Abstract— Diabetic retinopathy, a complication of diabetes that occurs as a result of vascular changes in the retina, It is a major cause of loss of vision. Automated image processing has the potential to assist in the early detection of diabetes, by detecting changes in blood vessel patterns in the retina.

In this research use logic fuzzy theory and digital image processing techniques to give high accuracy results in the classification of images of diabetic retinopathy to infected or sound based on the features they contain a different shape.

Keywords—logic fuzzy, diabetic retinopathy, digital image processing, statistical processes, Matlab.

I. INTRODUCTION

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The World Health organization estimates that 135 million people have diabetes mellitus worldwide and that the number of people with diabetes will increase to 300 million by the year 2025. Medical image analysis is one of the research areas that are currently attracting intensive interests of scientists and physicians. It consists of the study of digital images with the objective of providing computational tools that assist quantification and visualization of interesting pathology anatomical structures. [1]

The progress that has been achieved in this area over recent years, has significantly improved the type of medical care that is available to patients. Physicians can now examine inside the human body to diagnose, treat, monitor changes and plan different mechanisms more successfully than before. [2]

A lot of approaches have been suggested and identified as means of reducing stress caused by this constant check-up and screening related activities among which is the medical digital image signal processing for diagnosis of diabetes related disease like diabetic retinopathy using image of the retina . During the recent years, there have been many studies on automatic diagnosis of diabetic retinopathy using several features and techniques. (Banumathi et al., [3] have analyzed the performance of three different template-matching algorithms in respect of the detection of blood vessels in the retinal image for both gray level and colour images. Blood vessels detection using the proposed 2-D Gaussian matched filtering gives the complete and continuous vessel map of the blood vessels. Erbert F. Jelinek et al. [4], have proposed that fluorescein labeled retinal blood vessels of 27 digital images were automatically segmented using the Gabor wavelet transform and classified using traditional features such as area, perimeter and an additional five morphological features based on the derivatives of Gaussian wavelet derived data. Jyoti Patil [5] has proposed an efficient method based on Sobel method that differentiates between original diabetic image & processed image. Sobel method can show separates parts of the edges of nerves from whole image. This paper has demonstrated an automated system that is able to distinguish normal and abnormal vasculature on the optic disc. The focus of this work is on segmenting the diabetic retinopathy image and classifies the Exudates, micro aneurysms and hemorrhages. In this paper, an automated approach for classification of the disease diabetic retinopathy using fundus images is presented. 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. Fuzzy logic was applied to analyze training data to find an optimal way to classify images into to infected or sound and to diagnose the type of injury based on the features they contain.

II. THE EYE STRUCTURE

Eye is like a camera. The external object is seen as the camera takes the picture of any object. It is housed in socket of bone called orbit and is protected from the external air by the eyelids. The cross section of the eye is as shown in Figure (1) while that of retina is as shown in Figure (2). [6]

Light enters the eye through the pupil and is focused on the retina. The lens assists in focusing images from different distance. The amount of light entering the eye is controlled by the iris, by closing when light is bright and opens when light is dim. To the outside of the eye is transparent white sheet called conjunctiva. Ciliary muscles in ciliary body control the focusing of lens automatically.
Choroids form the vascular layer of the eye supplying nutrition to the eye structures. Image formed on the retina is transmitted to brain by optic nerve. Optic disk is brighter than any part of the retina image and is normally circular in shape. It is also the entry and exist point for nerves entering and leaving the retina to and from the brain. Near to the centre of the retina is an oval shape object called macula. The fovea is near the centre of the macula and it contains packed cone cells. Due to high amount of light sensitive cells, the fovea is responsible for the most accurate vision. [6] [7]

The retina is a multi-layered sensory tissue that lines the back of the eye. It contains millions of photoreceptors that capture light rays and convert them into electrical impulses. These impulses travel along the optic nerve to the brain where they are turned into images. There are two types of photoreceptors in the retina: rods and cones. The retina contains approximately 6 million cones. The cones are contained in the macula, the portion of the retina responsible for central vision. They are most densely packed within the fovea, the very centre portion of the macula. Cones function best in bright light and allow us to appreciate color.

