International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Microaneurysms Detection using Neural Networks

Mohak Chavan and Dr. A. R. Buchade

Department of Computer Engineering, PICT, Pune

Received 10 Nov 2020, Accepted 10 Dec 2020, Available online 01 Feb 2021, **Special Issue-8 (Feb 2021)**

Abstract

Diabetic Retinopathy is an eye abnormality and it is one of the main causes for the occurrence of eye blindness at an early age. The Diabetic Retinopathy (DR) is caused due to the disease named Microaneurysms, which damages the retinal blood vessels of an eye. This damage turned into leakage ultimately results into blindness of a person's eye. For detection of this abnormality, the images of the fundus from an eye are extracted and are passed for further classification steps. A machine learning technique, specifically Neural Networks, can be used to detect this leakage from the retinal blood vessels. The images used for the purpose of classification can also be pre-processed before applying the classification techniques. This preprocessing step helps in improving the efficiency and also increasing the accuracy of the model. These preprocessed images can be used for the purpose of classifying the presence of disease in the eye or not. The detection of Diabetic Retinopathy at an early age helps in reducing the damage occurring to an eye and also preventing the patient from going blind.

Keywords: *Neural networks; detect eye disease; diabetic retinopathy; microaneurysms; machine learning;*

Introduction

Machine learning is an application of artificial intelligence. Machine learning in system enables the ability to automatically learn and improve from the experience. The particular system need not to be explicitly programmed. It focuses on the development of computer programs that can learn itself by accessing the data [10]. The main application of machine learning is to learn and classify the given data to one of the class.

Classification using machine learning is the activity of classifying the given data and predicting new data using various classifiers provided by machine learning techniques. In this work, the classification of images is done for the sake of detecting the eye disease, in particular diabetic retinopathy. Diabetic retinopathy, which is also known as diabetic eye disease, is caused by long-term diabetes. This disease is the most common cause for the eye blindness. The only indication of this disease is given by Microaneurysms (MA). Because of this disease, the blindness is caused at an early age of 50.

Neural networks are a set of algorithms which are modelled after a human brain. It interprets sensory data through a kind of machine perception, labeling or clustering raw input. Neural networks help to cluster and classify the given input data. It groups an unlabeled data according to similarities among the example inputs and classify data when given a labeled dataset to train on [11].

Any neural network is composed of several layers. The layers are made of nodes. A node is just a place where computation happens, on a neuron in the human brain, which fires when it encounters sufficient stimuli. A node combines input from the data with a set of coefficients, or weights, that either amplify or dampen that input. These input-weight products are summed and then the sum is passed through a node's so-called activation function, to determine whether and to what extent that signal should progress further through the network.

Due to the presence of microaneurysms, it results into the leakage of blood vessels. This leakage of blood vessels is from the vessels carrying blood in retina. This leakage is very risky for the patients having diabetes. Due to this leakage the damage is caused to the retina, which is main part for the purpose of vision. This damaged retina now cannot capture the vision clearly and ultimately resulting into the eye blindness.

The images of the fundus of a human eye are extracted and are further processed. Machine Learning classifiers uses these images to classify the particular image as presence of Microaneurysms or not. Any machine learning algorithm at first needs to be trained for the purpose of classification. These algorithms can be trained in different types as in supervised, unsupervised or reinforcement. For the purpose of training, these algorithms take in the data, which can be labeled or unlabeled, along with various parameters and prepares a model for the particular parameters.

This model now can be used for the purpose of classification for the new images.
Also, the accuracy of the particular model can be calculated. According to the accuracy, the parameters passed to the algorithms can be changed and accuracy can be increased. The images of the fundus can be accessed from the different databases like DIARETDB 0[9], DIARETDB 1[8]. The literature survey is done in section II. While the proposed methodology is presented in section III. At last, section IV concludes this paper with the future work.

