A Software and a Hardware Interface for Reducing the Intensity Uncertainties Emitted by Vehicular Headlight on Highways

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Abstract- This paper proposes a hardware and a software interface for reducing the effects of Headlight glare. It proposes a Fuzzy Sensor and a Fuzzy Controller that uses fuzzy rule based design approach to reduce the Headlight glare emitted by the oncoming vehicles during night on the Highways. This in fact reduces accidents and puts the driver of the oncoming vehicle in a safety zone which might jeopardize the oncoming driver's visibility. In the conventional vehicles the illumination is adjusted manually by the driver. The proposed approach has the hardware circuit fit on to the Windshield, which provides ambient light source to oncoming vehicle, there by not producing blinding effect on the vision of the driver . This Hardware has to be fitted on to all the vehicles, so that it reduces the occurrence of accidents. Microcontrollers are usually designed to interface to and interact with electrical/electronic devices, sensors and high-tech gadgets to automate systems. Microcontrollers are used for automated decision making.

The PIC microcontroller has been used which reduces the intensity of light if it goes beyond tolerable limits, affecting the driver's vision. The concept of Fuzziness has been applied to the sensor and the Controller. The light intensity of the oncoming vehicle is received by the Fuzzy sensor. This input light intensity is fuzzified and checked for the tolerance limit. If this does not lie within the tolerance limit, the sensor passes it to the Fuzzy controller which converts it to an ambient light source and then on defuzzifying the output. The software has been developed using MATLAB.

Keywords: Fuzzy rules; fuzzy sensors; fuzzy controllers; fuzzification; defuzzification; Headlight glare; MATLAB

I. INTRODUCTION

Driving at night-time poses a severe challenge, as drivers have to watch the traffic control devices, oncoming vehicles, lane lines, pedestrians, animals, and other dangers. Incandescent light sources can illuminate the highways, but bright light sources or improper lighting may result in glare, thereby posing an unsafe environment to the drivers.

This paper proposes a Fuzzy based approach to reduce the headlight glare. The fuzzy sensor and the fuzzy controllers are fit onto the windshield, gives a solution to the headlight glare. The sensor includes the operation of checking the light source, if it is of over tolerance/under tolerance. There by the controller converting it in to low intensity if it is of high intensity and vice versa, providing ambient light source.

The light intensity(I) measured in Volts and the distance(D) in metres are received by the fuzzy sensor. The input parameters received by the fuzzy sensor are crisp input values (Numerical value). These crisp sets are converted in to fuzzy sets using the process of fuzzification and are evaluated using the fuzzy rules. The output light intensity(OI) calculated using the fuzzy rules is checked for the tolerance limit by the fuzzy sensor. If beyond the tolerance limit, the fuzzy sensor defuzzifies using centroid of maximum and then sends it to the fuzzy controller which converts it to ambient light source. The process of fuzzification and defuzzification is also carried out for the fuzzy controller.

The literature survey report [1,2,3,4,8] gives basic understanding of Crisp sets, Fuzzy sets, concepts of fuzzy controller, and of the Fuzzy Expert systems. In [5] the application of fuzzy logic controller to improve the energy efficiency of a dimmer light balance implemented in passive optical fiber day lighting system has been demonstrated. The Literature report in [6] proposes an automatic fuzzy controller which controls the switching of headlight intensity of automobiles. In [7] the fuzzy controller for the heart disease has been elucidated which gives the basic understanding of the components in Fuzzy systems.

II. METHODOLOGY

A Fuzzy system consists of four components: Fuzzifier, Inference Engine, Rule base and Defuzzifier. The components and the schematic representation of a Fuzzy system is elucidated in Fig. 1.

