iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VIII **Month of publication:** August 2019

DOI: http://doi.org/10.22214/ijraset.2019.8027

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

Fuzzy Expert System for the Detection of Glaucoma and Cataract

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Abstract: Glaucoma and Cataract are eye diseases which shares common symptoms like, high pressure on eye, damage of optic nerves, lens size and sometimes loss of eyesight. Blindness occurs when left untreated that affects peripheral vision. Early diagnosis of glaucoma and cataract requires regular checkups which is too expensive and time consuming. This work proposes fuzzy based decision constructed to overcome glaucoma and cataract at initial stage. Fuzzy rule-based system helps the medical practitioners to give accurate results by considering patients symptoms. The entire test performed on fuzzy system was done in presence of ophthalmologist, who further found these systems as precise and useful by comparing accuracy, sensitivity and specificity which results 97%, 98% and 96% respectively. This method is efficient and having low computational value.

Keywords: Glaucoma, Cataract, Fuzzy expert system, Graphical User Interface.

I. INTRODUCTION

The healing investigation of a disorder is a huge difficulty in ultra-modern world that needs engineering strategies to access information. With new advances in medicinal engineering and different control frameworks that have been won by the use of artificial intelligence strategies [1]. The technology has made a dynamic research that consists of fuzzy good judgment, synthetic neural networks and genetic algorithms. These kinds of strategies have a tendency to give vital records beginning from one to different kind and control life threatening troubles. The maximum accessible kind of method that gives help and assists to medical professionals in recognizing ailment is the improvement of the clinical detection of choice aid machine [1].The fundamental purpose of glaucoma and cataract are the steady lack of retinal Nerve fiber layers due to the growth in the intra ocular weight inside the eyes. The potential of those retinal nerve filaments is the change of perceived photo inside the form of alerts to the mind, wherein these signs are perceived as item. Damage to those nerve filaments creates spots and those blind spots prompts to visible impairment [2]. There are several methods to stumble on Glaucoma and cataract is Tonometry, Opthalmoscopy, Pachymetry etc. but these systems are high priced, tedious and needs high abilities [2]. Glaucoma could be: Open angle and Closure angle Glaucoma. Open-angle glaucoma consists of a huge cause amongst IRIS and cornea which in addition referred to as wide angle glaucoma. And this is the motive specialist’s needs greater particular and less high-priced gadget to hit upon glaucoma in its early stage.

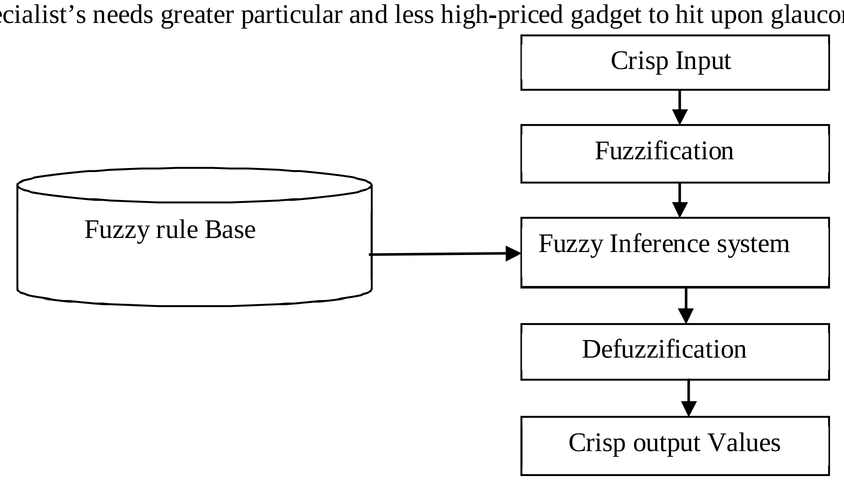

Figure1. Fuzzy Expert System [5]

