CLASSIFICATION OF GLAUCOMA STAGES USING DEEP CNN WITH 2D-COMAPCT-VMD IN FUNDUS IMAGES

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ABSTRACT: Diabetes has a consequence called glaucoma that can result in blindness. Using manual screening procedures to identify glaucoma in its early stages is costly and time-consuming. The high-level characteristics are acquired using a CNN model. The first layer of a pre-trained CNN model is reset using the Region of Interests (ROIs) of lesions retrieved from the annotated fundus pictures. After then, the model is adjusted such that the low-level layers pick up on the regional architecture of the lesion and healthy areas. In order to extract discriminatory characteristics from the fundus pictures unsupervised, we substitute the fully connected layer (FC), which encodes high-level features that are global in scope and domain-specific, with a new FC layer by considerably reducing the model complexity in this stage, the overfitting issue that determines whether diabetes is present is avoided. To create the final segmented image of the blood vessels in the Fundus image, the categorization for each pixel in the image is merged to determine whether they are normal or aberrant. In our work, the accuracy obtained for the proposed methodology is better.

INDEX TERMS:

Diabetes, Glaucoma, a CNN model, Region of Interests (ROIs), Fully-Connected (FC) Layer, Fundus Image.

I. INTRODUCTION

Glaucoma is a disease which leads to damage of optic nerve that causes eye contact. It is very serious factor for eye disease. Glaucoma is a eye disease, for early detection we can control vision loss and later stage detection may leads to complete loss of vision. Glaucoma typically effects older individuals, but can also occur in anger people. It often has no noticeable symptoms in its early stages, and can gradually worsen overtime. As such, regular eye exams are important for early detection and treatment.

Glaucoma is a highly prevalent eye disease, with an estimated 80 million individuals affected in 2022. Unfortunately, at least half of those with glaucoma are unaware that they have the condition. This is particularly problematic in developing countries, where up to 90% of cases may go undetected. Alarmingly, the number of people affected by glaucoma is expected to increase to 111.8 million individuals by 2040. These statistics highlight the importance of regular eye exams and early detection in preventing the progression of this potentially blinding disease.

There are several types in glaucoma which are :Open-angle glaucoma(it increases pressure within the eye), Angle-closure glaucoma(iris is too close to the drainage canals in the eye that causing them to become blocked), Normal-tension glaucoma(it also increases the pressure in eye within the normal range), Congenital glaucoma(cause by abnormal development of the eye's drainage canals), Secondary glaucoma (it causes injury or inflammation), Pigmentary glaucoma(causes blockage and increases eye pressure).

Fig. 1: Vision effects of glaucoma at different stages

POAG is not painful, has a potential to progress slowly over time, and typically shows no signs until the condition has been much worse. Vision distortion, acute eye pressure, nausea, and redness are among symptoms of PACG, which is typically chronic and asymptomatic [1].

K-nearest neighbour and support vector machine methods are now used for glaucoma detection. The machine learning techniques for classification and degeneration issues include the k-nearest neighbour algorithm and support vector machine algorithm [2], [9].

In the based on the previous algorithms, we are using the deep convolution neural network (CNN)

SVM: Support Vector machine is one of the best methods for supervised learning algorithms which is used for classification as well as regression problems. A new approach to categorising both linear and non-linear data. It searches for the linear optimal splitting hyper plan by using a non-linear mapping to turn the initial training data into a higher dimension with a new dimension [1], [2].

CNN: Convolution Neural Network is a category of Neural Network or Deep Learning that has proven very important factor in areas like image recognition, audio/video recognition. CNN is mostly used for image recognitions, image classifications, object detection and recognition faces etc [2].

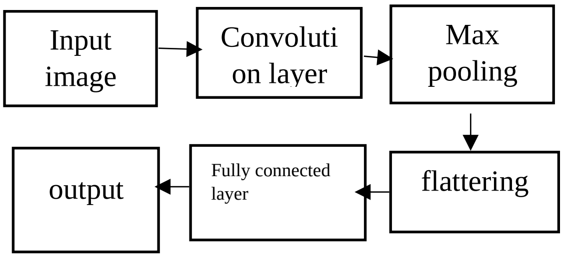

Fig. 2: Structure of CNN

A CNN image classification algorithm uses an input picture to analysis and categorized it [8], [9]. CNN is used to help computers see objects and carry out operations including object identification, object recognition, and picture categorization. An input picture is used to categorizes an image by deciding which class best fits its characteristics. A specialized type of neural network model called CNN was developed especially for utilising picture data. [8], [11].

