Diabetic Retinopathy Detection System using Machine Learning
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Abstract:
Diabetic retinopathy is an eye condition that can cause vision loss and blindness in people who have diabetes. It affects blood vessels in the light-sensitive layer of tissue in the back of your eye i.e. the retina. Determination of DR grades has an important role in the treatment process of the disease and preventing vision loss. In this paper machine learning algorithm based system was proposed to automatically discriminate grades 0 (normal), 1, 2, 3 and 4 of the DR from fundus images. Adaptive histogram equalization (AHE) is used for image pre-processing. Two machine learning algorithms: support vector machines and random forest are used for training and testing the model. Better performance is achieved by combining these algorithms together in order to create a strong learner or ensemble model.

Keywords: Image Processing, Machine learning algorithms, Support Vector Machines, Random Forest, Ensemble learning, Stacking.

I. INTRODUCTION

Diabetic retinopathy (DR) is a condition that may occur in people who have diabetes. It causes progressive damage to the retina. The disease is characterized by high blood sugar levels which cause damage to blood vessels in the retina. These blood vessels can swell, leak or they can close, stopping blood from passing through. Sometimes abnormal new blood vessels grow on the retina which can also steal your vision. The longer a person has diabetes, the more likely they will have diabetic retinopathy. If left untreated, diabetic retinopathy can cause blindness. The initial stages of diabetic retinopathy usually don’t have any symptoms. Some people notice changes in their vision, like trouble reading or seeing faraway objects. These changes may come and go.

As diabetic retinopathy gets worse, you will notice symptoms such as: seeing an increasing number of floaters, noticing colours appear faded or washed out losing vision, having blurry vision or having vision that change from blurry to clear, seeing blank or dark areas in your field of vision, and having poor night vision. In later stages of the disease, blood vessels in the retina start to bleed into the gel-like fluid in the centre of the eye i.e vitreous. If this happens, you may see dark, floating spots that look like cobwebs. Sometimes, the spots clear up on their own. But without treatment, the bleeding can happen again, get worse, or cause scarring. DR is the main factor of blindness among adults aged 20–74 years.

It is classified into five groups as follows: no DR, mild non-proliferative DR (NPDR), moderate NPDR, severe NPDR and proliferative DR (PDR). The determination of DR grades has an important role in the treatment process of the disease. Non-proliferative diabetic retinopathy (NPDR) is the milder form of diabetic retinopathy and is usually symptomless. Proliferative diabetic retinopathy (PDR) is the most advanced stage of diabetic retinopathy and refers to the formation of new, abnormal blood vessels in the retina. In this paper we ensemble machine learning algorithms, Support vector machine and Random forest which provides good accuracy to do the detection of DR. Here we detect whether a person has DR or not and also predict the severity of disease in grades. Adaptive histogram equalization is used for image pre-processing.

II. LITERATURE SURVEY

● In this paper, the input colour retinal images are of poor quality. So they were pre-processed using grayscale conversion, adaptive histogram equalization, discrete wavelet transform and other techniques. From the pre-processed images, features were extracted for classification. The two techniques used were SVM and PNN for the classification. Both techniques gave a good performance, but SVM is more efficient than PNN from the obtained results [1].
● This paper suggests some novel methods for the analysis of retina images. This used both the image processing & data mining concepts for retinal image analysis [2].
● A change in shape and size of blood vessels is a good indicator of detecting DR. In the same way presence of various lesions helps in detecting diabetic retinopathy. Thus various researches have been bifurcated in two ways as of automating blood vessels segmentation [3][6][7] and of identifying the lesions [4][5].
● Fundus imaging has been found to be a simple and cost-effective technique. It is worth noting that fundus angiography undergoes DR screening using three kinds of image modalities: (i) An RGB, (ii) red free channel, and (iii) fluorescent images [8].
● CAD programs are used to symmetrically analyse and segment basic retinal components and abnormal lesions within the retinal image for the early screening of DR. These CAD systems may reduce the time, cost, and efforts of clinicians in the manual analysis of retinal images [10,11].
● A comprehensive review of the image segmentation methods for optic disc, cup, and DR detection is presented in this paper [12].
● Another study highlighted image pre-processing, segmentation of basic and abnormal retinal features, and DR detection methods [13].
Patton et al. presented a review on the image registration, pre-processing, segmentation of pathological features, and different imaging modalities for DR diagnosis [14].

