A

Dissertation Report

On

AUTOMATIC DETECTION OF DIABETIC RETINOPATHY FOR COLOUR FUNDUS IMAGES

Submitted in Partial Fulfilment of the Requirements for the Award of Degree of

Master of Technology
In
Wireless & Optical Communication Engineering

Submitted By
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Certificate

This is to certify that the dissertation report entitled "**Automatic Detection of diabetic retinopathy for Colour Fundus Images**"submitted by **Sonali Rathore (2017PWC5525)**, in the partial fulfilment of the Degree Master of Technology in **Wireless and Optical Communication Engineering** of Malviya National Institute of Technology, is the work completed by her under our supervision, and approved for submission during academic session 2018-2019.

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Declaration

I, **SONALI RATHORE** hereby declare that the dissertation entitled **"Automatic Detection of diabetic retinopathy for Colour Fundus Images"** being submitted by me in partial fulfilment of the degree of **M.Tech (Wireless & Optical Communication Engineering)** is a research work carried out by me under the supervision of **Dr. K. K. SHARMA** and the contents of this dissertation work, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma. I also certify that no part of this dissertation work has been copied or borrowed from anyone else. In case any type of plagiarism is found out, I will be solely and entirely responsible for it.

Date : **SONALI RATHORE**

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(Sonali Rathore)

Abstract

Diabetic retinopathy (DR) is a chronic eye disease characterized by degenerative changes to the retina's blood vessel. In this thesis, we present a modified extracted feature for automatic detection of DR in digital fundus images. DR develops to some degree in nearly all patients with long-standing diabetes mellitus and can result in blindness. Screening of DR is essential for both early detection and early treatment. This thesis aims to investigate automatic methods for diabetic retinopathy detection and subsequently develop an effective system for the detection and screening of diabetic retinopathy.

The presented diabetic retinopathy research involves three development stages. Firstly, the thesis presents the development of a preliminary classification and screening system for diabetic retinopathy using eye fundus images. The research will focus on the detection of the earliest signs of diabetic retinopathy, which are the microaneurysms. This thesis will present a presents a robust and flexible approach for automated detection of retinal changes due to small red lesions by modified extracted features. The proposed approach was evaluated in the context of a regular diabetic retinopathy screening program involving subjects ranging from healthy (no retinal lesion) to moderate (with clinically relevant retinal lesions) .DR levels evaluation shows that the system is able to detect retinal changes due to small red lesions with a sensitivity of 100% at an average false positive rate of 0.33 lesions per eye on field of view of the retina by KNN classification. It is also hoped that the developed automatic detection techniques will assist clinicians to diagnose diabetic retinopathy at an early stage.

List of Abbreviation

DM	-	Diabetes Mellitus
DR	-	Diabetic Retinopathy
FCM	-	Fuzzy C-means
GLCM	-	Gray Level Co- Occurrence Matrix
KNN	-	K-nearest Neighbor
MA	-	Microaneurysms
RF	-	Random Forests
SVM	-	Support Vector Machine
TID	-	Type 1 Diabetic

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CHAPTER-1 INTRODUCTION

1.1 Background

Diabetic Retinopathy (DR) is a microvascular complication which may be found in patient of both insulin dependent (type 1) and non-insulin dependent (type 2) diabetes [1]. It majorly damages blood vessel of retina. The retina is a thin light-sensitive layer of tissue at the back of the interior eye. Retina is a reliable and direct way of monitoring the blood vessels in the human body. It has been vastly studied for association with a variety of diseases, like hypertension [38],[39], cardiovascular diseases [40],[41], and especially diabetes. This phenomenon has led many researchers to work on both how to improve the tools for taking retinal measurements and how to use these tools for studying retinal and other diseases. In initial stage of DR there is no direct symptom, but as time progress the patient may suffer blurred picture or complete loss of vision. People with diabetes are 25 times more likely to blindness than the general population [28].

In the early stages of DR, there are no warning symptoms and the changes in vision are not sensible. The signs of DR are microaneurysms (MAs), hard exudates, hemorrhage, macular edema, venous loops and venous beading. The impaired physiological functionality includes changes in the retinal blood flow rate, blood flow velocity, oxygen diffusion and intraocular pressure. All these parameters are believed to start changing much before the first stage of DR, affecting the vascular geometry before the first lesions appear [42]. According to presence of signs of DR, the stages of this disease which are described for the National Eye Institute (NEI) [29] are mild DR, moderate DR, severe DR and proliferative DR (PDR). Regular screening and early diagnosis of DR can reduce the disease progression [30].

When a diabetic patient is examined and found suffered with Diabetic Retinopathy, It directly referred to ophthalmologist for further diagnostic and treatment. This diagnostic process takes a lot of time and puts a considerable demand on diabetic eye care sources[31].

1.2 Research Objective

The objective of this study is to explore automatic techniques for diabetic retinopathy identification that can improve the management of diabetic retinopathy and then create an effective diabetic retinopathy screening scheme.

Firstly, the thesis has presented the development of a basic system for the screening and classification of diabetic retinopathy using eye fundus images, which is a system for general detection for diabetic retinopathy screening and will classify images into two respective cases: Normal and Diabetic Retinopathy. The research will then focus on the microaneurysms detection which is the earliest diabetic retinopathy signs.

Different image processing techniques are implemented in a variety of detection systems for microaneurysms which classify images into two main categories. The first categorization classifies them into detected and non-detected cases. The second categorization is based on Normal (No DR) and Diabetic Retinopathy cases. In addition, the thesis presents modified extracted features for diabetic retinopathy and maculopathy detection in eye fundus images [26].

In order to assist screeners to classify the retinal images effectively and with high confidence, an accurate retinal screening system is necessary. Therefore, to develop a diabetic retinopathy screening grading and classification system, effective techniques of image processing must be used. This research project examines the use of the fundus images for detecting the diabetic retinopathy features present in the eyes. This is a particularly challenging problem and this thesis proposes a novel use of image processing techniques in order to automatically detect the stages of retinopathy. To achieve this aim, highly efficient and accurate image processing techniques must be used to produce an effective screening of diabetic retinopathy.

The main objectives of the research described in this thesis are as follows:

i. To develop an automatic screening and classification system for diabetic retinopathy using fundus images in order to detect diabetic retinopathy at an early stage.

ii. To propose a novel use of image processing and classification techniques for early detection of the signs of diabetic retinopathy.