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II. PROPOSED SYSTEM

This segment explains the technique grasped in building the in general fuzzy inference framework for decision making system. The fuzzy inference framework is a shape that is dependent on fuzzy set theory, grabs a fuzzy representation of patient's indication and in like manner instigates fuzzy dating. With a particular expect to achieve unnecessary interpretability; the capacity to deal with speculation could be significant. Speculation guidelines permit more prominent principle base, rapid acceptance and exact fuzzy interpretability. A fuzzy ward choice assistance contraption achieves handle records and revel in perception of IF-ELSE pointers to gadget fuzzy deduction. In this way, a fuzzy handle structure permits a clear way for making arrangements a careful course of action with help from an uncertain territory. The given fuzzy set alluding to with an interest artistic creations portrays the data IF-ELSE assessment to its careful participation and it have to in an assortment of (0,1). The trapezoidal enrollment has four factors a,b,c and d in which an and d demonstrates feet of the trapezoid with participation of 0 degree and b and c as shoulder with participation of 1 degree.

III. METHODOLOGY

Figure 2 constitute the designing of the professional system through the use of nine input variables i.e. Intraocular strain (IOP), cup to disc ratio (CDR), rim to disc ratio (RDR), visual field, visual acuity, RNFL, lens size, corneal thickness and angle. The following step is to pick out the input variables i.e. we need to decide the fuzzy sets for each enter variable and the corresponding variety of the belonging to each fuzzy set. Fuzzy rule-primarily based lets in specialists' knowledge to take into account signs and symptoms of affected person and then primarily based on the policies developed offers a precise decision.