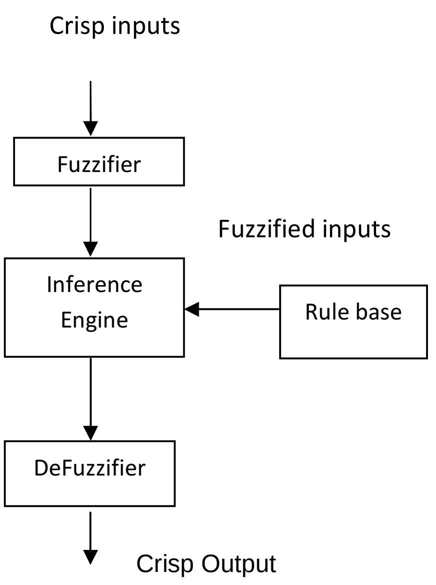

Fig.1. Schematic representation of a Fuzzy System

A. Hardware Environment

The hardware environment consists of a Light Sensor, amplifier, PIC microcontroller, MOSFET driver, MOSFET, Battery and a Headlight as shown in Fig. 2. The prototype of the proposed hardware is shown in Fig. 3.

LDR (Light Dependent Resistor) is used to measure the intensity of light rays. This element endures a change in resistance when it is subjected to light rays. This is used to sense the high beam of the approaching vehicle.

The amplifier is interfaced between LDR and Microcontroller (PIC 16F877A). Amplifier increases the amplitude of the signal sent by LDR to the microcontroller compatible level.

The ultrasonic sensor consists of a crystal oscillator which generates a high frequency signal .This signal is received by the receiver when it is reflected back by the approaching vehicle . The time between transmission and reception of the signal is used to measure the distance between the two vehicles.

The input for the Microcontroller is the Light source and the distance of the light source. PIC Microcontroller is programmed to reduce the intensity of light if it exceeds the tolerance limit. The microcontroller is a device that interfaces to sensors and performs computing. Peripheral Interface Controllers (PICs), are inexpensive microcontroller units that include a central processing unit and peripherals such as memory, timers, and input/output (I/O) functions on an integrated circuit (IC). They are called microcontrollers because they are used to perform control functions. PIC16F877A controller has various peripherals with 4k of flash memory which is very flexible. This IC is used to control the entire process

Headlight is the ultimate output device which is controlled by the IC. This control is enabled by switching the lamp on and off using the MOSFET which acts as a transistor switch. This is connected between the 12v power source and the headlamp.

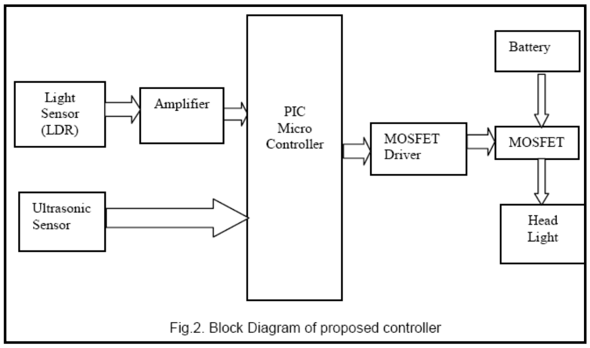

Fig.2. Block Diagram of proposed controller

Fig.3. Protype of the proposed hardware

B. Software environment

The Fuzzy sensor(Fig. 4) proposed has two input parameters. The first parameter being the Distance(D), which is the distance between the two approaching vehicles. The second parameter being the Input intensity(I), which is a measure of the light emitted by the oncoming vehicle. The output parameter is the Sensor Output(OI), which would be passed to the Fuzzy controller, if it lies beyond the tolerance limit. Using MATLAB-FuzzyLogicToolbox, the demonstrations of the system are shown in the figures below

