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Diabetic Retinopathy Diagnosing using Fuzzy Image Processing

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***Abstract*: Aim: To design diagnostic expert system using fuzzy image processing for diabetic retinopathy, measures diabetic eye morbidity.**

Method: From this research paper, diagnosing diabetic retinopathy using fuzzy image processing for diabetic patients. Firstly collection of OCT images of the patient who has diabetic retinopathy. Author's proposed method finds out the edge detection of the OCT image. Then fuzzy logic is applied on that result of image processing. Design a fuzzy rules and input- output parameter. This method gives accurate diagnosing the diabetic retinopathy from the image of the patient's retina images.

Result: This diagnostic system gives patient's eye morbidity, vision threatening of the diabetic patients. In the result, edges of the retina images, and from that retinal ruptures, thickness of the proliferative in the retina. From these result, diagnostic of diabetic retinopathy conditions such as PDR, NPDR, and NORMAL, and CSME in the diabetic patients.

Conclusion: author has design diagnostic system for endocrinologist and ophthalmology to diagnosed diabetic retinopathy in the patients. From this system doctors don't need patients for diagnosing purposed.

***Keywords* : Diabetic retinopathy, fuzzy inference system, image processing, fuzzy image processing.**

I. INTRODUCTION

Artificial intelligence is a branch of computer science that aims to create systems or methods that analyze information and allow the handling of complexity in a wide range of applications[1]. In today's era, artificial intelligence has subset of fuzzy inference system, machine learning, data science; image processing etc. Applications used in various fields aerospace, electronics, mechatronics, mechanical, computer science, and medical. In the medical field, fuzzy inference system uses in treatment, pharmacy, diagnosis. Fuzzy inference system formulates the reasoning process of the human language by means of fuzzy logic and controls the presence of uncertainty for variety of problem domains[2].

Diabetes mellitus is one of the major challenges experienced by healthcare organizations. Diabetes mellitus is a group of linked diseases in which our body can't control the amount of glucose in the blood[2]. Person who has diabetes, insulin is not produced properly or insulin is not use properly.

A small organ near the stomach known as pancreas, is produces insulin, also it secretes good enzymes in the digestion of food. People with type 1 diabetes can't produce insulin properly. A person with type 2 diabetes does not produce enough insulin. It changes hormonal condition in which the body is unable to use energy from the food especially glucose and sugar. Most common symptoms shown in person are vision threatening, weight loss, polyuria, polyphagia, polydipsia, impaired healing and exhaustion. Because of this disease people may suffer from different diseases such as cardiovascular diseases, retinopathy, neuropathy, strokes, deafness, dementia, slowdown in healing process, ganglion in foot.

In 2004, 3.4 million people died from diabetes diseases[3]. In 2015, World Health Organization surveys that 457 million people worldwide have suffering from diabetes mellitus diseases[3]. In 2019 Chennai, recent survey in newsletter that most young age peoples are suffering from diabetes and diabetic retinopathy because of their lifestyle, using mobile technologies and physical inactivity in their daily life. In 2019 Gujarat, on "World Diabetes Day", newspaper surveys that most young and children people have type 1 diabetes and type 2 diabetes diagnosed.

In 2010, WHO states that 4.2 million people cause of visual impairment in diabetic retinopathy. In 2015, WHO surveys that Diabetic Retinopathy is 5th leading visual impairment. Also WHO states that 4th leading cause of blindness in the world. In world, 285 peoples are suffering from visual impairment in 2015.

In Gujarat, Rajkot city, from 400 peoples are suffering from diabetes, from that every 86 people have a diabetic retinopathy; it comes from the retrospective study.

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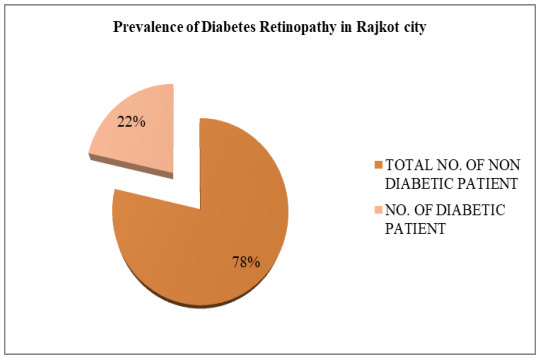


Fig. 1.Prevalence of Diabetes in Rajkot city

In Gujarat, 46% eye morbidity is seen in diabetic patients. The person who has diabetic retinopathy has 27% of vision threatening in eye; in Rajkot city has 5% of vision threatening.

