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SMART IRRIGATION USING FUZZY LOGIC METHOD

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ABSTRACT

This smart irrigation system optimizes water usage for agriculture. In this method we have implemented an open loop fuzzy logic control system using Mamdani control system. The inputs to the fuzzy logic control system are adapted from a humidity sensor, temperature sensor and the flux sensor in the field. The output for this system is the lamp and the water pump. The simulation is done using MATLAB software and SIMULINK. The membership functions and the rule based systems of the controller is illustrated in the following parts in this paper.

Keywords: smart irrigation, fuzzy logic mamdani control system, matlab, simulink.

INTRODUCTION

Agriculture is the source of the essential needs for food in all the civilizations. In today world, agriculture has become one of the main industries that contributes to vast job scopes. For agriculture to take place in mass scale, huge amount money is needed to be invested. Agriculture is dependent on climate condition, mainly water presence. Due to bad climate conditions, many crops are wasted which results in massive lost. In order to minimize the loss, many technology advancement are being done.

Water is the basic need of life. Crops need exact amount of water, too much or too little will damage the growth of the crops. The key in irrigation is striking to correct balance for optimal growth of the plant with reduced amount of water. The idea of irrigation origins from Egyptians and might even be older than that.

Automated irrigation is implemented in large areas of foliage through the use of automated and drop irrigation system [1] [8]. Automated irrigation system could not irrigate plants to a desired level and supply those plants with just the amount of water required for a normal uptake growth.

Irrigation controller is divided roughly into two main classes:

Open loop controller: Which means there is no error feedback from the controlled object [2]. In detail, the users set the time to start and the time to end. The pause intervals and the watering periods are set too. These parameters are set earlier or can be said pre-set parameters for the entire session. That is:

- How long the irrigation session should be lasting
- How frequent the irrigation period should repeat itself
- The amount of water that is needed in the irrigation

Closed loop controllers: These controllers are those that have a feedback combined with feed forward from the controlled object. The feedback is necessary to determine the amount of water needed for irrigation. There are several parameters that should influence the decision making process, for example some parameters that should be fixed during the process, and some parameters that should only be determine during the irrigation process by measuring the values. Thus when the condition changes, then the amount of water being used for the irrigation should also vary.

Input parameters that are used by the system are:

- Temperature;
- Flux/ light;
- Air humidity;

Output parameters are:

- Water pump
- Lamp

RELATED WORKS

"A Real time Implementation of a GSM based Automated Irrigation Control System using drip Irrigation Methodology" deal GSM based Irrigation Control System by Veena Divya, Ayush Akhouri, could provide the facilities of maintaining uniform environmental conditions [4]. For this, Android software is used for mobile devices that include an operating system, middleware and key applications. To begin the development of the applications on the Andriod platform using Java programming language, the Android SDK provides the tools and APIs which are necessary. This application makes the use of the GPRS feature of mobile phones as a solution for irrigation control system. This system covered lower range of agriculture land and not economically.

Purnima, S.R.N Reddy, done a research tittled," Design of Remote Monitoring and Control System with Automatic irrigation System using GSM-Bluetooth", and they proposed supplying water to land where the crop are being cultivated artificially [5]. Old school hand pumps, canal water and rainfall were the major source of water source for the irrigation. There are many drawbacks of this method such as under irrigation, over irrigation which then causes leaching and loss of nutrient content.

To deal with this drawback, fuzzy logic method and mobile network system saves more than 50% of the water. Which then became the reason for the increased yield.

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The paper of ''Image Classification Based on Fuzzy Logic'' by I. Nedeljkovic help in arrange SPOT image in fuzzy logic manner. It shows the knowledge about the spectral information for certain agriculture land cover classes is used. [6] To be more precise, in Matlab the input (image channels) and output variables (land classes) are introduced. The supervised classification conducted with PCI ImageWorks help in obtaining membership function. Then, fuzzy logic inference rules obtained using Matlab's Fuzzy Logic Toolbox which are tested and justified through the simulation of classification procedure at random sample areas. At the end Spot image classification was conducted. Fuzzy logic proved that it can satisfactorily use for image classification gives a higher accuracy in classification through experimental results.

