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Automated Detection of Retinal Lesions in Digital Retinal Images for Grading of Diabetic Retinopathy

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Abstract: Now a days, in world wide the common diabetes related eye disease is a major issue for blindness. By utilization of image processing technique the abnormal detection of retinal images is obtained through regular screenings in the early stage itself. The accurate and early detection of issues is essential to protect the vision of patient in advance because it is the starting stage of the diseases. In order to avoid the issues a new method is proposed for identifying the abnormal and normal sign of retinal lesions. The abnormal detection is done by the automated medical system with hybrid classifier and optic disc coordinates. Finally, the image region features are formulated to binary map with its services based on certain properties like color, shape, etc. It detects the macula region of the images with ROI and the final output is obtained. The proposed method evaluation is done by the available digital retinal image databases and provides better performances with higher accuracy than the previous methods. The performances indicate the accuracy in terms of finding lesions and unusual signs in retinal images while maintaining correct classification of normal images.

Key words: Lesions detection, retinal Images, ROI, hybrid classifier, correct

INTRODUCTION

In the past 50 year as per the studies of epidemiological in industrialized countries, Diabetic Retinopathy (DR) is one of the main reasons for blindness over the population. It affects the human retinal blood vessels which injury the eye vision or sudden vision loss, flashes and blurred vision. By the early detection the cruelty diseases are represented the presence of lesions in the retinal image using regular screening will prevent vision losses.

The components of retinal images are blood vessels, macula and optical disc and sign of changes are identified as an eye disease. The leakage and the fluid of the retinal surface are the beginning of failure or damage of the retina, it occurs in background DR. As per the DR, by the leakage the retinas become swollen and wet and have non proliferative DR (NPDR) and proliferative DR (PDR) stages in DR. Depends on the quantity and the presence of lesions the stages of NPDR will further divide into different stages by the classifier, i.e., mild, severe, normal and moderate. Figure 1 shows the image of normal retinal.

The implementation of the screening in large scale has eliminated the examining cost in manual. In retinal image the automatic screening system is performed by the

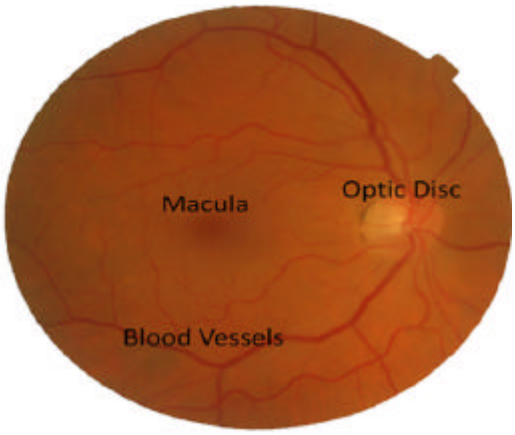

Fig.1: Healthy retinal image

possible solutions (Kahai *et al*., 2006). In clinics, computer aided diagnostic systems is performed using digital retinal images for diagnose eye diseases and to document the essential records. So, the abnormal and normal retinal images are able to differentiate it and reduce the workload in examining the images (.Niemeijer *et al*., 2010; Walter *et al*., 2002). About 60% of patients are affected with type II disease and mostly the public have type I which causes blood sugar, blindness, etc.

By the detection and early process about 50% of cases are prevented. Normally for 10 year or more age

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people are affected up to 80% and according the research statistics by early treatment and screening eyes and by monitoring eyes up to 90% of new cases are reduced. The retinal capillaries are visible as a spot locate, round, small in the retinal layer inside. So, finally, it will cause a blind spot which will break the visual of retinal field.

In this study, proposed a detection algorithm to detect and handle the related lesions of the retinal images. The extraction of features measurement is diagnosis the medical image to analysis the abnormal sign with better performances in an easy manner and robust than the previous methods. The automated detection system makes possible to view the retinal images the computer-aided grading process. According to industrialized countries, peoples are highly suffered by DR and every region almost.