Literature Survey

Cao et al. [1] uses the Principal Component Analysis for the purpose of dimensionality reduction. The dimensions of the fundus images are reduced for the gaining best efficiency using lesser number of dimensions of the data from the database. For the purpose of classification, different classifiers namely Random Forest, Neural Networks with one hidden layer and Support Vector Machine. The database used is DIAbetic RETinopathy DataBase - calibration level 1. The performance acquired by this paper is 0.985

Zeng et al. [2] uses Computer-aided diagnosis method is used to diagnose the disease automatically. The proposed method is based on deep learning algorithms. The Convolutional Neural Network model with the Siamese-like architecture is used for the purpose of training. The database used in this paper is from Kaggle diabetic retinopathy competition by EyePACS. This method gives performance of 0.951

In J. P. Vigueras-Guill´en et al. [3], they propose that for the assessment of health status of cornea and also estimating various clinical parameters require accurate segmentation of cell. This segmentation of endothelium cell is done automatically by using the proposed method of Support Vector Machine. This paper uses the images for the segmentation provided from In Vivo specular microscopy and the performance of 95.8% is achieved. S. Bourouis et al. [4] proposes a probabilistic learning approach, which is robust and hybrid, that contains the combination of advantages from generative and discriminative models. It uses a hybrid scaled dirichlet mixture models. New kernel as Support Vector Machine is proposed for the purpose of classification of retinal images. Here various datasets are used such as e-optha, HRIS, MESSIDOR, DIARETDB1, VDIS, DRIVE and HRF. According accuracies are achieved as 85.34, 91.22, 90.09, 85.55, 86.61, 84.99 and 86.55 respectively.

P. Costa et al. [5] proposes to accurately detect the Diabetic Retinopathy from the modified datasets. The modification to the datasets is done in the form of pixel level annotations which are provided by the experts. New methodology which is based on Multiple Instance Learning is proposed by this paper. This proposed method uses the information, which is implicit, present in image. The dataset forms the MESSIDOR database is used and gives performance of 90%.

Zhang et al. [6] proposes to evaluate the performance of a deep neural network for the purpose of automated screening of Retinopathy of Prematurity (ROP). Retinopathy of prematurity is one of the main causes of childhood blindness. Various classifiers are used for classifying dataset from Telemed-R which is handled by ROP Collaboration Group. AlexNet, VGG-16 and GoogLeNet are used as classifiers and the accuracy of 0.782, 0.979 and 0.980 is achieved respectively. In Z. Gao et al. [7] the proposal is to automate the diagnosis of Diabetic Retinopathy using the Deep Neural Networks for classifying the images of fundus. Proper treatment has been used for the purpose of labelling these images. For the purpose of classification, the modified versions of Convolutional Neural Networks are proposed. The datasets used are the combination of DIARETDB 0/1, MESSIDOR, DRIVE, STARE, REVIEW, Kaggle Diabetic Retinopathy, E-optha. These datasets are annotated and are also pre-processed. The accuracy achieved in this paper is of 88.72%.

Proposed Methodology

A node in any neural network looks like as shown in Fig. 1. As shown in Fig. 3, at first dataset is collected from various different databases like DIARETDB 0, DIARETDB 1. Now these images can be distributed for the purpose of training and testing of the model. Dataset is distributed into two parts namely: Training Data and Testing Data. Training data, as the word suggests, is used for the purpose of training the particular model. While the Testing data is used the testing of that particular model built using the training data.

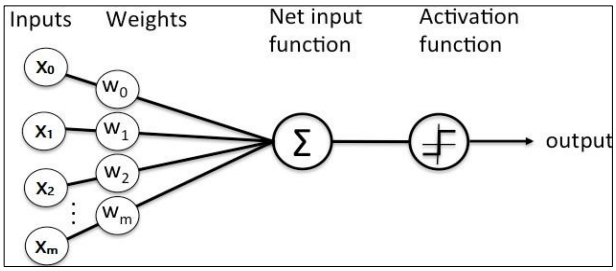

Fig. 1. Single Node Neural Network

A neural network can be also built using several multiple layers between the input layer and the output layer as shown in Fig. 2. A set of nodes at the same level is called a layer in neural networks. These multiple layers between input and output layers are also called as hidden layers. So, the output from the input layer is fed into the next immediate hidden layer. And thus, the output of each layer is now treated as input to the subsequent layer.
The training data is now passed to the input layer of the Neural Network. As explained, the nodes present in

the neural network process the given input using the predefined weights and produces the output with the help of the activation function. This output is now passed to the subsequent layers and finally the model is trained and built.

The feature extraction part of the training phase extracts the features of the given input images to the neural network. The important feature for the detection of microaneurysms is extracted from the green channel of the three distinct channels, RGB channels, of a coloured image. The importance of this channel has been noted by W. Cao, et al. [1].

