Implementation Of Automatic Wiper Speed Control And Headlight Modes Control Systems Using Fuzzy Logic

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Abstract: This research paper describes the design and simulation of the automatic wiper speed and headlight modes controllers using fuzzy logic. This proposed system consists of a fuzzy logic controller to control a car's wiper speed and headlight modes. The automatic wiper system detects the rain and its intensity. And, according to the rain intensity, the wiper speed is automatically controlled. Headlight modes automatically changes either from low beam mode to high beam mode or form high beam mode to low beam mode depending on the light intensity from the other vehicle coming from the opposite direction. The system comprises of PIC, impedance sensor, piezoelectric vibration sensor, LDR, headlamps and a DC motor to accurate the windshield wiper. Piezoelectric sensor is used to detect the rain intensity which is based on the piezoelectric effect. MATLAB software is used to achieve the designed goal.

Keywords: Fuzzy Logic, Impedance Sensor, Piezoelectric Sensor, Piezoelectric Effect

I. INTRODUCTION

A driver's safety and comfort level is the essential facts in manufacturing modern vehicle of automobile industry. However, in modern days, the accidents are most common in commercial vehicles. These accidents are caused due to human errors, road designs, poor visions and physical impairments of vehicle. Among them, one of the most traffic accidents is due to the poor visions, and it gives a distraction on the main task of driving. In bad weather conditions such as heavy rain, snow, fog and so on, the driver cannot see the front view well due to the rain drops, fog and snow. At that time, wiper is an essential component to wipe rain drops or any debris from the vehicle's windscreen. And, the headlight is a very useful device during night travel. But, when the drivers use the high bright beam, it causes a discomfort to the person travelling from the opposite directions. When this beam falls on a person, it glares him for a certain amount of time because our eyes are exposed to a very bright light source of around 10000 lumens [5]. When he uses the high intense beam in heavy rain condition, the light will reflect to him. And then, he can also get the glare. As a result, he can undergo road accidents. To avoid this problem, the drivers must change the high beam to low beam mode. But, the wiper actuation and the headlight modes switch have to be controlled by the driver himself. So, the drivers cannot focus on their primary task of driving. So, this could lead to car accidents on our roads.

II. SYSTEM DESCRIPTION

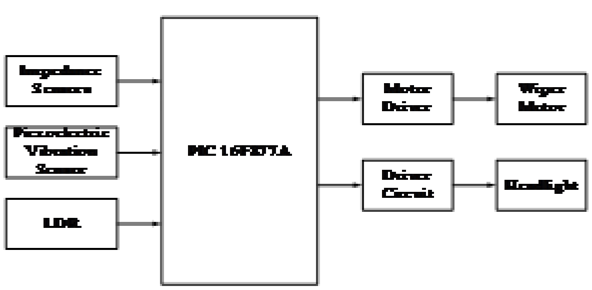


Fig.1 *Block Diagram of the Proposed System*

The overall system configuration is shown in figure 1. There are two main sections in this system: (1) an automatic wiper speed control system, and (2) an automatic headlight modes control system. In the wiper system, an impedance sensor is used to detect whether it is raining or not. To sense the rain intensity, a piezoelectric vibration sensor is used. This sensor is based on the piezoelectric effect. According to the signals getting from these two sensors, the controller decides the raining condition, and it drives the wiper at a low speed or at a high speed depending on the rain intensity. The headlight modes control system will operate depending on the rain condition and the light intensity from the other vehicles coming from the opposite direction. For this system, LDR is used to sense the light intensity. This system automatically switches the high beam mode into low beam to reduce the glare effect by sensing the approaching vehicle. Therefore, these two systems also eliminates the requirement of manual control by the driver which is not done at all times

A. Piezoelectric Sensor

It is a device that measures the pressure, acceleration, strain or force by using piezoelectric effect. And, it convert them to and electrical charge. When pressure (stress) is applied to a piezoelectric material, it vibrates and an AC voltage is produced. This effect is reversible. When a voltage is applied across the two sides of a piezoelectric material. This effect called "Piezoelectric effect".