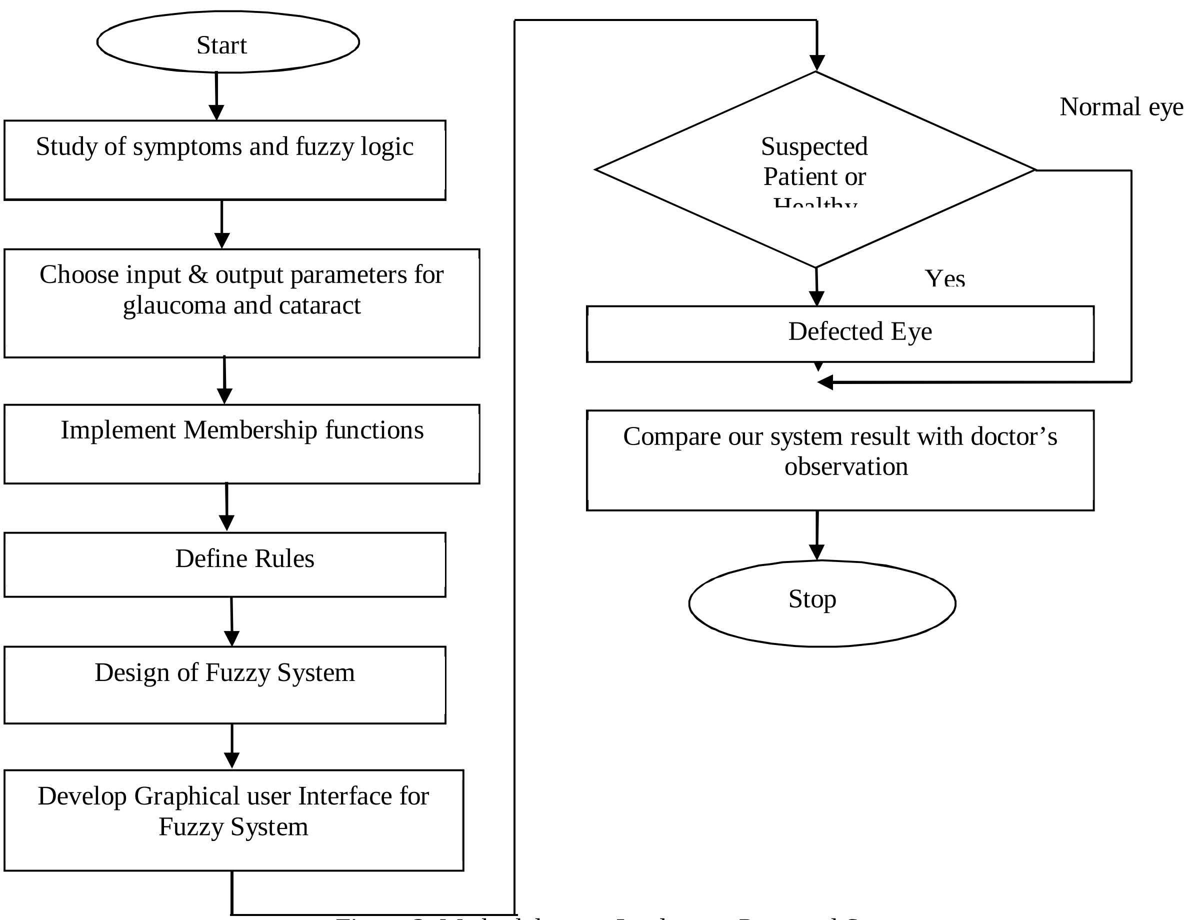

Figure 2. Methodology to Implement Proposed System

This proposed framework is applied to recognize the Glaucoma and cataract. The framework comprises of diverse input and output variable taken to evaluation of Glaucoma. The quantity of input assigns intraocular pressure, Cup to Disk Ratio, Rim to Disk Ratio, visible Acuity, Corneal Thickness, perspective among Iris and Cornea. Each input characteristic is hooked up with a few triangular club features.

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Mamdani interference framework is applied for diagnosing because of its capability to define professional records in a dynamic manner and works like humans. Likewise has a capability to address authentic packages.

The fuzzy diagnosis device, Fuzzy Inference machine (FIS) and Graphical person Interface (GUI) are very important in MATLAB. The diagram given beneath suggests the call of inputs on left and outputs on right. Depending at the reminiscence of the machine enter that may be stored is limited.

A. Input Variables

Nine input variables are used for designing this expert gadget which include Intraocular pressure (IOP), Cup to disc ratio (CDR), Rim to disc ratio (RDR), visual view, corneal thickness, angle, lens length, visible acuity, RNFL thickness. These inputs are used to be expecting the fitness popularity of a person. We need to decide the bushy units for each input variable and the corresponding range of the belonging to each fuzzy set.

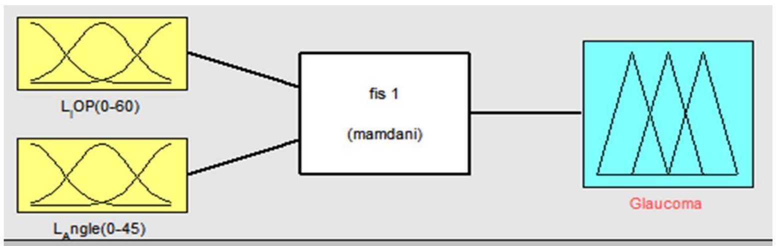

Figure 3(a): Fis file of Intraocular Pressure and Angle

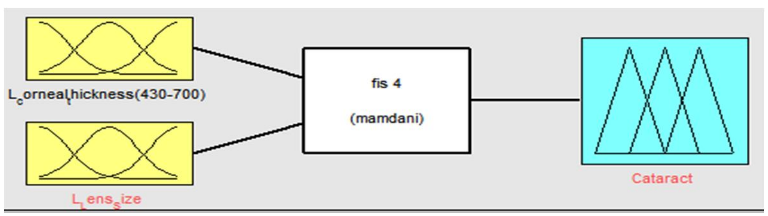

Figure 3(b): Fis file of Corneal Thickness and Lens Size

Figure 3: Hierarchical FIS with 9 inputs & 1 output

B. Membership Function

Enrollment capacity is utilized to characterize the states of all the participation capacities related with every factor. The apparatus allows you to show and alter the majority of the participation capacities. The Membership function editor allows editing and including both input and outputting variables. The inputs and output membership functions of the selected parameters are:-