The model built is now tested using the testing data which was divided from the original dataset earlier. The testing data is now passed to the built model. The model takes the data, processes the input based on the defined weights in the training phase and predicts the output. This predicted output is compared with the targeted/original output of the testing data.

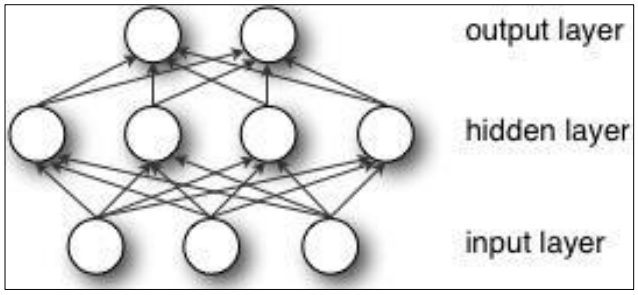

Fig. 2. Multiple (Hidden) Layer Neural Network

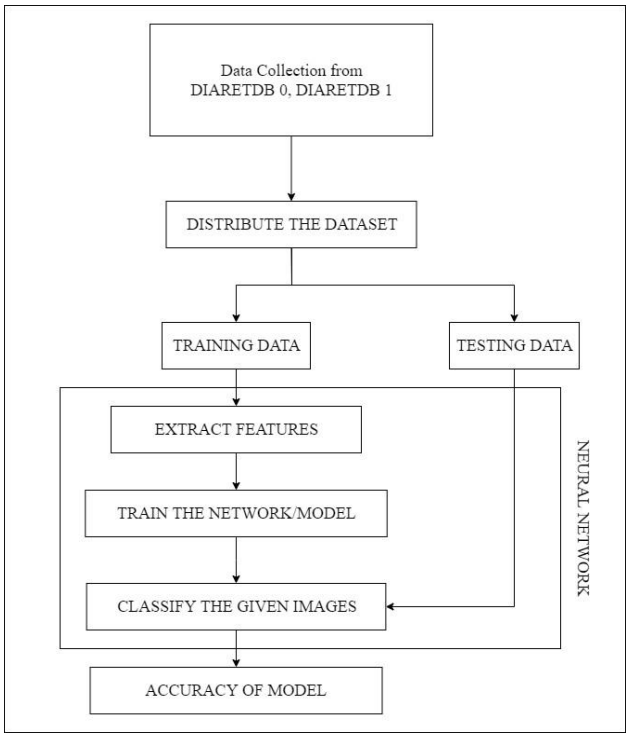

Fig. 3. Overview of System

On the basis of the comparison done between the predicted output and targeted output, the accuracy of the model is calculated. If the accuracy of the model passes the prefixed threshold value, then the particular built model is ready for the testing of new data. But if the accuracy does not pass the threshold value, then the error between the predicted and original output is calculated and the weights of all the nodes are changed accordingly.

A. Associated Mathematics

The equation for calculating the net input, as shown in Fig. 1, of Neural Network is:

Net Input:

$$y = (x_0 * w_0) + (x_1 * w_1) + \cdots + (x_m * w_m)$$

Therefore,

$$y = \sum_{i=0}^{m} (x_i * w_i)$$

where, $\boldsymbol{y}$ *is net intput,* $\boldsymbol{x_i}$ *is given inputs* $\boldsymbol{w_i}$ *is weight associated with each input*

There are various activation functions which can be used for calculating the output, namely:

Binary Step: The formula for binary step is stated below and the graph is shown in Fig. 4.

$$f(y) = \{0 \quad for\ y < 0\ 1 \quad for\ y \geq 0$$

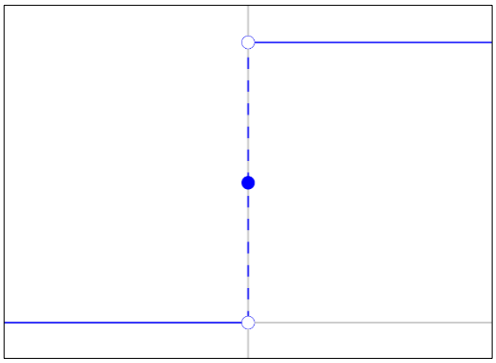

Fig. 4. Binar y Step Activation Function

Sigmoid/Logistic/Soft step Function: This activation function is used for smooth edge. The formula is stated below and the graph is shown in Fig. 5.