The paper "Recognition of weeds with Image Processing and Their Use with Fuzzy Logic for Precision Farming"[7] shows the methodology that developed for processing digital images in order to determine a weed map. According to the researchers the fuzzy logic approach should make sure to convert image data into sprayer command and the available fuzzy logic controller was just able to control of one nozzle. This study proves that greenness method can locate weeds and herbicide applications controlled by fuzzy logic automatically to obtain effective weed control.

PROPOSED MODEL

Fuzzy logic control system

The structure for fuzzy logic control system is illustrated in Figure-1. The system consists of four blocks that are Fuzzification, Inference engine, if-then rules and Dufuzzification similar to [9]. The inputs to the system will be analogue values. However, the Fuzzificaiton will allocate the crisp inputs into fuzzy sets. The if-Then are applied to the inference engine together with the fuzzified sets. The fuzzified inputs are then being put into different sets according to the membership functions. The output from the controller is the defuzzified form in the crisp form.

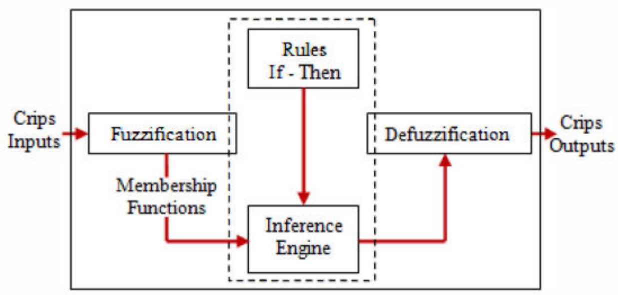

Figure-1. Fuzzy logic controller block diagram.

Open loop fuzzy logic controller

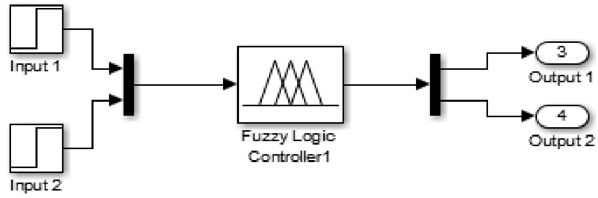

Figure-2. Open loop fuzzy logic controller.

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Fuzzy inference system

The proposed model for the smart irrigation system is illustrated in Figure-3. In this figure the inputs and outputs to the fuzzy logic controller shown. The inputs are coming from the humidity sensor, the temperature sensor and the flux sensor. The outputs are the water pump and the lamp that are connected to the field.

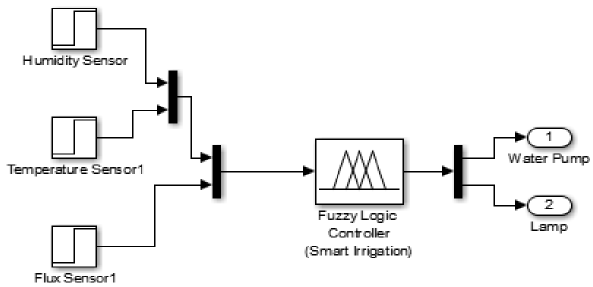

Figure-3. The fuzzy logic controller of smart irrigation system.

The fuzzy logic control system modelled in Matlab is being illustrated in Figure-4. In this figure the input variables are defined as Temperature, Humidity and the Illumination. The fuzzy Inference System is called the Smart Irrigaiton using Mamdani method. Lastly the outputs variables are shown that is the lamp and the water pump.

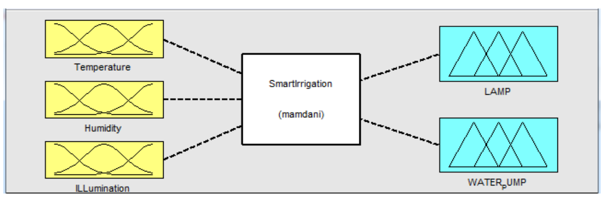

Figure-4. The fuzzy logic controller of smart irrigation system in Matlab.

