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Classification Approach for Diabetic Retinopathy Detection

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***Abstract*— An image is known as scalar in case if a single measurement is done at every location that exists in the image. Due to the development of high-speed, more accurate and less invasive devices, the medical imaging has been going through a revolution over the decade. Adequate software is also needed to be developed to handle such high level of imaging. The retinal images are evaluated to diagnose the DR. It is however, time consuming and resource demanding to manually grade the images such that the severity of DR can be defined. The KNN Classifier algorithm is implemented in MATLAB and results are analyzed in terms of accuracy, specificity and sensitivity. It is analyzed that KNN Classifier method performs well in terms accuracy, specificity and sensitivity as compared to SVM Classifier method.**

***Keywords*— Disk Segmentation, KNN, Vessel Detection**

I. INTRODUCTION

The measurements of 2-dimensional and 3-dimensional spaces are collected to generate an image. The radio absorption is X-ray imaging, RF signal amplitude in MRI, or acoustic pressure within the ultra sound images are some different kinds of measurements considered within medical images [1]. An image is known as scalar in case if a single measurement is done at every location that exists in the image. Due to the development of high-speed, more accurate and less invasive devices, the medical imaging has been going through a revolution over the decade. Adequate software is also needed to be developed to handle such high level of imaging [2]. Thus, the signal and image processing technology has developed new algorithms on the basis of partial differential equations and curvature driven flows.. A fundamental approach through which the scientific progress of different fields can be done is achieved on the basis of these newly developed models that use the data extracted from images. A disease that affects the retina present within a human eye is known as Diabetic retinopathy (DR). If this disease is not cured initially permanent blindness can be caused to the affected person due to the growth of this disease [3]. Enough trained ophthalmologists and proper awareness of such disease is not found within the developing countries [4]. However, it is possible to provide initial care to patients and delay the growth of this disease if proper treatment and few automated tools are introduced [5]. Even though the early diagnosis and continuous monitoring of diabetic patients is needed, few effective solutions for DR have been provided. The retinal images are evaluated to diagnose the DR. It is however, time consuming and resource demanding to manually grade the images such that the severity of DR can be defined. When the tiny blood vessels present within the retina are damaged, only then can one notice this problem [6]. Blood will flow from this tiny blood vessel and features are formed from the fluid that exists on retina. The kinds of features involved here due to the leakage of fluid and blood from the blood vessels are considered to be the most important factors to study this problem. There are three broader categorizations of DR depending upon their severities which are normal, NPDR (non proliferative DR) and PDR (proliferative DR). The disease which is categorized through the availability of micro aneurysms is

known as Non proliferative which is an early stage of DR [7]. Oxygen deprives within the retina and clouding vision is created due to the generation of new blood vessels once the diseases grows. Further, mild NPDR, moderate NPDR and severe NPDR are also the three categorizations of NPDR. In order to identify the micro-aneurysms and exudates features, various morphological operations are operated within the candidate extraction process. The image is then inverted by applying invert image technique [8]. Further, within the image, the holes are filled. Removing the optic disc before initiating the process is the most important step of exudate detection. Since the intensity, color and contrast are similar to the remaining attributes of fundus image, this step is considered to be important. The availability of high contrast circular shape areas is important to separate optic disc. Also, high contrast is shown by the vessels which are however, fewer and cover smaller area. The blood vessel included in the optic disc region can be removed using grayscale closing operator. For eliminating the region of low intensity, the final image is considered as a threshold at automatically chosen gray levels [9]. A flat disc structured element is used to ensure that all the neighboring pixels of threshold result are added in the chosen region. Classification is possible to extract features from fundus image once the exudates and micro-aneurysms are identified within the color image. The calculation of all the features is done and the values are forwarded to be applied in classifiers applied such as KNN, SVM, etc. [10]. Mainly the binary classification problems are handled through SVM technique. Here, the multi-class pattern recognition issue is studied. The multi-class issues can be solved using binary SVM classifiers in two different types. A classifier that is developed based on the Bayes' Theorem along with the assumption that the predictors are independent is known as Naïve Bayes Classifier. The presence of a specific feature within a class is irrelevant to the availability of another feature as per the assumption made by the Naive Bayes classifier.