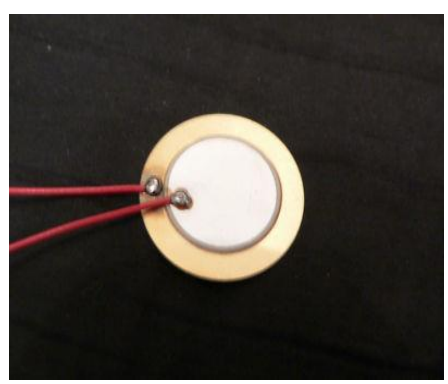


Fig. 2 *Piezoelectric Sensor [3]*

The generated voltage from a piezoelectric material can be calculated from the following equation.

$$V = S_v \times P \times D$$

Where V = Piezoelectric generated voltage (Volts)

S_v = Voltage sensitivity of the material (Volt *meters / Newton)

P = Pressure (N/m2)

D = thickness of material (meters)

Voltage sensitivity values are provided with the material when received from the manufacturer. Different materials and different geometry cuts give different sensitivities.

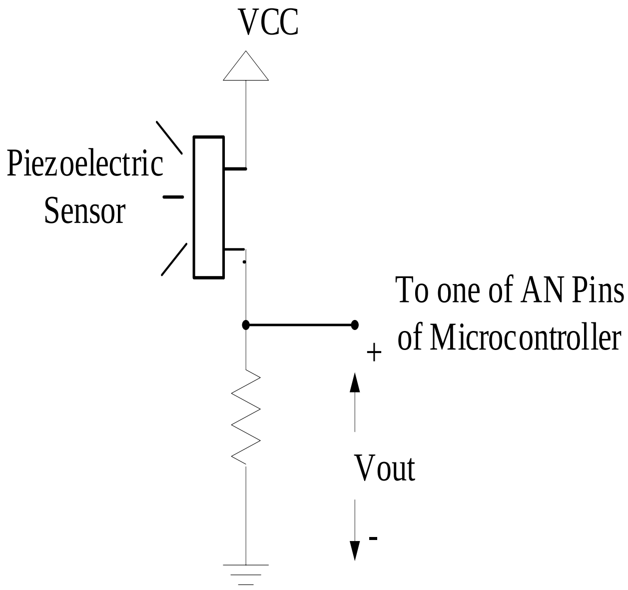


Fig. 3 *Vibration Sensing Circuit*

Fig. 3 is the vibration sensing circuit. It is uses as a rain intensity sensing one by using the piezoelectric effect. Depending on the rain intensity, there is a different voltage drop on the resistor. For example, due to the heavy rain, the sensor will vibrate more and there is a more voltage drop on the resistor.For testing this circuit, the water from the tap is poured on the sensor by opening the tap instead of the rain intensity. Then, there is a voltage drop on the resistor, and these voltages are recorded.

Table 1. *Voltages Generated by the resistor*

Rain Intensity	No Rain (tap is closed)	Raining (tap is opened little)	Heavy Rain (tap is opened more)
Voltage drop on resistor	0	0.12-0.18	0.19-0.25

B. LDR

It is a device that can detect the light. Its resistance varies according to the amount of light that falls on it. When the light level is low the resistance of the LDR is high. The relationship between the resistance R_{LDR} and the light intensity **Lux** for a typical LDR is

$$R_L = 500/ \text{Lux } K\Omega$$

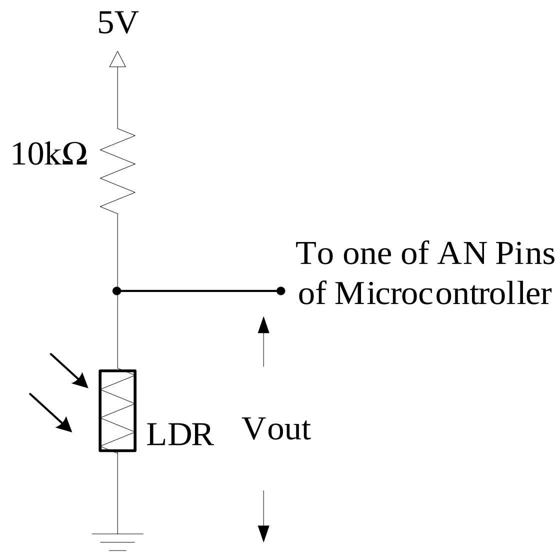


Fig. 4 *Light Intensity Sensing Circuit*

With the LDR connected to 5V through a 10KΩ resistor, the output voltage of the LDR is

$$V_{out} = 5 \times R_L / (R_L + 10)$$

Reworking the equation, the light intensity is obtained.

$$\text{Lux} = (2500/\text{Vout} - 500)/ 10$$

III . DESIGN PROCEDURE

In this paper, a fuzzy control algorithm is used to control the wiper speed depending on the rain intensity, and to change the headlight modes according to the light intensity from the other vehicles coming from the opposite direction. A fuzzy controller consists of three parts: Fuzzification, Fuzzy Logic Rule Base, and De-fuzzification.