1.3 Motivation and Contributions to the Thesis

Eye screening is important for the early detection and treatment of diabetic retinopathy. Regular screening can help detect patients with diabetes at an early stage thus, earlier identification of any retinopathy can allow changes in blood pressure or blood glucose to be managed efficiently to slow the rate of progression of the disease. The importance of the proposed research is to overcome the current problems faced in the diabetic retinopathy screening process.

Manual diagnosis by the ophthalmologist currently, clinicians uses non-mydriatic fundus cameras to capture retinal images. Based on the image produced from the fundus camera, the experienced screening team will diagnose whether or not patients have any conditions (including diabetic retinopathy). The diagnosis is carried out manually by screeners who assess any changes (abnormalities) on the retinal image. This process is both laborious and prone to error.

The proposed automatic diabetic retinopathy system would help save time, costs and ultimately the vision of patients. With appropriate automation (i.e., decision support systems) in place, preventative actions to protect vision can then be taken earlier and therefore can help reduce the number of diabetic retinopathy problems, in addition to the risk of blindness. A decision support system for clinical diagnosis would contribute greatly in assisting with the management and detection of diabetic retinopathy. An automatic system will assist an ophthalmologist (or optometrist) to detect diabetic retinopathy (and its detailed classification) in a more efficient and faster way compared with manual analysis, which is more time-consuming [31].

Developing effective techniques of image processing for the diabetic retinopathy detection are a popular research area and many researchers focus on and contribute to the advancement of this study area. Most researchers focus on finding and proposing an accurate technique or method for detecting certain features of diabetic retinopathy through exploring the eye fundus images. Although there have been immense advancements in this area of research, there are still lacunae or spaces for improvement. The proposed techniques in this research will most notably benefit the realm of image processing in a number of areas or ways that include the provision of an accurate method for effectively detecting features of diabetic retinopathy.

To summarise, diabetes mellitus is the main health problem. One of the diabetes mellitus health effects is diabetic retinopathy, which causes blindness. Therefore, an effective tool to help in diabetic retinopathy detection is essential. A computer-based imaging screening method is needed to be developed where effective and cost-effective approaches are required. Automatic detection systems of diabetic retinopathy for patients with diabetes using the eye fundus photography will help the screening process by providing a user- or patient-friendly approach in addition to a cost-effective screening tool. Automatic classification systems with high accuracy of diabetic retinopathy screening will help in decreasing the workload for healthcare personnel in the process of the early detection of diabetic retinopathy [32].

1.4 Thesis Outline

The outline of the thesis is as follows.

In Chapter 1, we provide an overview of diabetic retinopathy screening and a more detailed investigation of the problems. The research aims and objectives of this study are also presented. In addition, the motivations which have led to this research, the contributions of the thesis and the research methodology are presented in this introductory chapter.

In Chapter 2, we describe the background and the literature review in addition to basic information on diabetes mellitus and diabetic retinopathy, as well as the prevalence of diabetes mellitus and diabetic retinopathy worldwide. It also provides information on the level of advancement in the area of image processing for diabetic retinopathy screening systems. The chapter also highlights the implementation of image processing techniques on medical and non-medical images, which is the core of this research work.

In Chapter 3, we discuss the research methodology used, including the process of data collection for this study. The research design, as a guide for planning the research development, is also presented. The experimental datasets, which consist of the existing datasets are presented in Chapter 3 in greater detail. The proposed system is presented using the previously described datasets and image processing techniques. Each system presents a combination of different techniques, such as different pre-processing techniques, different feature parameters and different classifiers in the diabetic retinopathy screening system. Extracted feature those proposed by other researchers is different.

The evaluations of the developed systems are also presented in Chapter 3, where it presents the efficiency and the validity of diabetic retinopathy classification through the developed systems.

In Chapter 4 we present the overall results analysis of a dataset. It presents the overall result analysis for the automatic developed systems. The chapter discusses the analysis performed on the expert diagnosis, including descriptive and inferential analysis. In order to generate a variance of system testing results and system performance, the overall analysis of the developed systems are presented in two ways: intensity features and modified extracted features. In addition, some discussions on the findings of this study are presented.

In Chapter 5 we summarise the accomplishments of the research work. It concludes the contents of the thesis and also highlights some recommendations for future research work. It also provides information regarding the research contributions, which have benefited a number of areas.

CHAPTER- 2 LITERATURE REVIEW

2.1 Introduction

Diabetes Retinopathy is a significant public health concern. The diabetes epidemic is leading to an increasing number of severe and chronic complications, including those that are sight-threatening. Diabetic Retinopathy (DR) is a complication of diabetes caused by high blood glucose. Diabetic retinopathy is a microvascular complication of both insulin-dependent (type 1) and non-insulin dependent (type 2) diabetes [2]. It is one of the diabetes mellitus complications that damage blood vessels inside the retina. The retina is located at the back of the eye. Diabetic retinopathy commonly affects both eyes and can lead to vision loss if it is not promptly treated.

2.2 Diabetes Mellitus

Diabetes mellitus is a disorder caused by constant hyperglycemia of variable severity, incidental to a lack or lessened efficacy of insulin .It is defined diabetes mellitus as a chronic condition due to an excess of glucose circulating in the bloodstream. Diabetes is a disorder caused by high levels of glucose in the blood. It happens either when the pancreas does not produce enough insulin or because cells do not respond to the insulin produced. Insulin is a peptide hormone, produced by beta cells of the pancreas, a large gland which is located behind the stomach. There are two types of diabetes mellitus, which are Type 1 diabetes and Type 2 diabetes [18].

The increasing numbers of cases of diabetes are due to the following factors: a longer lifespan, modern lifestyles (urbanisation, mechanisation and industrialisation) and also environmental and social factors, such as an unhealthy diet, obesity and physical inactivity in addition to uncontrolled hypertension and smoking [32].

Meanwhile, the main symptoms of both types of diabetes are thirst, urinating frequently (particularly at night), tiredness, weight loss, loss of muscle bulk, skin infections and urinary infections.

2.2.1 Diabetic retinopathy

Before the mid-19th century, some patients with diabetes suffered from significant visual impairment. No sign of cataract was detected but the symptoms responded favourably to improved glucose management. However, the link between diabetes and suspected ophthalmic pathology remained elusive until the invention of ophthalmoscopy. In 1855, the diabetic macular changes the connection between retinal findings and diabetes

remained somewhat controversial in the scientific community well into the 20th century[2].

Nowadays DR is well known as a potentially sight-threatening complication of T1D [10] It is often the first micro vascular complication to appear and accordingly some stage of DR is commonly detected in adults with T1D. The retina, the light sensitive tissue lining the back of the eye, undergoes structural changes as blood vessels become progressively damaged due to exposure to hyperglycaemia. The speed of the process varies according to several predisposing factors. Usually both eyes are affected, but the stage of DR is not necessarily symmetrical. Ocular perfusion problems due to carotid artery disease might be suspected if the level of fundus pathology is very asymmetrical between the eyes.

