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Simulation of SMART Shower in Terms of Mamdani and Sugeno Style Using Fuzzy Logic

Derrick J. Castillo[1*], Rionel Belen Caldo[2]

[1]*Computer Engineering Department*
Lyceum of the Philippines University- Laguna (LPU-L)

Abstract: A shower is a place in which a person bathes under a spray of, typically warm or hot, water. Most showers have temperature, spray pressure and adjustable showerhead nozzle settings. Showering is common in Western culture due to efficiency of using it when compared to a bathtub. Its use in hygiene is therefore common practice. A shower uses less water on average than a bath: 80 litres for a shower compared to 150 litres for a bath. In this paper, Fuzzy Logic is used to create an algorithm to control the mechanism of the Smart Shower. The idea of Sugeno and Mamdani is applied to the smart shower in terms of input and output of the shower wherein the output depends in the input's current condition. In this innovation, the shower depend its output water temperature to the temperature and humidity of the environment via sensors. It can detect the distance of the user to the shower itself determining the proper water output. It has also a function where you can select different modes of temperature if the user did not want the shower to depend its temperature on the sensors itself, together with different modes of water outputs whether you want a full (Level 3), medium (Level 2), or the minimal blast (Level 1) of water if the user wants to do it manually. In addition, the smart shower can record user's everyday usage determining how many gallons of water used in every bathing, the temperature you have within the weekend and the water output levels creating another mode that is based on your weekly usage. This is to save energy for the sensors itself and make it more comfortable to use.

Key Words: Shower, Fuzzy Logic, Sensors, Temperature, Humidity

1. INTRODUCTION

Nowadays, Smart devices are becoming popular. These smart devices include Smart TV's, Smart Phones, Smart Watches, Smart Tablets and all other smart devices out there today. Smart showers are one of that rising smart devices out there in this generation. According to Wikipedia, the original showers were neither indoor structure nor man-made, but were common natural formations: waterfalls. The first mechanical shower, operated by a hand pump, was patented in England in 1767 by William Feetham, a stove maker from Ludgate Hill in London. His shower contraption used a pump to force the water into a vessel above the user's head

and a chain would then be pulled to release the water from the vessel. Showers are almost and commonly found at home and hotel bathrooms. Showers can be Smart also by using different sensors and other software tools. Due to the fast changing of technologies and innovations, people are getting involved with the use of the fastest and easiest way to make a reliable and new design of technology that will benefit all of its users together with the environment as the proponent is also concerned at the environment. One of this is the use of a sensor that uses fuzzy logic to control electronic systems. Fuzzy Logic is a flexible, programmable and easy to modify system algorithms. Unlike in a normal sensor, if the innovator wants to improve the design, he/she needs to remake the whole system again with his/her modifications applied. In Fuzzy Logic, the innovator just needs to reprogram the system [1] [2].

Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1. By contrast, in Boolean logic, the truth values of variables may only be 0 or 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions [2].

In this paper, the proponent used a new approach to design a Fuzzy Logic Based Smart Shower. The Fuzzy Logic has concept of getting and acquiring the output from the current input or state. The output temperature and water level of blast will base on the input temperature and humidity provided by the sensors. Fuzzy Logic will be used in order to create an algorithm for this system. The Smart Shower will record user's everyday usage determining how many gallons of water are you using, the temperature you have within the weekend and the water output levels creating another mode that is based on your weekly usage. This is to save energy for the sensors itself and make it more comfortable to use.

1.1 Statement of the Problem

There is in need of a Smart Shower to identify the temperature and humidity of the environment. The problem of the study also comprises the following:

- Accuracy and measurability of the system
- Reliability and flexibility of the machine
- Consistency and dependability of the mechanism.

1.2 General Objectives

- To simulate a Smart Shower that can identify the temperature, humidity and distance of the user using Fuzzy Logic.