The retinal difficulties are related to diabetes, by timely process the loss of vision is prevented efficiently. Representation of images in visual to review as photo helps medical professionals to have an efficient process with great energy and time (Walter *et al*., 2007; Larsen *et al*., 2003). It is a machine learning techniques used to perform diagnosis and analysis at the initial stage for better accuracy and performances in detecting the lesions of retinal images (Sinthanayothin *et al*., 1999).

Literature review: In this study, literature review of detecting and classification of retinal image is presented. In recent year all over the world the main cause of blindness is diabetic. By early detection of diseases and treatment the loss of vision and upcoming cases can be reduced. In order to detect the disease, some image processing techniques are implemented.

Diabetic retinopathy is an optical appearance of systemic disease which affects the people from 10 years. Intimidating statistics show that the new cases can reduce by the early treatment and monitoring of the eyes. By the image processing technique classifier and lesion detection the new cases can easily detect for the treatment or prevention (Patwari *et al*., 2013;Ram *et al*., 2011).

By regular screenings process of image processing will automatically detect the abnormalities of the image. The presences of lesions/ exudates are detected to find the normal and abnormal signs in retinal images. By brightness adjustment with the method of local-window-based verification and statistical classification method the detection accuracy has achieved 100%, while maintain the correct retinal image classification of 70%. By this process it helps medical professionals by saving time and better visual process (Akram and Khan, 2012; Wang *et al*., 2000).

For automatic lesion segmentation the mathematical morphological methods are used to segment the region of the images for the detection of lesion/exudates (Osareh *et al*., 2009). It is essential for diagnosis of diabetes with the classification of moderate or severe cases of non-proliferative diabetic retinopathy. The exudates area is divided to optical disk after the segmentation process of the images. When compared to moderate and severe case of diabetes the significant difference is ($p = 0.05$). For better visual and report the computer aided quantification and grading of retinal images is performed (Wu *et al*., 2014; Sinthanayothin *et al*., 2000). Earlier detection is in three stages of system by filter banks. It classifies the MA or non- MA and formulate each region based on its properties. By combining of support vector machine and Gaussian mixture model the accuracy of the system is improved (Tariq *et al*., 2013; Akram *et al*., 2013a).

Table 1: Performances analysis of the proposed work

Methods	Sensitivity (%)	Specificity (%)	Accuracy (%)
Niemeijer *et al*. (2010)	100	87	–
Fleming (2006)	85.4	83.1	–
Quellec *et al*. (2008)	89.62	–	0.929
Keerthi (2011)	88.46	–	–
Walter *et al*. (2002)	88.5	–	–
Kahai (2006)	100	67	–
Quellec *et al*. (2008)	–	–	0.927
Larsen *et al*. (2003)	71.4	96.7	82.6
Sinthanayothin (1999)	77.5	88.7	–
Ahmed	94.90	100	–
Osareh *et al*. (2009)	93	94.1	93.4
Haniza *et al*. (2012)	94.25	99.2	–
Tariq *et al*. (2013)	97.06	98.55	97.83
Akram *et al*. (2013)	98.64	99.69	99.40
Proposed system	99.35	98.2	99.52

By spot lesion detection algorithm, the background pathologies of the diabetic highlight the lesion detection with its location, size and shapes. The unique adaptive multiscale morphological processing technique is performed to generate the area of lesion and enhancement of it. The segmentation of regions is performed for scale map the region and as per map the over-detections are removed. The algorithm performance evaluation shows the improvement of spot detection of lesions with high sensitivity (Zhang and Fan, 2006).

A novel hybrid classifier is used to extract the lesions and classify it based on the signs in the region of retinal images. The features are formulated and performed with the filter bank to detect the accurate lesion with the possible candidate region. By m-Mediods and Gaussian mixture model the classification accuracy and processing are improved. Detecting and grading of abnormal blood vessels are based on multivariate m-methods based classifier (UsmanAkram *et al*., 2014). Through, the multilayer technique the optical disc and the pattern are categories according to the grade of each state or region and coordinates of the disc (Akrama *et al*., 2013b; Yazid *et al*., 1997; Reza *et al*., 2011). The existing performances are illustrated in Table 1 for analysis and comparison of the system.