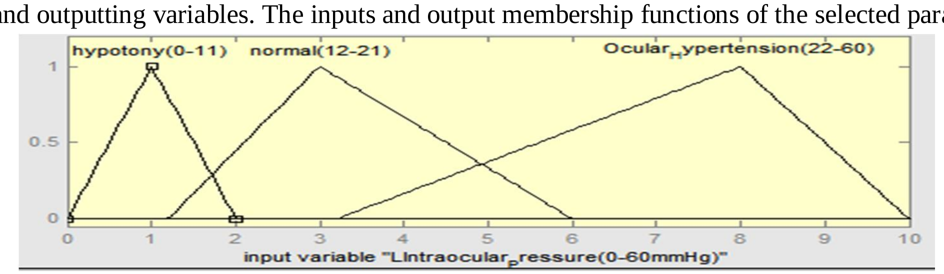

Figure 4(a). Membership function plots for Intraocular Pressure

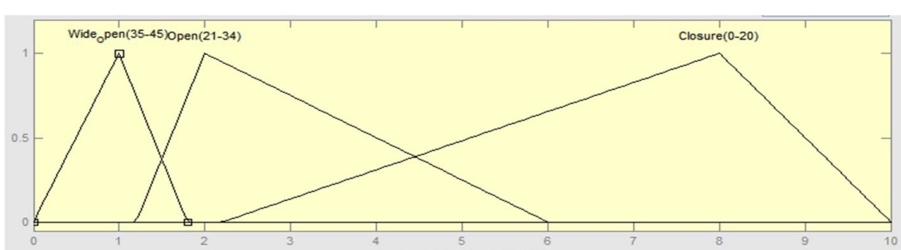

Figure 4(b). Membership function plots for Angle

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It is the procedure of the unification of the guidelines. The enrollment elements of all the standard consequents recently cut during principle assessment are taken and consolidated into a solitary fuzzy set. The procedure various cut resulting enrollment capacities are changed into one fuzzy set for each yield variable. The deduction strategy utilized is the Mamdani induction technique. Table1. demonstrates the scopes of Membership work parameters for the info factors..

Table 1. Ranges of Membership function parameters for the Input variables

Sr.No.	Input variables	Membership Functions	Ranges
1	Intraocular pressure	Hypotony	[0 1 2]
		Normal	[1.2 3 6]
		Ocular hypertension	[3.2 8 10]
2	Angle	Extremely Narrow	[0 1 1.8]
		Narrow	[1.2 2 6]
		Wide open angle	[2.2 8 10]
3	Cup to disc ratio	Normal	[0 2 2.5]
		Near Normal	[2.2 3 7]
		Glaucomatous eye	[4.2 8 10]
4	Rim to disc ratio	Normal	[0 2 5]
		High Glaucomatous	[2.2 6 7]
		Severe Glaucomatous	[6.2 8 10]
5	Corneal thickness	Thick	[0 3 3.8]
		Average	[3.2 4 7]
		Very Thin	[4.2 8 10]
6	Visual Acuity	Normal	[0 3 5]
		Moderate Low Vision	[3.2 6 8]
		Severe Low Vision	[6.2 9 10]

C. Output

The proposed fuzzy inference system (FIS) provides following outputs for the detection of Glaucoma:

1) Normal eye (0-3)
2) Glaucomatous eye, Cataract eye (3.1-5.3) Mild
3) Glaucomatous eye, Cataract eye (5.4-7.6) Moderate
4) Glaucomatous eye, Cataract eye (7.7-10) Severe

