International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Detection and Classification of Exudates by Extracting the Area from RGB Fundus Images

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Abstract*: *A technique for exudate detection in fundus image is been presented in this paper. Due to diabetic retinopathy, an abnormality is caused known as exudates. The loss of vision can be prevented by detecting the exudates as early as possible. The work mainly aims at detecting exudates which have been present in the green channel of the RGB image by applying few preprocessing steps, 2D-DWT and feature extraction. The extracted features are fed to three different classifiers such as KNN, SVM, and NN. Based on the classifiers result the exudate is classified as normal, soft exudate and hard exudate, if exudate is present the extraction of ROI of exudate is done based on canny edge detection followed by morphological operations. The severity of the exudates is established in the area of the detected exudate. The NN, with ROI, was smeared on RGB fundus images for location of exudate. The NN was castoff with image processing methods by which we achieved a 100% success rate.

Index Terms*: *Exudates, Canny edge detection, Diabetic retinopathy, DWT, Fundus image, KNN, Morphological operations, NN, SVM.

I. INTRODUCTION

The blindness is basically caused due to three major problems of diabetes. Diabetic retinopathy (DR) is considered as one of the major problems among retinopathy, cataracts, and glaucoma those affect the blood-vessels in the retina. Diabetic retinopathy occurs while minute vessels leak fluid and swell or irregular new plasma vessels develop obstructing ordinary vision.

Diabetic retinopathy is an extensive problem of visual deficiency. The irregularities like hemorrhages, microaneurysms, and exudates are important indications that show a significant effect in the identification of diabetic-retinopathy. Initial recognition of these irregularities might inhibit the loss of vision because of diabetic retinopathy. Fundamentally exudates are lipid-lesions capable to be realized in optical imageries. Exudates that are found are characterized by hard and soft exudates. Hard exudates originate as extreme yellow areas and soft exudates have uncertain appearances. Developing a clinical decision support system for automatic recognition of exudates may assist ophthalmologists in the identification and early treatment of diabetic retinopathy. Fig. 1 displays the signs of diabetic retinopathy.

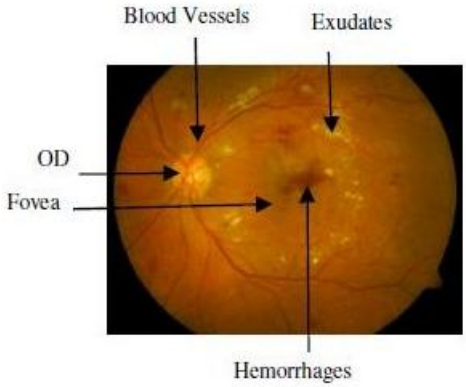

Fig. 1 Diabetic retinopathy symptoms in retinal image

The paper as a whole speaks about extracting the Exudate region from the loaded test image. Initially, the green channel from the loaded colored retina image is extracted. Further segmentation of green channel is done using discrete wavelet transformer which is pre-processed using histogram analysis and feature extraction. The database features and extracted test image feature are smeared for three different classifiers, the classifier results are compared in terms of accuracy, sensitivity, and specificity. Finally, if exudate is present in the test image, the extraction of exudate region ROI is done based on canny edge detection and morphological operations. Brief idea about diabetic retinopathy is given in the introduction section. In the literature survey section we have explained few existing methodologies and their outcomes. The proposed methodology is explained in section 3, followed by results in section 4.

II. LITERATURE SURVEY

The literature gives several algorithms to detect different types of exudates by using fundus imageries. Exudates sections show greater gray concentration and contrastness in fundus imageries. The particular effort by means of image processing algorithm on Fundus image to find exudates has been described. Morphological and Neural Network Based Approach is presented by Sangita Bharkad et.al [1], optic disk (OD) is removed with the assistance of morphological-operators. OD is concealed within the green part of the image to avoid the miss-classification amongst OD province and hard exudates region. Formerly features of the green constituent image are figured and smeared to neural-network for the location of hard exudates.