II. LITERATURE REVIEW

Ashish Issac, et.al (2018) proposed a novel approach through which the pathologies which point to the presence of DR are detected automatically. Also, the severity of DR is graded with the help of proposed framework [11]. A normalization process is applied for highlighting the bright lesions. Further, the regional minima operations and morphological flood filling approaches are performed in the next step. The complexity of the system is reduced and efficiency is increased when the false positives are rejected using geometrical features. The two databases named DIARETDB1 and MESSIDOR are used for conducting experiments for proposed approach in real time. It is seen through the conducted analysis that the grading of severity of disease has achieved around 92% and 86% of sensitivity respectively in both the databases.

Narjes Karami, et.al (2017) proposed a dictionary learning (DL)-based approach which is applied on digital fundus images to detect the DR automatically [12]. Depending upon the best atomic representation of fundus images as per the learned dictionaries generated by K-SVD algorithm, the detection method is introduced. However, the normal and diabetic classes are discriminated with the help of learned dictionaries provided by K-SVD. Thus, the designing of discriminative atoms is important to be done here for which the images are represented atomically with the help of best discriminative atoms. On the basis of best sparse representation, the classification rule is generated which states that the test image is a part of the class that has least numbers of best particular atoms. Tests were conducted on 30 color fundus images by applying the proposed approach which showed that the normal and diabetic images respectively provided 70 and 90% of accuracies.

Shailesh Kumar, et.al (2018) proposed enhancement in DR detection approach in which the accurate area is extracted along with the number of microaneurysm present within the fundus images [13]. In order to identify and handle the DR, it is important to perform regular screening of eyes. The number and area of MA are the two features which are determined in this approach. The previously existing approaches were used initially within the pre-processing stage. Other different techniques are used to detect the microaneurysms. The linear SVM has provided proper classification of DR. it is seen that around 96% of sensitivity and 92% of specificity is achieved through this proposed approach.

Enrique V. Carrera, et.al (2017) proposed a computer-aided diagnosis which is based on the digital processing of retinal images such that DR can be detected in early stages [14]. The grade of NPDR at any retinal image is classified automatically through this approach. Any kinds of features which can be utilized by SVM to identify the retinopathy grade of every retinal image are extracted through the image processing stage performed initially. A database which includes around 400 retinal images that are categorized depending upon their 4-grade scale is used to test the performance of proposed approach. Thus, around 95% of sensitivity and 94% of predictive capacity is achieved here. It is also evaluated that with respect to the changes, the robustness of proposed approach is also high.

Nikita Kashyap, et.al (2017) proposed a novel approach through which the query image from retinal database can be identified and retrieved [15]. This is mainly an image retrieval approach in which a retrieval process is generated. The color histogram feature is extracted and the feature vector of required size is identified by setting the number of bins within the histogram to design the retrieval process. In between the query and database image, Euclidean distance is calculated to check the similarity. As compared to RGB color space, the performance of color histogram retrieval system present within HSV color space is better. The tasks of professionals for analyzing each fundus image are minimized by the proposed approach. For improving the diagnostic performance, a prototypical DR image management system is generated here.

Harini R, et.al (2016) proposed Fuzzy C-means clustering and morphological processing such that Microaneurysms and Exudates can be detected from the retinal fundus images [16]. The approach segments the blood vessel and the morphological operations through this proposed scheme. Images are gathered from hospitals and other publically available databases to generate the database. SVM classifier is applied for classifying the images. Depending upon the certain parametric values the classification is performed here. The sensitivity, accuracy and specificity of proposed approach are evaluated which show high level of improvement.

III. RESEARCH METHODOLOGY

i. Optical disc elimination: Within the fundus images, the brightest part of a normal eye is the optical disc. Mainly this part exists either in elliptical or oval shape. The OD is seen as a bright yellowish or white area within the colored fundus images. For the optic disc, high and similar intensity values are available for exudates. Thus, the removal of optic disc from the retinal image is very important. The region properties and area identification are used for masking and removing this brighter optic disc. The optic disc and blood vessels are detected by applying edge detection algorithm after preprocessing. The counter detection is performed using canny edge detection algorithm. All the local maxima known as the gradient is preserved for improving the blurred edges by the canny edge detection algorithm. Thus, the boundaries of features are detected optimally through this. The mask image is generated by creating and then inverting the image using the logical black and white function. The mask image is generated and then removed from the edge detected image within this process.

