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Diabetic Retinopathy Detection System (DRDS); A Novel GUI Based Approach for Diabetic Retinopathy Detection

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ABSTRACT

Diabetes observed as DM (diabetes mellitus) describes a collection of metabolic diseases in which the individual has high blood sugar. Probable complications that can be caused by poorly controlled diabetes: Eye problems, Foot problems, Skin problems, Heart issues, cardiovascular disease, etc. Diabetic retinopathy (DR), a widespread complication of diabetes, affects the blood vessels within the retina. Diabetic Retinopathy is human eye disease which causes damage to the retina of the eye and it may eventually lead to complete blindness. Detection of diabetic retinopathy in the early stage is essential to avoid complete blindness. Many physical tests like visual acuity test, pupil dilation, and Optical Coherence Tomography (OCT) can be used to detect diabetic retinopathy but are time-consuming and affects patients as well. As Diabetic Retinopathy is increasing to a very great extent, so it is necessary to detect at the initial stage. Therefore, fuzzy rule-based allows experts knowledge to consider symptoms of the patient and then based on the rules developed gives a precise decision. We have used 9 Input Parameters (IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP and Triglyceride) in fuzzy GUI (graphical user interface). Our proposed System presents recognition of normal eye, diabetic retinopathy (Severe) and Diabetic Retinopathy (Mild) on the basis of these Parameters. Fuzzy rule-based allows experts knowledge to consider symptoms of the patient and then based on the rules developed gives a precise decision. This technique is efficient and has low computational cost. This research is different from existing research because in other research researchers only work on image processing but in proposed work metabolic parameters such as, Fasting blood sugar, HDL, LDL, HB, HBA1C, BP and triglyceride are included. This work helps the ophthalmologist.

***Keywords*:** Fuzzy Expert System; MATLAB Tool; GUI; Diabetic Retinopathy (DR); FIS.

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I. INTRODUCTION

The therapeutic examination of an infection is a major problem in this world. The therapeutic branch is one in all the foremost recent branches that need engineering strategies to get the information. With new advances in therapeutic engineering and different management structures that have been selected by the utilization of artificial intelligence Strategies [28]. Artificial intelligence has made a dynamic research that includes fuzzy logic, artificial neural networks and genetic algorithms. Each one of those systems collaborates and gives imperative information beginning with one type to another and oversees life threatening problems. The most open sort of artificial intelligence that gives help and aid to health specialist in perceiving infection is the change of the clinical diagnosis of decision support system [28].

Diabetic retinopathy or diabetic eye disease is caused by diabetes mellitus which manifests itself in the eye retina. Diabetic eye disease is one of the most frequent causes of complete blindness in many developed countries. Diabetic retinopathy occurs when high blood glucose damages the small vessels that provide nutrients and oxygen to the retina [1]. These blood vessels will swell up and disclose or they will close up, stop blood from passing through. Generally abnormal new blood vessels grow on the retina. All of these changes can steal your eye site [3]. In Portugal, the figure of people engaged in screening programs of this illness similarly those already identified for cure has been increasing since 2009. DR is of two types: non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) [2].

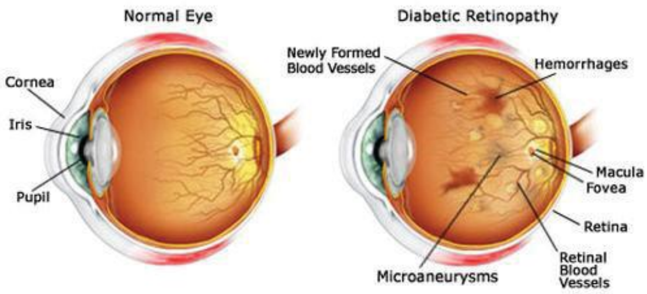

Figure 1(a):- Normal Eye & DR Eye [13]

Diabetic retinopathy is human eye disease that causes harm to the retina of the eye and it is going to eventually result in complete visual defect. Detection of diabetic retinopathy in the early stage is crucial to avoid complete sightlessness. several physical tests like visual field test, pupil dilation, optical coherence tomography can be used to detect diabetic retinopathy but are time-consuming and affects patients as well[1]. Because of this reason, there's a basic need to develop more accurate and less expensive masterpiece for early determination of diabetic retinopathy. So, this paper proposed fuzzy based decision-making system for early diagnosis of diabetic retinopathy which might be one amongst the useful applications with the capability to detect DR in the early stage, Due to their intense lead it yields better results.