MATERIALS AND METHODS

Proposed Work: Early diagnosis and the detection of abnormal sign will prevent the loss of vision. In order to provide better performance the proposed classifier and detection technique is designed and implemented. Also to prevent a sudden loss of the vision grading method is used and the proposed algorithm improves the accuracy and the performances of the system. In this study, the main aim is to detect the retinal lesion and to classify the sign of the detection for identification of issues in retinal image in order to prevent diseases. The process of the proposed system flow work is shown in Fig. 2 (Akram *et al*., 2014). The procedure of the proposed system is done according to the following steps:

- Read the Input image
- Convert the image into gray scale
- As per segmentation of image, detect the lesion
- Evaluate the thickness of the lesions
- Extract the lesion location in the retinal image
- Evaluate the lesion distance from fovea and optical disk, also ROI- Region of Interest is calculated to find the complexity of the retinal images.
- Finally, classify the images based on the obtained results as Normal, Mild, Moderate and severe

In proposing method the fovea region, optical disk and lesions are detected to measure the distance and location for classification of retinal image. It predicts the functions with the condition enhancement process and the region is cropped the detected part according to radius. So, the optical disk is neglected from the image and then masking the region. Finally the lesion detection finds the region, which closes to fovea of the image and classifies the image as per the classification condition.

Extraction of pixel differences between the foreground and background of the images is removed by pre-processing the retinal images. The foreground pixel of the image is estimated and retained the process of eliminating the unwanted pixels. The segmentation estimation of the background noise detection is performed before macula detection of the images.

The next stage of pre-processing is macula Detection, which is used for grading the diabetic maculopathy. The macular area will affect the central vision and the severe cases will cause blindness. By this technique, the blood vessels are enhanced and detect the localities. Finally, the detection distance from optic disk are estimated and locate the pixel of the region.

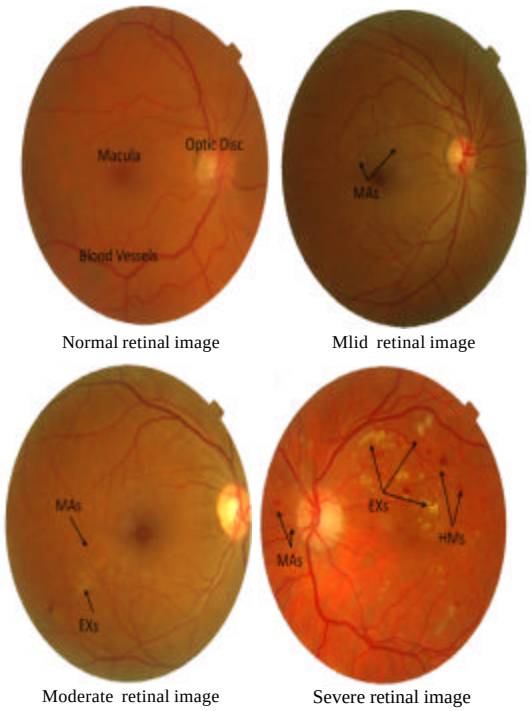

Fig. 2: Human retinal stages

By the computer based diagnostic system with proposed enhanced detection of lesions of images is implemented for the classification of normal and abnormal images by detecting the lesion. It identifies the significance of the differences in the images by the appearances of the images. The region of the images will appears as gray image or dark or red image with high contrast. Based on the regional presence the accurate image is defined by using enhancement approach of the proposed system. By enhanced contrast enhancement technique the process of detection provides better performances than the others. As given below the function of detecting is performed:

$$P = 255\frac{\left[\left(1+\exp\left(\frac{m_w - f}{\sigma_w}\right)\right)^{-1} - \Phi_w\left(\phi_{i\min}\right)\right]}{\left[\Phi_w\left(\phi_{i\max}\right) - \Phi_w\left(\phi_{i\min}\right)\right]} \quad (1)$$