Fuzzification: Converting the physical values of the current process signal, the error signal.

Rule-Base: A group of rules may use several variables both in the condition and the conclusion of the rules.

De-fuzzification: Converting all the fuzzy terms created by the rule base of the controller to crisp terms (numerical values).

A. Fuzzifier

Wiper Speed Control System

Fig. 6 shows the membership functions of the fuzzy input and output variables for the wiper speed. The membership functions for the raining are defined as No Rain and Raining while those for the rain intensity are defined as Drizzle, Raining and Heavy in fig. 6 and 7 respectively. And, the membership functions for the wiper speed are defined as Off, Low and High in fig. 8.Raining and Rain Intensity are measured in Volts. Table.1 shows the fuzzy logic rule base for the wiper speed control system.

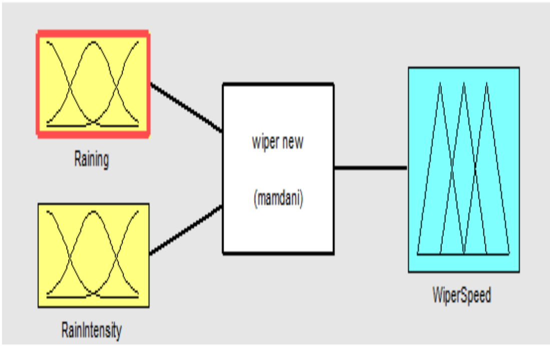


Fig. 5 *FIS Editor of Fuzzy Logic Controller for Wiper Speed Control*

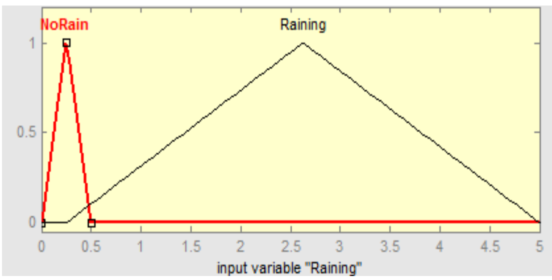


Fig. 6 *Membership Functions of FLC for Raining*

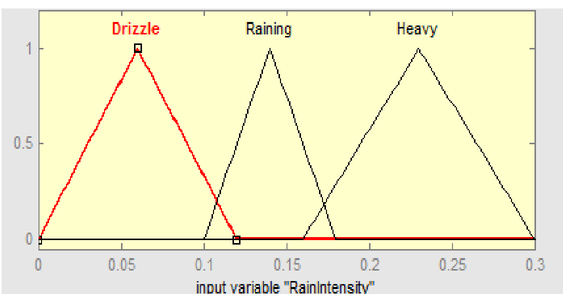


Fig. 7 *Membership Function of FLC for Rain Intensity*

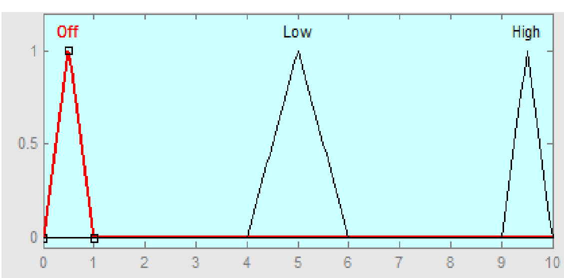


Fig.8 Membership Function of FLC for Wiper

Headlight Modes Control System

In this system, the system fuzzy sets S (Satisfactory), JA (Just Acceptable) and UB (Unbearable) are assigned to the light intensity. And, the linguistic variables for the headlight modes are defined as LBM (Low Beam Mode) an HBM (High Beam Mode). Light Intensity is also measured in Lumens. The rule matrix representation for this system is shown in table 2.