III. EXISTING SYSTEMS AND ITS PROBLEMS

Ophthalmologists have a vast array of imaging tools to choose from sophisticated devices that would have astonished our ancestors in their time. But sometimes this abundance of options can be a curse more than a blessing. These tools require that both physicians and technical staff are well trained in their use. A system was developed that considered the significance of optic disc segmentation for reliable glaucoma and DR screening. In that the author considered morphological features to segment the optic disc boundary. The finite impulse response (FIR) filter was applied to remove retinal vessels and to extract morphological features for disc extraction. However, the algorithm was unsuccessful on low bright disc colour images. A generalized method for the detection of vascular structure in pathological retinal images developed a vascular detection system using fundus images. However, the approach had less significance in the detection of lesions that contribute to an incorrect vascular structure. An algorithm for blood vessel segmentation in fundus images presented an unsupervised coarse segmentation approach for vessel detection. However, the algorithm was unsuccessful in the determination of the vessel diameter and was also found less satisfactory at segmenting vessel structures on low contrast images. An optimization method was employed for accurate vessel segmentation and also a template matching approach using a Gabor function for the detection of the centre of vessel lines. All these methods are reported as being less satisfactory based on the following reasons: (i) A numerous amount of pre-/post-processing steps were utilized to extract the vessel tree; (ii) methods were tested on a small set of retinal images and had limited cover of the varied-sized locations of an image; and (iii) it also reported a much higher running time during the detection of vessel pattern which is not so reliable.

IV. PROPOSED SYSTEM

As mentioned earlier this system predicts whether an individual has diabetes retinopathy or not. Easy access and understanding makes it user-friendly. After a user gives input of proper data, our system checks whether he/she has diabetes retinopathy or not by using machine learning. One can provide his/her fundus image directly to the system or by taking the fundus image using the fundus camera attached (if it is provided). The proposed system will classify the disease into different grades, so the user could easily find the severity of the disease. Our first step is data collection. We have collected our dataset from Kaggle website. The dataset contains IDRID image set to predict whether an image have signs of diabetic retinopathy or not. The images are pre-processed using image processing technique – adaptive histogram equalization. The dataset is divided into two sets, one for training and the other one is used for testing. Then features and labels of the dataset are identified which classifies the images into different grades. In the training set, two different classification algorithms have been fitted for analysing performance of the model. The algorithms we used are random forest and support vector machine. After the system has done learning from training datasets, testing data is provided without outputs. Then we get the accuracy of the system for the prediction of diabetic retinopathy. The final model provides the output using the knowledge it gained from the data on which it was trained.

V. METHOD EMPLOYED

Image processing techniques and two machine learning algorithms are used in this diabetic retinopathy detection system.

A. Image pre-processing

Images are pre-processed in order to find the features of images. Different methods are used for pre-processing. The RGB images are cropped and resized in-order to reduce the black area around the eyeball.

Adaptive Histogram Equalization (AHE)

Adaptive histogram equalization is an image processing technique used to improve contrast in images. It accomplishes this by effectively spreading out the most frequent intensity values, i.e. stretching out the intensity range of the image. This allows for areas of lower local contrast to gain a higher contrast. Here AHE is used for improving the contrast of images. If the image after AHE is dark, perform a contrast stretch in the image. Rotation and flipping is performed by random selecting the images, in order to equalize the number of images in each grade for training.

B. Machine learning algorithms and ensemble method

The algorithms used are Support vector machine and Random forest.

1)Support vector machine (SVM): Support Vector Machines are a type of supervised machine learning algorithm i.e. data set is trained in such a way that it may give predetermined output that provides analysis of data for classification and regression analysis. SVM is mostly used for classification. We carry out plotting in the n-dimensional space. Value of each feature is also the value of the specific coordinate. It breaks down the model into hyperplanes and classifies the objects. It represents a data set as points of cloud in the space. The aim here is to construct a hyper-plane that divides the data sets into various categories. The hyper-plane divides the data set into the categories so that data mining and classification can be done effectively. This hyper-plane should be at maximum margin from the different categories. However, if categories in which data sets have to be classified are large then sophisticated technique is used known as kernel configuration.

2)Random forest: Random forest algorithms can be used both for classification and the regression problems. It is a supervised classification algorithm. As the name suggests, this algorithm creates the forest with a number of trees. In general,
the more trees in the forest the more robust the forest looks like. In the same way in the random forest classifier, the higher the number of trees in the forest gives the high accuracy results. Overfitting is one critical problem that may make the results worse, but for the Random Forest algorithm, if there are enough trees in the forest, the classifier won’t over fit the model. The classifier of Random Forest can handle missing values, also the Random Forest classifier can be modelled for categorical values.