$$f(y) = \frac{1}{1 + e^{-y}}$$

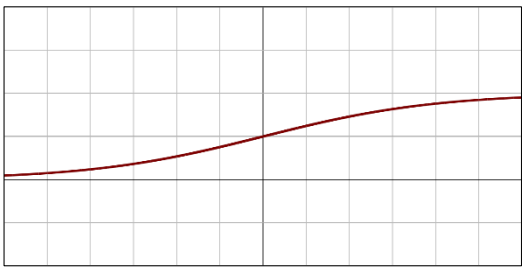

Fig. 5. Logistic Activation Function

Concussion & Future Work

Here, in this work, several different algorithms provided by machine learning and used for the purpose of detecting the most common eye disease,

which is Diabetic Retinopathy, are compared. It is observed that the algorithms used for the classification purpose provides good accuracy. But the implementation of Neural Networks for the same purpose provides better accuracy compared to others though much more time is taken for the training phase. The datasets specific for this purpose are also mentioned. Additionally, the accuracy of each dataset is mentioned and compared to other datasets. In the future, the design and implementation of the neural network algorithm provided by the machine learning can be done which will lead to the increase in the accuracy of detecting Diabetic Retinopathy.

References

[1] W. Cao, N. Czarnek, J. Shan and L. Li, "Microaneurysm Detection Using Principal Component Analysis and Machine Learning Methods," in IEEE Transactions on NanoBioscience, vol. 17, no. 3, pp. 191-198, July 2018.

[2] X. Zeng, H. Chen, Y. Luo and W. Ye, "Automated Diabetic Retinopathy Detection Based on Binocular Siamese-Like Convolutional Neural Network," in IEEE Access, vol. 7, pp. 30744-30753, 2019.

[3] J. P. Vigueras-Guill´en et al., "Corneal Endothelial Cell Segmentation by Classifier-Driven Merging of Oversegmented Images," in IEEE Transactions on Medical Imaging, vol. 37, no. 10, pp. 2278-2289, Oct. 2018.

[4] S. Bourouis, A. Zaguia, N. Bouguila and R. Alroobaea, "Deriving Probabilistic SVM Kernels From Flexible Statistical Mixture Models and its Application to Retinal Images Classification," in IEEE Access, vol. 7, pp. 11071117, 2019.

[5] P. Costa, A. Galdran, A. Smailagic and A. Campilho, "A Weakly-Supervised Framework for Interpretable Diabetic Retinopathy Detection on Retinal Images," in IEEE Access, vol. 6, pp. 18747-18758, 2018.

[6] Y. Zhang et al., "Development of an Automated Screening System for Retinopathy of Prematurity Using a Deep Neural Network for Wide-Angle Retinal Images," in IEEE Access, vol. 7, pp. 10232-10241, 2019.

[7] Z. Gao, J. Li, J. Guo, Y. Chen, Z. Yi and J. Zhong, "Diagnosis of Diabetic Retinopathy Using Deep Neural Networks," in IEEE Acces, vol. 7, pp. 3360-3370, 2019.

[8] It.lut.fi. (2019). DIARETDB1 - standard diabetic retinopathy database. [online] Available at: http://www.it.lut.fi/project/imageret/diaretdb1/ [Accessed 9 Apr. 2019].

[9] It.lut.fi. (2019). DIARETDB0 - Standard Diabetic Retinopathy Database. [online] Available at: http://www.it.lut.fi/project/imageret/diaretdb0/index.htm l [Accessed 25 Apr. 2019].

[10] Expertsystem.com. (2019). What is Machine Learning? A definition - Expert System. [online] Available at: https://www.expertsystem.com/ machinelearningdefinition/ [Accessed 20 Mar. 2019].

[11] Pathmind. (2019). A Beginner's Guide to Neural Networksand Deep Learning. [online] Available at: https://pathmind.com/wiki/neural-network [Accessed 25 Nov. 2019].

[12] En.wikipedia.org. (2019). Activation function. [online]Available at: https://en.wikipedia.org/wiki/ Activation_function [Accessed 30 Nov. 2019].