International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 3 | ISSN : 2456-3307

Survey on automated detection of referable Diabetic Retinopathy using machine learning

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ABSTRACT

Diabetic retinopathy is a complication of diabetes, that results in the rupture of the blood vessels in the light-sensitive region of the eye also known as the retina. This situation can occur in a person who has either type 1 or type 2 diabetes. Excess sugar levels in a diabetic person block the blood vessels that nourish the retina of the eye. So as to compensate this shortcoming the retina grows new blood vessels, however, this new blood vessel can rupture easily. The traditional means to detect diabetic retinopathy is to undergo regular screening and then to consult a doctor. This is a significant time-consuming task as there is a shortage of experienced ophthalmologist, as a result, 45% of the patient suffer from vision loss even before they are diagnosed. Another major problem associated with this method is that there is significant inconsistency among doctors who diagnose diabetic retinopathy, as a result, there are chances that diabetic retinopathy can go undetected at its early stage. The automated detection involves training a machine learning model that can detect new cases of diabetic retinopathy from retinal fundus images which have been graded by experienced ophthalmologists. The decision for predicting the degree of diabetic retinopathy has been done using machine learning algorithms such as deep convolution network, SVM and Naïve Bayes.

Keywords : Diabetic retinopathy, Machine learning, Convolutional neural network, SVM, Naïve Bayes.

I. INTRODUCTION

Diabetes is a metabolic disease wherein a person has high blood sugar level in his body which may be a result of either insufficient production of insulin by the pancreas or inability of the body to use the insulin so produced or it can be both of them. As of 2016, there are about 415 million people suffering from diabetes and it is expected to grow to about 642 million by 2040. This increased blood sugar level in the body can lead to a variety tissue damage, Diabetic retinopathy being one of them. India is expected to have around 79 million suffering from diabetes by end of 2030. All type 1 diabetic and more than half of type 2 diabetic are expected to develop diabetic retinopathy [1][2]. The longer a person is suffering from diabetes the greater the chances of developing diabetic retinopathy. If left untreated it can lead to permanent vision distortion or blindness. It is the largest cause of blindness among people of the age group of 20 to 74 in most countries [3].

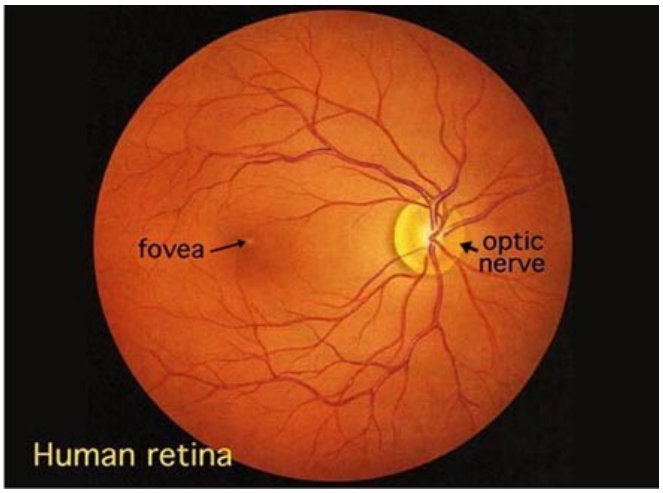

Figure 1: Image of retina

The various factors that lead to diabetic retinopathy are:

- A long duration of diabetes.
- Poor diabetic control.
- Poor control of sugar levels.
- High cholesterol.
- Pregnancy.

There are four stages of diabetic retinopathy:
1.Mild non-proliferate diabetic retinopathy.
2.Moderate non-proliferate diabetic retinopathy.
3.Severe non-proliferate diabetic retinopathy.
4.Proliferate diabetic retinopathy.

If not detected early clinical course of action is difficult to predict, they can either undergo laser photocoagulation or retinal detachment by means of surgery. So, it is mostly recommended for a person with diabetes to undergo yearly screening if he has no or mild diabetic retinopathy, 6 months if he has moderate or severe diabetic retinopathy and weakly treatment evaluation if he has proliferated diabetic retinopathy or diabetic macular edema [4].
Automating the task of grading diabetic retinopathy into mild, moderate, severe and proliferate removes the barrier of access and reduces the overall time for screening and evaluation from few weeks to just few hours.
Machine learning is one of the 6 main domains of Artificial Intelligence(AI) which aims to identify the hidden pattern in data and provide a way to automate tasks without being explicitly programmed. One of the important phases of ML (Machine learning) is feature engineering which is to identify features required for prediction, however when using deep learning [5] algorithms there is no need for featuring engineering as the algorithm itself has the ability to identify the features on its own from a large set of data samples.

The various algorithms that are being studied here are SVM, Naïve Bayes, Random forest and deep convolutional neural networks.