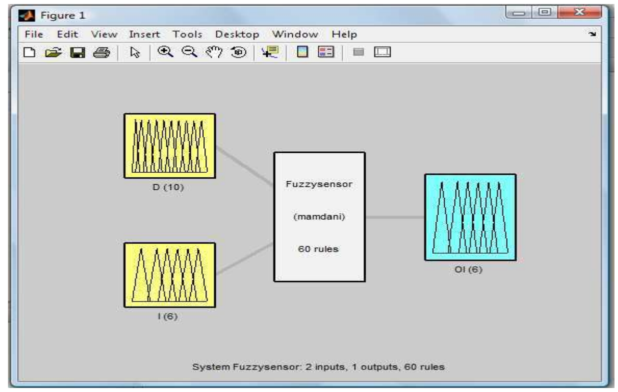

Fig. 4. The structure of the fuzzy sensor

1) Fuzzy inference process

The Fuzzy Inference Process follows the steps as shown below

Fuzzification of the input variables.
Defining Membership functions.
Fuzzy Inference.
Defuzzification.
Fuzzification of input variables.

A crisp set of input data are mapped to fuzzy sets using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. Linguistic variable means the input or output variables of the fuzzy systems whose values are words or sentences, instead of numerical values. A linguistic variable can be decomposed into a set of linguistic terms.The crisp values got for the input parameters D and I are converted in to fuzzy sets. To fuzzify the parameters, linguistic variables are used (Table I, II, III). The Distance(D) has 10 fuzzy sets, input Intensity(I) consists of 6 fuzzy sets, and the output parameter ouput Intensity(OI) consists of 6 fuzzysets.

TABLE I. FUZZY SETS, LINGUISTIC VARIABLES FOR INPUT INTENSITY I(V) AND ITS RANGE

Input Parameter	Linguistic value	Fuzzy sets	Range
Input Intensity(I)	JustNoticeable	JN	0-3.50
	Noticeable	N	3.00-6.50
	Satisfactory	S	5.00-8.50
	JustAcceptable	JA	7.00-10.50
	Disturbing	D	9.00-12.50
	UnBearable	UB	11.00-14.50

TABLE II. FUZZY SETS, LINGUISTIC VARIABLES FOR DISTANCE D(MTS) AND ITS RANGE

Input Parameter	Linguistic value	Fuzzy sets	Range
Distance(D)	VeryClose	VC	0-25
	Close	CL	12-50
	VeryNear	VN	37-75
	Near	N	62-100
	ModeratelyNear	MN	87-125
	ModeratelyFar	MF	110-150
	Far	F	135-175
	VeryFar	VF	160-200
	PrettyVeryFar	PVF	185-225
	BoundaryZone	BZ	210-250

TABLE III. FUZZY SETS, LINGUISTIC VARIABLES FOR SENSOR OUTPUT LIGHT SOURCE OI(V) AND ITS RANGE

Output Parameter	Linguistic value	Fuzzy sets	Range
Output Intensity(OI)	JustNoticeable	JN	0-3.50
	Noticeable	N	3.00-6.50
	Satisfactory	S	5.00-8.50
	JustAcceptable	JA	7.00-10.50
	Disturbing	D	9.00-12.50
	UnBearable	UB	11.00-14.50

Defining Membership functions

Membership functions are used to map the crisp input values to fuzzy linguistic terms and vice versa. A membership function is used to quantify a linguistic term. After fuzzification is carried out, the next process is to define the membership functions in the fuzzy sets for the input and output parameters. The Triangular membership function is used for constructing the fuzzy sets. The membership function for the input parameters is shown by the figures (5-6). The membership function of the output parameter is shown in figure.7.