Fuzzy set speculation was exhibited by Prof. Lofti Zahed in 1965 [29], which make it feasible to identify therapeutic qualities into human reasonable form [27]. The yielding use of the fuzzy logic has been utilized for various applications. The best benefit of the fuzzy expert structure lies in the way that experts can show questionable, complex system into direct human legitimate shape by using human experience and learning as fuzzy rules as set of linguistic factors [30]. The present paper discussed a master structure by making use of fuzzy logic to recognize Diabetic Retinopathy from its suggested symptoms. The precise speculation is settled by using understanding data set a record having 9 special traits. By using medical expert data fuzzy standards are made that may be used as a bit of higher cognitive process. This paper gives data based on expert system for finding of diabetic retinopathy. The therapeutic business using the field of man-made insight has viably moved from clinical research center o real applications. Moreover, laying out and implementing results for examination of diabetic retinopathy by using fuzzy interference system is arranged. By including at least 9 symptoms of diabetic retinopathy fuzzy interference systems is made. The fuzzy rules based system utilizes therapeutic expert's data for knowing patient's signs and give an exact decision per fuzzy guidelines are made.

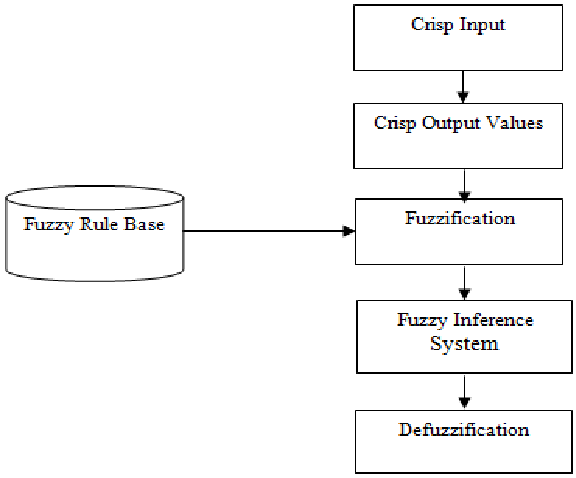

Fig -1 (b): Fuzzy Expert System [31]

1.1 Diabetic Retinopathy Disease Diagnosis Parameters:

There are several parameters to be considered in order to differentiate the healthy and diabetic retinopathy eye. Most important parameters are as follows:

1.1.1 Intraocular Pressure

In the healthy eye, middle chamber of the eye produces the aqueous fluid. This fluid then flows around the lens, enters into the drainage meshwork and then comes out of the eye. If drainage meshwork is blocked, fluid does not move out of the eye. As a result, fluid inside the eye increases. This increases the pressure inside the eye and causes damages to the optic nerve or retinal nerve fiber layers and in turn leads to loss of vision. Tonometry is the device used to measure the pressure inside the eye. This device measures the pressure in terms of millimeters of mercury (mmHg). In the normal eye, IOP is usually between 10-20 mmHg. Higher IOP inside the eye may increase the risk of eye diseases like DR and glaucoma, but does not mean that the person has diabetic retinopathy because in some cases normal people may have higher IOP [25].

1.1.2 Visual Field

The Visual field of a human eye is the total area covered by the eye in which objects are visible from peripheral or side vision. Visual field varies from one person to another person. Visual field or field of vision is measured by the technique called visual field test and it is also called as Perimetry test. This test makes use of the perimeter device for the measurement. Most of the ophthalmologists use the perimeter device to detect, monitor and examine the eye diseases by estimating visual field. Perimeter device detects the vision loss areas of the patient eye to diagnose DR and other diseases such as storks by regularly conducting the test [25].

1.1.3 Hba1c

An A1C blood examination measures the proportion of hemoglobin (the oxygen-carrying macromolecule in your red blood cells) covered with sugar. It measures your average blood sugar level over the past 2 to 3 months. The A1C examination provides you and your health care provider a calculation of your improvement. Most people with diabetes should have an A1C test every three to six months; people how are meeting their treatment goals may need the test only twice a year. The A1C examination is a measure of however well your glucose is in restraint. It can also be a better tool for decisive if a person with pre-diabetes is succeeding toward or has developed kind 2diabetes. Adults over age forty five with high blood pressure, obesity, or a family background of diabetes also are advised to get an A1C examination for the reason that they have a bigger danger of developing kind 2 diabetes. Finding out you have an elevated A1C is a cue to make encouraging changes to your way of life [24].

1.1.4 Blood Pressure

Blood pressure (BP) is the force of blood flow in your blood vessels. A blood pressure examination reveals two readings. The peak range is the systolic blood pressure (BP) that measures the pressure as your heart beats and pushes blood from side to side your blood vessels. The lowest range is the diastolic blood pressure (BP) that measures the pressure ones your blood vessels relax between heartbeats. Individuals with the polygenic disorder (diabetes) should have their blood pressure checked at each meeting with their care contributor. When your blood pressure is also high, your heart has to work more durable, raising your risk for heart failure, stroke, eye issues, and kidney problems. Treating high blood pressure with goes on a diet, way of life changes, and medicine (if needed) is vital to avoid physical condition complications [24].