### III. DIABETIC RETINOPATHY

Diabetic retinopathy is caused by damage to blood vessels of the retina, the light sensitive inner layer of the eye. The eye, a vital organ of the human body, gives us the sense of color, shape and state of physical objects. However, if abnormalities occurs in the eye because of diseases such as Conjunctivitis, Fungal Keratitis, glaucoma, diabetic retinopathy, fungal infection, diabetes then eye may be damaged. [8]

Retinopathy is also more likely to occur earlier and be more severe if the diabetes is poorly controlled. Almost everyone who has had diabetes for more than 30 years will show signs of diabetic retinopathy. Symptoms of diabetic retinopathy include Blindness, Blurred vision, Floaters and Shadows or missing areas of vision. Many people with early diabetic retinopathy have no symptoms before major bleeding occurs in the eye, so everyone with diabetes should have regular eye exams.

Usually, ophthalmologists recognize diabetic retinopathy based on features, such as exudates, hemorrhages, microaneurysms, [9] hemorrhages and microaneurysms are the first clinically observable lesions indicating diabetic retinopathy. Therefore, their detection is very important for a diabetic retinopathy screening system.

### IV. REPROCESSING OF IMAGES

The image preprocessing techniques include Gray scale Conversion, Fuzzy Logic depending on the number of statistical measures such as mean, standard deviation, variance, energy, Homogeneity and Entropy.
V. GRAY SCALE CONVERSION

The color image of an eye is taken as input image and is converted to a gray scale image. Colors in an image may be converted to a shade of gray by calculating, for example, the effective brightness or luminance of the color and using this value to create a shade of gray. This may be useful for aesthetic purposes, for printing without colors and for image computations that need a single intensity value for every pixel. Color to gray scale conversion performs a reduction of the three dimensional color data into a single dimension. The results of normal and diabetic retinopathy affected Eye Images for original and after applying gray scale conversion are shown in Figure (3).

![Gray Scale Conversion](image_url)

Figure (3) normal and diabetic retinopathy affected Eye Images for original and after applying gray scale conversion

VI. STATISTICAL OPERATIONS

- **Mean \( \bar{X} \):** The average, and calculated from:

\[
\bar{X} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} I(i, j)}{n \times m}
\]  

... (1)

Where \( I(i, j) \) is the pixel value at point \( (i, j) \) of an image of size \( m \times n \), which can be of the same equation (1) calculated the rate of colors (red \( R \), blue \( B \), green \( G \)) as follows:

\[
I_i = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} I_i(i, j)}{n \times m}
\]  

... (2)

\( i \): one of the three colors (RGB).

- **Standard deviation \( \sigma \):** is a statistical measure of the precision for a series of repetitive measurements. The advantage of using \( \sigma \) to quote uncertainty in a result is that it has the same units as the mean value. It is calculated from:

\[
\sigma = \sqrt{\frac{1}{n \times m} \sum_{i}^{n} \sum_{j}^{m} (I(i, j) - \bar{X})^2}
\]  

... (3)

- **Variance** : Average total square deviations of the values from the middle of the arithmetic:

\[
\sigma^2 = \frac{1}{n \times m} \sum_{i}^{n} \sum_{j}^{m} (I(i, j) - \bar{X})^2
\]  

... (4)
Energy: Energy is used to describe a measure of "information" when formulating an operation under a probability framework; the equation is formulated as follows:

\[ \text{Energy} = \sum_i \sum_j P_{ij} \quad \ldots (5) \]

where \( P_{ij} \) refers to the probability distribution functions, which contains the histogram counts. The energy reaches its maximum value of 1 when an image has a constant gray level. The larger energy value corresponds to the lower number of gray levels, which means simple. The smaller energy corresponds to the higher number of gray levels, which means complex.