Once DR is present, its severity can vary from minimal non-proliferative changes to florid PDR. The prevalence of DR becomes almost universal with a long duration of T1D.

2.2.2 Pathogenesis of diabetic retinopathy

Unsatisfactory glycaemic balance is a fundamental contributor to the pathophysiology of DR. With time, hyperglycaemia causes the retinal vasculature to suffer a progressive dysfunction. The exact details to explain the pathogenesis of DR are not fully understood, although several interconnecting biochemical pathways are suspected to influence the development and progression of DR[11].

2.2.3 Prevalence of diabetic retinopathy

DR is fairly uncommon during the first three to five years after the onset of T1D and before puberty. The duration of T1D, both prepubertal and postpubertal years, is reflected in the time of DR onset. The years after puberty have a stronger impact and contribute twice as much to the development of DR than the years before puberty. Microaneurysms are usually the first clinical sign of DR and the initial detection is often based on retinal screening images[13].

The duration of T1D quite accurately predicts the presence of DR.The probability of diabetic changes occurring in the fundus increases with the post diagnosis time such that after 20 years, some degree of DR will be rather universally detected.

2.2.4 Classification of diabetic retinopathy

The time of DR onset and the severity of its manifestation vary significantly between individuals according to the presence of multiple protective and predisposing factors. The severity of DR can be broadly divided into three stages based on diabetic fundus changes; non-proliferative DR, pre-proliferative DR and proliferative DR[13]. In addition, diabetic maculopathy may appear at any stage of DR.it is to be classified for screening purposes This consists of disease severity starting from no apparent retinal changes to PDR.

2.2.4.1 Non-proliferative diabetic retinopathy

Non-proliferative DR is the least severe and usually symptomless form of DR in the international clinical classification system. A regular ophthalmic follow-up is usually sufficient for patients with non-proliferative DR. It commonly first presents with microaneurysms appearing as small red spots on the superficial layers of the retina. Microaneurysms are focal saccular dilatations often on the venous side of the retinal capillaries; they usually result from weakening of the capillary walls induced by the loss of pericytes. Other non-proliferative DR findings include intra retinal haemorrhages, resulting largely from ruptured retinal microaneurysms.

Superficially situated microaneurysms give rise to flame shaped haemorrhages due to the distinctive structure of the surrounding nerve fibre layer[14] .Microaneurysms located deeper in the retina, e.g. in the outer plexiform layer, form haemorrhage. Retinal microinfarctions, also known as cotton-wool spots or soft exudates, originate from occlusions of the precapillary arterioles in the nerve fibre layer. The lesions are white and fluffy in appearance and are often situated near to the vascular arcades. The microinfarction's typical appearance is created by the focal accumulation of axoplasmic debris from retinal ganglion cell axons. Lipid deposits, also referred to as hard exudates, are often associated with retinal oedema. The condition is caused by focal or diffuse vascular hyper permeability accumulating lipids and proteins in the inner and outer plexiform layers of the retina . Aggregated lipoprotein formations can be seen as well-defined yellowish deposits on the fundus. Lipid deposits can vary from singular small specks to diffuse large lesions on the edges of oedematous retinal area.

2.2.4.2 Pre-proliferative diabetic retinopathy

Pre-proliferative DR is characterised as severe non-proliferative DR.The microvascular fundus changes are more pronounced than in non-proliferative DR but neovascularisation is not present. Classification of DR is basis on three characteristics.

1. Intraretinal haemorrhages in all four quadrants of the fundus.
2. Definite venopathy in two quadrants.
3. Prominent intraretinal microvascular abnormality in one quadrant.

Potential symptoms of pre-proliferative DR depend mainly on the extent of macular involvement. Pre-proliferative DR may rapidly advance to PDR or remain static. utilizing a more detailed classification of DR, detected severe non-proliferative DR and very severe non-proliferative DR to carry 15% and 45% respective risk of progressing into PDR with high-risk characteristics[13].Retinal laser photocoagulation may be needed to prevent progression into PDR in advanced cases of pre-proliferative DR.

2.2.4.3 Proliferative diabetic retinopathy

Proliferative diabetic retinopathy is an advanced form of DR resulting from the accumulation of microvascular damage in the retina. When the metabolic needs of retinal cells are no longer fulfilled, new vascular growth is induced in an attempt to restore the lost balance. The hallmark of PDR is ischemia-induced neovascularisation of the optic disc and/or retina. Neovascularisation often appears near to the vascular arcades on the border of perfused and ischemic retina. In the absence of significant diabetic maculopathy, the first symptom of diabetic ophthalmic pathology noticed by the patient may be blurring of the visual field due to vitreous haemorrhage[14]. Fragile new blood vessels originate from the venous vasculature and may perforate the inner limiting membrane, gaining access to vitreous. The progression of neovascularisation is usually accompanied by surrounding fibrous connective tissue growth.

2.2.4.4 Diabetic maculopathy

Diabetic maculopathy is caused by microvascular changes accumulating in the central retina and resulting in ischemic, focal, diffuse or mixed macular oedema . Ischemic macular oedema can be seen in severely non-perfused fundus with leakage of fluid from the remaining vascular structures[15]. Focal macular oedema is predominantly caused by microaneurysms with high permeability. Diffuse macular oedema results from damaged capillary areas leaking fluid between the retinal layers.

Cystoid macular oedema can be seen in conjunction with any of the macular oedema types. It creates a flower petal-pattern in the fovea as vascular leakage forms large fluid filled cystoid spaces in the outer plexiform and inner nuclear layers of the retina. Lipid deposits, consisting of accumulated lipoproteins, may become aggregated in the proximity of any type of diabetic macular oedema.