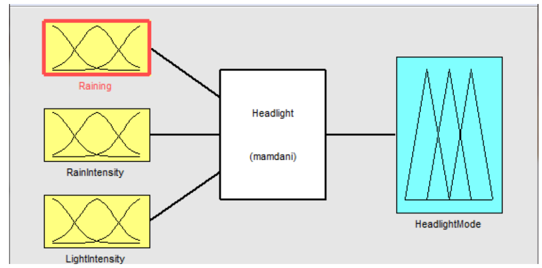


Fig. 9 *FIC Editor of Fuzzy Logic Controller for Headlight Modes Control System*

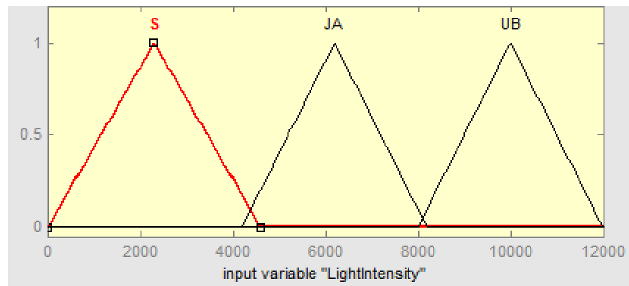


Fig. 10 *Membership Function of FLC for Light Intensity*

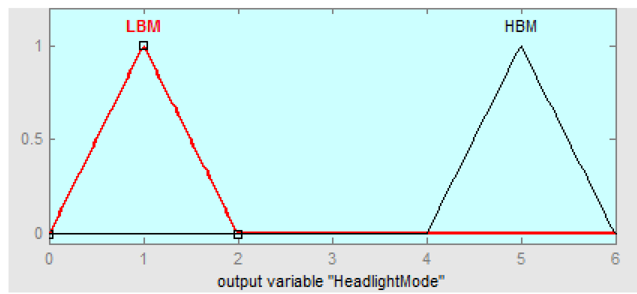


Fig. 11 *Membership Function of FLC for Headlight Modes*

B. Rule Base

Table 2. *Rule Base for Wiper Speed*

Raining/ Rain Intensity	Drizzle	Raining	Heavy
No Rain	Off	Off	Off
Raining	Low	Low	High

Table. 3 *Rule Base for Headlight Modes*

NO.	INPUTS			OUTPUTS
	IF (Raining)	IF(Rain Intensity)	IF(Light Intensity)	THEN(Headlight Modes)
1	No Rain	Drizzle	S	HBM
2	No Rain	Drizzle	JA	HBM
3	No Rain	Drizzle	UB	LBM
4	No Rain	Raining	S	HBM
5	No Rain	Raining	JA	HBM
6	No Rain	Raining	UB	LBM
7	No Rain	Heavy	S	HBM
8	No Rain	Heavy	JA	HBM

9	No Rain	Heavy	UB	LBM
10	Raining	Drizzle	S	HBM
11	Raining	Drizzle	JA	HBM
12	Raining	Drizzle	UB	LBM
13	Raining	Raining	S	HBM
14	Raining	Raining	JA	LBM
15	Raining	Raining	UB	LBM
16	Raining	Heavy	S	LBM
17	Raining	Heavy	JA	LBM
18	Raining	Heavy	UB	LBM

C. Fuzzification
Select two input variables of fuzzification process from the wiper speed control system to show how fuzzification is done in both the two systems.

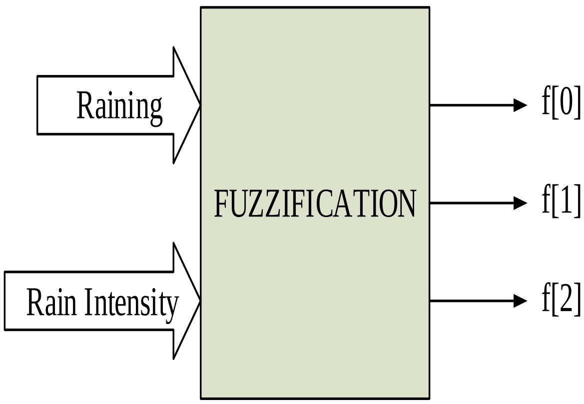


Fig. 12 *Fuzzifier Block*

Table 4*. Result of Fuzzification*

Input Variables	Values	Region Selection	Fuzzy Set Calculation
Raining	x = 4.01	0.25< x <5	f0 = (5-4.01)/(5-2.625) = 0.42
Rain Intensity	x = 0.11	0.1< x < 0.18	f1 = (0.12-0.11)/(0.12-0.06) = 0.17 f2 = (0.11-0.1)/(0.14-0.1) = 0.25