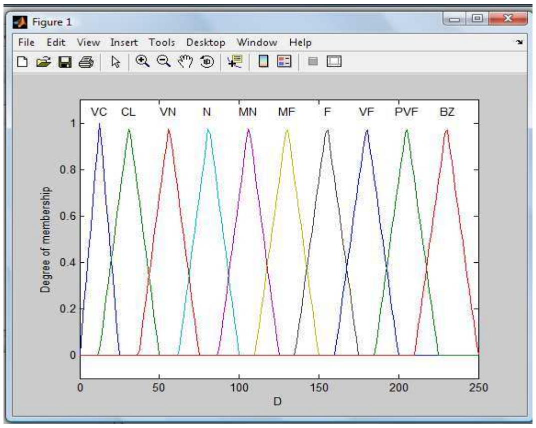

Fig. 5. The membership function of D(Distance)

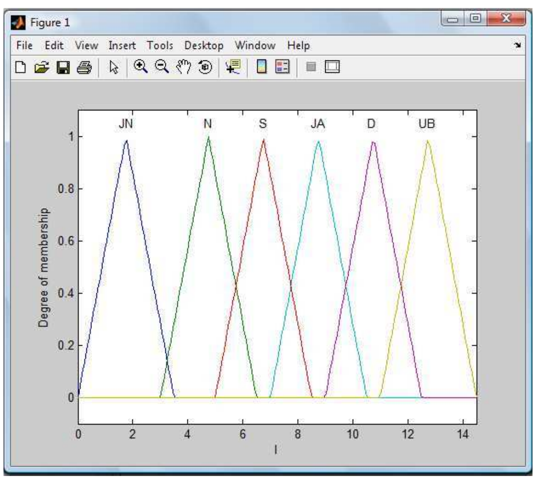

Fig.6. The membership function of I(inputIntensity)

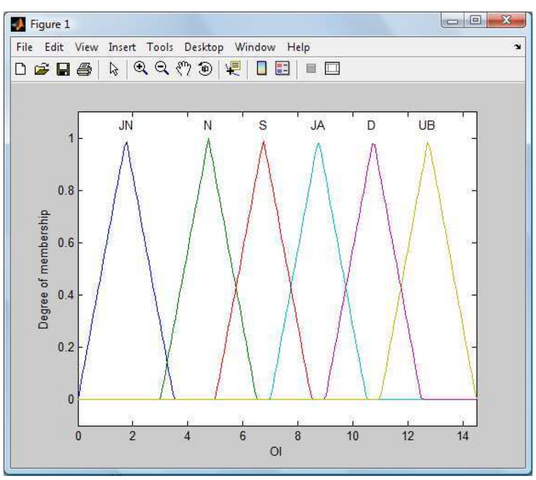

Fig. 7. The membership function of OI(Output Intensity of sensor)

The triangular membership function is a function of vector x and it depends on the three scalar parameters a, b, and c and it is represented as in eq. 1

$$f(x;a,b,c) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a} & a \le x \le b \\ \frac{c-x}{c-b} & \le x \le c \\ 0, & c \le x \end{cases} \quad (1)$$

For example the input parameter of the fuzzy sensor, Input intensity (I) which takes on 6 fuzzy sets JN, N, S, JA, D, UB and their respective ranges are (0-3.50), (3.00-6.50), (5.00-8.50), (7.00-10.50),(9.00-12.50), (11.00-14.50). The triangular membership function for the fuzzy set JN is given by $\boldsymbol{\mu}_{JN}$(x)(eq 2)

$$\mu_{JN}(x) = \begin{cases} 0; & x \le 0 \\ \frac{x-0}{1.75}; & 0 \le x \le 1.75 \\ \frac{3.50-x}{1.75}; & 1.75 \le x \le 3.50 \\ 0\ ; & 3.50 \le x \end{cases} \quad (2)$$

Similarly the triangular membership function is calculated for all the fuzzy sets N, S, JA, D and UB. This as well goes for the other input parameter D.

Fuzzy Inference

A rule base is constructed to control the output variable. A fuzzy rule is a simple IF-THEN rule with a condition and a conclusion. The fuzzy input values are processed using the set of rules. Each rule processes the information using different input parameters; the output of each rule is different. In order to construct the fuzzy rules we construct rule matrix (Table IV) and rule bases. Row captions in the matrix contain the values that Distance can take, column captions contain the values for Input Intensity, and each cell is the resulting command when the input variables take the values in that row and column. For example, the cell (4, 3) in the matrix can be read as follows: If Distance is F(far) and the Input Intensity is S(satisfactory) then the Output Intensity is S(satisfactory).