1.1.5 Cholesterol

Cholesterol is a waxy, fatlike substance found in every cell in your body. It's a necessary component to produce hormones, cell membranes, and vitamin D, and to help your body digest fat. Cholesterol is in addition in foods that have animal origins, like red meat, poultry, seafood, and dairy farm products. There are several types of cholesterol, two of which are vital for individuals with glucose to observe [24].

1.1.5.1Low-density lipoproteins (LDL)

Low-density lipoproteins (LDL) are known as bad cholesterol and may cause the buildup of plaque in vessel walls, which can cause the heart failure or stroke [24].

1.1.5.2High-density lipoproteins (HDL)

High-density lipoproteins (HDL) are known smart cholesterol and seem to protect against cardiopathy (heart problems).

1.1.5.3Triglycerides

Triglycerides are a kind of fat created within the body. Folks that are overweight or heavy are bodily inactive, smoke, or drink massive amounts of alcohol or carbohydrate are a lot of likely to own high levels of triglycerides, that will increase the danger for the cardiovascular (heart) disease.

A fasting blood examination to assess the lipid profile of the patient —which measures total cholesterol, Low-density lipoproteins (LDL) and High-density lipoproteins (HDL) cholesterol, and triglyceride ranges—should be done once a year. Intake a lot of fruits and vegetables also fiber-filled whole grains, exercise often, and losing weight if necessary, and maintaining good glucose manage will facilitate get better your cholesterol and triglyceride levels [24].

II. RELATED WORK

A brief survey of the related work in the area of DR diagnosis is presented in this section.

Furtado P. et. al. [2017] proposed segmentation of Eye Fundus Images (EFI) by density clustering in diabetic retinopathy. The objective was to compare the quality of the resulting segmentation using a set of metrics: runtime is the time segmentation takes to run versus the number of super pixels. The author concluded that Simple Linear Iterative Clustering (SLIC) + Density-based spatial clustering of applications with noise (DBSCAN) isolate lesions better [2].Bhatia k. et. al. [2016] proposed methods such as ANN, SVM etc. to develop an automated system to detect the case of diabetic retinopathy among the diabetic patients and is aimed at helping ophthalmologists to detect early symptoms of diabetic retinopathy with ease and also highlights various technologies used for diagnosis and detection of diabetic eye disease [1].Dhanasekaran R. et.al. [2016] proposed work on Gaussian Mixture Model (GMM) classifier which is used to identify whether the input retinal images are normal or abnormal images. The average classifier accuracy is found to be 97.78% [9].Kusakunniran w. et. al. [2016] proposed the methods for the automatic retinal image quality assessment and the hard exudates segmentation. The quality assessment was performed based on the contrast histogram. Both optic disk and hard exudates segmentations are based on the image thresholding using iterative selection and the grabcut. Author concluded that the proposed method achieves more than 90% accuracy [12]. Labhade J. et.al. [2016] proposed soft computing techniques (Support Vector Machine (SVM), Random Forests, Gradient boost, AdaBoost, Gaussian Naive Bayes) for DR detection and each provides different accuracy. The author concluded that the SVM classifier provides better testing accuracy up to 88% while random forests Technique and Gradient boost provides 83%. The Gaussian NB and AdaBoost classifier gave poor accuracy [13].Paing M. et.al [2016] proposed a system for detecting and classification of DR using ANN. The author detected lesions namely blood vessels, exudates and microaneurysms from input images and then extracted necessary features and classified using ANN classifier. The author concluded that sensitivity, precision, and accuracy of the system were 95%, 95%, 96% respectively [14]. Zohora S. et.al. [2016] proposed a review on various automated techniques using different algorithms which result in better performances for exudates detection. The author concluded that among the various approaches used the performance of fuzzy c-means clustering techniques detect exudates more accurately than other methods explained in exudates detection [15]. Ashe S. S. et. al. [2016] proposed intensity based preprocessing algorithm which is suitable for the detection of the optic disc (OD) and macula before the analysis of diabetic retinopathy. Optic disc and macula are two major factors which need to be localized before analyzing diabetic retinopathy condition. Detection was based on intensity based threshold selection criteria. The result shows that proposed algorithm can detect OD and macula region effectively [8].Ibraheem S. et. al. [2015] proposed the classification of the disease diabetic retinopathy into Exudates, micro aneurysms and hemorrhages by using fundus images. In order to diagnose the disease diabetic retinopathy, a number of features such as mean, standard deviation, variance, energy, homogeneity, and entropy of the pre-processed images are extracted to characterize the image content. The author concluded that the classification accuracy can provide a better result and image processing techniques can reduce the work of ophthalmologists [10].Sangwan S. et. al. [2015] proposed the classification of Normal, NPDR or PDR affected eye with the high accuracy percentage of 92.6%. The author concluded that SVM can be used efficiently and efficiently as a classifier for detecting eye related diseases caused by diabetic [16].Ahmad A. et. al. [2014] proposed a review on techniques in digital image processing and pattern classification employed for the detection of diabetic retinopathy and compares them on the basis of different performance measures like sensitivity, specificity, accuracy. The author concludes that in the preprocessing stage, green channel response is the most popular step in reported literature as it reliably provides maximum contrast to distinguish between the microaneurysm, hemorrhages, and exudates while histogram equalization and image normalization has equal importance [5].Shojaeipour A. et. al.[2014] proposed a CAD system for the diagnosis of diabetic retinopathy by using digital retina images and classifying these images into two categories, diabetic retinopathy eyes and non-diabetic retinopathy eyes (healthy eyes). The author concluded that the capability of the system increased, and the possibility of errors are reduced with each training epoch [6].