D. Inference Engine
The inference engine accepts three inputs from the fuzzification process, and involves two AND operators. It is used to select minimum input value for the output. To get the output (R), the max-min composition is used.
R0 = f0 ^ f1 = 0.17 R1 = f0 ^ f2 = 0.25

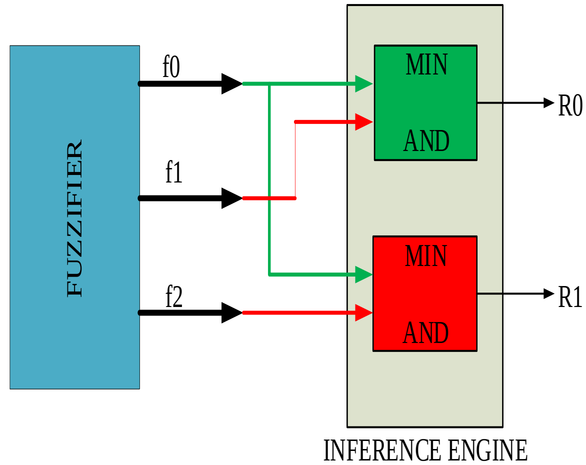


Fig. 13 *Block Diagram of Inference Engine*

E. Rule Selector
Two crisp values of raining and rain intensity accepted by the rule selector. This gives singleton values of output functions under algorithm rules applied on the design model. To find the corresponding singleton values (S0 and S1), two values are listed in table 5.

Table 5. *Illustration of Rules for the Applied Modes*

Rule No	Inputs		Singleton Values of Outputs	Singleton Values
	Raining	Rain Intensity	Wiper Motor Speed	
1	Raining	Drizzle	Low = 5	S0
2	Raining	Raining	Low = 5	S1

F. Defuzzification
After estimating its input, the defuzzification process provides the crisp value outputs [6]. Two values of R0, R1 from the outputs of inference engine and two values of S0, S1 from the rule selector are inputs of defuzzifier. Defuzzifeir uses the center of gravity (COG) is used to estimate the crisp value output.

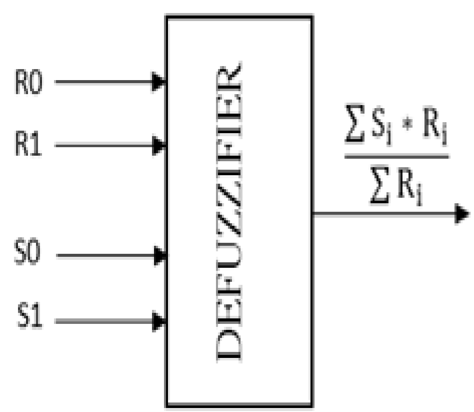


Fig. 14 *Rule Base*

Fig. 15 *Block of Defuzzification*

IV. RESULTS AND DISCUSSION

The design values for two outputs is shown in fig. 16. According to the results of inference engine:

$\sum Ri = R0+R1 = 0.17+0.25 = 0.42$

Table 6. *Design Value for Wiper Speed*

i	Ri	Si	Ri*Si
0	0.17	5	0.85
1	0.25	5	1.25

$\sum Si*Ri = 2.1$

$\sum Si*Ri/\sum Ri = 2.1/0.42 = 5$

V. SIMULATION RESULT OF FUZZY LOGIC CONTROLLER

The results of the simulation of fuzzy logic based wiper speed control and headlight modes control are shown is fig. 12 and 13 respectively. For the wiper speed control system, the two FLC inputs Raining and Rain Intensity are 4.1 and o.11 respectively. So, it is in both a drizzle and raining conditions. Therefore, the FLC output, Wiper Speed, is 5. It means that the controller drives the wiper at a low speed.