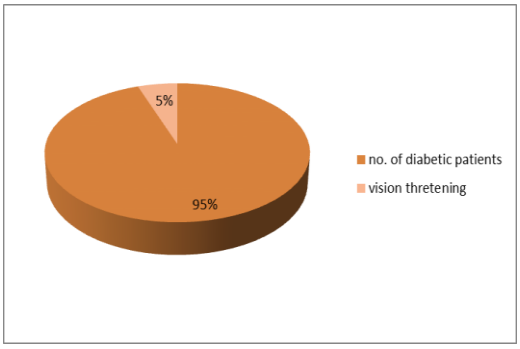


Fig. 2.Vision Thretening in eye

In Rajkot city, CSME is 16.5%, NPDR is 35% and PDR is 10% seen in diabetic retinopathy patients.

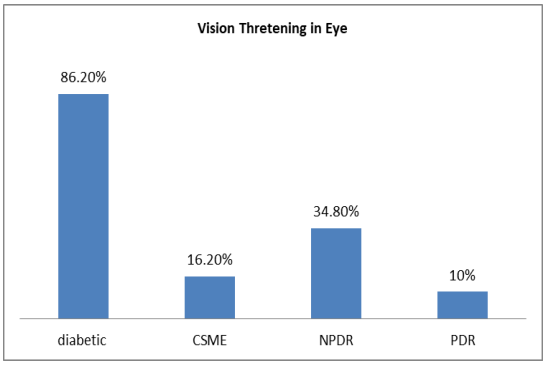


Fig. 3.Vision thretening in diabetic patient's eye.

II. DIABETIC RETINOPATHY

A. Anatomy of human eye

Human Eye is most vital organ for human beings; helps them to sense the color, shape and state of physical objects[4]. The eye is nearly a sphere with an average diameter of approx.20mm. Three membranes enclose the eye cornea, sclera, outer cover, choroid, and the retina.

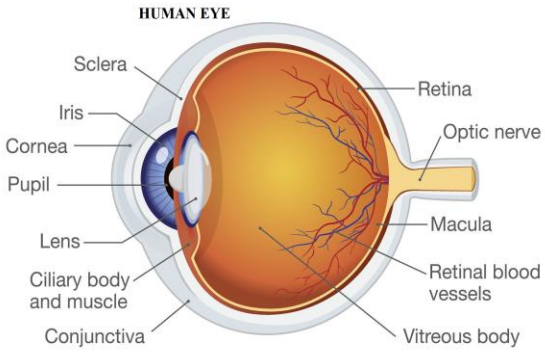


Fig. 4.Human Eye.

The cornea is a tough transparent tissue that covers the anterior surface of the eye. Continuous with sclera is an opaque membrane that encloses the remainder of the optic globe. The choroid is directly below, the sclera. The retina is a multilayered sheet composed of neurons, photoreceptors, and support cells[4]. Retina is most metabolically active organ in the human body. Retina is very sensitive to ischemia and nutrient imbalances.

Diabetes causes damages to the blood vessels of the retina are known as diabetic retinopathy. Retina is light sensitive tissue that back part of the eye, allowing seeing details in objects. DR is shown in working age people and person who has type 1 diabetes since long term. Many people with type and type 2 diabetes suffer from blindness.

B. Symptoms and risks

- Difficult in reading
- Eye pain
- Shadow in eyesight
- Eye pressure
- Color perception
- Blurry of double vision
- Spots in our vision.

Sometimes peoples do not observing symptoms for this disease. It causes because of blood glucoses level is too high; so that it damages small blood vessels of the retina. Most common risks of developing in diabetic retinopathy, who are suffers from diabetes mellitus diseases. Pregnancy, high blood pressure, high blood sugar levels creates the risks of developing diabetic retinopathy.

C. Classification of DR

Diabetic retinopathy is divided in two types: proliferative and non-proliferative. The blockage or abnormal of new blood vessels which are comes from our retina.