Each pixel in a 3D picture will contain three values, or independent channels, representing the red, green, and blue color values. A 0-255 number represents the intensity of a pixel at that particular location. We want the computer to be capable of differentiate between all of the photos it is shown. For this task, the computer searches for basic elements like edges and curves before building up to more complicated ideas through a sequence of convolutional layers [3].

In CNN, input image pass through series of Convolution layers, Pooling(down-sampling) layer and fully connected layers and finally produce the output which can be simple class or a probability of classes that best describes the image [8]. In CNN number of parameters for the network to learn is significantly lower than multilayer network. There are different types building blocks in CNN like **Padding, Pooling** [2]**,** [8].

PADDING: The optimal method is padding, which involves copying pixels from the image's edge and adding as many pixels as are required for the convolutional core to process the edge pixels. So, we can fix the Border Effect Problem with Padding [2].

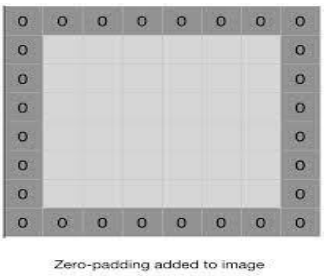

Fig. 3: Zero Padding

POOLING: Down sampling the detecting features in feature maps requires pooling. The matrix formed from the image is taken using max-pooling or avg-pooling, where filter & stride is fixed. When we placed the filter, it chooses maximum or average values.

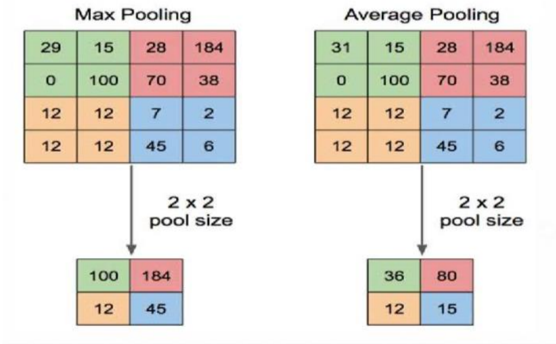

Fig. 4: Pooling

II. DATABASE

A database is collection of datasets or Data-objects, which is mainly called as Database management system (DBMS). In this work, the database is collected from Kaggle. Kaggle is one of the biggest data science community tool. Kaggle is a platform with large number of datasets present in it. In this work, we have collected glaucoma datasets. So, we used the Kaggle data base, as it contains several numbers of datasets of fundus images in it and the data set is give as input for the detection of the glaucoma stages. In the dataset we have the trained data which contains several fundus images with different stages effected by glaucoma and the non-glaucoma fundus images. The glaucoma datasets consist of three stages i.e., normal, abnormal initial and abnormal advanced. In this database we've selected the images based on the disease information. Kaggle dataset is used as an input for glaucoma. In which, it contains 100 sets of images for glaucoma. The database is in the format of .tif files. We have a future scope on developing our work with different databases. These are datasets are used for characterizing glaucoma disease in our work.

A. Normal B. Abnormal Initial C. Abnormal Final

Fig. 5: Glaucoma stages

III. METHODOLOGY

A. Proposed work

In this method, firstly we have given the retinal image as an input and we use image enhancement to increase the quality of an image. As it undergoes the images prepossessing steps which have green channel extraction, image resizing, CLAHE and 2D-VCMD. So, where the eye consists of red, green and blue nerves and the more information is available in the green nerve so we use the green channel extraction and the next one is image resizing which adjusts the size of the input image.

The data from the 2D-CVMD is given to the Deep Convolution neural networks. In CNN the arrangement comes with 3 layers. Each layer has divided six steps which has input image, convolution layer, batch normalization, relu layer, pooling and soft-max layer.

In above steps, at first image is taken from the 2d compact vmd and then image pixel values of input volume are multiplied with convolution filter and add bias gives o/p volume. The convolution operation identifies the edges & features of the image.

