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Prediction of Flood Detection System: Fuzzy Logic Approach

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Abstract: This paper presents the fuzzy logic approach for flood detection system in order to assist in providing early warning to consumers about the possibility of flooding. Therefore, the main purpose of this study is to investigate the relationship between water level and climate condition, and to evaluate how fuzzy logic expert system plays an important role in prediction of flood detection system. In this paper, a fuzzy logic expert system model, based on Mamdani approach, is developed to predict the flood detection in terms of control action. Verification of the developed system is carried out through theoretical, simulation and experimental data.

Keyword: Flood detection, Fuzzy logic, Water Level.

I. INTRODUCTION

Flood Hazard is a phenomenon or event that gives rise to a threat or danger to humans. Therefore, the flood detected system is developed in order to resolve the existing problems that occur from floods. When the water rises, circuit sends signal to the system. The system also prevents short circuits which can cause fire or electric shock to the residents who are concerned saving their property and important documents from damage due to flooding. For this study, a prototype has been made that could be based on by changing it as a resident area. Several experiments have been carried out providing water to show the water rises till the level that contributes a signal to the circuits. Four fundamental units such as fuzzification unit, the knowledge base (rule base), the inference engine and defuzzification unit are necessary for the successful application of fuzzy modeling approach. This work presents the construction of fuzzy knowledge-based model using if-then rules for the prediction of flood detection system based on Mamdani approach.

II. EXPERIMENTAL PROCEDURE

Figure 1 illustrates the basic components of flood detection system. The system is comprised of distribution fuse box, GSM modem, transmitter box, electronics box, and receiver box respectively. Flood detection system design is divided into two parts: the first stage and second stage. The first stage is designed to give early warning that the flood has come. Software design is divided into three sections, namely the sending, receiving and sending a short message to the persistent phone number using GSM modem. While the hardware design is divided into two: transmit and receive circuits. The second and third level is designed to cut off power supply into the miniature circuit breaker (MCB). Electronic circuits are used to cut off the electricity supply in case of emergency. Hardware circuit is designed using the Protel 99 SE software.

Figure 1: Flood Detection System

III. FUZZY LOGIC EXPERT SYSTEM

Fuzzy logic expert system (FLES) generally comprises four principal components (K.M. Passino, 1998- M. Gopal, 2009). They are: Fuzzification, Rule, Inference-which creates the control actions and Defuzzification. For implementation of fuzzy values into the system, water level (WL) and climate condition (CL) are used as input parameters and control action (CA) is used as output. For fuzzification of these factors the linguistic variables very low (VL), low (L), low medium (LM), medium (M), high medium (HM), high (H) and very high (VH) are used for the inputs. While for control action (CA), the linguistic variables are S1 (started action for flood situation), S2 (started flood alarm system), S3 (send SMS to user stating that flood is detected), S4 (MCB supply disconnected), and S5 (MCB disconnected and emergency light switches on) are used for the output. In this study, a Mamdani max-min inference approach and the center of gravity defuzzification method have been used because these operators assure a linear interpolation of the output between the rules (K. Carman, 2008). For the input and output parameters, a fuzzy associated memory is formed as regulation rules. Total of 25 rules have been formed. Parts of the developed rules are shown in Table 1.

Table 1: Inference rules of controller parameters

Linguistic variables	Type	Coefficients (degree)		
		c_1	c_2	C3
VL	Z-shaped	0	3	-
L	Triangular	0	3	6
M	Triangular	3	6	9
H	Triangular	6	9	12
VH	S-shaped	9	12	-

Several options of rules bases of different sizes are studied for the input variables under consideration. The coefficients of membership functions for the fuzzy inference system (FIS) parameters are given in Table 2-4.

Table 2: Coefficients of membership functions for FIS parameter of WL

Rules	Input variables		Output variable
	WL	*CL*	*CA*
1	VL	VL	S1
-----	-----	-----	-----
5	VL	VH	S2
-----	-----	-----	-----
14	M	H	S3
-----	-----	-----	-----
20	H	VH	S4
-----	-----	-----	-----
25	VH	VH	S5

Table 3: Coefficient of membership functions for FIS parameter of CL

Linguistic variables	Type	Coefficients (degree)		
		c_1	c_2	C3
VL	Z-shaped	0	300	-
L	Triangular	0	300	600
M	Triangular	300	600	900
H	Triangular	600	900	1200
VH	S-shaped	900	1200	-

Table 4: Coefficients of membership functions for FIS parameter of CA

Linguistic variables	Type	Coefficients		
		c_1	c_2	c_3
S1	Z-shaped	0	0.25	-
S2	Triangular	0	0.25	0.5
S3	Triangular	0.25	0.5	0.75
S4	Triangular	0.5	0.75	1
S5	S-shaped	0.75	1	-