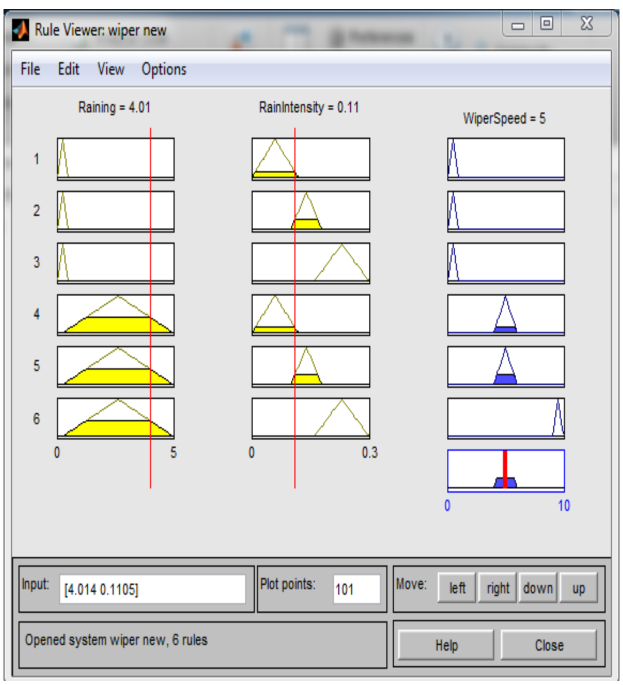


Fig. 16 *Rule Viewer of FLC for the Wiper Speed Control System*

For the headlight modes control system, Raining is defined 2.5, and Rain Intensity is defined 0.15, and Light Intensity is defined 6000. So, this is a raining condition and the light intensity is just acceptable. Then, the FLC output is 1. So, the controller automatically switches from high beam modes to low beam mode.

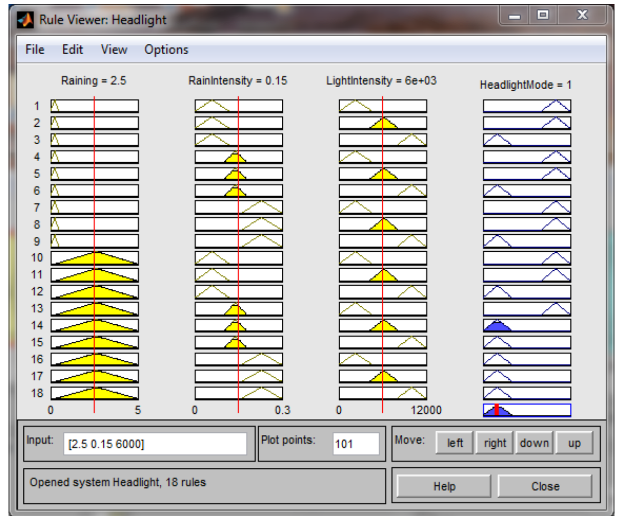


Fig. 17 *Rule Viewer of FLC for the Headlight Modes Control System*

Table 7*. Comparison of calculated and simulated results.*

Result	Wiper Speed
Design Value	5
MATLAB Simulation	5
% error	0

The surface viewer of FLC for simulation results are shown in fig. 18.

(a)

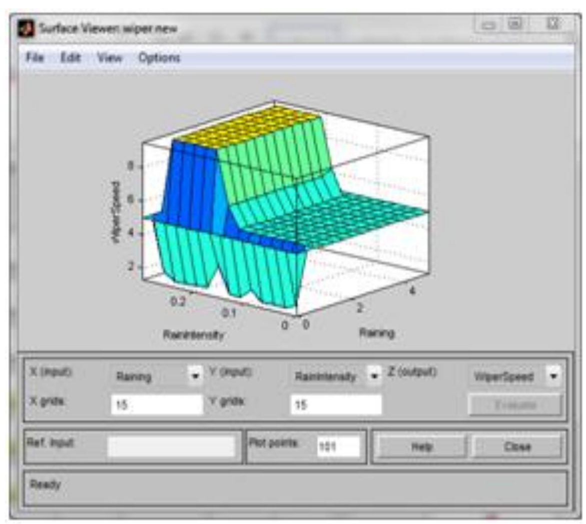


Fig. 18 *Surface Viewer (a) Wiper Speed Control System;*

(b) Headlight Modes Control System

The checking with MATLAB command box for FLC of the two systems is shown in fig. 19.