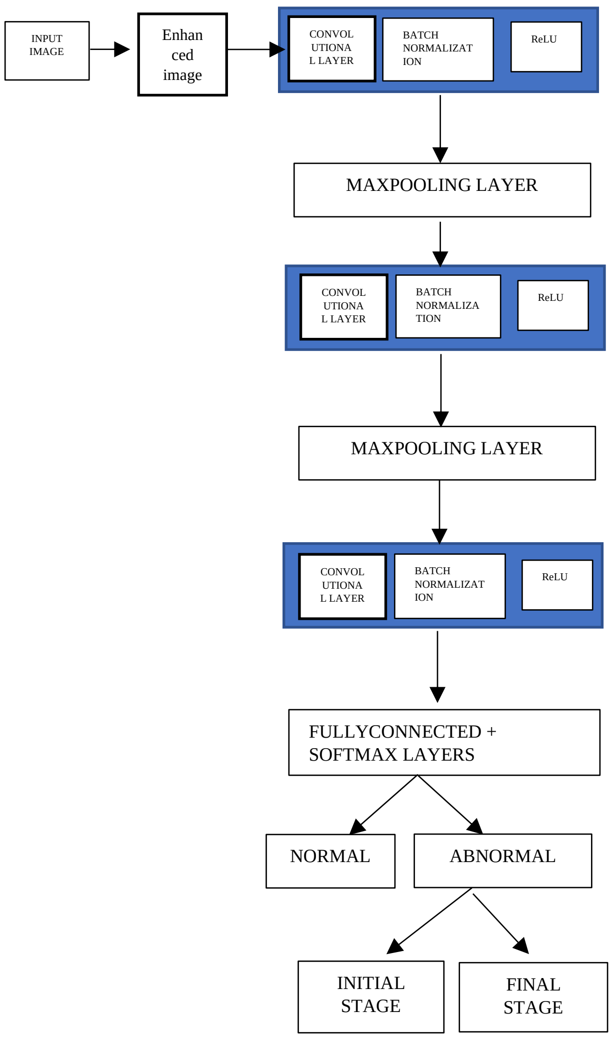

Fig. 6: CNN Block Diagram

As the output data is given to the batch normalization which normalizes image values from mean=0& standard =1 deviation. The layer performs ReLU operation by checks the available elements are linear or not. After checking multiple times the image is in linear. If the data is linear then it gives to pooling layer. In pooling, according to the data it goes under Max-pooling or avg-pooling. The function of pooling layer is to reduce size or dimension of the image. For performing the pooling operation, we need to fix the filter of size & stride. For performing the layer, the filter must put in left top corner and extract maximum value if it is max-pooling. Then the image pixels are slide or stride to other ones. The layer is reducing the size and enhances the features from the image. It is the CNN model to categorized the above steps.

So, in the CNN the layer is repeated again and again for another two times by that the image will get linear. It proceeds to the fully connected layer which match the predefined trained data. The input to the fully connected layer is the output from the final pooling or Convolutional layer, which is flattened and then fed into the fully connected layer. The trained data have health and unhealthy images. If the output of convolution layer matches the trained data the result gives normal or abnormal if abnormal then it is starting or advanced stage.

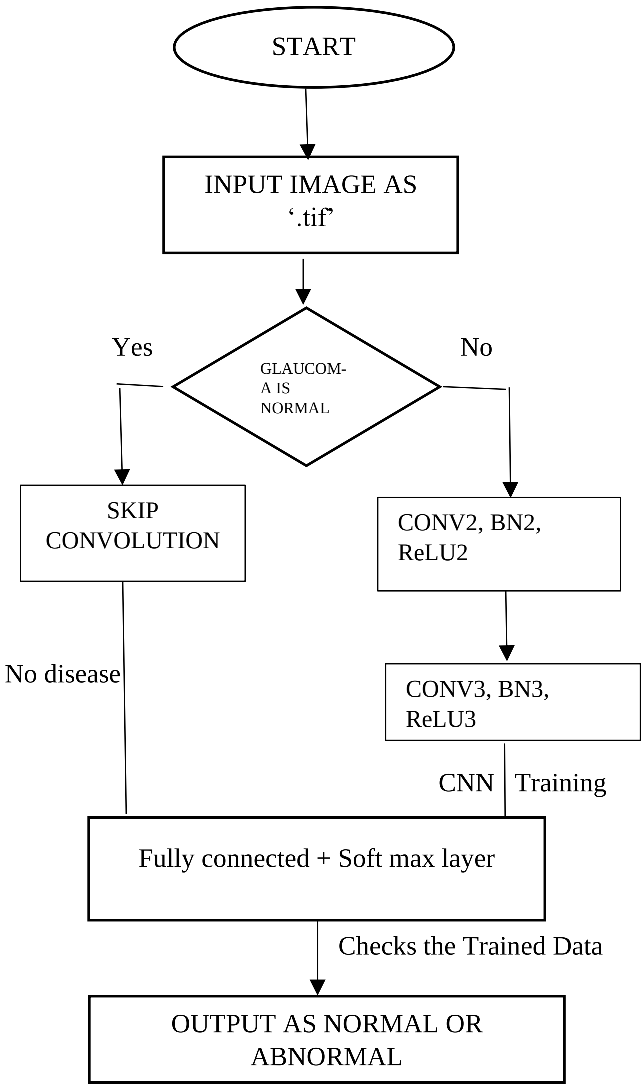

Fig. 7: Flow-Chart

B. **2D-CVMD**

In the detection of glaucoma stages the fundus images are given as input in this the image processing is done in it. For the image processing the 2-Dimensional compact variational mode decomposition is used [5].