Revised Manuscript Received on 22 May 2019.
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Experimental outcomes demonstration the healthier capability of algorithm 95.45% specificity, 100% sensitivity and 97.46% accuracy. This exertion is able to extend for lesion founded location of hard exudates in retinal imageries. 3σ Control Method by Mohammed Shafeeq Ahmed et.al [2], the work presented in this is to identify the exudates through fundus imageries in RGB color-space, thus simplify a representative analysis close to technique implemented by anophthalmologist. An arithmetical quantity three sigma is castoff to calculate the color concentration variety of exudates pixels. Retinal imageries are pre-processed to improve the color concentration and optic disk (OD) is eradicated since it portions comparable topographies through exudates. The objective of the work is to identify exudates from RGB fundus imageries, the preprocessed imageries are further categorized founded on evidence mined from 3 sigma control technique. The removal of optic-disc is a key phase in pre-processing; Hough-Transform technique promises that eradicated portion is OD only not exudates and it likewise castoff to attain worthy outcomes. The technique has produced inspiring outcomes with 99.93% sensitivity and 99.99 % specificity. The obtained results are encouraging and likewise enables the ophthalmologist in identifying the disease. Wavelet Transform and PNN Approach by C. Nivetha et.al [3] recommends a technique to discover the exudates as of blood-vessels of eye through diabetic-retinopathy management. For examination, input retinal images are detached and hooked on 3 planes i.e., red, green and blue, as of that green channels are designated, that is additionally administered by means of Daubechies wavelet-transform to approximation grey-level co-occurrence matrix (GLCM) topographies. These topographies are handled by means of probabilistic-neural-network (PNN) and contribution retinal image is associated with the dataset image to categorize it as usual or unusual. Morphological-operations are smeared to irregular image to mine the blood-vessels and further fuzzy C-means gathering is smeared in mined blood-vessels to discover exudates. The sensitivity and accuracy of the outcome attained by this method are relatively healthier and are 97% and 96% respectively. The technique can be smeared competently and the blood-vessels and exudates may be competently located. An Effective Preprocessing Method for exudates analysis by Nita Nimbarte et.al [8] proposed a well-organized pre-processing procedure, to increase the contrast amongst contextual and exudates area and process highlights the main workings of the human retina, i.e. the OD and exudates for calmer subdivision. For feature extraction, Kirsch and Linde-Buzo-Gray (LBG) established a collecting technique. In principal one, an effective procedure founded on Kirsch technique has remained engaged for cheerful section subdivision monitored with morphological-operations. In the additional procedure, LBG gathering technique with morphological-operations functional for exudates recognition. The procedure is established on openly obtainable DIARETDB1 databank. Owed to its distinctive presentation procedures, this system has remained effectively functional to imageries of adjustable excellence. The relative training is finished to examine the effectiveness of the method. It is confirmed that Kirsch-algorithm identified optimistic lesion with sophisticated accuracy and dependability than LBG methodologies. Receiving-operating-curve (ROC) and weighted-error-rate (WER) demonstrations that presentation of this technique is operative to identify exudate in retinal image.

A Fuzzy-Neural Network-Classifier (FNN) founded the organization of retinopathy by Deepthi K Prasad et.al [9] proposed an innovative procedure for identifying DR by means of hybrid classifiers. It comprises pre-processing of imageries, subdivision of region-of-interest, feature extraction, and organization. Retinal constructions like exudates, microaneurysms, hemorrhages, and blood-vessels are segmented. The organization is accomplished with incorporation of accurateness of organization. The investigation is accepted out through the MESSIDOR dataset. Results are associated alongside numerous presentation metrics like sensitivity, accuracy, and specificity. Neuron fuzzy classifier is castoff for precise organization of DR into multi-stages. The amalgam organization result expands the complete accurateness level of multi-stage DR and procedure notices the DR infection in the former phase that provisions for medical handling procedure. An accurateness close to 100% and low average error ratio of 0.012 is achieved by means of this technique.

III. PROPOSED METHODOLOGY

The detailed methodology and process of the proposed exudates detection is been described in the below block diagram.