2.2.4 Risk factors of diabetic retinopathy

The prevalence of DR becomes nearly universal after a long duration of T1D.DR is a heterogeneous microvascular complication in terms of severity and time of presentation. Several non modifiable (e.g. duration of T1D, pregnancy, puberty, genetic predisposition) and modifiable (e.g. hyperglycaemia, hypertension, dyslipidaemia, nephropathy, anaemia etc.) risk factors influence the development and progression of DR[16]. The modifiable risk determinants require special attention as their contribution to DR can be influenced positively as well as negatively by self-management and treatment adherence. The duration of T1D is a highly predictive non-modifiable risk factor for the onset and progression of DR. The probability of DR increases with cumulating post-diagnosis years. As DR advances, further progression also becomes more probable. However, some patients seem to be non-susceptible to developing diabetic complications, regardless of T1D duration. The factors providing prolonged protection from complications are insufficiently understood. Puberty is an independent risk factor for DR. In addition, the number of prepubertal years after T1D diagnosis and their glycaemic quality contribute to the risk of DR. However, the years after puberty have a stronger impact on the development of DR Microvascular fundus changes can progress rapidly during pregnancy due to gestational changes or the related glycaemic fluctuations. The evaluation of DR is advisable before, or at the latest early, in pregnancy Advancing DR in need of treatment should preferably be stabilised during preconception care. There is convincing evidence from family aggregation and twin studies to support the influence of genetic factors.

2.2.5 Treatment of diabetic retinopathy

In laser treatment, Lasers of multiple wavelengths can be used to treat different ophthalmic conditions. The high prevalence of diabetes and DR has made the laser an especially important tool in managing DR and in preventing visual impairment. Laser treatment to retina is administered with short laser pulses of the selected beam size, creating a focal retinal burn in a controlled manner [17]. The radiation energy of the laser pulse

is mostly absorbed by the pigment epithelium and underlying choroid. However, it increases also focally the temperature of the retina and the heat effect alters retinal morphology, creating a permanent scar.

Pan retinal laser photocoagulation has been the standard of care for decades in treating PDR. Pan retinal photocoagulation is applied with a relatively large spot size and the treatment covers the majority of retinal surface usually leaving only the macular area untouched. The retina has high metabolic activity and reducing the area of retinal tissue by pan retinal laser treatment reduces oxygen demand and ischemia in the fundus.

Any one of the following three conditions indicate clinically significant macular edema and point to a need for treatment.

1. Retinal thickening ≤500μm of the centre of the macula.
2. Lipid deposits ≤500μm of macular centre with adjacent retinal thickening.
3. Retinal thickening of at least one disc diameter (1500μm) situated at any part within one disc diameter from the centre of the macula.

2.3 Previous Work on Diabetic Retinopathy

Currently, image processing techniques are widely used as a means of diagnosing diseases, including eye diseases. Computer-based imaging tools are necessary to effectively detect signs of diabetic retinopathy. Early detection would allow the ophthalmologist to treat patients before major damage occurs and would present the best chance of protecting the patient's vision. The automatic diabetic retinopathy grading system would allow a faster and more efficient diagnosis. Preventive actions could be taken early to protect vision and avoid blindness.

Diabetic retinopathy screening is currently a common research area, in which some researchers focus on finding and proposing several techniques or methods for detecting certain features of diabetic retinopathy (i.e., microaneurysms, haemorrhages, exudates,and neovascularisation). Nonetheless, there are some researchers who propose the development of automated systems for detecting and classifying normal or abnormal diabetic retinopathy.

Digital image processing systems generally have three main parts: image preprocessing, feature extraction and classification.

2.3.1 Image Processing Technique

Preprocessing is the process of enhancing or improving features of image data for the next processing task. According to image preprocessing methods can be classified into four cat-

egories: pixel brightness transformations, geometric transformations, local preprocessing and image restoration. However, some papers classify image preprocessing methods into image enhancement and image restoration only.

Pixel brightness transformations deal with pixel brightness, and consist of brightness corrections and greyscale transformations. The brightness of pixel is adjusted in brightness correction according to the current brightness and image location; whereas in greyscale transformation, the brightness values contrast of the image is enhanced. The greyscale image is defined as a data matrix which the values are indicated by the shades of grey [33]. The grayscale transformations are mainly used for manual viewing in which the image is simply defined in an improved contrast. For example, greyscale transformation provides a clear contrast to an X-ray image. Greyscale transformation technique includes histogram equalisation for enhancement of contrast. The technique creates an equal distribution of brightness level for the image [28]

Geometric transformations offer the removal of geometric misrepresentation that happens during the image capturing process. The two basic steps of a geometric transform are pixel coordinate transformation and brightness interpolation. In addition, a significant purpose of image restoration methods, are to subdue degradation. The image restoration methods apply the concept of deconvolution across the whole image [34].

Local preprocessing methods utilise a small pixel neighbourhood in order to generate an output image with a new brightness value. Two common groups are used to achieve this, namely smoothing and edge detection. Smoothing is used to reduce noise or other minor fluctuations in the image. Gradient operators determine edges where the locations undergo fast changes. There are two components of edge detection, which are magnitude and direction. Most gradient operators such as Roberts, Laplace, Prewitt, Sobel, Robinson and Kirsch can be expressed using convolution masks [35].

Amongst the preprocessing techniques used in the present diabetic retinopathy detection system are greyscale conversion, green channel extraction, contrast enhancement, filtering, morphological operations [36], segmentation and thresholding among others. Within the scope of diabetic retinopathy detection, optic disc elimination and blood vessel removal are two main processes that are widely used as an additional stage, before the next process is performed. In addition, the localization of the fovea and macula are important for the detection of maculopathy. This detection of these retinal structures also requires some preprocessing techniques.

2.3.2 Feature Extraction

After performing the pre processing techniques ,feature extraction is performed to obtain the features from the preposoed image. Basic features for diabetic retinopathy are mean, Area and standard deviation.In addition there are many features diameter, perimeter, aspect ratio and intensity features. The feature can be classified in shape feature, colour feature, intensity feature and fourier descriptors' feature[23] [24]

2.3.3 Classification

Classification is done by two categories of classes .class 1 includes supervise class and class 2 includes unsupervised class. There are various classifiers to classify the output result. The classification of the images as normal or DR is performed by using the Support Vector Machine (SVM) classifier, a supervised learning algorithm [37].classification is done by the SVM classifier and neural network [23].

CHAPTER-3 MODIFIED SCHEME FOR RETINAL CHANGE

3.1 Introduction

In this chapter, the details of the proposed method for image retinal change using the modified extracted features are presented. The flow chart of overall process is given below.