The 2D-CVMD which means the given fundus image will get decomposed the image decomposition is occurred in it. The decomposition will occur in different modes and the features from the image such and resolution of the pixels, textures will get extracted which are related to the glaucoma stages.

As in the CVMD the image is divided into section particles to extract the more features from the given fundus image. As we compare to the other methods the 2D-CVDM can extract the more features from the fundus images which we can get the high accuracy rate.

C. Convolution Filter

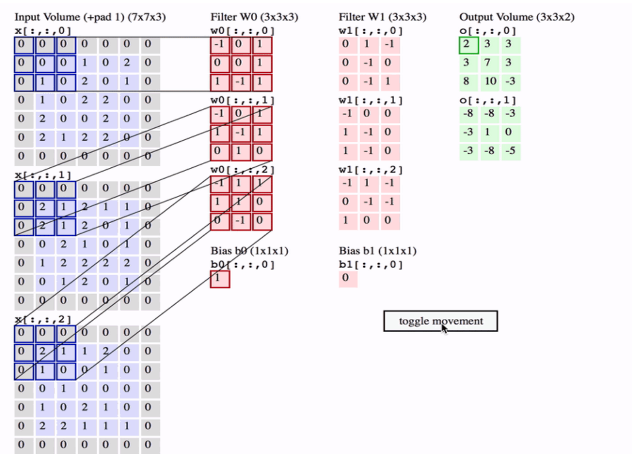

Fig. 8: Convolution filter

To perform the convolution operation using convolution filters the above operation is used, at first image is taken from the 2d compact vmd and then image pixel values of input volume is multiplied with convolution filter and add bias gives o/p volume.

D. HISTOGRAM

Histogram is a graphical representation of the input data [12]. Where it represents according to the intensity of the pixel values which are inherited in the fundus image. The graph is drawn by the number pixels have certain intensity values in the image and also according to the mean and standard deviation values of the pixels in the image.

In the adaptive histogram where the mean value is equalized to 'zero' and the standard deviation value will be equalized to 'one'.
As according to the data of mean and standard deviation data the adaptive histogram will be adjusted.

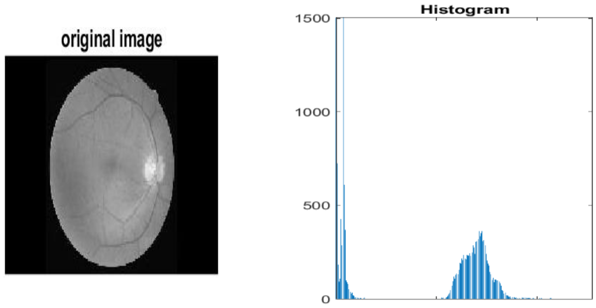

Fig. 9: Original Image and It's Histogram

Histogram Equalization: It is the process, which is used to equalize the values for the histogram of original image. The below Fig. 10 shows the histogram equalization of retinal image.

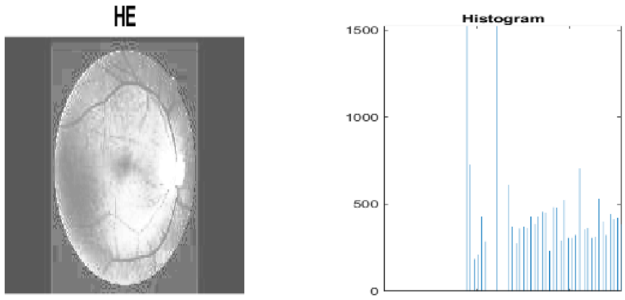

Fig. 10: Histogram for HE

IV. RESULTS & GRAPHS

The table shows the accuracy levels, Accuracy mainly depends on number of epochs, iterations and minimum batch loss. Base learning rate is used to learn the core information of the image and it is constant for every CPU. If we increase the no. of epochs and the no. of iterations also increases and then the Accuracy will also increase.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Min-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:02	62.96%	1.2784	1.0000e-04
15	15	00:00:18	96.30%	0.0541	1.0000e-04