Homogeneity: It can be calculated homogeneity from the following equation:

\[ \text{Homogeneity} = \sum_i \sum_j \frac{P_{ij}}{1 + (\hat{g} - j)^2} \quad \ldots (6) \]

Entropy: The entropy of a system as defined by Shannon [11], gives a measure of uncertainty about its actual structure. Shannon’s function is based on the concept that the information gain from an event is inversely related to its probability of occurrence. Shannon defined the entropy of an n-state system as:

\[ H = -\sum_{i=1}^{n} p_i \log(p_i) \quad \ldots (7) \]

where \( p_i \) is the probability of occurrence of the event \( i \) and

\[ \sum_{i=1}^{n} p_i = 1 \quad 0 \leq p_i \leq 1 \quad \ldots (8) \]

VII. FUZZY LOGIC TECHNIC

Fuzzy Logic is becoming an essential method of solving problems in all domains. It gives tremendous impact on the design of autonomous intelligent systems.

Fuzzy Logic is a means of dealing with information in the same way that humans or animals do. Fuzzy Logic is built around the concept of reasoning in degrees, rather than in Boolean (yes/no 0/1) expressions like computers do.

Before we can apply fuzzy processing to an image, it is necessary to map the original image into the fuzzy domain. Since in some case we are trying to call the new domain the perception domain [10]. The formal fuzzy image-processing technic defined in Equations (1) to (3) is as follows. I(x,y) is the original image, F defines a set of mapping functions to map the original image into the fuzzy domain, (0,1), or perception domain. The perception domain is used when the image processing algorithm deals with the perception domain is used when the image processing algorithm deals with the perception of a subjective characteristic of the image. The perception mapping is also made to the (0,1) interval. However, the qualifier of perception provides a better meaning in some case [10].

The image in the fuzzy domain is represented by \( I_F(x,y) \). The fuzzy image is processed by a fuzzy set of operators \( F \) yielding a new fuzzy image \( I_F(x,y) \). Finally, the fuzzy image is mapped back to the original domain through the defuzzification function \( D \). The processed image in the original domain is represented by \( I(x,y) \):

\[ F: I(x,y) \rightarrow I_F(x,y) \quad \ldots (9) \]

\[ D[I_F(x,y)] = I(x,y) \quad \ldots (10) \]

VIII. DIAGRAM OF PRESENT STUDY

Figure (4) shows the diagram of present study.

![Diagram of proposed system for diagnosis of Diabetic Retinopathy](image-url)

Fig. (4) Block diagram of proposed system for diagnosis of Diabetic Retinopathy.
IX. RESULT & DISCUSSION

Table (1) Shows the results of application the statistical operations by used the equations (2 to 8) on sample of the images (figure -3-) used in this study.

Table (1) shows the results of Statistics of present samples.