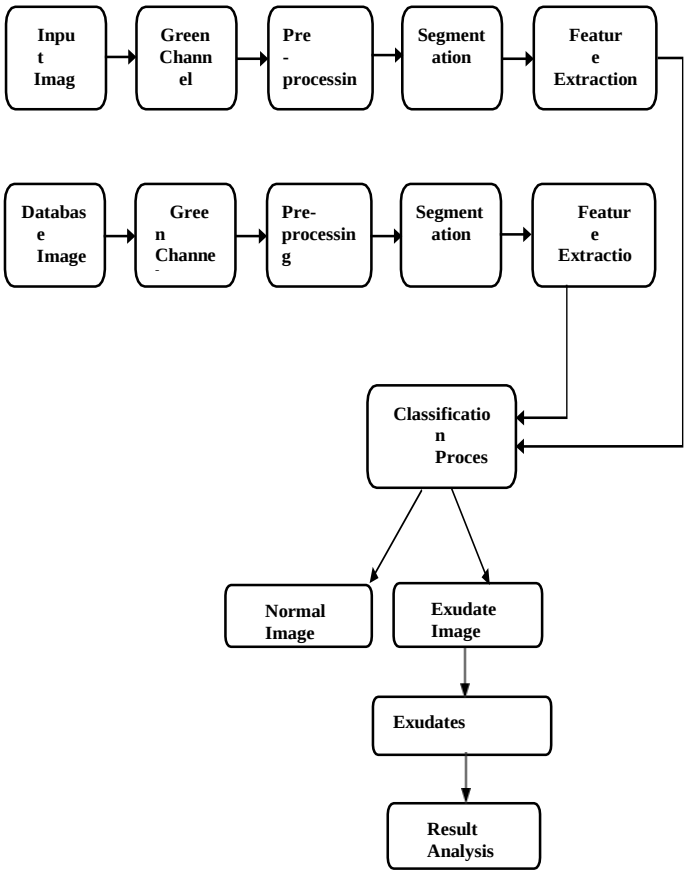


FIG 2. DETECTION AND CLASSIFICATION OF EXUDATES FROM FUNDUS IMAGES

A. *Image Acquisition (Describe of Dataset)*

In this work, the input images used are obtained from the BTGH (private) dataset [6]. It consists of 90 fundus images of 1500 x 1152 dimensions of which 30 are normal and 60 contain signs of DR. Each image is captured using ZEISS Visucam 500 fundus camera. This dataset is cited to assess the performance of this method.

B. *Histogram Equalization based Pre-Processing:*

A graphical demonstration of tonal scattering in a digital image is given by histogram. It strategies the number of pixel values for every tonal value. By observing the histogram for an image a spectator can be capable to evaluate the complete tonal scattering at a glimpse. This technique frequently upsurges the universal contrast of several imageries, particularly once the functioning statistics of the image is characterized by adjacent contrast standards. Concluded this modification, the intensities can be improved circulated on the histogram. This permits for parts of subordinate indigenous contrast to increase a sophisticated contrast. Histogram-equalization achieves this by efficiently scattering out maximum frequent intensity standards.

C. *Image Segmentation using 2D-DWT*

The wavelet-transform has increased extensive recognition in signal dispensation and image density. In recent times the JPEG committee has unconstrained its new images coding customary, JPEG- 2000, this has remained founded upon DWT. Wavelet-transform decomposes a signal into a group of basis capabilities, which are known as wavelets. Using dilation and shifting to single prototype wavelet called as mother wavelets, these wavelets are obtained. This DWT is remained familiarized as an extremely effectual and stretchy technique for sub-band disintegration of images. The 2D-DWT in recent days is proven as an important technique in image processing. This is a multi-decision examination and it decomposes imageries into wavelet co-efficient and scaling purpose. In Discrete-Wavelet Transform, signal energy essences to particular wavelet coefficients. This distinctive is suitable for compacting imageries [9].

D. *Feature Extraction*

Solidity, minor axis distance, eccentricity, extent, and strangeness are few shape features use in this paper. This structures were taken from research [3] in the directive to mine shape feature in diseased section. Eccentricity is castoff to distinguish whether exudate shape is a circle or line segment. It is the ratio of the distance among foci of the ellipse and its principal-axis distance. An ellipse with eccentricity as 0 can be acknowledged as a round, whereas an ellipse with eccentricity as 1 can be acknowledged as a line fragment. Gray Level Co-occurrence Matrix (GLCM) extract second order statistical texture features. Texture feature withdrawal use in the research are the correlation, contrast, energy, and homogeneity. Contrast of pixel and its neighbours is considered over all the image pixels. Contrast amongst neighborhood pixels can be calculated by contrast. Color is a distinguishing feature for image illustration which is invariable regarding scaling, rendition, and replacement of image [9]. Skewness, Mean and kurtosis are castoff to characterize color as features.