III. PROPOSED SYSTEM

This part rectifies the approach accepts in building the general fuzzy system for decision-making framework. The fuzzy interference system is a structure which is dependent on fuzzy set speculation, grabs a fuzzy representation of patient's sign and likewise induces fuzzy relationship. With a particular objective to accomplish fuzzy depiction to fullest i.e. to fulfill high interpretability, the capability to deal with speculation is extremely hard. The word generalization suggests that ability to express the state-action as practical. Generalization rules permit additional rule base, quick acceptance, and better fuzzy interpretability. A fuzzy dependent decision support system finishes expert data and involvement in cognizance of IF-ELSE rules to arrange fuzzy interference. Subsequently, a fuzzy expert structure allows a direct way to plan an arrangement with the uncertain area. The given fuzzy set relating to an interesting work describes the data credit to its correct enrollment and it should be in a range of (0, 1). Fuzzy is a set which has no new value and has a fuzzy borderline. The triangular membership plot is a function having three variables a, b, c, where a and c signify feet of triangular with membership degree 0 and b represent the peak of triangular with membership degree 1.

IV. METHODOLOGY

In Fig 4, for designing the expert system nine input variables i.e. IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP, and Triglyceride are used. These inputs are used to predict the health status of person. After selecting the input variables consecutive step is to fuzzify the variables i.e. we have to determine the fuzzy sets for every input variable and the corresponding range of the belonging to each fuzzy set. Fuzzy rule-based allows experts knowledge to consider symptoms of patient and then based on the rules developed gives a precise decision.

Online primary medical aid symptoms evaluation implies pointing out of those symptoms that are significant for the analysis of disease and then infer from the database/rule-base the possible disease.

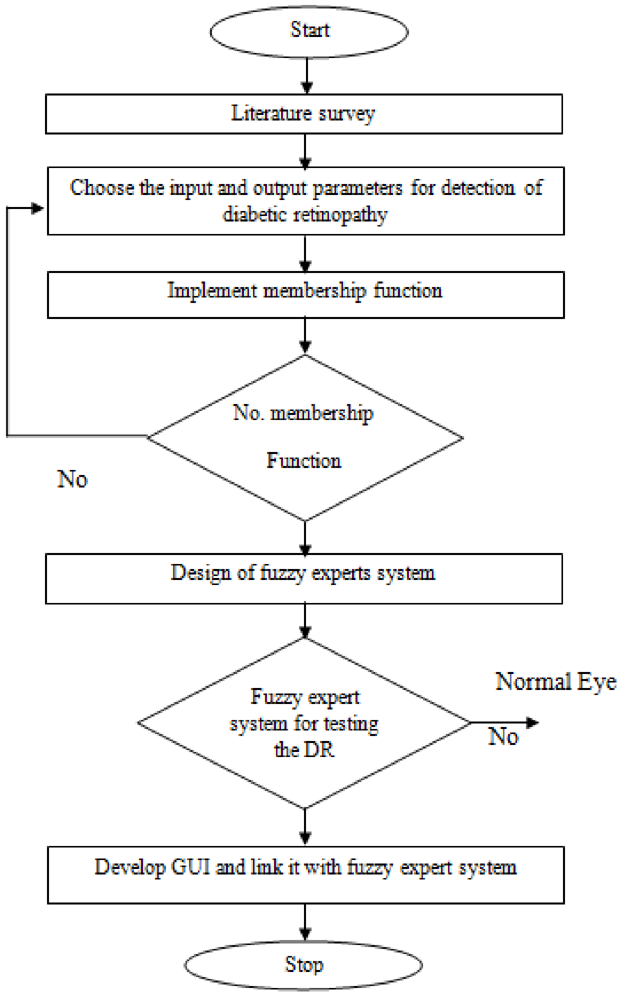

Fig -4: Framework of Proposed System.