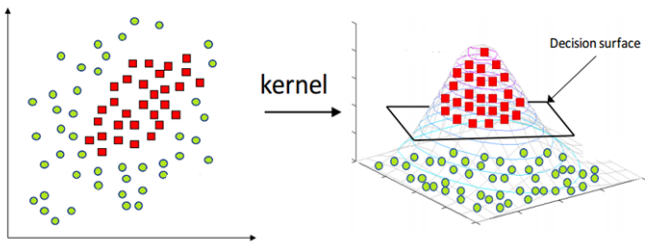

Figure 2:SVM decision boundary

II. LITERATURE SURVEY

A. SUPPORT VECTOR MACHINE

Support vector machine aims to find an optimal hyperplane that can divide the different classes instances, they can be used for both binary and multiclass classification, our case being multiclass classification. However, for SVM to be able to correctly classify the image samples we need to explicitly extract the features [6].
The features extracted here are:
1.Blood vessels.
2.Microaneurysms.
3.Hard exudates.
Blood vessel: Here we are trying to extract the blood-vessel density from the retinal image. The RGB (red-green-blue) image is converted into CMY (cyan-magenta-yellow) representation and then the magenta component is separated. The contrast of the magenta colour gives us the blood-vessel density.
Microaneurysms: They are the lumps appearing in the bold-vessels, they appear like small round dots near the blood vessels. For this, the green components are extracted. Finally, a disk dilation is performed to highlight the microaneurysms.
Hard exudates: Just like detecting the blood-vessels, we need to convert the RGB image to CMY and then isolate the magenta component. Standard threshold binarization is applied to the magenta component. Finally, the binarized image is improved by changing the retinal contour to white.

Once the features are extracted we can now apply SVM to classify our images to detect the degree of

diabetic retinopathy. In this, we find an optimal decision boundary that can classify well on our extracted features. It converts the feature to higher dimension so that it can separate them effectively. The images are classified based on which side of the decision boundary they fall in.

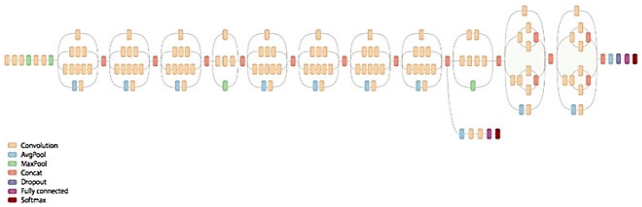

Figure 3:inception v3 architecture

B. NAÏVE BAYES

Naïve Bayes is based on Bayesian probability theorem, they can be used for both numeric and non-numeric features. They perform well on feature of higher order dimensionality and relatively simple when compared to traditional machine learning strategies. Just like SVM we need to extract the features before feeding the data to the algorithm.

The various stages involved in pre-processing [7] are:

1.Elimination of optic disk.

2.Image transformation.

Elimination of optic disk: The hard exudate resembles the optic disk as a result the classifier might falsely classify the image so, we first eliminate the optic disk.

Image transformation: The image obtained from the fundus camera consists of three colour channels RGB of which green channel is used for detection of diabetic retinopathy. We convert the RGB image to grey scale and perform contrast-limited adaptive histogram equalization on green channel.

Once this is done we can apply the naïve Bayes algorithm. The algorithm determines the likely hood of all the classes of DR by calculating the probability of each of the classes as per Bayes theorem and then outputs the class with greatest likelihood as the prediction of the algorithm.

$$P(C \mid A) = \frac{P(A \mid C)P(C)}{P(A)}$$

C. DEEP CONVOLUTION NEURAL NETWORK

With the advent of deep learning there has been a significant improvement in the field of computer vision [5]. We are able to achieve error rate far less than that of human beings. The deep learning makes use of large neural network to perform the prediction for diabetic retinopathy [8]. The algorithm makes use of the pixel intensities of the large image dataset to determine the severity of DR. The weights of the deep neural network are initially set to random values, based on this random value it makes the severity prediction and then compares it with the known severity and finally the weights of the neural network are altered to reduce the error rate. This process is repeated over the entire training dataset until desired accuracy is reached. A special kind of neural network called convolution neural network is used for training as it performs well on imaged data. It is based on locally connected neurons rather than fully connected neurons, as they can extract features on their own from the training images. The specific neural network used in this paper [8] is inception v3 [9] which is shown in figure 3.

Stochastic gradient descent [10] was used to optimize the weight of the network. Ten such networks were made and their linear average was computed as the final prediction output as per the ensemble model [11]

III. CONCLUSION

From the study on automated detection of diabetic retinopathy using various machine learning we can conclude that deep convolution neural network provides a clean and an efficient way to handle unstructured data such as images and can classify a range of images form cats to medical images. Unlike other machine learning algorithm, it doesn't require any complex feature engineering and offers higher sensitivity and specificity.

IV. ACKNOWLEDGEMENT

We would like to express our great attitude to R&D, department of computer science and engineering, KSIT, for their constant guidance.

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