Input variable membership functions

The temperature input variable has three membership functions as illustrated in Figure-5. They are denoted by Low, Medium and High. The universe of discourse has the unit of Celsius that has a range of 0-100 degrees. The Low has the range of 0 to 30 degrees, medium the range of 30 to 40 degrees and high has the range of 40 to 100 degrees. The type of membership function for the Low and High is trapezoidal and the medium is in the form of triangular.

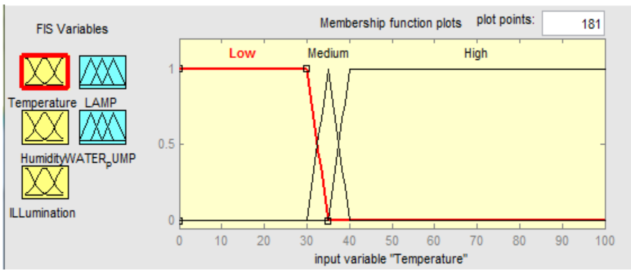

Figure-5. The input membership function of temperature.

The humidity input variable has three membership functions as illustrated in Figure-6. They are denoted by Dry, Normal and Moist. The universe of discourse has the unit of voltage that has a range of 0-100 units. The Dry has the range of 0 to 35 units, normal has the range of 35 to 70 degrees and Moist has the range of 70 to 100 degrees. The type of membership function for the Dry and Moist is trapezoidal while the type of membership function of the normal is triangular.

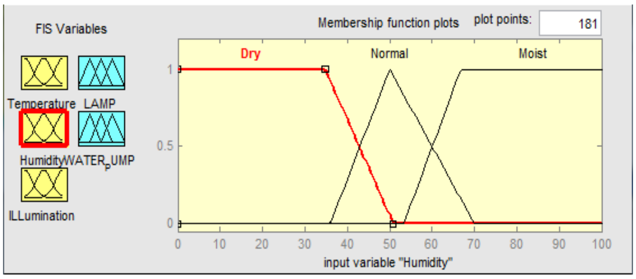

Figure-6. The input membership function of humidity.

The Illumination input variable has three membership functions as illustrated in Figure-7. They are denoted by Dark, Normal and Bright. The universe of discourse has the unit of flux that has a range of 0-500 units. The Dark has the range of 0 to 160 units, normal has the range of 160 to 340 degrees and Moist has the range of 340 to 500 degrees. The type of membership function for the Dark and Bright is trapezoidal while the type of membership function of the normal is triangular.

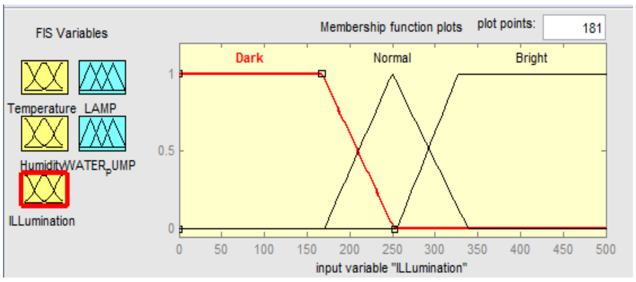

Figure-7. The input membership function of illumination.

Output variable membership functions

The Lamp output variable has three membership functions as illustrated in Figure-8. They are denoted by Low, Medium and High. The universe of discourse has the unit of flux that has a range of 0-500 units. The Low has the range of 0 to 150 units, medium has the range of 150 to 300 degrees and high has the range of 300 to 500 degrees. The type of membership function for the Low and High is trapezoidal while the type of membership function of the Medium is triangular.

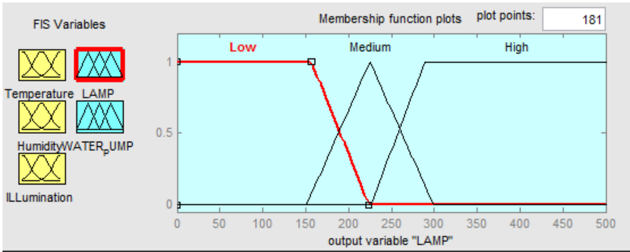

Figure-8. The output membership function of lamp.

The Water pump output variable has two membership functions as illustrated in Figure-9. They are denoted by on and off. The universe of discourse has the unit of mv that has a range of 0-400 units. The off has the range of 0 to 150 units, and on has the range of 150 to 400 units. The type of membership function for the Off and On is custom trapezoidal that simulates the on and off of the water pump.