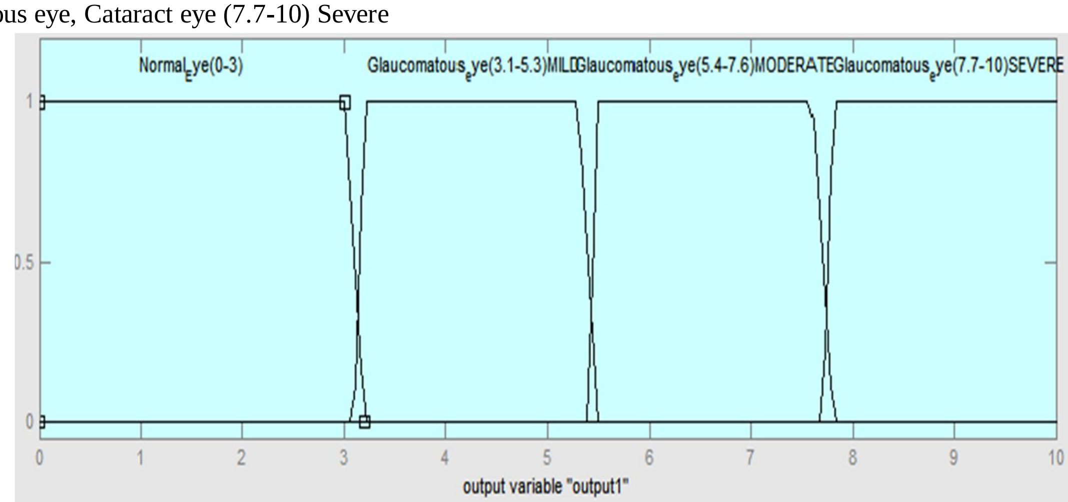

Figure 5: Membership Plot for Output

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D. Rule Editor

Rule Editor is for adjusting the once-over of rules that describes the introduction of the structure. It contains an outsized editable substance field for appearing and making rules. Guideline Editor is what's more has some acquainted with places of interest unfaltering as those inside the FIS (fuzzy Inference system) Editor and Membership perform Editor, close by with the menu bar and moreover the status line.

Rules = M^i

[23

M = Membership functions

I = Input parameters

1. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
2. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
3. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
4. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
5. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
6. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
7. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
8. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
9. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3))
10. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3)
11. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3)
12. If (LIntraocular_Pressure(0-60mmHg) is hypotony(0-11)) and (LAngle(0-45) is Wide_Open(35-45)) and (LCup_to_Disc_Ratio(0.1-0.9) is Normal(0.1-0.3)

Figure 6: Rule Editor

E. Fuzzification and Defuzzification

In the structure of any fuzzy ace system Fuzzification is the starter step. The arrangement of mapping a crisp estimation of a commitment to investment degrees in a couple of fuzzy phonetic elements. Defuzzification is the turnaround method of Fuzzification. It's the methodology for uniting the cushioned yield of the extensive number of standards to give one crisp worth. Along these lines worth yield is given by the Defuzzification system in the wake of evaluating its data regard.

IV. EXPERIMENTAL RESULTS

A. Rule Viewer

Rule Viewer to analyze the fuzzy inference system. By using this as a diagnostic tool to check for instance, the implication of the results are find by using the individual membership function shapes. The instructions of the complete fuzzy inference process are displayed by the Rule Viewer. In the inferior right, there is a text field where you can enter a specific input value. Figure 7 displays the rule viewer of the proposed system. It indicates the outcome of entire proposed system. From the left side at the peak we get defuzzified values, we get =6.6 which means person is Normal.