E. *Classification*

Allocating objects to their respective classes founded on data mining processes are called classifiers. Classification procedures comprise 2 chief stages; in an initial stage, they attempt to discover a prototypical for a class characteristic as a purpose of supplementary variables of the datasets, and in next phase, they put on formerly considered prototypical on the novel and hidden datasets for defining the associated class of every record [10].

a. KNN Classifier

Nearest-neighbor classifiers are originated on information by equivalence, which is by associating a specified examination type with teaching types that are comparable to it. The teaching - types are designated by *n* characteristics. Every type characterizes a fact in an *n*-dimensional planetary. In this technique, all teaching - types are stockpiled in an *n*-dimensional arrangement planetary. Once specified an unidentified type, a k-nearest-neighbor classifier (KNN) examinations the configuration interplanetary for *k* teaching - types that are contiguous to an unidentified type. These *k* preparation types are of the unidentified type [10].

Euclidean distance is castoff as a distance metric to measure the closeness. The Euclidean distance amongst two arguments or tuples $X_1=(x_{11}, x_{12},\ldots,x_{1n})$ and $X_2=(x_{21}, x_{22},\ldots, x_{2n})$ obtained from Calculation.

b. Support Vector Machine

Using a nonlinear mapping to get a higher dimension data

$$dist(X_1, X_2) = \sqrt{\sum_{i=1}^{n}(x_{1i} - x_{2i})^2}$$

from original training is done by support vector machine (SVM) algorithm With-in new measurement, it examinations for linear optimal extrication hyper-plane. A hyper-plane is a "judgment border" unscrambling the types of unique class after another. Through applicable non-linear planning to a satisfactorily high measurement, data as of two modules can continuously be disconnected by a hyper-plane. The SVM discover this hyper-plane by means of support-vectors and margins.

c. Neural Network (NN)

A system or circuit of neurons was conventionally mentioned as a neural network. The current practice of the word frequently denotes to artificial-neural-networks that are tranquil of artificial nodes or neurons. Hence the word could mention to moreover biological NN, through up of actual artificial NN or biological-neurons, for resolving artificial-intelligence (AI) difficulties. The associates of a biological neuron are exhibited as masses.

An optimistic mass replicates an excitatory assembly, while

undesirable standards mean inhibitory influences. All contributions are improved by a mass and added.

F. *Exudate segmentation*

Founded on classifier outcomes subsequent stages are castoff for segmentation of the exudate in original images. Cotton-wool spots are communal grayish white coverings of staining in nerve fiber level infarcts or pre-capillary principal obstructions. In additional words, they are an ischemic occasion of an actual small quantity of tissue [7].

Hard exudates region look like yellow-white intra-retinal pledges that may differ as of small flecks to greater patches and these may progress into trinkets known as circinates. Hard exudates are principally through up of additional cellular lipid that has seeped from irregular retinal tubes. Hard exudates are found primarily in the macular area and fats are combined and spread into fundamental macula (fovea), visualization can be harshly negotiated [7].

G. *Canny edge detection*

It is a method to extract useful structural information from vision substances and melodramatically decrease the number of statistics to be handled. It has remained extensively functional in numerous computer-vision organizations. Canny has found that necessities for the solicitation of edge recognition on different vision organizations are comparatively comparable. Therefore, an edge recognition resolution to discourse these necessities can be employed in a wide variety of circumstances.

H. *Morphological operations*

Binary imageries may encompass abundant inadequacies. In specific, the binary areas shaped by modest thresholding are biased by texture and noise. Morphological image handling follows the objectives of eliminating these inadequacies by secretarial for the method and construction of the image. These techniques can be protracted to grayscale imageries. Dilation and erosion are 2 rudimentary morphological operations complicated in gray image handling.

Algorithm: Detection and Classification of Exudates from Fundus Images

Step 1:- Read the input color retinal image (select only one image--normal or soft or hard)

Step 2:- Select the green channel image

Step 3:- Pre-Processing using histogram

Step 4:- Segmentation using 2D-DWT

Step 5:- Feature Extraction Process

Step 6:- Database Loading Process (load all images at a time)

- Select the green channel image
- Pre-Processing using histogram
- Segmentation using 2D-DWT
- Feature Extraction Process

Step 7:- Classification / Matching Process using KNN (1), SVM (2) and NN (3) Methods

- Normal Image
- Soft Exudate Image
- Hard Exudate Image

Step 8:- Comparison (1, 2 and 3) and Classification results analysis (Accuracy, Sensitivity and Specificity etc.)