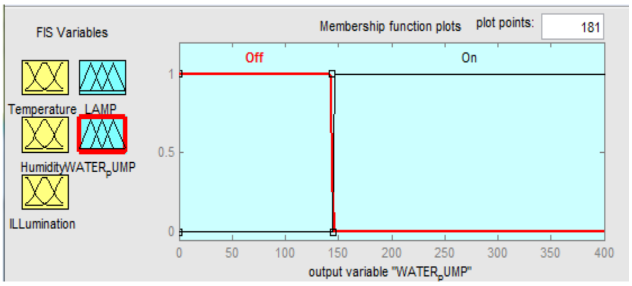

Figure-9. The output membership function of water pump.

If-then rules

The if-then rules are made in the "Rules" part of Matlab. These can be shown in Figure-10.

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1. If (Temperature is Low) and (Humidity is Dry) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is Off) (1)
2. If (Temperature is Low) and (Humidity is Normal) and (ILLumination is Dark) then (LAMP is High)(WATER_PUMP is Off) (1)
3. If (Temperature is Low) and (Humidity is Moist) and (ILLumination is Dark) then (LAMP is High)(WATER_PUMP is Off) (1)
4. If (Temperature is Low) and (Humidity is Dry) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is Off) (1)
5. If (Temperature is Low) and (Humidity is Normal) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is Off) (1)
6. If (Temperature is Low) and (Humidity is Moist) and (ILLumination is Normal) then (LAMP is High)(WATER_PUMP is Off) (1)
7. If (Temperature is Low) and (Humidity is Dry) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is Off) (1)
8. If (Temperature is Low) and (Humidity is Normal) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is Off) (1)
9. If (Temperature is Low) and (Humidity is Moist) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is Off) (1)
10. If (Temperature is Medium) and (Humidity is Dry) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is Off) (1)
11. If (Temperature is Medium) and (Humidity is Normal) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is Off) (1)
12. If (Temperature is Medium) and (Humidity is Moist) and (ILLumination is Dark) then (LAMP is High)(WATER_PUMP is Off) (1)
13. If (Temperature is Medium) and (Humidity is Dry) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is Off) (1)
14. If (Temperature is Medium) and (Humidity is Normal) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is Off) (1)
15. If (Temperature is Medium) and (Humidity is Moist) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is Off) (1)
16. If (Temperature is Medium) and (Humidity is Dry) and (ILLumination is Bright) then (LAMP is Low)(WATER_PUMP is Off) (1)
17. If (Temperature is Medium) and (Humidity is Normal) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is Off) (1)
18. If (Temperature is Medium) and (Humidity is Moist) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is Off) (1)
19. If (Temperature is High) and (Humidity is Dry) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is On) (1)
20. If (Temperature is High) and (Humidity is Normal) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is On) (1)
21. If (Temperature is High) and (Humidity is Moist) and (ILLumination is Dark) then (LAMP is Medium)(WATER_PUMP is On) (1)
22. If (Temperature is High) and (Humidity is Dry) and (ILLumination is Normal) then (LAMP is Low)(WATER_PUMP is On) (1)
23. If (Temperature is High) and (Humidity is Normal) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is On) (1)
24. If (Temperature is High) and (Humidity is Moist) and (ILLumination is Normal) then (LAMP is Medium)(WATER_PUMP is On) (1)
25. If (Temperature is High) and (Humidity is Dry) and (ILLumination is Bright) then (LAMP is Low)(WATER_PUMP is On) (1)
26. If (Temperature is High) and (Humidity is Normal) and (ILLumination is Bright) then (LAMP is Low)(WATER_PUMP is On) (1)
27. If (Temperature is High) and (Humidity is Moist) and (ILLumination is Bright) then (LAMP is Medium)(WATER_PUMP is On) (1)

Figure-10. Denoting the crisp values to inputs and outputs.

The if-then rules can be also illustrated in talbes (1-6) where every two inputs is taken with a one corersponding outputs that make up an overal 6 tables.

Table-1. Input humidity & illumination with lamp output.

