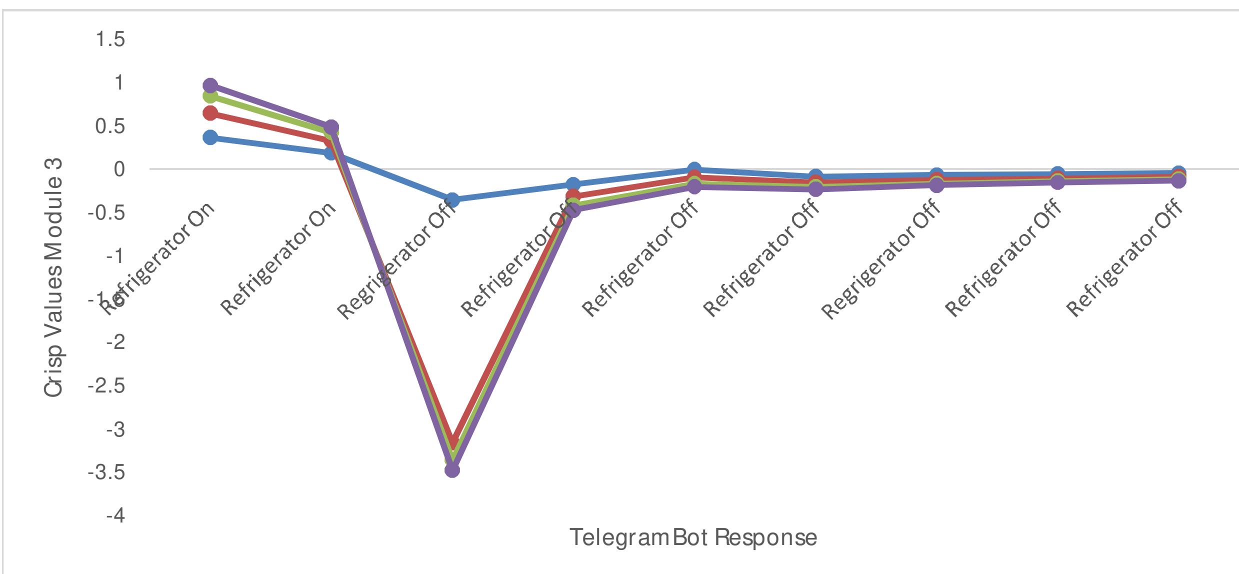


Figure 5: BOT response to Crips Values in Module 3(Refrigerator).

In the result shown in figure 3, the Crips values of 0.9, 0.70, 0.50, 0.30, 0.45, 0.35, 0.25, 0.15, 0.30, 0.23, 0.17, 0.10, 0.23, 0.18, 0.13 turns the lighting bulbs off, while the Crips values of 0.08 can make the decision of either turning on or switching on the lighting bulbs. Consequently, the Crips values of 0.18, 0.14, 0.10, 0.06, 0.15, 0.12 and 0.05 turns the lighting bulbs on in module 1. In module 2, the diagram shown in figure 4, which depicts the telegram Bot response on the Crips values, 0.36, 0.28, 0.20, 0.12, 0.18, 0.14, 0.10, 0.06, 0.12, 0.09, 0.07, 0.04, 0.09, 0.07, 0.05, 0.03, 0.07, 0.06, 0.04, 0.02 turns the fan on, while the Crisp values of -0.36, -0.28, -0.20, -0.12, -0.18, -0.14, -0.10, -0.66, -0.12, -0.09, -0.07, -0.04, -0.09, -0.07, -0.05, -0.03 turns the heaters on. Subsequently, the diagram depicted in figure 5, the Crips values of 0.36, 0.28, 0.2, 0.12, 0.18, 0.14, 0.1, 0.06 turns the refrigerator on, while the values -0.36, -0.28, -0.20, -0.12, -0.18, -0.14, -0.10, -0.66, -0.07, -0.04, -0.09, -0.05, -0.03, -0.06, -0.02 turns the refrigerator off reason being that the room temperature of the appliance is still cold.

5CONCLUSION

This work has focused on creating a chat-bot for home intelligent system that automatically makes decision based on fuzzy Crips values in providing the user that convenience to make decisions pertaining to his electrical appliances through mobile devices equipped with wireless network. It provides adequate response time to the telegram chat bot in the electrical appliances classified as module 1 for lighting bulbs, module 2 for fans, heaters and air conditioners, and module 2 for refrigerators. The study employed multiple sensors of pewatron zirconia in the circuitry panel with Freescale S32 K micro controller system embedded in a telegram chat bot which is an innovative and exciting way of creating applications in a home intelligent system.

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