To design a Fuzzy Diagnosis System, Fuzzy Inference System (FIS) and Graphical User Interface (GUI) are very powerful toolbox in MATLAB. The FIS editor displays instruction about a fuzzy inference system. There's a simple and understandable diagram at the down that shows the names of each input on the left and those of each output on the right. However, the number of inputs may be limited by the available memory of your machine.

4.1 Input Variables

For designing the expert system nine input variables i.e. IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP, and Triglyceride are used. These inputs are used to predict the health status of the person. After selecting the input variables consecutive step is to fuzzify the variables i.e. we have to determine the fuzzy sets for every input variable and the corresponding range of the belonging to each fuzzy set.

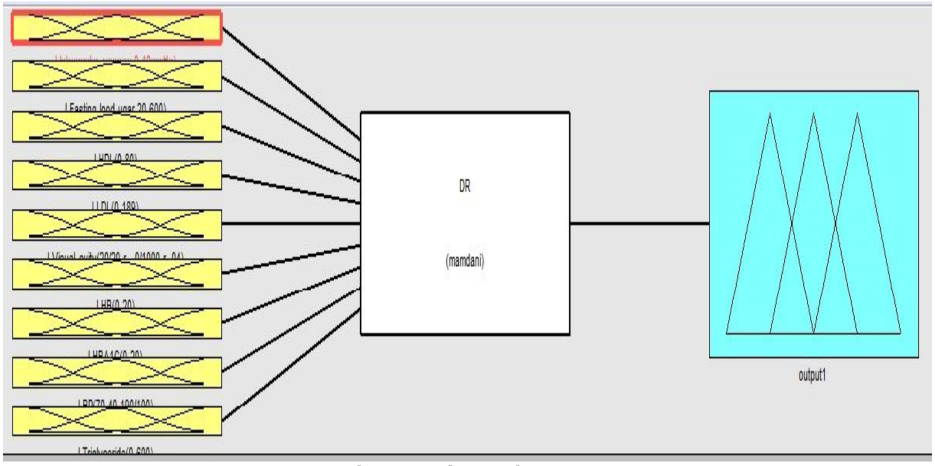

Fig -4.1: Mamdani FIS Editor with 9 inputs & 1 output.

4.2 Membership Functions

All the membership functions are connected with each variable. The membership functions of parameters are shown below and don't depict the definite shapes of the membership functions.

The membership function is used to edit rules and show all of the membership functions for the integrated fuzzy inference system, including both input and output variables.

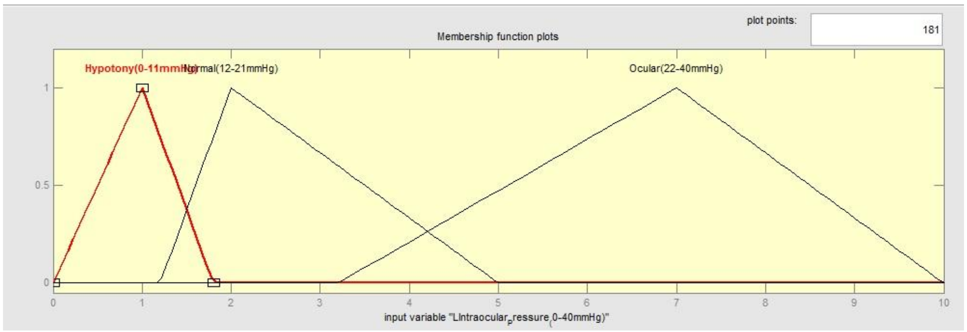

Fig 4.2(a): Membership Plot for Intraocular Pressure

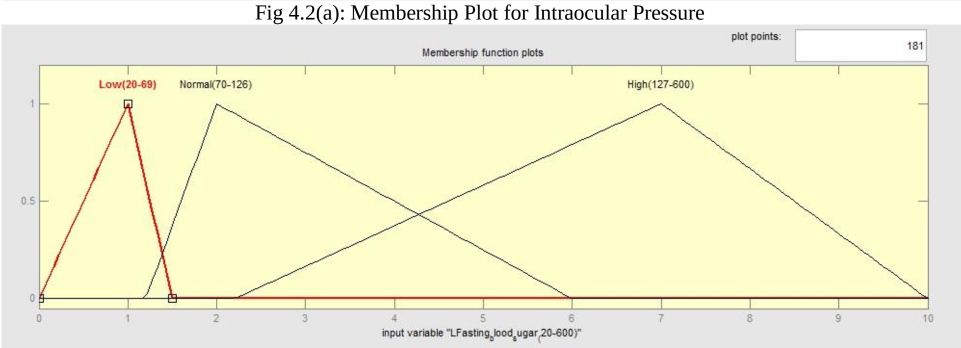

Fig 4.2 (b): Membership plot for Angle

It is the method of the unification of the rules. The membership functions of the entire rule previously antecedently clipped during rule evaluation are taken and combined into one fuzzy set. The process a number of clipped subsequent membership functions are changed into one fuzzy set for each output variable. The inference methodology used is the Mamdani inference method.