TABLE IV. RULE MATRIX REPRESENTATION

D/I	JN	N	S	JA	D	UB
BZ	JN	JN	JN	S	JA	D
PVF	JN	JN	N	S	D	D
VF	JN	JN	N	S	D	D
F	JN	N	S	S	D	D
MF	JN	N	S	JA	D	D
MN	N	N	S	JA	D	D
N	S	S	S	JA	D	UB
VN	S	S	S	D	D	UB
CL	JA	JA	D	D	UB	UB
VC	JA	D	D	UB	UB	UB

The Rule matrix is a simple graphical tool for mapping the Fuzzy system rules. It accommodates two input variables namely Distance(D), Input Intensity and expresses their logical product (AND) as one output response variable OI(output intensity).

The rule matrix is used to formulate the rule bases. For instance we formulate 10*6 rules for the fuzzy sensor. Linguistic rules describing the control system consist of two parts; an antecedent block (between the IF and THEN) and a consequent block (following THEN). Antecedent block consists of input linguistic variables that may be combined using AND operators. Consequent part contains the output of the fuzzy rule. The figure below (Fig. 8) and (Fig. 9) shows the snapshot of the rule base for the sensor. In the figure below, the value of D=189, I=7.25 and OI=5.2. This implies that the output light intensity is moderate; the sensor judges it to be of the acceptable limit and it need not send it to the controller. The surface viewer of the fuzzysensor is given(Fig. 10)

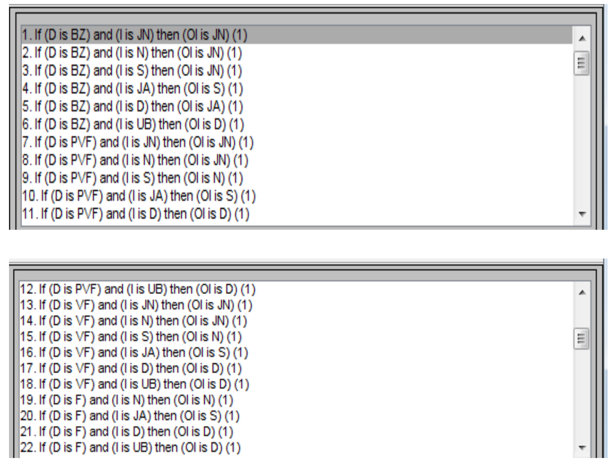

Fig. 8. Snapshot of the rulebase for the Fuzzysensor

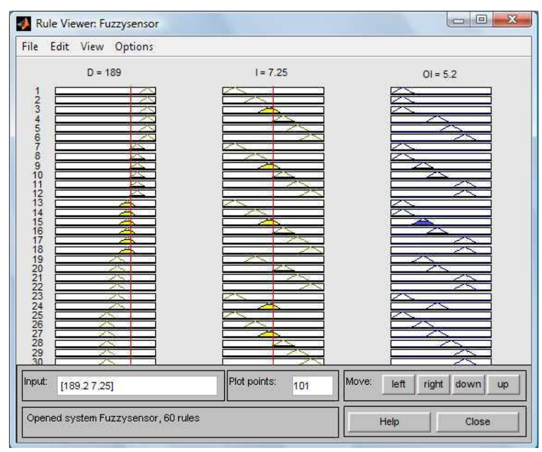

Fig. 9. Computing the value of OI for I=13.9 and D=250

If the output light intensity I is higher(9.00 and above), the sensor sends it to the controller and the fuzzy controller (Fig. 11) converts it into an ambient light source.