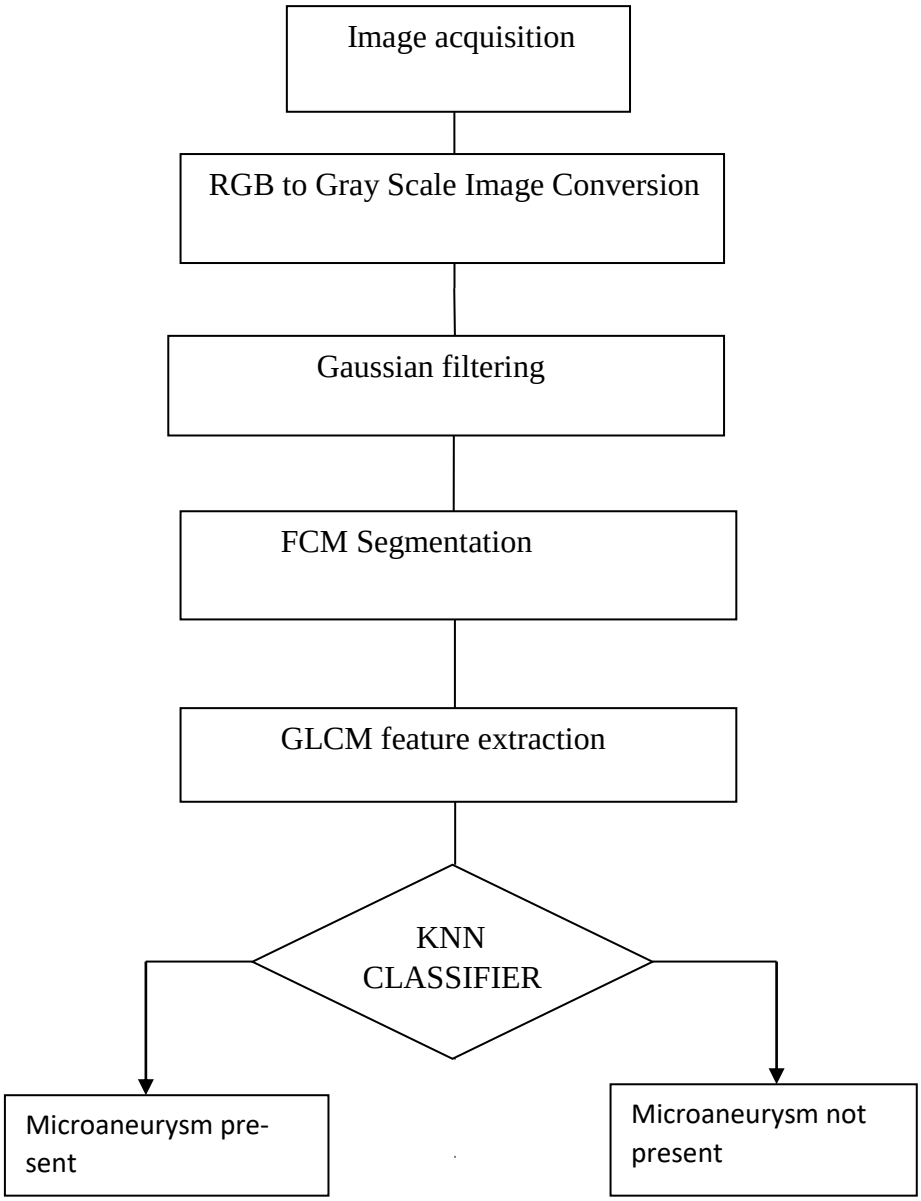


Fig 3.1 FLOW CHART OF MODIFIED METHOD

The input image is generally in RGB (Red, Green, and Blue) format .The input image is converted in to gray scale. The input image which is affected by the noise and it is filtered by Gaussian filter. The image is segmented by fuzzy C means algorithm. After segmenting image modified feature extraction is performed.

There are 13 features which is extracted and discussed in section 3.3.Microaneurysm detection is performed by extracted modified features. In proposed method three classifiers KNN (K-nearest Neighbor) ,SVM(Support Vector Machine) and RF(Random forest) are used to classify the result. The best result is obtained from the KNN Classifier.

3.2 Inputs

Data for the study is obtained from diabetic retinopathy detection [19].

In this data set there are available 7.2 GB data. I have taken only 35 images of dataset for training purpose and 89 images for testing purpose.