Specific Objectives:

- To save energy and water usage.
- To develop a system that can deliver optimum desired temperature of a human body in every season
- To achieve a green and environmental – friendly system.
- To test the accuracy, reliability, measurability, and flexibility of the system

2. METHODOLOGY

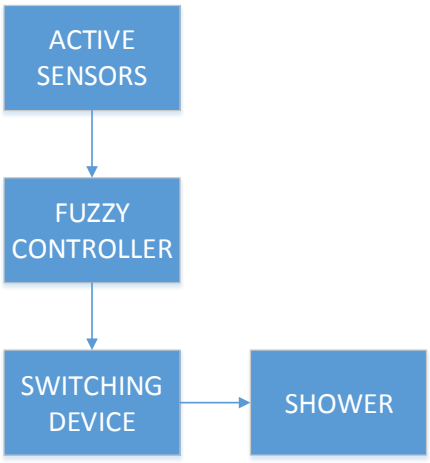

Figure 1. Over all operation of the system

The overall operation of this project is shown in Figure 1. The first process will be based on the measurements of temperature, humidity and the

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distance of the user to the shower by the sensors. After that, the fuzzy controller will make the decision based on the If-Then rules. Then if the fuzzy controller have its parameters set for the operation, it will deliver signals to the switching device to apply the parameters for the expected output. The If-then Rules will be shown by the figure below. The sensors for the distance will be active to monitor real time distance of the user (Mahbob et al., 2009).

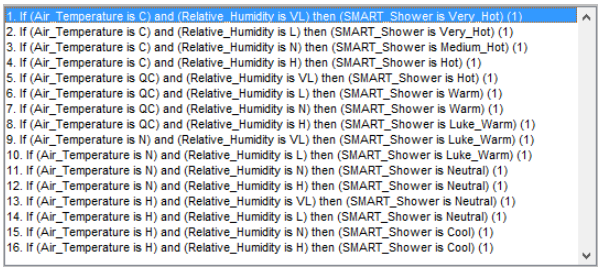

Figure 2. If-Then rules of Temperature and Humidity using fuzzy logic

Every fuzzy logic system must have a rule base. In this figure, the If-Then Rules is stimulated using Fuzzy Logic. The simulations of Temperature and Humidity is applied with sugeno Style and the labels of each terms above is specified as: In terms of temperature: C-"Cool", QC-"Quite Cold", N-"Normal", H-"Hot". In terms of humidity: VL-"Very Low", L-"Low", N-"Normal", H-"High"(Hasim et al., 2011).

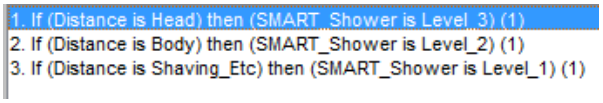

Figure 3. If-Then rules using fuzzy logic

Figure 3 shows the If-Then rules in terms of the distance of the user to the shower using Fuzzy Logic, The simulations of the distance is applied with Mamdani Style. The water output or the water blast of the shower will always depends on this function to be able to save energy and water. It has three levels, Level 1 is at only 40%, Level 2 is at 70% and Level 3 is at 100% or full blast. The distance is based at the original size of a regular bathtub (55 inches). Head distance is from 0 to 12 inches, Body distance is from 12 inches to 22 inches, and Shaving and Etc. is from 22 inches to 55 inches. The terms of modes in terms of distance are also have its description, Head Distance, where the user is rinsing his/her head, proving 100% full blast, Body Distance, where the user washes his/her body, providing a 70% blast and lastly, the Shaving Etc., where the user is able to do their things without having disturbance from the showing proving only 40% water blast [3].