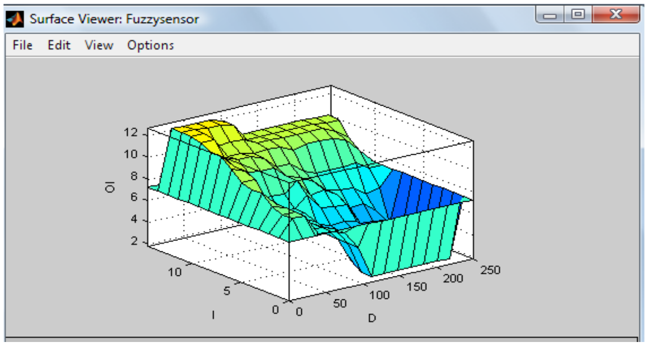

Fig. 10. Surface viewer of the Fuzzysensor

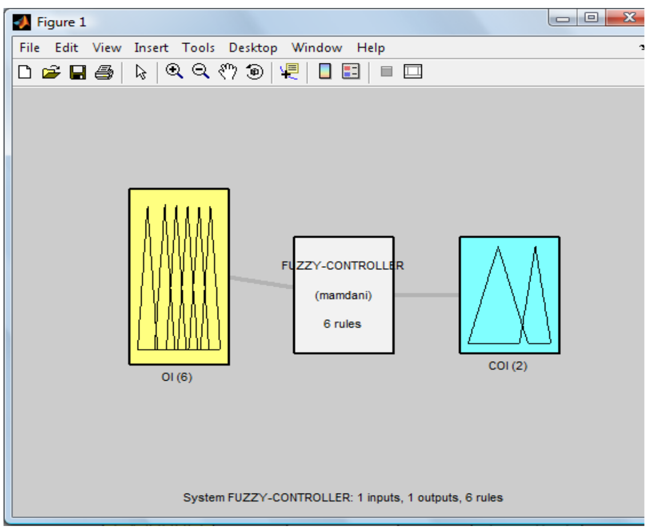

Fig.11. The structure of the Fuzzy Controller

The Fuzzy controller accepts the OutputIntensity(OI), if it is of either Disturbing(D),or UNBEARABLE(UB) it converts it to an ambient light source. The Fuzzy controller's ouput is the ControllerOutputIntensity(COI) (Table V)

TABLE V. THE LINGUISTIC VARIABLES FOR COI AND ITS NUMERICAL RANGE

Linguistic value	Notation	Numerical range
ReduceLightSource	RLS	9.00-14.50
AmbientLightSource	ALS	0-9.00

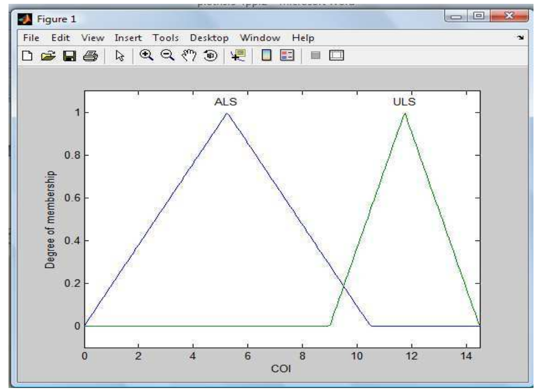

Fig. 12. The membership function for the ControllerOutputIntensity(COI)

The membership function for the output intensity of the fuzzy controller is shown (Fig. 12). The rule bases for the fuzzy controller(Table VI) is as shown below. The snapshot of the rule base for the fuzzy controller is shown(Fig.13).