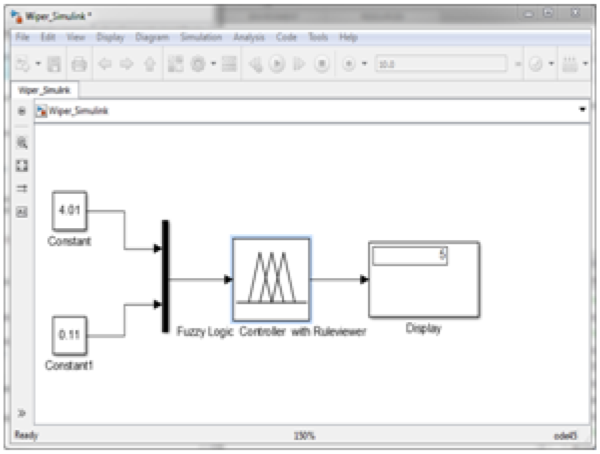
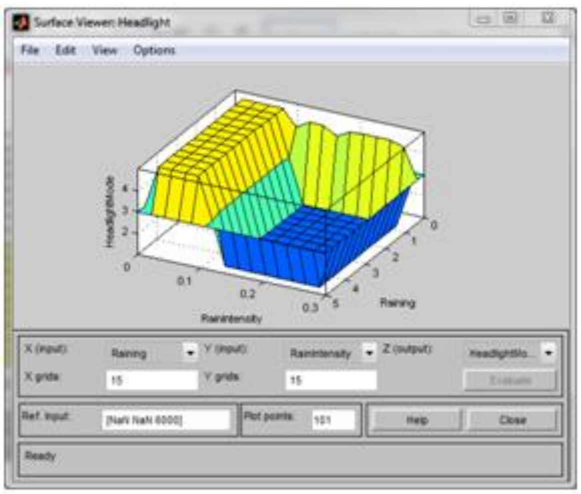


Fig. 19 *Checking with MATLAB Box (a) Wiper Speed Control System; (b) Headlight Modes Control System*



(b)

VI. CONCLUSION

The system will operate automatically without manual action of human beings. The drives do not need to focus on wiper speed, intensity of headlamp and collision. The system will give a new dimension of comfort and aid to the drivers who work during rains at night and traffic prone areas. So, the drivers can more concentrate on the basic ABC(accelerator, brake and clutch) of driving. Therefore, this system can provide the safety to drivers. So, this system is very useful for drivers, and improves drivers' comfort level. The whole system is based on the fuzzy logic control. FIS editor of Matlab fuzzy logic controller is used to obtain the rule viewer and surface viewer.

REFERENCES

[1] Mr. Anil G. Bansode, Prof.S.O. Rajankar and Dr. M. G.Ghatule, "Design and development of smart automatic windshield wiper system: fuzzy logic approach", International Journal of Engineering and Science, Vol.1, Issue 1, PP 14- 20, August 2012

[2] Mrs. Niraimathi.S, Dr. Arthanairee A.M, Mr. M.Sivaakumar, "A Software and a Hardware Interface for Reducing the Intensity Uncertainties Emitted by Vehicular Headlight on Highways", International Journal of Innovative Technology and Creative Engineering, Vol. 1, No 11, November 2011.

[3] Shantanu Dharmadhikari, NaeemTamboli, NileshGawali, Prof. N. N. Lokhande, "Automatic Wiper System", International Journal of Computer Technology and Electronics Engineering, vol.4, Issue 2, pp.15-18, April 2014.

[4] Surface vehicle recommended practice, 'Passenger Car Windshield Wiper system'

[5] A.S.MAsaduzzaman, Mohammad Mahmudul Islam, Shuva Paul, MdFarhatAlam, MdMashuker Rahman",Automatic High Beam Controller for Vehicles", International Journal of Scientific & Engineering Research, vol. 4, Issue3, March-2013.

(b)

[6] Tarun Kumar Das, Yudhajit Das, " Design of a Room Temperature and Humidity Controller Using Fuzzy Logic", American Journal of Engineering Research, Vol. 2, Issue 11, PP 86-97.