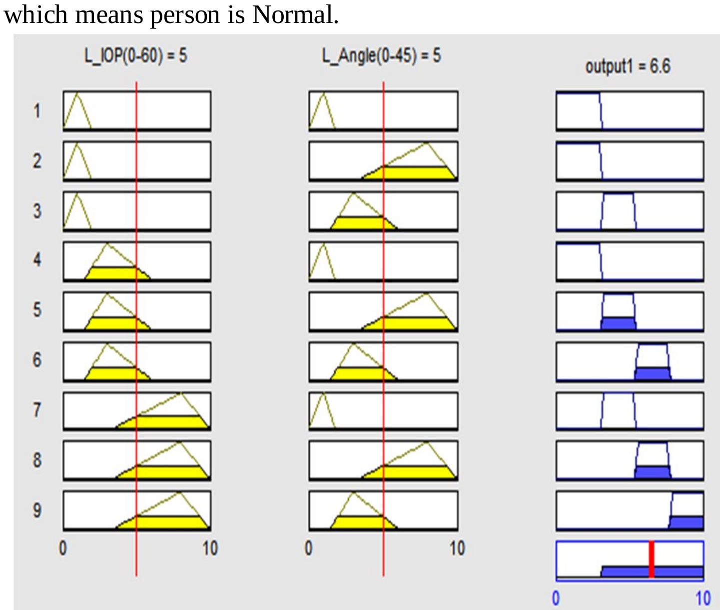

Figure 7: Rule Viewer

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B. Graphical User Interface

MATLAB Graphical User Interface is the boundary information from the MATLAB graphic objects created for human-computer interaction. Guide automatically generates 2 forms of MATLAB files; accustomed store the command operates of the MATLAB program.

The m-file provides a code to initialize the graphical user interface and contains a framework. Graphical user interface click-backs, the routines that execute once a user interacts with a GUI component. Using the M-file editor, you'll add code to the click-backs to perform the functions you wish.