Step 9:- if image is Exudate image, **detect the exudates part** in retina image

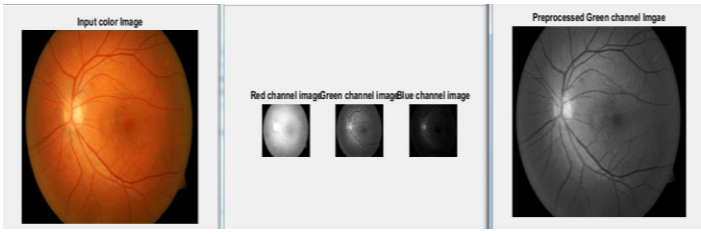
- Take the Step 4 output image
- Apply the **ROI** Segmentation
- Apply the **Canny edge** detection
- Apply the **Morphological** operations
- Detect the exudates

Step 10:- Calculate the affected area of exudates (based on total White Pixels)

IV. RESULTS AND DISCUSSIONS

A. EXTRACTION OF EXUDATES

a. Normal Exudates:



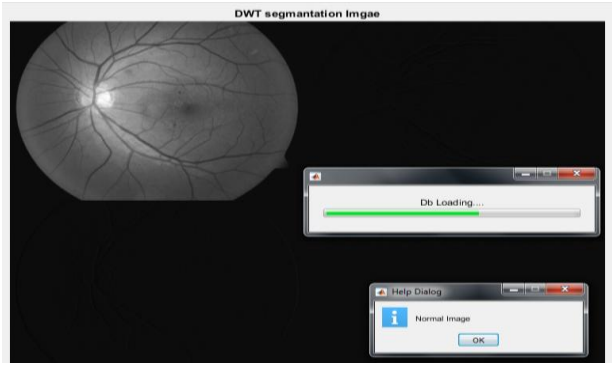
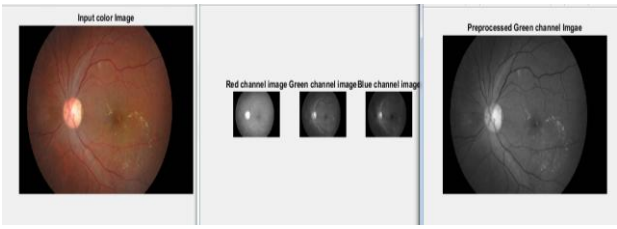


Fig 3. Normal

b. Soft Exudates



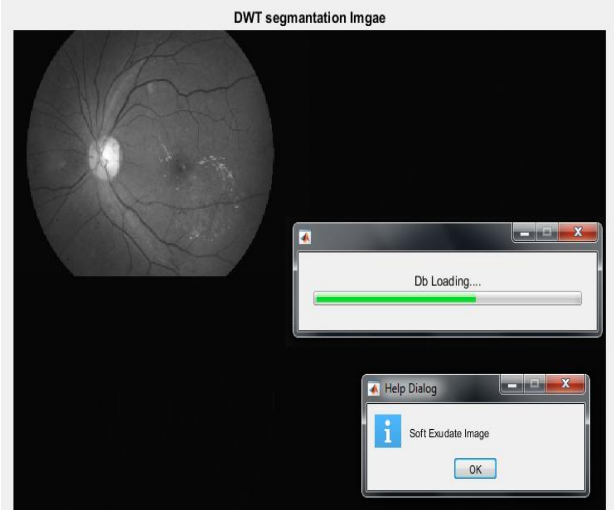
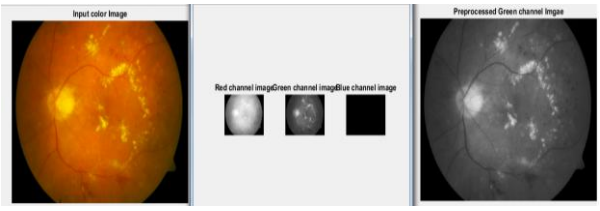