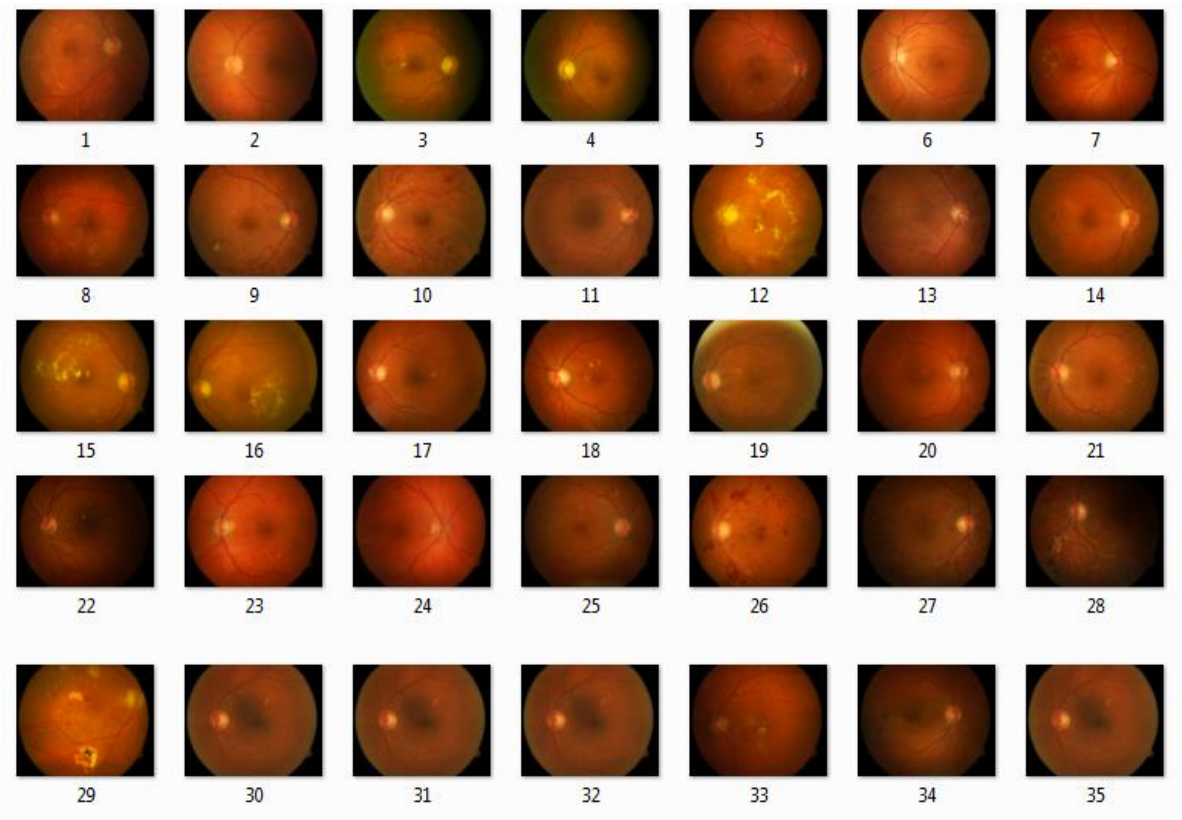
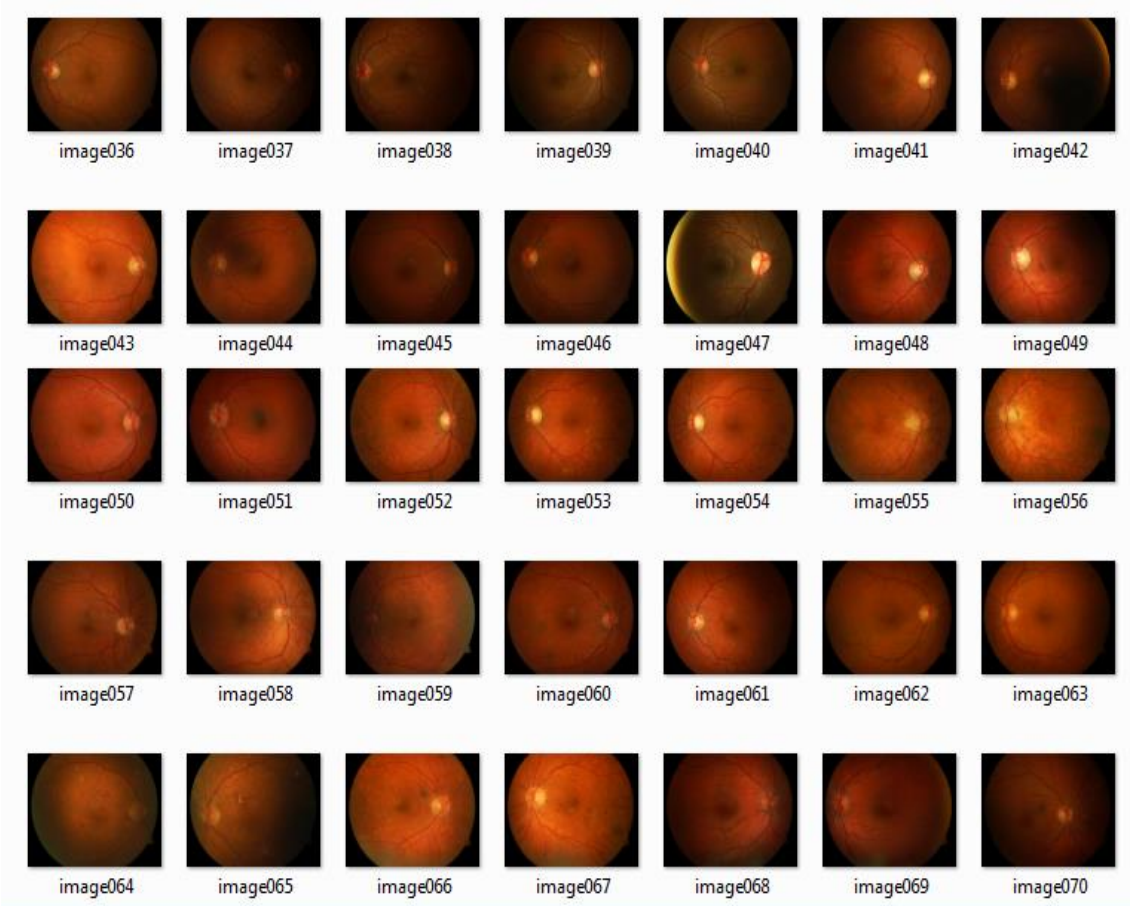


Fig 3.1 TRAINING DATA SET



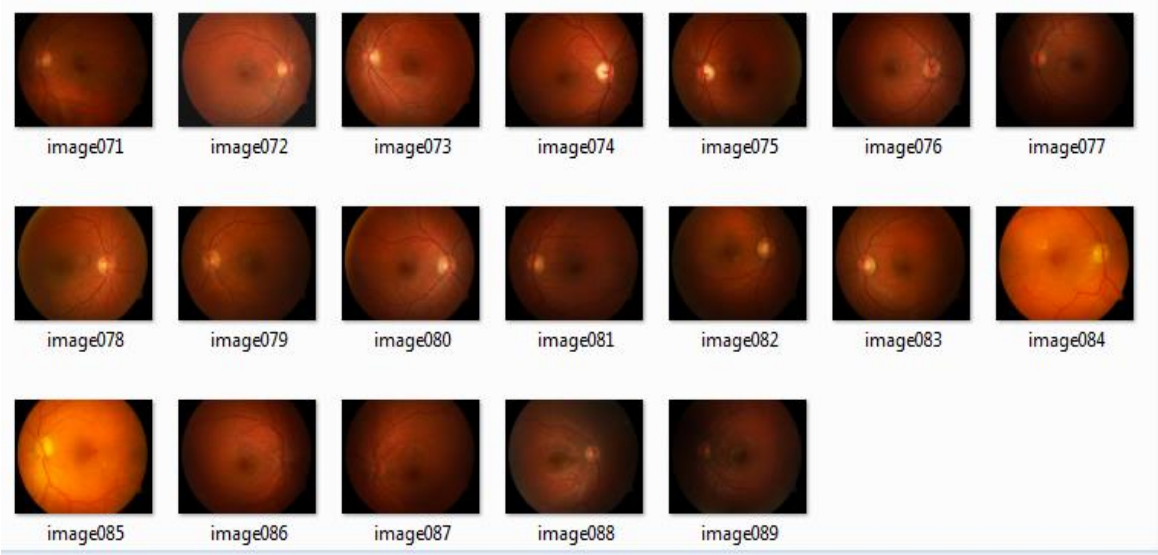


Fig 3.2 TESTING DATA SET

3.3 Modified Features Based Extracting

Feature extraction is the process in which the number of resources required to describe a large set of data accurately. The Modified feature extracting method is presented by adding the GLCM feature to increase the sensitivity of the overall process. The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second-order statistical features. It has been used in a number of applications; third and higher-order textures consider the relationships among three or more pixels. Gray Level Co-Occurrence Matrix (GLCM) has proved to be a popular statistical method of extracting features from images. According to the co-occurrence matrix, features measured from the probability matrix to extract the characteristics of texture statistics of remote sensing images. In this proposed method important features correlation, energy, entropy, homogeneity are extracted from diabetic retinopathy images.