Table. 1: Results of Glaucoma Classification using CNN

In order to get the results, we apply CNN training using an optimizer called **ADAM OPTIMIZER.** This optimizer is the best, simple and time saving optimizer. The trained data is applied to the Adam Optimizer by using Mini-Batch-Size, Max-Epochs, Validation-Frequency, Initial-Learn-Rate, Plots and training-progress. To perform operation on the image, the size of the image must be 128, in which the Mini-Batch-Size is used. Epoch is a set or collection of facts, and as we increase [1] the number of epochs then the training of data is increases. So, we can get better results, but it takes more time. The number of calculations used for each epoch is called Validation Frequency and there are 5 calculations for each epoch. The initial learn rate is given by factor as le-4 and then graph is plotted as shown in below.

When the input image is given, it is compared with the trained data, the trained data contains the images and images contains blood vessels colour, texture and Histogram Images. All these are, i.e., blood vessels colour, texture and Histogram Contrast levels are compared with the input image. So, then the results will be given as Normal or Abnormal (Initial, Advanced).

The Training Progress shows that relation between accuracy and loss. So, based on number of epochs accuracy increases and loss of information will decrease.

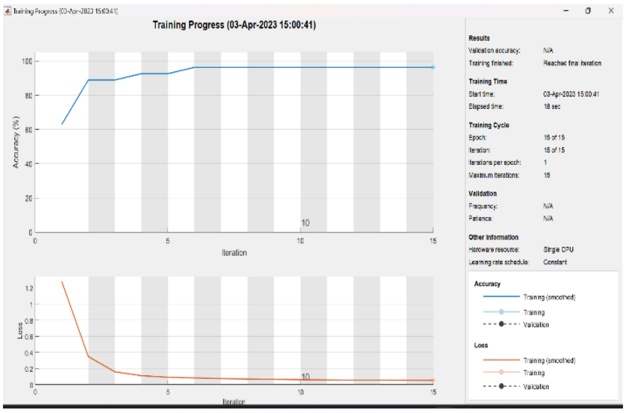

Fig. 11: Plot of accuracy (%) of the model vs Different iteration

The input image will be given as'image_number.tif' format, then the histogram is plotted for original image, Histogram Equalization and CLAHE. The stage of the Glaucoma is displayed as if its normal then as 'Normal Stage', if its abnormal then it will be displayed as 'Abnormal Early Stage' or 'Abnormal Advanced Stage'. Finally, it displays as Deep Learning of Glaucoma classification successfully completed".

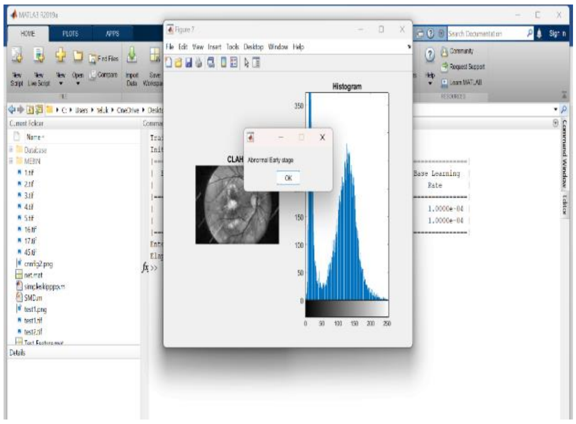

Fig. 12: Glaucoma Stages

V. CONCLUSION

In this paper, we developed a new system for categorizing the various phases of glaucoma. In this work, CNN and a recently developed 2D-CVMD based algorithm have been applied. The classification performance of the suggested framework is enhanced by the 2-D-C-VMD approach. Fundus photos that have undergone preprocessing have been divided up into several VMs using VMD. The twelve most important characteristics in this study can perform better in terms of categorization. Preprocessed fundus pictures have been divided into several VMs using VMD. The twelve most important characteristics in this study are capable of generating higher classification performance. As there is less calculation complexity, the suggested solution provides greater accuracy and speed. A tenfold cross-validation procedure is used to validate the outcomes of the suggested approach. The experiment's results show that the suggested ways outperformed cutting-edge techniques because they obtain the highest categorization. Our method is effective for earlier and more accurate glaucoma detection, with a 99% accuracy rate for early-stage glaucoma identification.

VI. REFERENCES

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