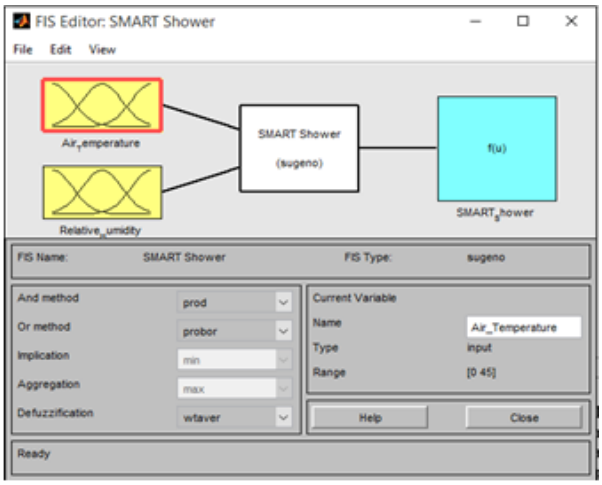

Figure 4. Simulation of of Temperature and Humidity using fuzzy logic – sugeno style

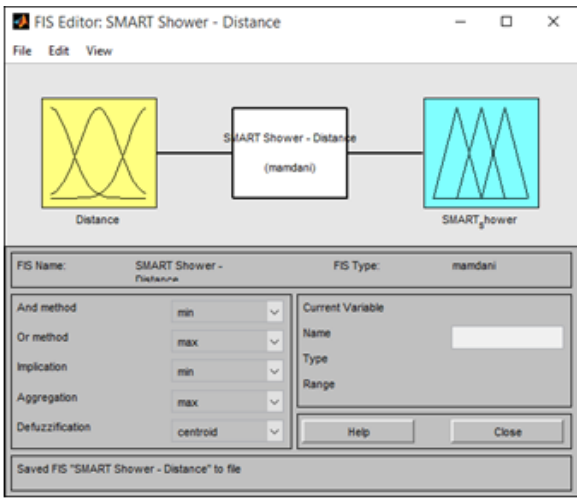

Figure 5. Simulation of Distance of user from the SMART Shower using Fuzzy Logic – Mamdani style

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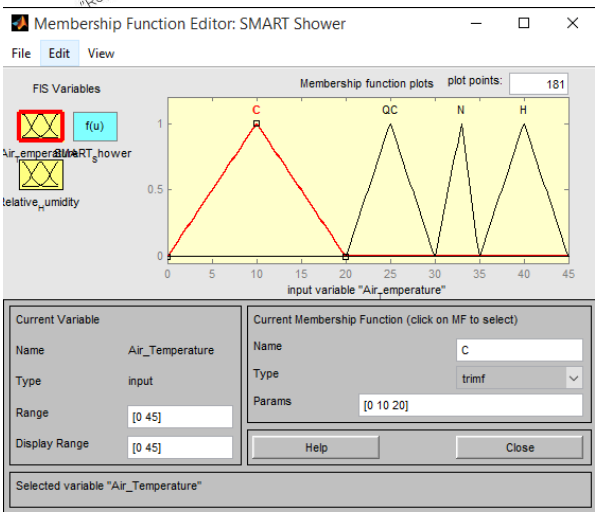

Figure 6. Membership functions of the Temperature of the SMART Shower using fuzzy logic – Sugeno style

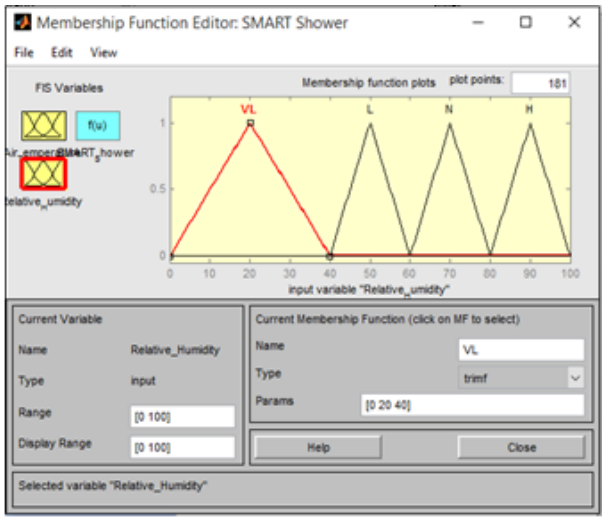

Figure 7. Membership functions of the Humidity of the SMART Shower using Fuzzy Logic – Sugeno style