TABLE VI. THE RULE BASES FOR THE FUZZY CONTROLLER

Rule	OI	COI
1	JN	ALS
2	N	ALS
3	S	ALS
4	JA	ALS
5	D	RLS
6	UB	RLS

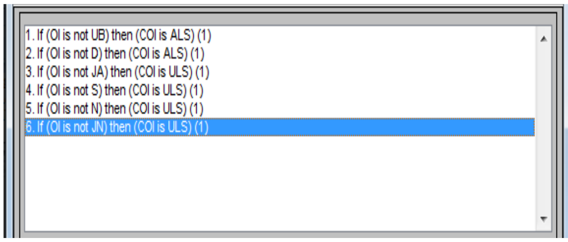

Fig. 13. Snapshot of the rule base for the Fuzzy controller

The figure below (Fig. 14) shows the rule viewer of the Controller. In the figure below, the value of OI=13.2 and that of COI=7.45 . This implies that the output light intensity is Unbearable; the sensor judges it not to be of the acceptable limit and it sends to the controller for turning it in to an ambient light source. The Surface viewer of the controller is shown(Fig. 15).

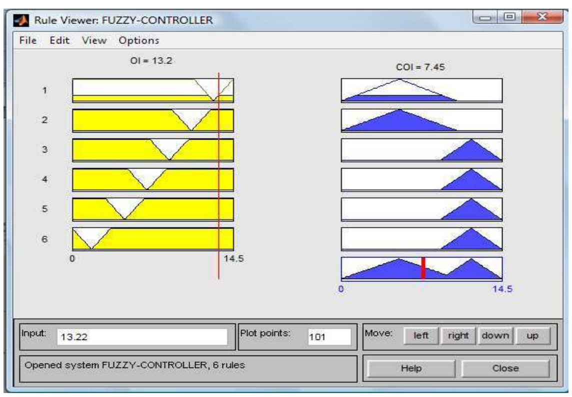

Fig. 14. Rule viewer of the Fuzzy controller

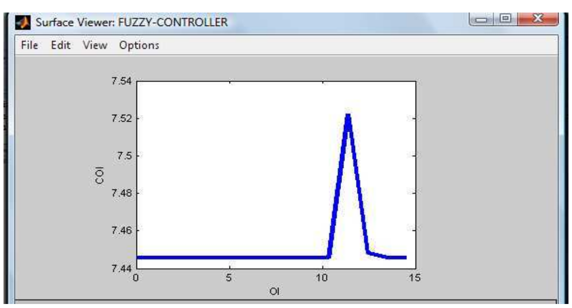

Fig. 15. Surface viewer of the Fuzzy controller

Defuzzification

The fuzzy sets are converted to crisp values. Here the fuzzy sets represented by s-op(Sensors output) and ols(fuzzy controllers output) are converted to crisp sets(Numerical values). Centre of area method has been used. General formula for COA is (Eq:3)

$$z^* = \int \mu_c(z) z dz / \int \mu_c(z) dz \quad (3)$$

III. IMPLEMENTATION

The hardware implementation has been done using the PIC micro controller. The software implementation has been carried out using the Fuzzy Logic Toolbox. MATLAB Fuzzy Logic Toolbox has been used to encode fuzzy sets, fuzzy rules and to perform inference process for both the fuzzy sensor and the fuzzy controller. The hardware and the software has been tested.

IV. CONCLUSION

This paper has proposed a software and a hardware Interface for Reducing the Intensity Uncertainties Emitted by Vehicular Headlight on Highways. Hardware and software interface applies fuzzy design to reduce the headlight glare which in places the Drivers in a comfortable zone of visibility which in turn minimizes the Accidents. The fuzzy sensor and the controller uses the fuzzy logic to control the intensity of light. The conventional controllers would not be very efficient in controlling the headlight glare as there would be discrete values either high/low beam but the fuzzy controller has the continuous light intensities rather than high/low beam. The fuzzy sensor and the controller has to be fitted onto the windshield of the two oncoming cars. This fuzzy system comprising the sensor and the controller reduces the headlight glare and therefore reduces the accidents on the highways during transportation at night. PIC Microcontroller has been used to reduce the intensity of light. This system would necessarily prove to be beneficial for the drivers as the driving becomes secure without ruining the vision of the driver at both the end of the vehicles.

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