4.3 Rule Editor

Rule editor is for editing the list of rules that define the performance of the system. The rule editor comprises of an outsized editable text field for displaying and writing rules. rule editor is, in addition, has some acquainted with landmarks constant as those inside the FIS (fuzzy Inference system) editor andmembership perform Editor, along with the menu bar and also the status line.

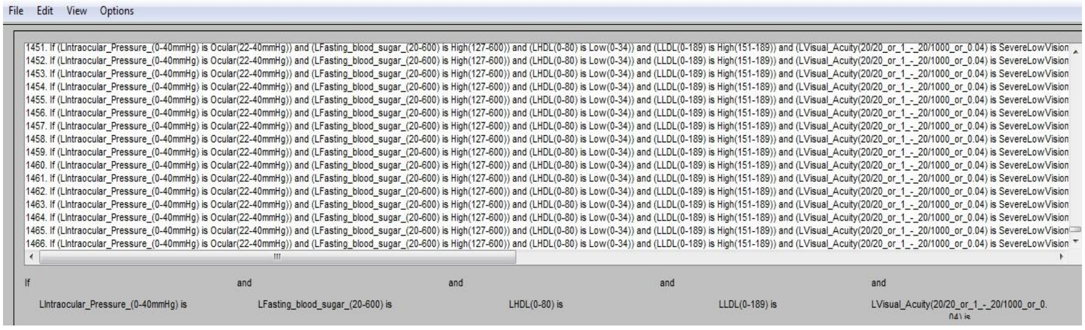

Fig 4.3:-Rule Editor

4.4 Fuzzification and Defuzzification

Fuzzification is the initial step in the design of any fuzzy expert system. It is the technique of mapping a crisp value of an input to membership degrees in several fuzzy linguistic variables. Defuzzification is the inverse process of Fuzzification. It's the method of combining the fuzzy output of all the rules to give one crisp value. Thus crisp value output is given by the Defuzzification method after estimating its input value.

V. EXPERIMENTAL RESULTS

5.1 Rule Viewer of some fields as follows:

Rule viewer to analysis the fuzzy inference system. Use this viewer as a diagnostic to check, for instance, the individual membership function shapes implication the results. The rule viewer displays the instructions of the complete fuzzy inference process. In addition, there are the now intimate items like status line and the menu bar. In the lower right, there is a text field where you can enter a specific input value. Figure 5.1 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 =5.45 which means the person is normal.

Fig 5.1: - Rule Viewer

5.2 Surface Viewer

Surface viewer to analysis the dependence of 1 of the outputs on any 1 or 2 of the inputs that is, it create and plot an output surface plot for the fuzzy inference system. It generates a 3-d surface from 2 input variables and one output variable of a FIS.