There are features of the Co-occurrence matrix. Some important modified features are defined below.

1. Angular Second Moment (Energy)

Angular Second Moment is also known as Uniformity or Energy. It is the sum of squares of entries in the GLCM Angular Second Moment measures the image homogeneity. Angular Second Moment is high when image has very good homogeneity or when pixels are very similar.

$$\text{ASM} = \sum_{i=0}^{Ug-1} \sum_{j=0}^{Ug-1} p_{ij}^2 \tag{3.1}$$

where i, j are the spatial coordinates of the function p (i, j),

Ug is gray tone.

2. Inverse Difference Moment

Inverse Difference Moment (IDM) is the local homogeneity. It is high when the local gray level is uniform and inverse GLCM is high.

$$\text{IDM} = \frac{\sum_{i=0}^{Ug-1} \sum_{j=0}^{Ug-1} p_{ij}}{1+(1-j)^2} \tag{3.2}$$

IDM weight value is the inverse of the Contrast weight.

3. Entropy

Entropy shows the amount of information of the image that is needed for the image compression. Entropy measures the loss of information or message in a transmitted signal and also measures the image information.

$$\text{Energy} = \sum_{i=0}^{Ug-1} \sum_{j=0}^{Ug-1} -p_{ij} * logp_{ij} \quad (3.3)$$

After detecting candidate regions, several modified features are extracted from each candidate region.

The complete list of features of one testing image is shown in table 3.1.

Table 3.1

EXTRCTED FEATURE OF THE IMAGES

Features	**value**
Energy	0.0510
IDM	365.23
Correlation	0.0113
Entropy	0.9673
Standard deviation	0.4886
Contrast	0.0113
Homogeneity	0.9943
Mean	0.3070
variance	0.1087
smoothness	1.000
kurtosis	1.1881
Rms	0.3940
Skewness	0.4337

CHAPTER-4 SIMULATION AND RESULTS

4.1 Simulation

The simulation of the proposed method is done using MATLAB, and the one test image is taken from the testing data set and the result obtained for each step of simulation of the propsed method is given below.

The input image is taken which is shown in figure 4.1

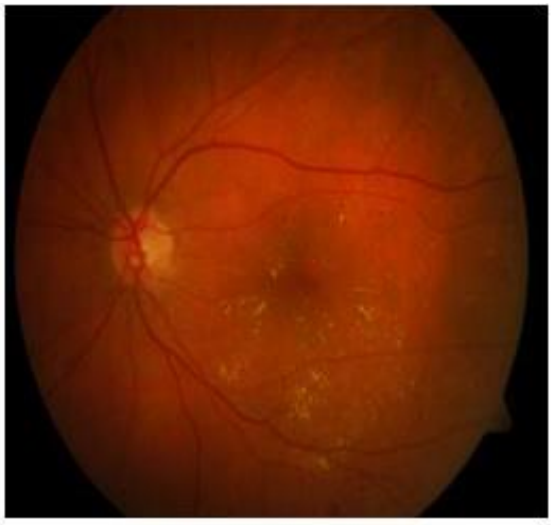


Fig 4.1 INPUT IMAGE

The image is in RGB format .That image is converted RGB to Grayscale. It is shown in fig 4.2

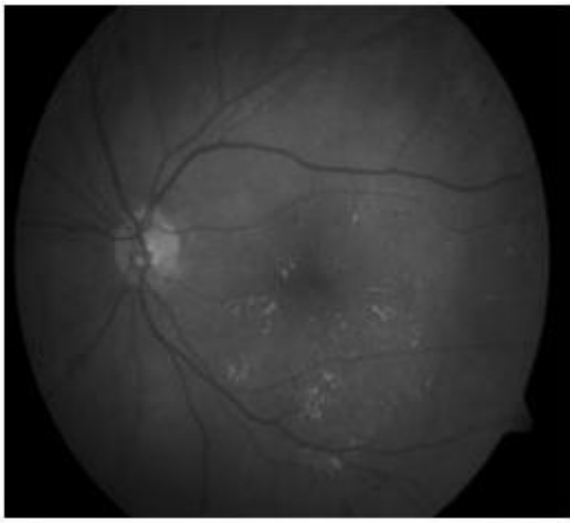


Fig 4.2 GRAYSCALE IMAGE

The noise is present in the Grayscale converted image .The noise is removed by Gaussian filter. The filtered image is shown in fig 4.3.

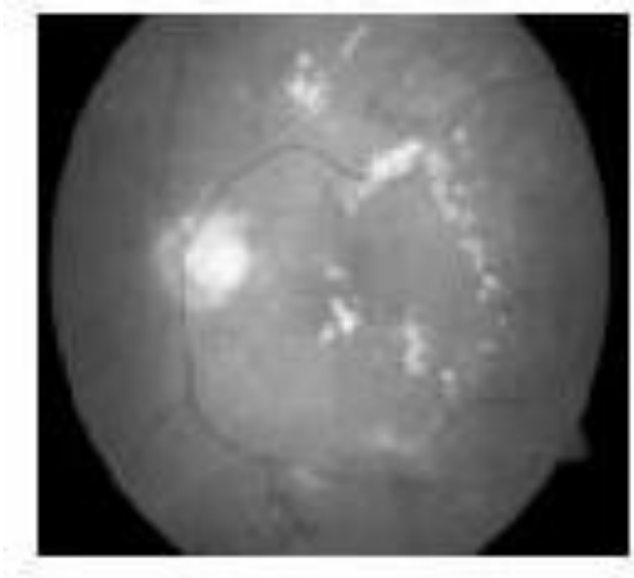


Fig 4.3 GAUSSIAN FILTERD IMAGE

After filtering process,the image is segmented by FCM algoritm. Extracting is done by modified features to obtain the desire output.After feature extaction ,retinal change detection is performed.The desired output is shown in figure 4.4**.**