Where:

Φ_w = The indicate the sigmoid function

ϕ_{imin} and ϕ_{imax} = The represent the minimum and maximum value of the intensity of the retinal image

m_w and σ_w = The mean and variances of the function are denoted as

p = The proposed technique

As well as, the proposed system performed with genetic algorithm in the image processing environment. The binary region of the output is extracted by low threshold value. The non lesion pixels are removed and it performs by filling the holes in connected regions. Also, eliminate the spurious region. Therefore, the various phases of lesions are detected and the final binary map of the image is obtained only with lesion detection of retinal images. Based on Region Of Interest (ROI) the complexity of the image is estimated. It calculates by adding the texture, location, contrast, edginess and intensity.

The proposed enhanced hybrid classifier is used to represent the regions and to detect the classes of the lesion. The approach of multimodal will classify the normal and abnormal of the images. After lesion detection and masking of images, the classification approach is performed to separate the features differences based on the classes. The enhanced method and process are analyzed by local fisher discriminant analysis. It performs to achieve direction identification between maximized class difference. As a result of classifier the proposed approach provides the identification and classification within the similarity classes. By the presence of proposed approach the samples are computed based on the training sample classes within the set of classes:

$$V_{n^{v}_{m^{g}}} C_k$$

$$M^{w}_{m,n} = \{\exp\left(\frac{\|v_n, v_m\|^2}{\varsigma_n \varsigma_n}\right) \times \frac{1}{i_k} \quad (2)$$

$$0 \text{otherwise}$$

if;

$$V_{n^{v}_{m^{g}}} C_k$$

Where:

v = A database set with i samples and it represented the set of samples as per the classes trained
k = The classifier function and
m = The weight of the multimodal distribution function

Here, the sample distances are estimated with the neighbour classes and the computation of the matrix are generalized with the decomposition of the features. As per the proposed classifier framework retinal image lesion is tested by the prediction based on various classes' evidence measurement and it perform as given below:

$$\text{Class}(x) = \text{argmax} \forall \text{class}_n \left(\frac{\sum_{n=1}^{c} w_k}{pc_k\left(a = \text{class}_n | x\right)} \right) \quad (3)$$

Where:

x = The lesion classification test
$Pc_k(a = class_n|x)$ = The sample probability of classes
w_k = The class prediction of classes related to weight and
C_k = The classes of the samples set used for the evaluation of the proposed algorithm

The process of the enhanced hybrid classifier is performs the steps as given below:

- The training data are separated into various validation sets and training sets randomly
- By using the proposed hybrid classifier the trained data are represented and classified
- The validation sets are then classified the samples by testing it using the normality of each generated model
- From the tested data the final sets are classified with learning process of weight and its sets are filtering the samples for the lesion detection from the samples
- By genetic process, the optimal search and classification perform the random extraction of trained data for better accuracy than the existing system

After the process of proposed hybrid classifiers, the label of each stage of regions is graded to the input image. Based on the extraction of lesion of retinal image and its type the grading process is performed after classifying the stages. As given below the classification of retinal images are performed:

- Severe: identification of high lesion in retinal images than the moderate level is specified as severe
- Moderate: find less lesion than the severe is specified as moderate Image
- Mild: if the process is satisfies the level of detection is less than the other stage is represented as mild
- Normal: no detection of lesion is said as Normal or Healthy retinal image

RESULTS AND DISCUSSION

Performance Analysis: In this study, the proposed work performances analysis and comparison of the proposed