3) Ensemble method: Ensemble learning helps to improve machine learning results by combining several base models. This approach allows the production of better predictive performance compared to a single model. In order for ensemble methods to be more accurate than any of its individual members, the base learners have to be as accurate as possible and as diverse as possible. In ensemble learning, we call weak learners or base models that can be used as building blocks for designing more complex models by combining several of them. The idea of ensemble methods is to try reducing bias and/or variance of such weak learners by combining several of them together in order to create a strong learner or ensemble model that achieves better performances. Stacking is the ensemble learning technique used in this diabetic retinopathy detection system. It combines multiple classification or regression models via a meta-classifier or a meta-regressor. The base level models are trained based on a complete training set, then the meta-model is trained on the outputs of the base level model as features. Stacking ensembles are often heterogeneous.

VI. SYSTEM MODEL

This system model presents an easy approach which speeds up the detection and classification of the disease diabetic retinopathy. The fundus camera captures the image of the interior surface of the eye which includes retina, optic discs, macula and the blood vessels. The system classifies the image into categories such as grade 0, grade 1, grade 2, grade 3, grade 4. These grades are related to the following clinical conditions: grade 0 represents no DR. Grades 1 is mild NPDR and grade 2 is moderate NPDR. Grade 3 shows severe NPDR. Finally, grade 4 represents the most serious condition proliferative DR. Our system is modelled as a website. The image uploaded by the user goes through image pre-processing. The image is first cropped and the system converts the RGB image into grey image and further resizes it. Adaptive Histogram Equalization applied to the image improvises the contrast of the image. Followed by the adaptive histogram equalization, rotate and flip the images and make the number of images same in all grades for training. Pre-processed images are saved and two sets are created, i.e.; grading datasets and identifying datasets.

As mentioned earlier, we split the entire dataset into two sets: 85% for training and 15% for testing. Then we fit the training data in the machine for training by ensemble two algorithms. Two models are trained in this system. One for identifying whether the user has diabetic retinopathy or not and another to predict grading of the disease. During training the images are flattened and its features are extracted. Machine is learned from the random training set and from that, the testing set is analysed with respect to the training set. We use two ML algorithms for training the machine. Support vector machines and random forest algorithms are grouped together. Stacking is the ensemble learning technique used here which combines multiple classification or regression models through a meta-classifier or a meta-regressor. System models for training and testing are shown in Fig.4 and Fig.5 respectively.

VII. EXPERIMENTS AND RESULTS

The result we will obtain from the system is a prediction of intensity of the disease in grades. As mentioned before we have used two machine learning algorithms by an ensemble learning method called stacking. First, we trained our dataset with these two algorithms and then we built an ensemble model. Then, we tested our testing dataset in this model. The two models which are trained will give different accuracies.
Early detection of Diabetic Retinopathy is essential in preventing blindness. Ophthalmologists diagnose this disease through various typical examinations and experimental procedures by visualization of certain retinal vessels, micro aneurysms, with the help of ophthalmoscopes which would often delay the proper treatment. The patients would have to undergo regular screenings so that they can be cured on time. At later stages, the vision loss could not be retrieved, however highly automated systems are required for the early grading of this disease. Hence, we have tried to construct an ensemble to predict if a patient has diabetic retinopathy using features from retinal photos. Despite the shortcomings in reaching accurate performance, we have improved the training and testing phases of our datasets. Images were procured from the Fundus Camera and pre-processing were done using prevalent techniques in order to improvise the learning. These images were classified under SVM and Random Forest Algorithms which were subjected to ensemble. Accuracy of the system was obtained in predicting various grades of DR. The structure of our research has been built in such a way that with proper dataset and minor alteration it can work to classify the disease in different classifications.

**IX. FUTURE SCOPE**

Accurate prediction of grades could aid the ophthalmologists in detection of Diabetic Retinopathy. Converting the fundus images into augmented visuals through various screens can be useful to observe the anatomical features of the Retina. In order to improve the accuracy of the Classifier, the number of various extracted features could be expanded. Also the number of sample datasets in testing and training could be increased in determining accurate results. The images gathered from certain publicly available benchmark databases could further enhance the algorithm. Grouping more number of good ML algorithms will help in getting more accurate results.

**X. REFERENCES**