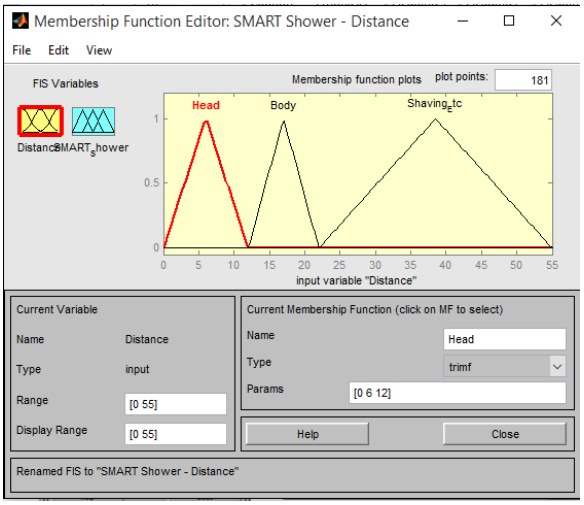

Figure 8. Membership functions of the Distance of user from the SMART Shower using fuzzy logic – Mamdani style

4. SPECIFICATION OF CIRCUITS AND MODES

Table 1. Temperature levels of the modes

MODES	**TEMPERATURE** (DEGREE CELCIUS)
Very hot	37
Medium hot	34
Hot	32
Warm	30
Luke warm	28
Neutral	OFF (based of faucet temp.)
Cool	21

The table above shows the different water temperatures that are acceptable by the human body. It has different modes of temperature to obtain the best temperature for every situation given to the system [4].

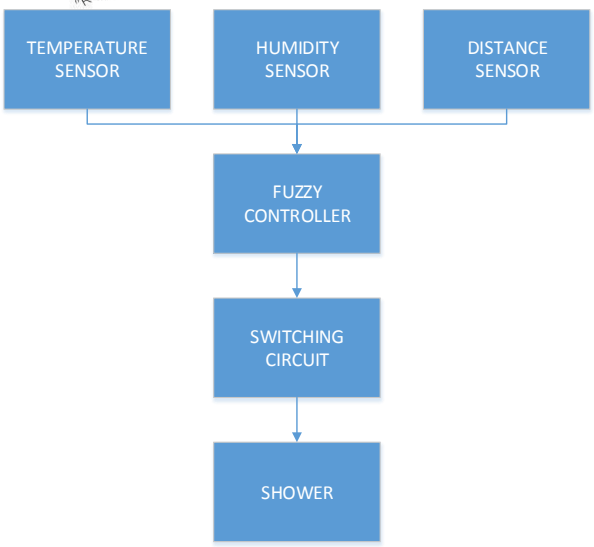

Figure 9. Overall circuit connection

Figure 8 shows the overall circuit connection of the sensors to the machine itself. Three sensors are used to make this project possible: the Temperature, Humidity and Distance sensors.

4. RESULTS AND DISCUSSIONS

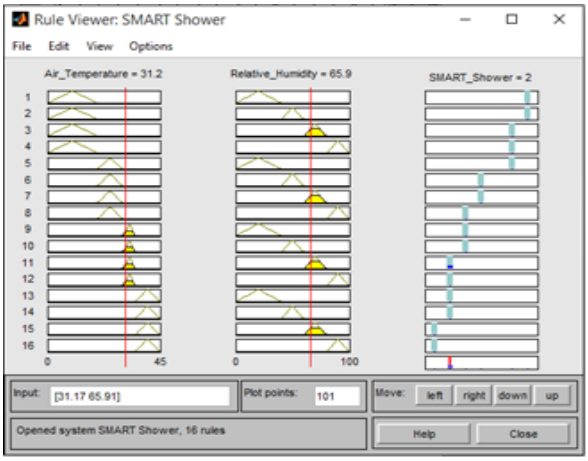

Figure 9. Sample simulation of Temperature and Humidity using fuzzy logic – Sugeno style

In figure 9, the sample simulation of temperature and humidity is shown from the rule editor of the fuzzy logic, in the figure, the temperature is about 31.2 degrees Celsius and about 65.9% relative humidity. When the humidity is above 50%, it was expected to affect to the feeling of the user makes the feeling hotter. So, the output temperature of the smart shower is Neutral, and will be based on the temperature of the faucet [5].