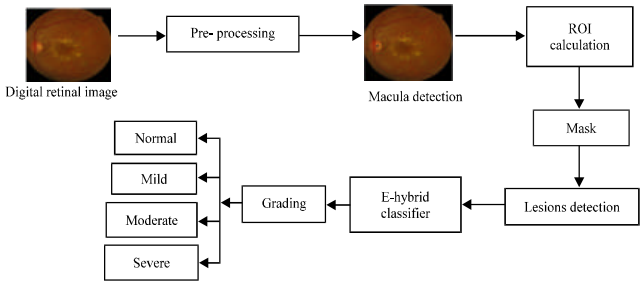

Fig. 3: Proposed system-flow work diagram

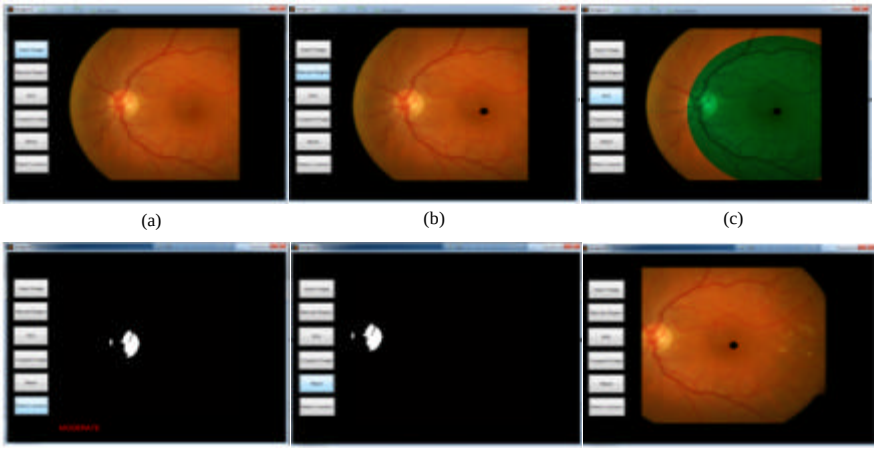

Fig. 4: Identification of moderate image

Table 2: Analysis of classifier

Classifier	Complexity	Execution time (sec)
GMM	O (ng)	2.93e-004
SVM	O (ns)	8.28e-004
m-Mediods	O (nm)	3.17e-004
Proposed Classifier	O (nh)	3.03e-004

system and the existing system is presented. Experiments of the proposed work are carried out with the available retinal images. The performances and results of each stage of the system indicate the accuracy achieved in classifying images while maintaining the normal retinal images with its classification. The comparison of the proposed work and existing work is illustrated in Table 1. The system Accuracy (Acc), specificity (Spe) and sensitivity (Sen) are calculated according to the performances of the system and it evaluated using the following expression. The performances are evaluated as per the metrics of the images. In Table 2, the system execution time and the complexity of the classifier are presented:

$$\text{Acc} = \frac{(\text{TP} + \text{TN})}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \quad (4)$$

$$\text{Spe} = \frac{\text{TN}}{\text{TN} + \text{FP}} \quad (5)$$

$$\text{Sen} = \frac{\text{TP}}{\text{TP} + \text{FN}} \quad (6)$$

The TP-true positive indicates the correct region classification by the classifier, TN-true negative specify the un-corrected region of the image classification, FP-False Positive denote the uncorrected region when classifying the image region and FN-false negative indicates the wrong classification of the uncorrected region of the image.

The input images are represent the detection of the macula, the ROI operation shows the cropped images, image masking and finally, the detection of lesions and the classification of images by the classifier is shown in Fig. 3-6.