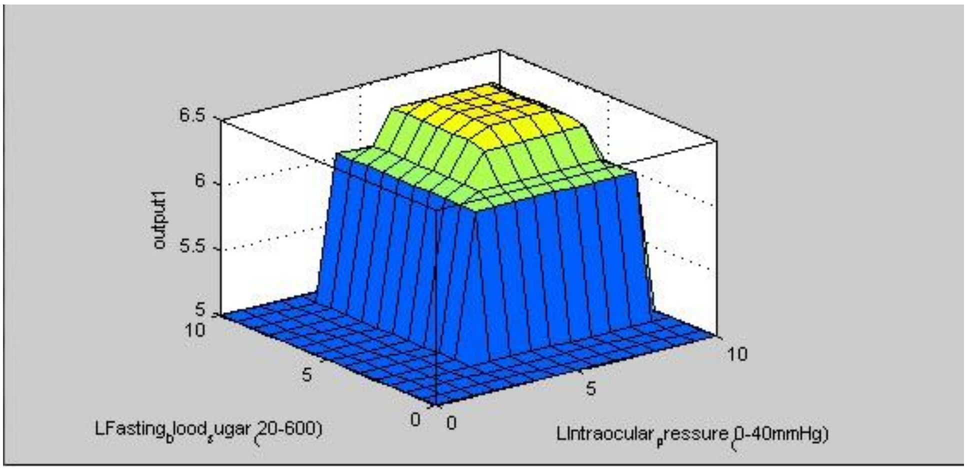

Fig 5.2(a):- Surface view of Intraocular Pressure and Angle

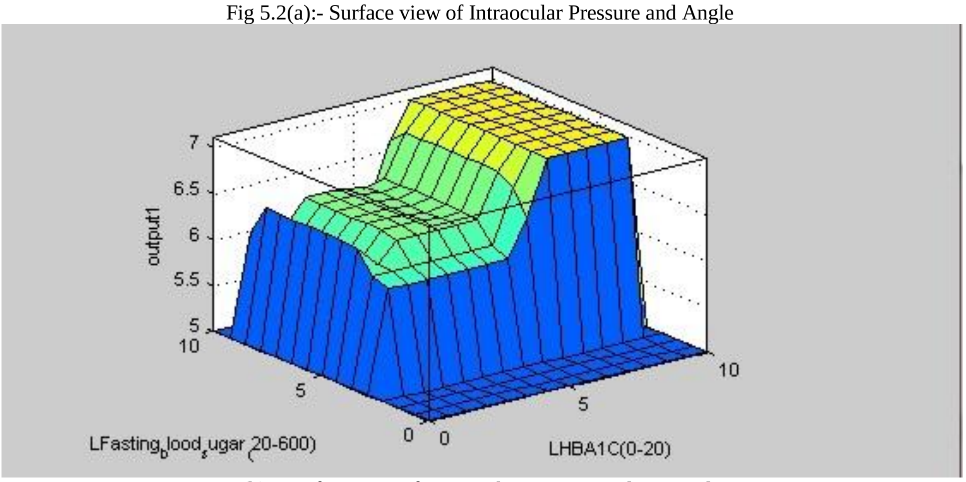

Fig 5.2(b):- Surface view of Intraocular Pressure and Cup to disc ratio

5.3 Graphical User Interface

MATLAB GUI (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; one is for MATLAB interface figures and another is for M-file, accustomed store the command operates of the MATLAB program.

The M-file provides code to initialize the graphical user interface and contains a framework for the 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.