- *Non-Proliferative diabetic retinopathy*

Abnormally high blood glucose level damages retinal capillaries. The weakened blood vessels become leakier; so that fluid leaks into the retina; this results in fluid deposition under the macula, macular edema and irregular in normal functions of macula. It causes loss of vision. It creates low resolution in eye.

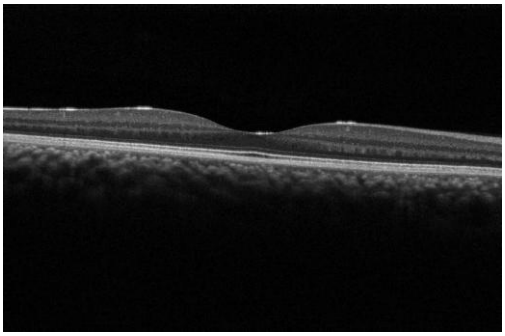


Fig. 5. NPDR.

Early NPDR is starting leakage in retina. Moderaate NPDR shows the spots of leages in retina. Severe NPDR is starting stage of PDR and blood vessels are totally leaks within the retina and resolution is very low.

- *Proliferative diabetic retinopathy (PDR)*

Proliferative retinopathy, in which retina has increased in metabolic requirement; a new blood vessels growth is abnormal and grows in center of the eye. On the surface of retina, form a new abnormal blood vessels and scar tissues. The scar tissue can pull on the retina and it causes retinal detachment and loss of vision.

If blood vessels grow on the iris; it can clog the drainage system of the eye causing glaucoma, pain and vision loss.

Fig. 6.PDR.

III. FUZZY IMAGE PROCESSING

A combination of fuzzy logic and image processing is known as Fuzzy image processing. This is used for determining the boundaries of images. This process is used for collection of all methods that understand, represent and processes in the images and their segments and features as fuzzy sets[5]. Fuzzy techniques selected for representation, processing and problem solving. Main stages of fuzzy image processing are as follows: image fuzzification, modification of membership values and image defuzzification. The fuzzification is a coding of image data and defuzzification decoding of image data for results.

Compute fuzzy image processing steps are as follows:

- Step 1
  A fuzzy input is defining the degree of membership of each input using membership function.
- Step 2
  By applying fuzzy operators, after inputs has been fuzzified by giving membership function. “IF – THEN” antecedent is used for design fuzzy rules. Result gives to the output functions so that input has two or more membership values from fuzzified input value.
- Step 3
  Membership function weight is between 0 and 1. Third steps is implication method, is the process of determining the output of the fuzzy rules consequent.
- Step 4
  Aggregating all output is the next step in which all fuzzy sets that represents the outputs of each rule combined into a single fuzzy set.
- Step 5
  Defuzzifying is the process of final desired single number output.

Fuzzy image processing is an emerging field in the medical applications. It is applied in the different fields such as automatic control, data classification, decision analysis, experts system, computer vision, and mechanical, aerospace, pharmacy, etc. it is a multidisciplinary nature, fuzzy inference system, fuzzy ruled based systems, fuzzy logic controllers, fuzzy soft, fuzzy modeling.

IV. PROPOSED METHOD

Author proposed a method design is based on the fuzzy image processing. OCT images of the retina are given for the processing. Resultant image of the retina shows edge detection with filtered image. From that image fuzzy rules are sets and output shows the diabetic retinopathy in eyes or not. It compares with the manual segmentation results of the previous work images.

A. Data

First step of this proposed method is collection of colored retina OCT or fundus images for processing. These images are collected from the eye hospital. This data set contains 20 OCT images captures through optical coherence techniques for capturing retinal images. From these images contains all desired data required to perform diagnostic of diabetic retinopathy.

B. Image processing

In this steps, OCT retinal images are processing are as follows:

1. Read retina image
2. Convert retina RGB image to GRAY image.
3. Then filter the gray image
4. Subtraction of filtered gray image and gray image
5. Find edges in subtracted grayscale image
6. Convolution with filter coefficient.
7. Select threshold for finding diabetic retinopathy

Author has designs a program, starts from the import retina image; then it converts RGB image to the gray image; then this gray scale image is filtered used for linear camera motion. To find the edges in the images authors has do subtractions of gray scale image from filtered image, in result it shows edges of the infected retina portions.

C. Fuzzy inference system

Lofti A Zadeh introduced the theory of fuzzy logic in the late 1960s. Fuzzy logic look like the human decision making approach. This gross over explanation of the real world problems and based on degrees of truth rather than usual true or false or 1 or 0 like Boolean logic.