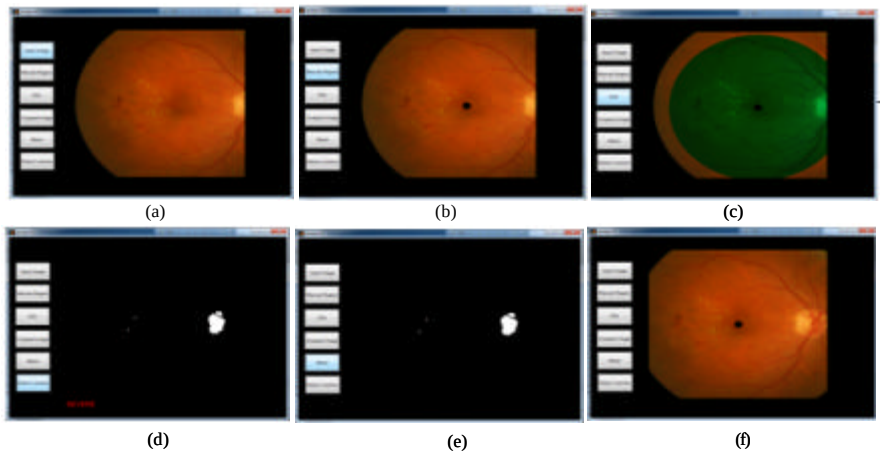

Fig. 5: Identification of severe image

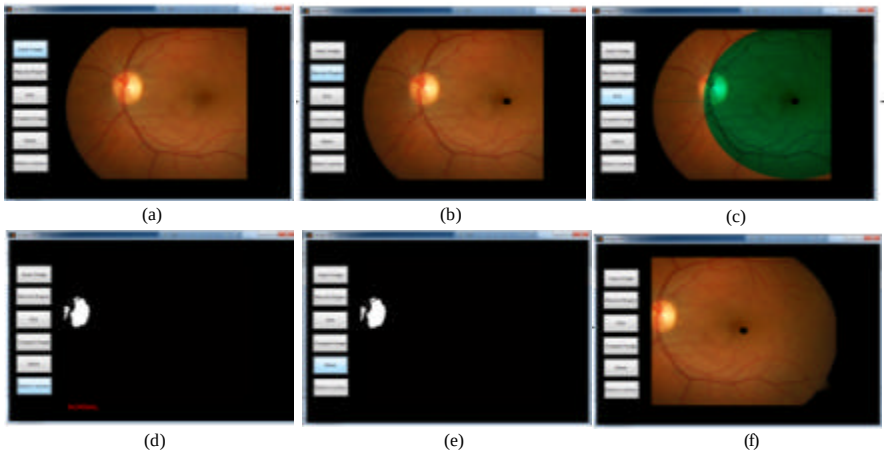

Fig. 6: Identification of normal image

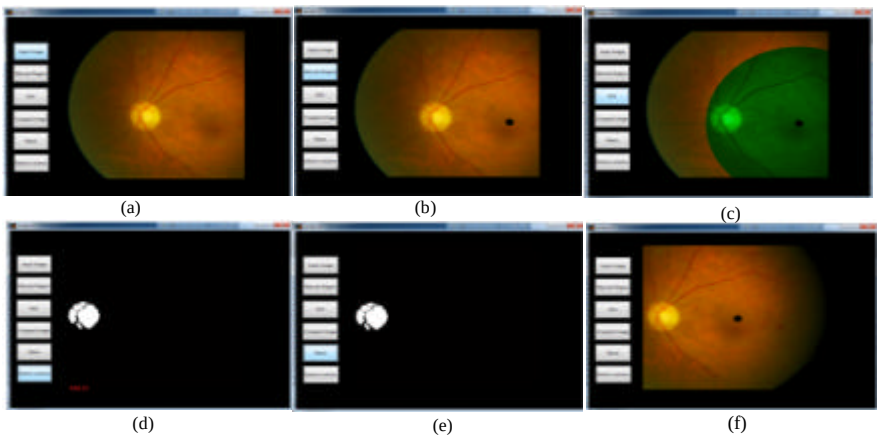

Fig. 7: Identification of mild image

CONCLUSION

The difficulty of diabetic retinopathy will cause blindness; according to the research statistics the causes of diseases can able to reduce by the early detection and treatment. In this study a new approach is proposed with the detection of diabetic by using the classifier and techniques of image processing. The proposed model is implemented

with the genetic processing of detection and classification of retinal image. The analysis of proposed system shows better performances than the existing system in accuracy, execution time, specificity and sensitivity. The performances of the proposed system in the automated medical system are obtained for grading the classification of the retinal images. Future work, improve the efficiency of detecting macula and lesion of the retinal images by a new method. Also, evaluate the results with more database sets.

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