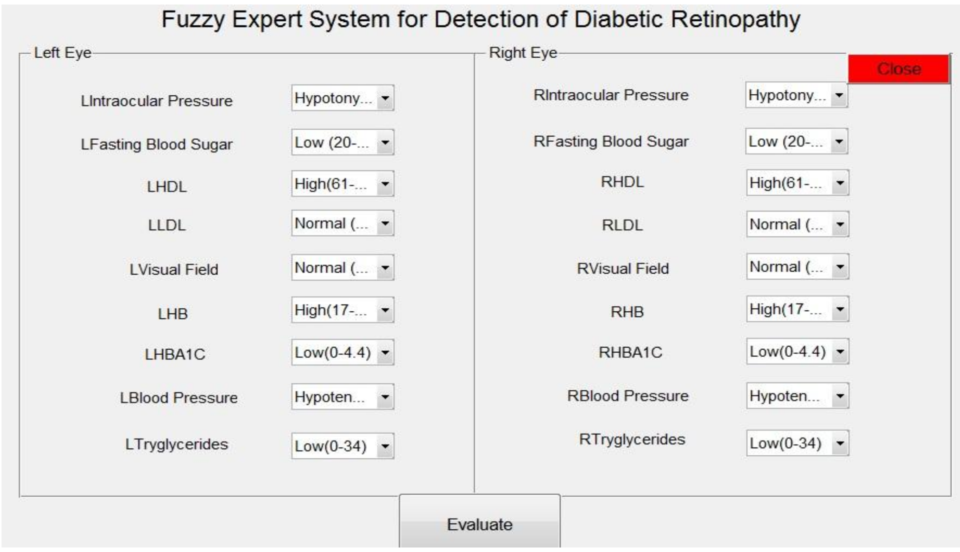

Fig 5.3(a): - diabetic retinopathy Detection GUI with Input Parameters

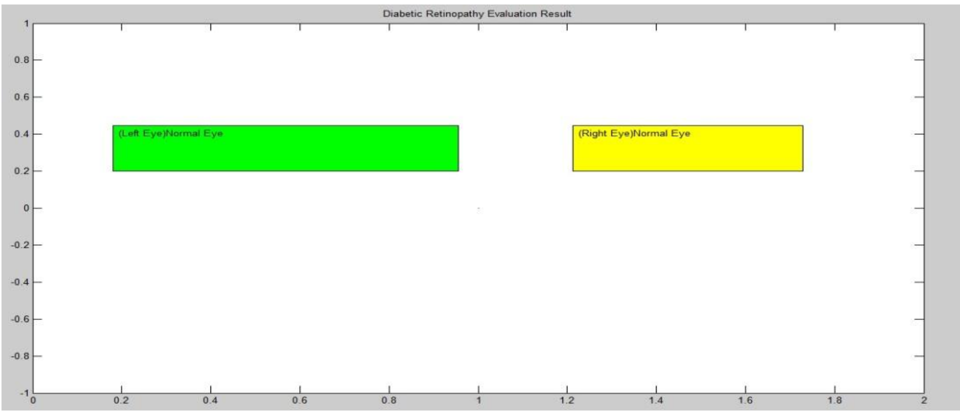

Fig 5.3(b):: - Glaucoma Detection for Both Eyes

There are nine parameters that are used to detect diabetic retinopathy are IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP and Triglyceride. In Graphical User Interface (GUI), we used 9 parameters on both left eye and right eye. The results will be evaluated of each eye (left and right) one by one based on fuzzy rules and dataset.

Firstly we took dataset of 150 participants from ophthalmologists and then we analyzed these dataset with fuzzy expert system. Our proposed system presents recognition of normal eye and diabetic retinopathy eye on the basis of parameters (IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP, and Triglyceride).Fuzzy rule-based allows experts knowledge to consider symptoms of patient and then based on the rules developed gives a precise decision. The outcome of 137 dataset was similar with the outcome of Ophthalmologists. For same evaluated results accuracy of our system is compared with respect to expert advice using relationship as:

$$\alpha = \frac{\beta}{\gamma} \times 100$$

α = Accuracy of fuzzy expert system
β = No. of correct decisions
γ = Total No. of patients
we have reached 91.3% accuracy by doing this whole process.

Table I represents the result of 9 parameters computed by proposed method for the test the doctor's observation. It was found that all the results were classified as diabetic retinopathy.

TABLE I.

Sr. No.	**IOP**	**FBS**	**HDL**	**LDL**	**Visual Field**	**HB**	**HBA1C**	**BP**	**Triglycerides**	**Result Of DR**
1	Normal	Normal	Normal	Near Normal	Normal	Normal	Normal	Normal	Normal	Normal Eye
2	Normal	High	Normal	Normal	Normal	Normal	Normal	Hypertension	High	Normal Eye
3	Normal	High	Normal	High	Moderate Low Vision	Normal	High	Hypertension	Normal	DR Mild
4	Hypotony	High	Low	High	Moderate Low Vision	Normal	Normal	Hypertension	High	DR Mild
5	Hypotony	Normal	Low	Normal	Moderate Low Vision	High	High	Normal	Normal	DR Mild
6	Ocular	High	High	High	Moderate Low Vision	Normal	Normal	Hypotension	Low	DR Mild
7	Ocular	High	Low	High	Moderate Low Vision	Low	High	Hypotension	Normal	DR Severe
8	Ocular	High	Low	High	Severe Low Vision	Normal	High	Normal	High	DR Severe
9	Ocular	High	Low	High	Severe Low Vision	Low	High	Hypertension	High	DR Severe

VI. CONCLUSION & FUTURE SCOPE

Diabetes is a chronic disease which is a serious concern in recent years. On the other hand, the human eye is a metabolically active organ means the blood affected by diseases is sure to affect the eye at the early stages and diabetes is one of such kind of disease. If the severity of diabetes is more, there is a chance of blindness. Therefore, at the early stage detection is essential for processing of diabetic retinopathy conditions. In this proposed paper, we have exhibited a fuzzy structure on decision supportive network for the finding of diabetic retinopathy. The proposed fuzzy interference framework predicts the normal eye, diabetic retinopathy (Mild), Moderate diabetic retinopathy and diabetic retinopathy (severe) and is aimed at helping ophthalmologists to detect early symptoms of diabetic retinopathy with ease.

The proposed strategy can manage different sources of input which can be far superior to handle vulnerability during the investigating period. This present framework can be extended by expanding the number of inputs. Therefore, This Technology will have a great impact in future and will be beneficial for Society.

SIGNIFICANCE STATEMENTS

This study discovers the easier, faster and cheaper way to it is detect diabetic retinopathy. It is beneficial for the society as it is possible to detect diabetic retinopathy with only two of the nine tests available. The patient can opt for more tests for better clarity if the first two show normal eye according to our Fuzzy expert system. This system also shows the level of severity of diabetic retinopathy i.e.

a) Normal eye
b) Mild diabetic retinopathy
c) Moderate diabetic retinopathy
d) Severe diabetic retinopathy

This study will help the researcher to uncover the critical faster detection of diabetic retinopathy which usually takes some time to get detected as the nine tests are expensive. This test involves nine parameters i.e., IOP, visual field, fasting blood sugar, HDL, LDL, HB, HBA1C, BP, and Triglyceride. Previous researcher used a maximum of two parameters.

Thus, a new theory on easier, faster and cheaper detect of diabetic retinopathy may be arrived at.

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