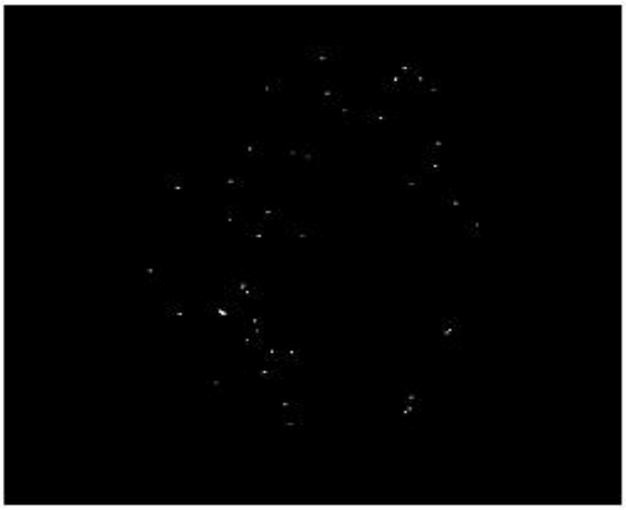


Fig 4.4 OUTPUT MICROANEURYSM IMAGE

4.2 Results

There are some parameter is given below.which are true positive(TP), false postive(FP), true negative(TN), false negative(FN).where TN is number of normal images which were correctly classified as normal and TP is number of diabetic images which were correctly classified as diabetic images. FN is number of diabetic images which were wrongly classified as normal and FP is number of normal images which were wrongly classified as diabetic images.

$$\text{Sensitivity} = \frac{TP}{TP+FN} \tag{4.1}$$

$$\text{Specificity} = \frac{TN}{TN+FP} \tag{4.2}$$

$$\text{FPR(false postive rate)} = \frac{\text{FP}}{\text{TN+FP}} \tag{4.3}$$

$$\text{FPR} = 1\text{-Specificity} \tag{4.4}$$

The performance evaluation of the proposed method is carried out, and quality metrics sensitivity and average false positive rate per eye are compared with SVM, RF and KNN Classifier. The comparison result is shown in table 4.1.

Table 4.1

COMPARISON RESULTS OF VARIOUS CLASSIFIERS

Classifier	Sensitivity (%)	false positive rate
SVM	89.66	0.66
RF	89.66	0.16
KNN	1.00	0.33

From table 4.1,The sensitivity and false postive rate are achieved of 89.66% and 0.66 respectively by SVM Classifier. The sensitivity and false postive rate are achieved of 89.66% and 0.16 respectively by RF Classifier. it is observed KNN classifier performed best among the three classifiers and achieved a sensitivity of 100% at an average false positive rate of 0.33 per eye shown in fig 4.4 it shows the free-response receiver operating characteristics (FROC) curves for the systems with various classifier and feature combinations. The blue line indicates the retinal change detection sensitivity (100%) of the proposed approach on the testing set of 89 images.

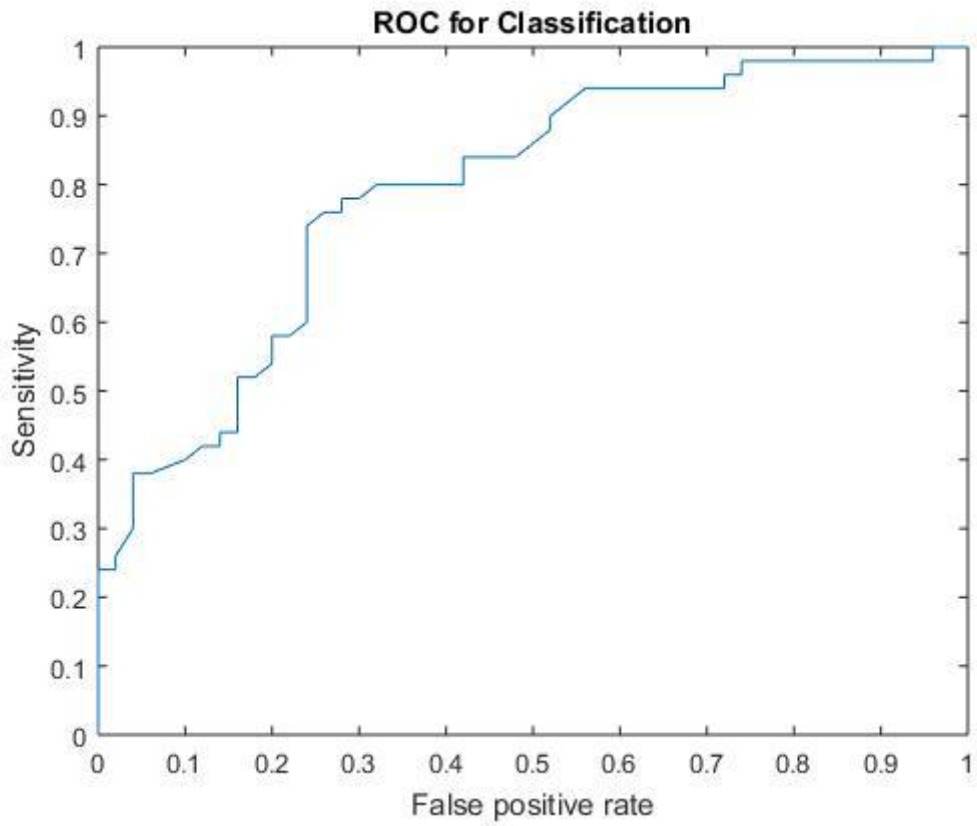


Fig 4.5 KNN CLASSIFIER FROC CURVE

Table 4.2

COMAPRISON WITH PROPOSED METHOD WITH EXISTING METHOD

Parameter	Existing method(SVM Classifier)	Proposed method (KNN classifier)
Sensitivity	98%	100%
False positive rate	2.5	0.33

In proposed method SVM result is compared with existing SVM classifier. The retinal change detection sensitivity is decreased from 98% to 89.66 and false positive rate is decreased 2.5 to 0.66. The result is improved in only one aspect. In proposed method KNN Classifier is used to a sensitivity of 100% at an average false positive rate of 0.33 per eye shown in fig 4.4. From table 5.2 the overall results we have achieved based on the proposed method are better than the previous methods mentioned in the literature.

CHAPTER-5 CONCLUSION AND FUTURE WORK

5.1 Conclusion

In this thesis, we have modified a robust and flexible multistage approach for detecting retinal changes due to small red lesions such as microaneurysms in fundus images. The system was applied to large retinal fields of 89 diabetic eye. In the modified method to detect retinal abnormalities by modified features extraction is used. The proposed method is evaluated with respect to DR screening program which is subjected to no retinal lesion to retinal lesions DR levels. Evaluation is done with respect to sensitivity and false positive rate. The proposed system is able to detect retinal abnormalities due to DR lesions with a sensitivity of 100% at a average false positive rate of 0.33.

5.2 Future work

The present work can be extended in many directions. Firstly the same work can be achieve to zero positive false rate by use of applied more features.

Even though the target of the Fundus Image analysis system presented in this thesis is to detect the retinopathy caused by the metabolic syndrome, this system can also be extended to detect other diseases that affect the retina.

This proposed method can be extended to video images in future.

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