	Dark	**Normal**	**Bright**
Dry	Medium	Medium	Medium
Normal	High	Medium	Medium
Moist	High	High	Medium

Table-2. Input humidity & illumination with water pump output.

	Low	**Medium**	**High**
Dry	Medium	Medium	Medium
Normal	High	Medium	Medium
Moist	High	High	Medium

Table-3. Input humidity & temperature with water pump output.

	Low	**Medium**	**High**
Dry	Off	Off	On
Normal	Off	Off	On
Moist	Off	Off	On

Table-4. Illumination & temperature with lamp output.

	Low	**Medium**	**High**
Dark	Medium	Medium	Medium
Normal	Medium	Medium	Medium
Bright	Medium	Medium	Low

Table-5. Illumination & temperature with water pump output.

	Low	**Medium**	**High**
Dark	Off	Off	On
Normal	Off	Off	On
Bright	Off	Off	On

RESULTS

In this part a set of crisp values have been applied to the fuzzy logic control system in Matlab. As illustrated in Figure-11, the values of 29.8,62,215 have been applied to the input variables of temperature, humidity and illumination. The corresponding crisp outputs of the fuzzy logic on the Lamp and Water pump is illustrated in Figure 12 that are 344 and 722, respectively.

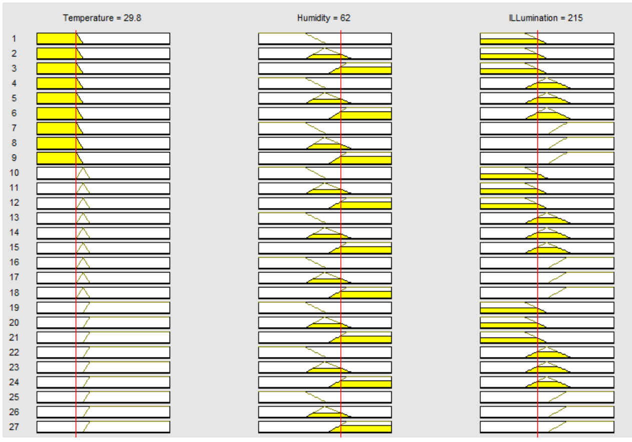

Figure-11. Denoting the crisp values to inputs.

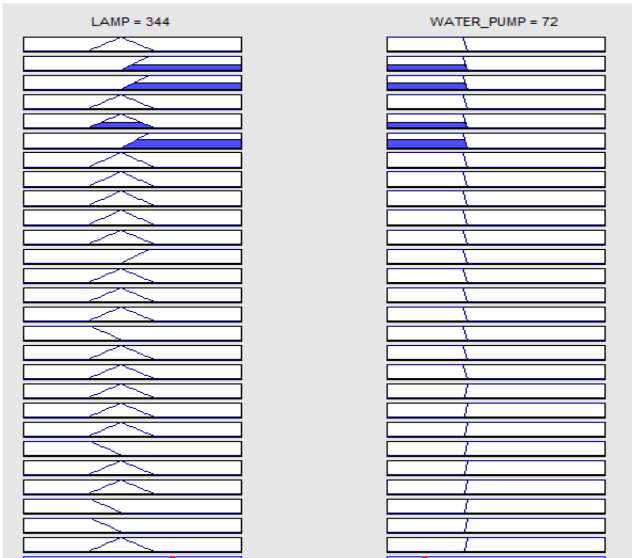

Figure-12. Observing crips values of outputs.

The illumination and temperature vs lamp level can be also seen in Figure-12.

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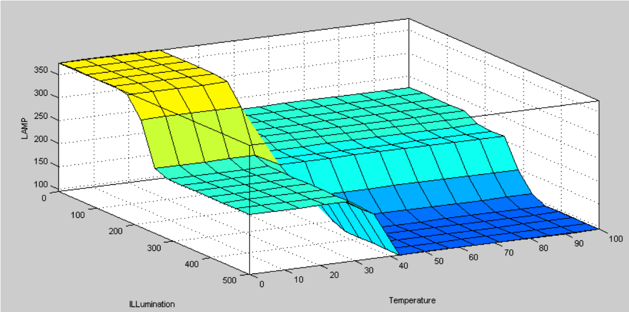

Figure-13. Temperature and illumination vs lamp level.