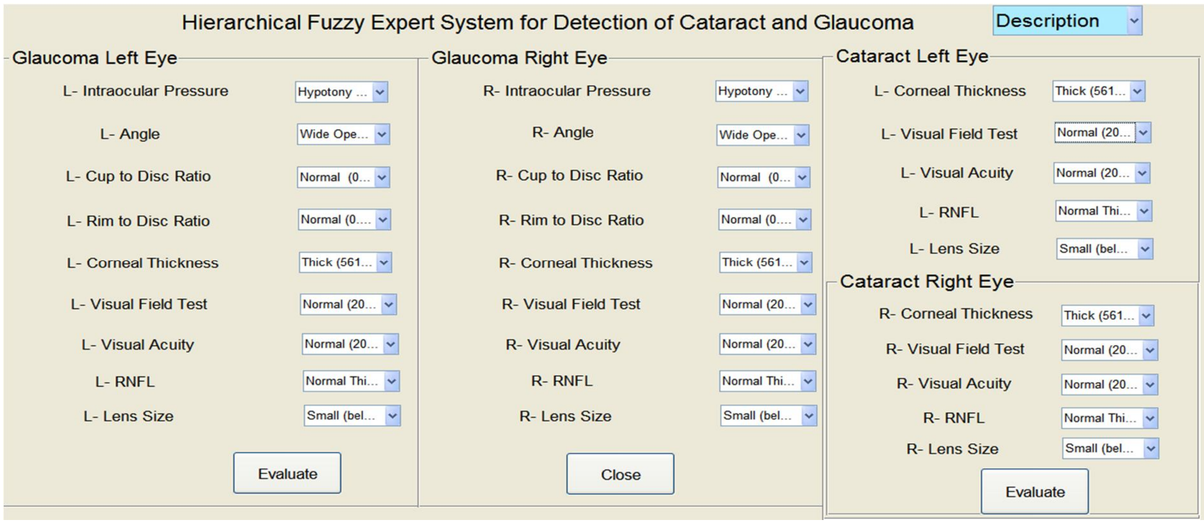

Figure 8(a). Glaucoma Detection GUI with Input Parameters

Figure 8(b). GUI showing Decision on Glaucoma according to Input Parameters

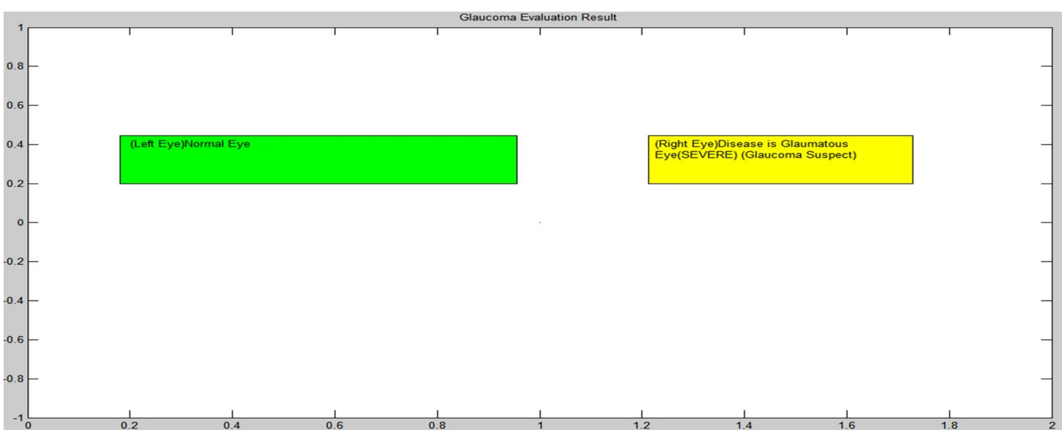

Figure 8(c). Glaucoma Detection for Both Eyes

The projected method represents recognition of normal eye and glaucomatous eye by using the parameters (IOP, CDR, RDR, Angle, Field of vision, and Corneal Thickness).In fuzzy inference system (FIS) there are 729 rules that are defined among which 100 rules were selected randomly. Among 100 rules 50 rules are of normal patient and 50 rules are of glaucomatous patient, and then the outcome are compared with the ophthalmologist .The result shows that 97 rules are similar as that of ophthalmologist results. Thus, accuracy of the system comes 97% [26].

$$\text{Accuracy} = \frac{\text{No. of correct Patients}}{\text{Total No. of Patients}} \times 100 \qquad (1)$$

$$= \frac{97}{100} \times 100 = 97\%$$

Sensitivity is described as the ratio of authentic Positives (TP) to the sum of TP and false Negatives (FN). TP is the case whilst a glaucomatous image is classed as glaucoma and FN is the case while a glaucomatous image is classified as non-glaucoma [26].

$$\text{Sensitivity} = \frac{\text{True Positive(TP)}}{\text{True Positive(TP)} + \text{False Negative(FN)}} \qquad (2)$$

$$= \frac{49}{49+1} = 0.98 = 98\%$$

Specificity is described ratio of true Negative (TN) to the sum of TN and false Positives (FP). TN is the case when a non-glaucomatous photo is classed as non-glaucoma and FP is the case when non-glaucomatous photograph is classified as glaucoma [26].

$$\text{Specificity} = \frac{\text{True Negative (TN)}}{\text{True Negative (TN)} + \text{False Positive(FP)}} \qquad (3)$$

$$= \frac{48}{48+2} = 0.96 = 96\%$$

V. CONCLUSION

Glaucoma and Cataract are most huge-ranging sickness at present, so within the early on identification is notably crucial to hold individuals experiencing Glaucoma. The proposed gadget can control stand-out resource of information which might be far cutting edge to deal with weakness all through examining period. The results are contrasted and logical dataset of a hundred patients; the framework gives promising results over 97% precision. This present system might be stretched out through growing wide assortment of sources of info. In this way, this innovation will have a surprising effect in future.

VI. ACKNOWLEDGMENT

The author would really like to extend his thanks to Dr. SM Bhatti (M.B.B.S, D.O.M.S., M.S. (ophth.) Prof.& head dept. of ophthalmology) and Dr. Ashok Sharma (M.B.B.S, D.O.M.S., M.S.(ophth.)) for useful discussions and feedback for enhancing the thoughts, results and theoretical framework.