ii. Blood vessels extraction and removal: It is important to remove blood vessels and optical disc from the retinal image in order to detect the microaneurysms and exudates. This is due to the fact that their concentration levels are similar. The high levels of contrasts vessels present in the blood are removed by applying dilation on the intensity image. There are different shapes in which structure elements (SE) exist. The optical disc and blood vessels are removed here using the flat disc shaped structure.

iii. **Detection of exudates and micro-aneurysms:** The exudates features are identified once the blood vessels and optical disc are removed from the image. The bright lesions of retina image are known as exudates. The morphological closing operation is utilized for identifying such features. Upon the eroded fundus image, this closing operation is applied [12].

iv. **KNN** can be used for both classification and regression predictive problems. However, it is more widely used in classification problems in the industry.

Preprocessing Technique

- RGB to Gray scale Image conversion.
- Green channel extraction.
- CLACHE Histogram Equalization.

Segmentation Approach

Optic Disc Segmentation and Elimination

Gray scale Conversion

Median Filtering

Maximum Intensity Pixels

Candidate Disc Extraction

Circular mask By Dilation and Erosion techniques.

Blood vessels Extraction

Resize median Filtered Image

Apply Morphological operation (Opening process)

Remove Background pixels

Gray scale Conversion

Binarization

Apply 2D DWT Wavelet Transform

Extract coefficients by using Haar wavelet decomposition at Level-3

Dark and Bright Lesions Segmentation

Color space Conversion

Green Channel Extracted from new updated RGB Image

Intensity based Thresholding

Flood Filling Operation (Microaneurysms and Hemorrhages)

Quantitative Analysis of DR lesions by Classification using K-Nearest Neighbor (KNN) classifier

Fig. 1 Building block representation of KNN Classifier system for discovery of Diabetic Retinopathy (DR).

IV. EXPERIMENTAL RESULTS

The KNN Classifier research is implemented in MATLAB and the results are evaluated by comparing the KNN and SVM Classifier approaches.

TABLE I
ACCURACY COMPARISON

Images	SVM Classifier	KNN Classifier
1	0.9046	0.9515
2	0.9086	0.9597
3	0.9051	0.9595
4	0.9173	0.9266
5	0.9342	0.9503
6	0.9269	0.9662
7	0.8156	0.8486
8	0.8325	0.8486
9	0.8495	0.8588
10	0.9003	0.9344

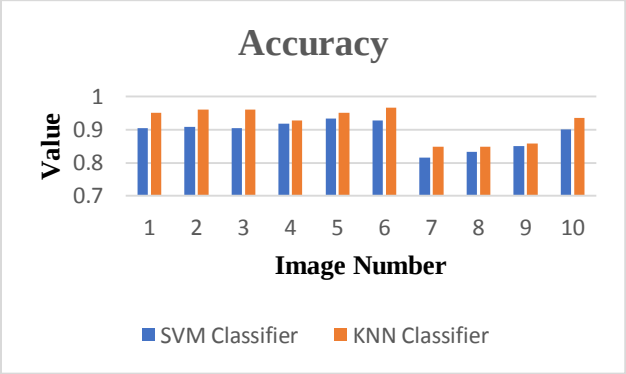

Fig. 2 Accuracy Analysis

As shown in figure 2, the accuracy of the KNN Classifier and SVM Classifier is analyzed on different set of images. It is analyzed that KNN Classifier has the high accuracy as compared to SVM Classifier.

TABLE II
SENSITIVITY COMPARISON

Images	SVM Classifier	KNN Classifier
1	0.7335	0.9256
2	0.7966	0.8068
3	0.9831	0.9933
4	0.9153	0.9545
5	0.9322	0.9424
6	0.6949	0.7151
7	0.8136	0.8438
8	0.8305	0.8907
9	0.8475	0.8577
10	0.8983	0.9851