The illumination and temperature vs water pump have been illustrated in Figure-11 using the "Surface" rule viewer in Matlab.

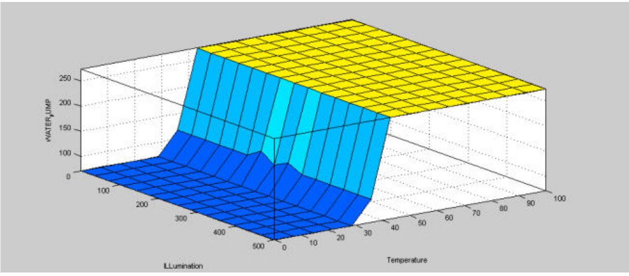

Figure-14. Temperature and illumination vs water pump.

The fuzzy logic control system has been transferred to the matlab workspace under the name "Smart Irrigation". Then the corresponding circuit diagram has been build in simulink to test the results. The three inputs multiplexer has been constructed with a two inputs multiplexer being cascaded. The inputs are being fed into the system in the forms of step functions. The order of the inputs must be same as the order of the inputs variables being constructed in Matlab. The values of 29.8, 62, 215 has been fed into the system for temperature, humidity and illumination, respectively. The outputs from the system also should keep the order when being constructed in fuzzy logic controller toolbox. The output 1 is for the variable lamp and the output 2 is for the water pump. The Simulink model can be illustrated in Figure-15.

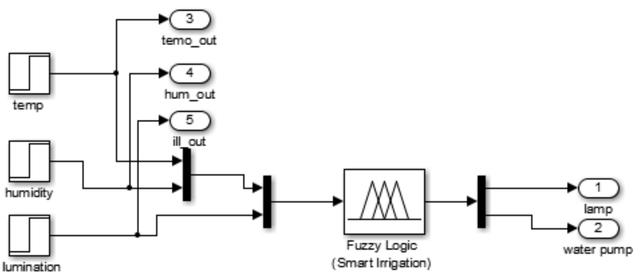

Figure-15. Testing the fuzzy logic controller in simulink.

The results of inputs vs outputs to the fuzzy logic control system is being plotted and illustrated in Figure-16.

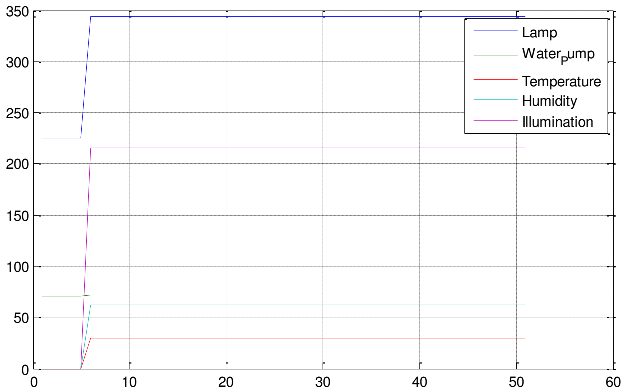

Figure-16. The result of fuzzy logic controller test in simulink.

DISCUSSIONS

As the result were elaborately described in the result section, the fuzzy logic system seems to have been simulated correctly. The rule viewer part in Matlab gave the correct deffuzification computing of the fuzzy logic control system given its crisp values. Moreover, the system was tested in Simulink using three inputs and two outputs and the same crisp result obtained in result section were found that were plotted.The values shown in Figure-16 is identical to the values obtained from the fuzzy logic controller toolbox at Figure-12 proving this fuzzy logic simulaiton to be successful.The crisp values given in Figure-12 fires the rules number 2, 3, 5, 6 that is coloured in blue. This means that the corresponding crisp value is the average of these four rules. Table-5 denotes the rules of temperature and illumination vs. the lamp output. This can be graphically viewed in Figure-13, where the low values occur if both the temperature and illuminations are high.

This relation can be viewed in Table-6 as well where the temperature and illumination vs. the water pump. It is graphically illustrated in Figure-14 that when the temperature is high, the water pump is also turned on that is the same result being put in Table-6.

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