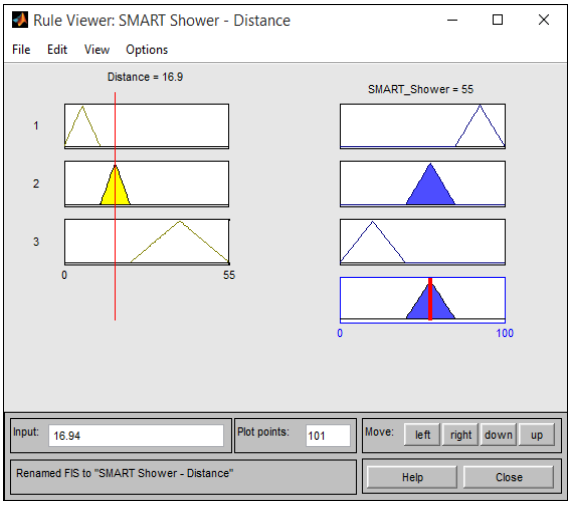

Figure 10. Sample simulation of distance of the user to the SMART shower using Fuzzy Logic – Mamdani style

In figure 10, the sample simulation of Distance of the user to the SMART Shower is shown from the rule editor of the fuzzy logic. In the figure, the distance of the user form the shower is 16.9" and it is recognized by the SMART Shower as a Body Distance therefore, SMART Shower will be only at Level 2.

Trials	Temperature	Humidity	SMART Shower Temp	Linguistic Calculation
1	36.5	69.50%	1	Cool
2	22.9	20.50%	6	Medium Hot
3	31.2	83.20%	2	Neutral
4	16.3	44.10%	7	Very Hot
5	23.3	47.10%	4	Warm
6	32	45%	3	Luke Warm
7	8.05	37.70%	7	Very Hot
8	19.6	65%	6	Medium Hot
9	30	51.40%	2	Neutral
10	27.5	17.70%	6	Medium Hot

Table 2. Sample Simulations with SMART Shower outputs of different Temperature Levels and Humidity

Table 2 is indicating different sample Temperature levels together with the Humidity were done using the Rule Viewer of the fuzzy logic. It shows that the outputs indicated are acceptable to the expected outputs. Therefore, the parameters set to the SMART Shower are well arranged and accurate.

Trials	Distance (inches)	SMART Shower Blast	Linguistic Classification
1	6.54	85	Level 3
2	17.3	55	Level 2
3	28.5	20	Level 1
4	44.4	20	Level 1
5	19.3	55	Level 2

Table 3. Sample simulations with SMART shower blast output of different Distances.

Table 3 is indicating a different sample distance was done using the Rule Viewer of the fuzzy logic. It shows that the outputs indicated are acceptable to the expected outputs. Therefore, the parameters set to the SMART Shower are also well arranged and accurate.

5. CONCLUSION

An approach for simulation of SMART Shower in terms of Mamdani and Sugeno style using fuzzy logic was developed. It was found that the most important thing in this project is its sensors; all of the inputs of the SMART Shower will always depend on the inputs of the sensors. The sensors should be always well maintained to obtain accurate measurements and outputs for the SMART shower. In the future, it is recommended to use an ultrasonic sensor to get more accurate measurements and make the system more innovative in line with its concept design. Besides that, Wi-Fi connectivity can also be added to the SMART Shower to provide weekly record fast via Internet.

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