Author has used fuzzy inference system applied a Mamdani Fuzzy Inference System.

Author has created fuzzy inference system (FIS) for edge detection. Then specify the image gradients, Ix and Iy. There are two input parameters and one output parameters for diagnostic purposed. In the input parameter threshold and filter are named as Ix and Iy. In the output black and white means patient's has PDR or normal. Output named as an Iout. Iy and Ix membership function are 0 to 1 between. Zero mean Gaussian membership function is suited for this edge detection. The gradient value for a pixel is 0 then it fits to the 0 membership function with a degree of 1. Fuzzy rules are made for trained the diagnostic system such as:

- If Ix is 0 and Iy is 0 then Iout is white
- If Ix is not 0 and Iy is not 0 then Iout is black

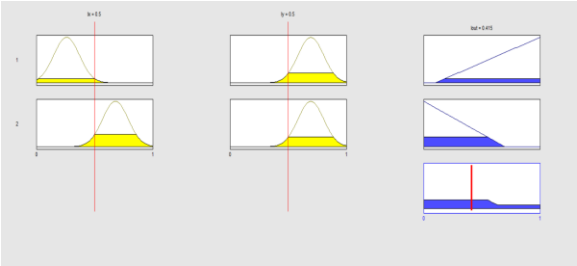
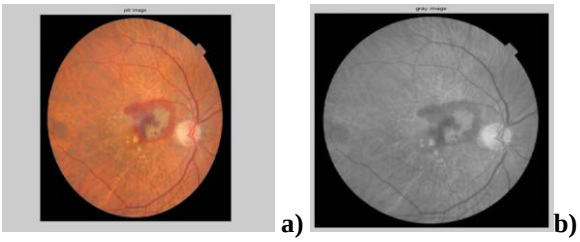


Fig. 7. Fuzzy rules

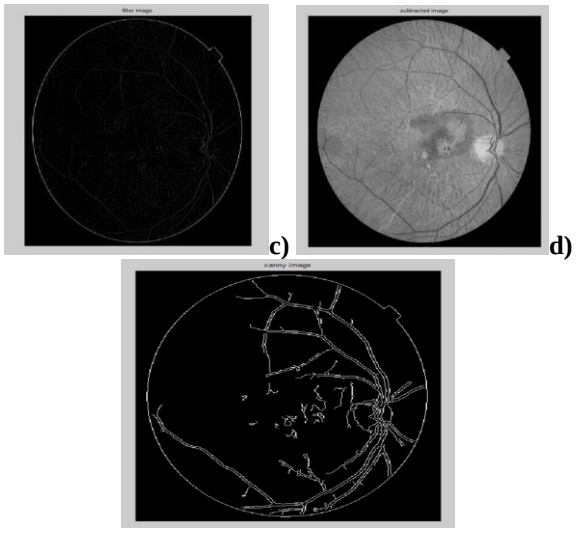
V. RESULTS

This diagnostic proposed system is easy to diagnose eye examinations. A manual eye examination takes more time for diagnosing. From this system, retinal ruptures, blockages in blood vessels, spots in retina are easy to examine within few minutes. Multiple diabetic retinopathy images such as normal, PDR, NPDR, and CSME are used in this work. Sizes of images are 24.5KB, 512*382 pixels, 24bits. Author's proposed work fuzzy logic stimulated using MATLAB on the various retinal images. Author has apply this method on three different retinal conditions images so that it gives accurate results.

Canny filter is used in this work; it is best suited for medical applications. Canny filter is used for edge detection; detect edges with threshold suppressed at the same time. Using this smooth the images with a Gaussian filter to reduce noise and unwanted details or shows details of the defected portion in retina. It detects all the edges that are stronger than threshold.