Fig 4. Soft Exudates

c. Hard Exudates Image



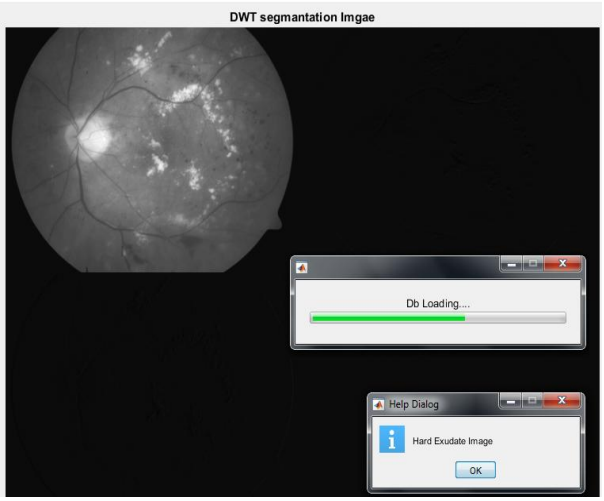
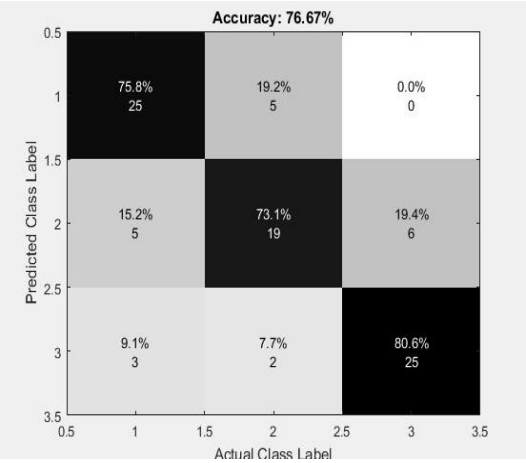
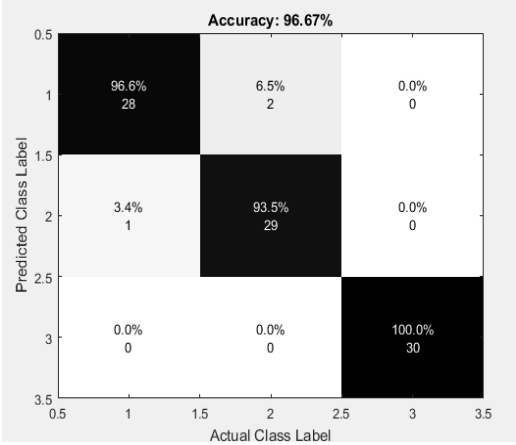


Fig 5. Hard Exudates

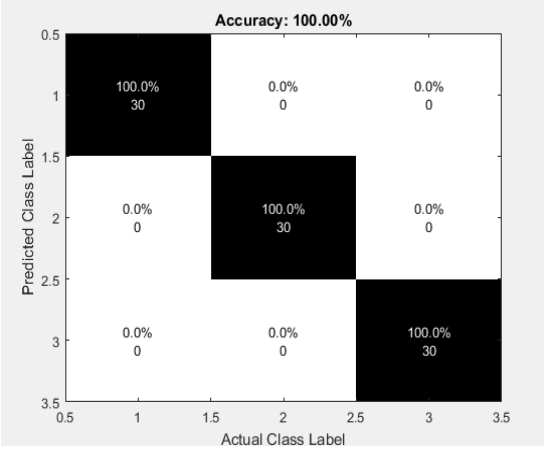
B. Comparison of SVM, KNN and NN Classifier Results:



(a)



(b)



(c)

Fig 6. Classifier results: (a) SVM; (b) KNN; (c) NN

The result of the proposed approach for detection of exudates shows the overall accuracy result was 100% for BTGH (private) dataset for detection of diabetic retinopathy using NN. The error rate for image base analysis was also significantly reduced. The sensitivity is 100% and specificity is 100% which is better when compared with other works and makes it suitable for automatic detection and classification of diabetic retinopathy. The results of BTGH (private) database with a different classifier is shown in the table below

CLASSIFIER	SVM	KNN	NN
ACCURACY	76.67%	96.67%	100%

Table 1: Results of different classifiers

V. CONCLUSION

The work mainly aims at detecting exudates which is present in the green channel of the RGB image by applying few preprocessing steps, 2D-DWT and feature extraction. The extracted features are fed to three different classifiers such as KNN, SVM, and NN. Based on the classifier result if exudate is present the extraction of exudate ROI is done based on canny edge detection followed by morphological operations. The severity of the exudates is established in the area of the detected exudate.

ACKNOWLEDGEMENT

Authors thank BTGH, Kalaburagi, for providing the permission to access the dataset of fundus images and providing the required assistance from the experts of the department.

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