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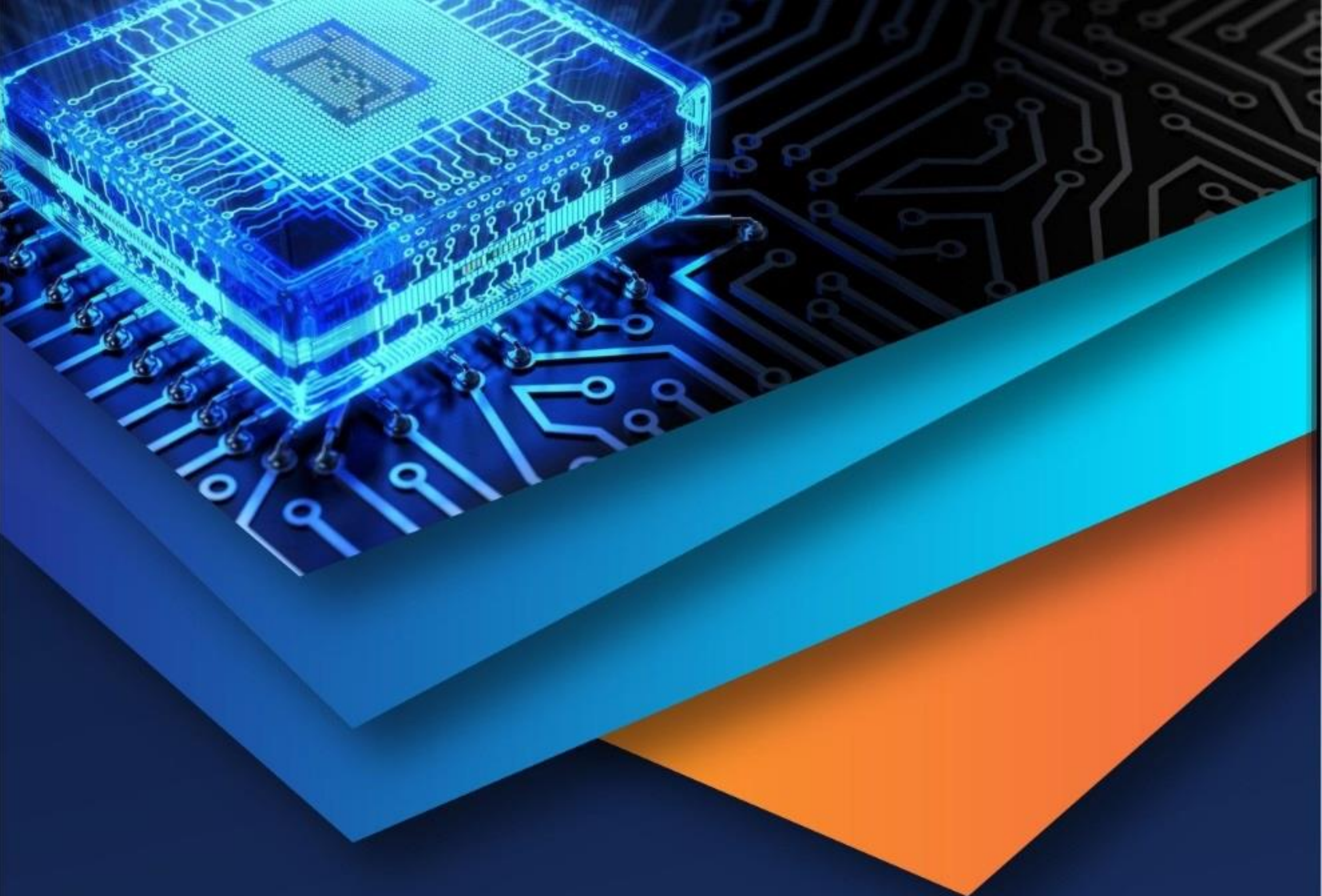

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