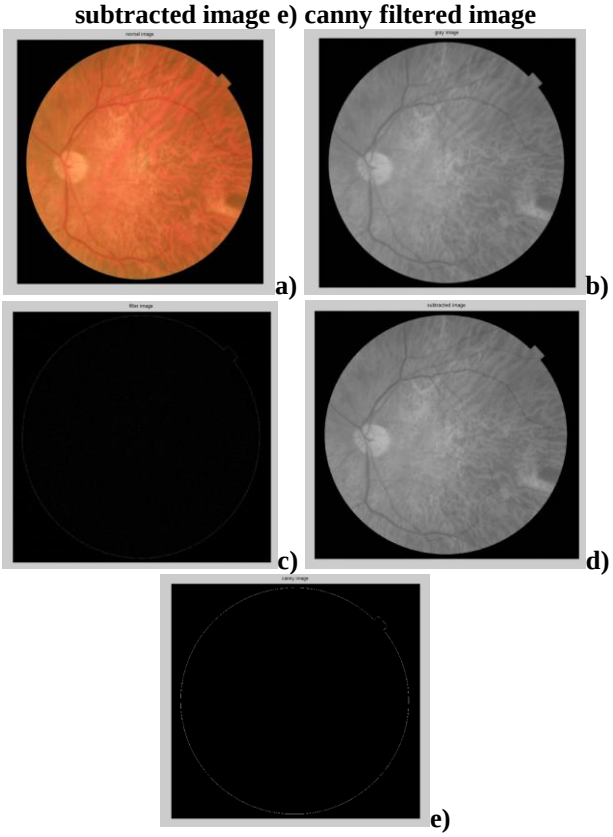


a) **b)**



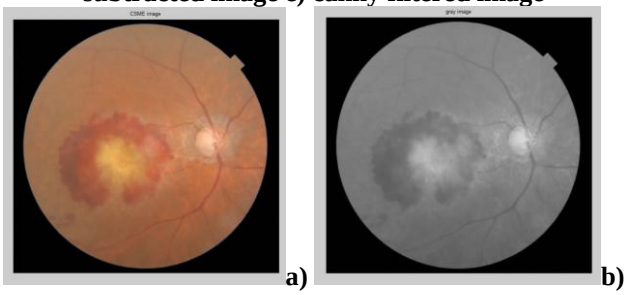
c) **d)**

Fig. 8.a) PDR image b) gray image c) filter image d) subtracted image e) canny filtered image



a) **b)** **c)** **d)** **e)**

Fig. 9.a) Normal image b) gray image c) filter image d) subtracted image e) canny filtered image



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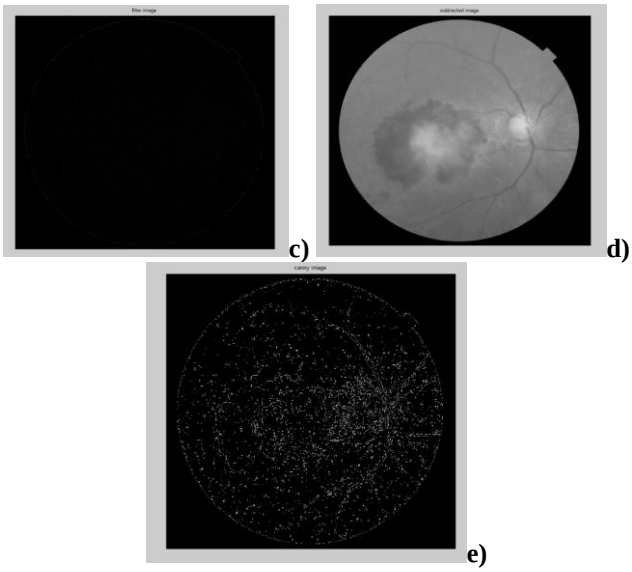

Fig. 10. a) PDR image b) gray image c) filter image d) subtracted image e) canny filtered image

VI. CONCLUSION

This diagnostic method deals with different stages of diabetic retinopathy images through taking all informative images. Endocrinologist and ophthalmologist have easy to diagnose diabetic retinopathy. This diagnostic method measures against the ophthalmologist categorized images. It is easy to extract diabetic retinopathy stages such as normal, PDR, CSME and NPDR. A result shows that proposed diagnostic system modifies by using fuzzy image processing to overcome the disadvantages of old techniques. This method is used for the analysis, prediction of retinopathy, diagnostic purposes. in this fuzzy image processing first findout the edges of the image using canny filter and second most important part is making fuzzy rules. It gives more accuracy than manual diagnostic system. It helps in diagnosing retinal ruptures, ruptures in blood vessels, spots in retina, and different stages of NPDR, PDR, CSME, retinal hemorrhage, and blockage in blood vessels.

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