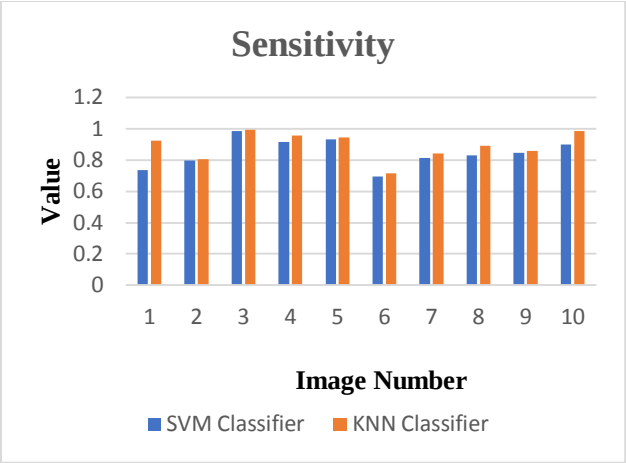

Fig. 3 Sensitivity Analysis

As shown in figure 3, the sensitivity of the KNN Classifier and SVM Classifier is analyzed on different set of images. It is analyzed that KNN Classifier has the high accuracy as compared to SVM Classifier

TABLE III
SPECIFICITY COMPARISON

Images	SVM Classifier	KNN Classifier
1	0.6415	0.8756
2	0.8076	0.8761
3	0.9941	0.9978
4	0.9263	0.9727
5	0.9432	0.9721
6	0.7059	0.7892
7	0.8246	0.8656
8	0.8415	0.8935
9	0.8585	0.8705
10	0.9093	0.9213

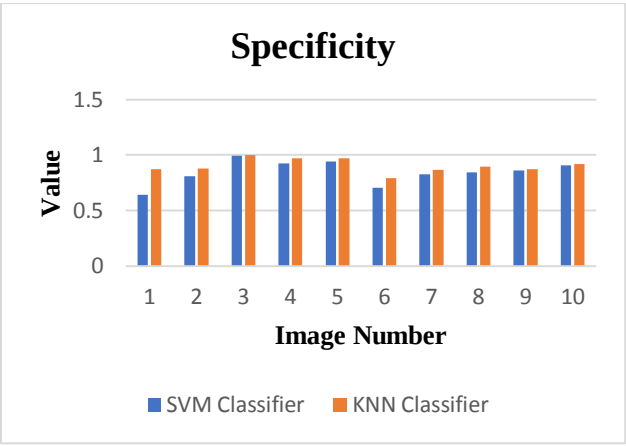

Fig. 4 Specificity Analysis

As shown in figure 4., the specificity of the KNN Classifier and SVM Classifier is analyzed on different set of images. It is analyzed that KNN Classifier has the high accuracy as compared to SVM Classifier.

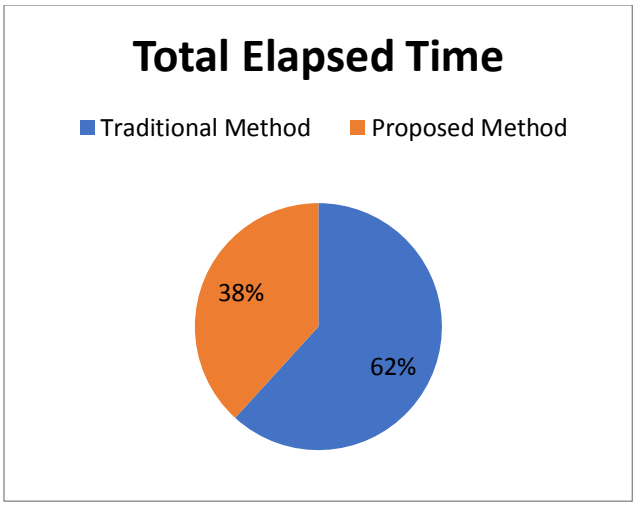

Fig. 5 Execution Time Analysis

As shown in figure 5, the execution time of the KNN Classifier is compared with the SVM Classifier. It is analyzed execution time of the KNN Classifier is low as compared to SVM Classifier.

V. CONCLUSION

The retinal images are evaluated to diagnose the DR. It is however, time consuming and resource demanding to manually grade the images such that the severity of DR can be defined. When the tiny blood vessels present within the retina are damaged, only then can one notice this problem. Blood will flow from this tiny blood vessel and features are formed from the fluid that exists on retina. The diabetes retinopathy detection has the three phases which are pre-processing, feature extraction and classification. In this research work, the KNN classification method is applied for the classification of diabetes portion from the image. It is analyzed that KNN Classifier method has high accuracy, sensitivity and specificity as compared to SVM Classifier method.

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