<table>
<thead>
<tr>
<th>Samples # 10</th>
<th>Mean</th>
<th>Std</th>
<th>Var</th>
<th>Energy</th>
<th>Homogeneity</th>
<th>Entropy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>161</td>
<td>59.2</td>
<td>801</td>
<td>0.071</td>
<td>0.0608</td>
<td>1.7328</td>
</tr>
<tr>
<td>Max</td>
<td>205</td>
<td>80.7</td>
<td>1020</td>
<td>0.452</td>
<td>0.172</td>
<td>3.3764</td>
</tr>
<tr>
<td>Sum</td>
<td>2119</td>
<td>900</td>
<td>15244</td>
<td>2.93</td>
<td>3.62</td>
<td>50.46</td>
</tr>
<tr>
<td>Average</td>
<td>211.9</td>
<td>90.0</td>
<td>1524.4</td>
<td>0.293</td>
<td>0.362</td>
<td>5.046</td>
</tr>
<tr>
<td><strong>Exudates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>173</td>
<td>68.78</td>
<td>982</td>
<td>0.0502</td>
<td>0.124</td>
<td>2.26</td>
</tr>
<tr>
<td>Max</td>
<td>218.7</td>
<td>92.8</td>
<td>1762.56</td>
<td>0.611</td>
<td>0.452</td>
<td>5.383</td>
</tr>
<tr>
<td>Sum</td>
<td>2110</td>
<td>865.8</td>
<td>12400</td>
<td>3.67</td>
<td>3.46</td>
<td>43.0</td>
</tr>
<tr>
<td>Average</td>
<td>211</td>
<td>86.58</td>
<td>1240</td>
<td>0.367</td>
<td>0.346</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Microaneurysms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>180</td>
<td>72.25</td>
<td>1090</td>
<td>0.257</td>
<td>0.214</td>
<td>2.92</td>
</tr>
<tr>
<td>Max</td>
<td>227.24</td>
<td>97.129</td>
<td>19576</td>
<td>0.579</td>
<td>0.43</td>
<td>5.19</td>
</tr>
<tr>
<td>Sum</td>
<td>2208.6</td>
<td>5908.62</td>
<td>14517</td>
<td>4.58</td>
<td>5.85</td>
<td>58.9</td>
</tr>
<tr>
<td>Average</td>
<td>220.86</td>
<td>590.862</td>
<td>1451.7</td>
<td>0.458</td>
<td>0.585</td>
<td>5.89</td>
</tr>
<tr>
<td><strong>Hemorrhages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>191</td>
<td>79.2</td>
<td>1180</td>
<td>0.299</td>
<td>0.267</td>
<td>3.82</td>
</tr>
<tr>
<td>Max</td>
<td>239</td>
<td>105</td>
<td>1881.6</td>
<td>0.759</td>
<td>0.706</td>
<td>6.47</td>
</tr>
<tr>
<td>Sum</td>
<td>2489.41</td>
<td>971.2</td>
<td>15800</td>
<td>6.746</td>
<td>5.687</td>
<td>59.65</td>
</tr>
<tr>
<td>Average</td>
<td>248.941</td>
<td>97.12</td>
<td>1580</td>
<td>0.6746</td>
<td>0.5687</td>
<td>5.965</td>
</tr>
</tbody>
</table>

Figures (5 to 12) show the windows resulting from the application fuzzy logic (in Matlab 2012a) on samples (images) in study is based on the statistical results in the tables (1).

Fig. (5) The Interface of fuzzy logic in Matlab with statistical results
Fig. (7) Rule viewer Decisions window depending the results of statistical operations for normal & Exudates case images

Fig. (8) Models of three-dimensional graphics between the input statistical values and as a result of the decision for normal & Exudates case images

Fig. (9) Rule viewer Decisions window depending the results of statistical operations for normal & Microaneurysms images
Fig. (8) Models of three-dimensional graphics between the input statistical values and as a result of the decision for normal & Microaneurysms case images.

Fig. (11) Rule viewer Decisions window depending the results of statistical operations for normal & Hemorrhages images.
Fig. (12) Models of three-dimensional graphics between the input statistical values and as a result of the decision for normal & Hemorrhages case images

From the last figures (5-12), showing a comparison between the normal case and three infected cases, because the shapes found easy to distinguish between the normal and infected cases depending on the statistical values of the samples used in the study, which gives the possibility of the application of the software on any new cases (normal image of eye or abnormal of diabetic retinopathy). Once the inclusion of the new features of the image values in the interface of rule viewer Decisions.

X. CONCLUSIONS

In this study, an automated approach for classification of the disease diabetic retinopathy into Exudates, micro aneurysms and hemorrhages using fundus images is presented. In order to diagnose the disease diabetic retinopathy, a number of features such as such as mean, standard deviation, variance, energy, Homogeneity and Entropy of the pre-processed images are extracted to characterize the image content. These statistics have helped to distinction accuracy by the proposed method (Fuzzy). Experimental results show that the classification accuracy can provide a better result. Thus, Image processing techniques can reduce the work of ophthalmologists thus can use the provided program by specialists or non-specialists because It is a good property managed to deal with any new sample.

REFERENCES

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