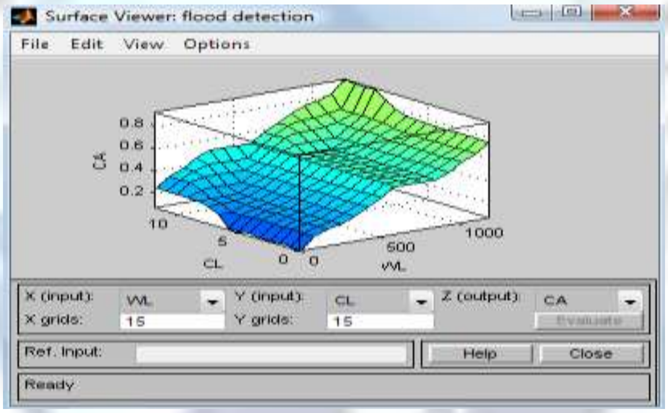
This conversion of a fuzzy set to single crisp output in order to take action is called defuzzification. In this stage, the output membership values are multiplied by their corresponding singleton values and then are divided by the sum of membership values to compute .

$$CA^{crisp} = \frac{\sum_i b_i \mu_{(i)}}{\sum_i \mu_{(i)}} \qquad (1)$$

where b_i is the position of the singleton in the i th universe, and $\mu_{(i)}$ is equal to the firing strength of truth values of rule i.

IV. RESULT AND DISCUSSION

The Figure.5 shows the output variable "CA" is developed from the corresponding rules base against its two inputs of WL and CL. The surface plot depicts the impacts of the flood detection parameters.



X (input): WL
X grids: 15
Y (input): CL
Y grids: 15
Z (output): CA
Ref. Input:
Ready

Figure 5: Control surfaces of the fuzzy inferring system

The validation of the developed system in this study has been carried out by making comparison between theoretical, simulation and experimental data. The first stage; the analysis made in the time taken for the transmission of short messaging system (SMS) to the users. Results of the theoretical calculations are displayed in graphical form as shown in Figure 6. From the graph, it can be stated that the arrival time depends on the quantity used character. Many characters are used, so a lot of time to be taken into consideration.

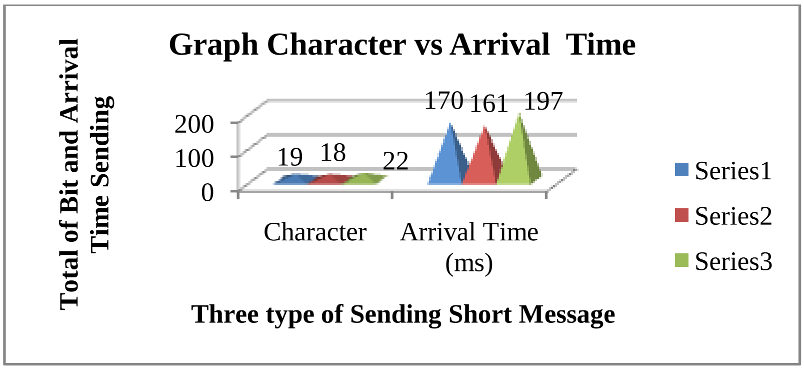


Figure 6: Graph output of quantity character vs. arrival times

For the second and third stages, the analysis has been made in two conditions: without water and with water. Each state is developed with three sections: theoretical, simulation and practical. The simulation result has been obtained using MULTISM software and the output voltage readings have been taken from the multi-meter. Resistance of multi-meter is set by the user. On the other hand, the practical results have been obtained based on the readings taken from a digital multi-meter and the resistance is set by the factory. The overall results from three analyses are shown in Figure 7. From the laboratory experiment, it has been observed that the microcontroller successfully continuously has sent the SMS. The use of SMS, however, shows some delay at certain busy hour time, due to the unavailability and traffic busy of GSM network. From the results it can be concluded, that by using the minimum input voltage of the circuit, it can disconnect the incoming voltage at the MCB. Moreover, the resulting circuit is functioned according to the desired level.

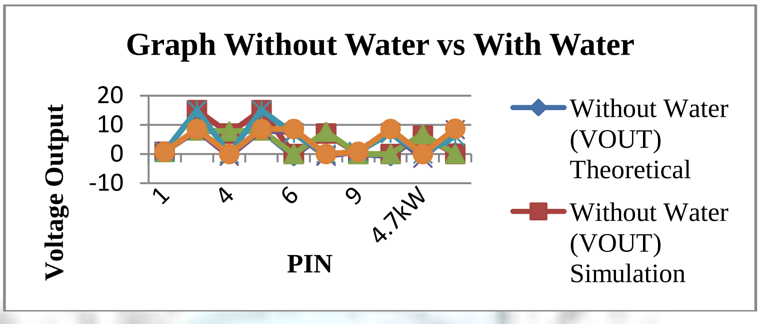


Figure 7: Variation of voltage output with the variation of PIN positions

V. CONCLUSION

Prediction of system performance is necessary for environmental applications as well as water researches. The results indicate that there is less variability of the measured data and simulated data of the flood detection system. However, the conclusions drawn from this study are as follows:

(a) The developed prototype flood detection system indicates three short messaging services (SMS) in three conditions: during the system activate, the flood occur, and safety level.
(b) The developed system could detect the increase in water level due to and cut off sources of electricity in the house successfully.
(c) The prototype hardware and software interface are also proven to be integrated successfully based on the ability of the microcontroller to communicate and control the overall system operation.

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