Grenze International Journal of Engineering and Technology, Jan Issue

Detection of Cataract and its Level based on Deep Learning using Mobile Application

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***Abstract*—The human eye has a natural lens that refracts the incoming light rays to help us see objects. Cataracts could be the reason why the eye's natural lens becomes cloudy. When proteins in the lens start breaking down, causing cataracts, objects may appear cloudy, fuzzy, or even less colorful. If Cataract is not identified and treated in the early stages, it could lead to complete blindness of the eye. It is mainly observed in older age groups than the younger age group, however, there are cases witnessed even in young people. We are creating a mobile application using AI and deep learning that can detect the existence of cataracts to help with the scarcity of ophthalmologists. With this application, patients can use their smartphones to click the photograph of a patient's eye and feed the data into this AI-based system that is developed using deep learning technologies. The model then determines whether the eye has a nuclear sclerotic, cortical, or posterior subcapsular. The effect of this system will result in far improvement in the delivery of public services, diagnosis and treatment, prioritization of patients, and ultimately, the prevention of blindness. This system will demonstrate encouraging outcomes.**

***Index Terms*— Deep-Learning, Image-processing, Machine-Learning (ML), Computer-Vision, Video-Analysis, Mobile Application, Smart-Phone, etc.**

I. INTRODUCTION

The most common eye condition that impairs human vision is cataract, though there are many more. A Cataract is basically a white film formed over the cornea of the eyes and results in blurry vision. As per recent studies, there are around 19 - 20 million people who are diagnosed with cataract and majority of these were from Rural or suburban regions. And Availability of Advance Machine/Camera which is used to identify this eye disease can't be presumed in such regions. Hence it can lead to ignorance or certain delay in diagnosing the cataract Ref. [13,14]. To avoid such situations we are working on creating a mobile application which can detect the Cataract and predict it's level with precautionary measures just by using the smartphone camera.

Deep learning techniques are widely used in recent years to detect diseases automatically without any human intervention. These techniques are most suitable for the automatic detection of diseases, their severity, and help in their diagnosis by predicting their precautionary measures and medicines to completely eliminate the disease. These methods are proved to have high accuracy and achieve faultless results Ref. [11]. With the use of slit-lamp and fundus images, AI may be used as a telediagnostic system that test and identify individuals who have cataracts. To accurately identify and categorise referable cataracts, this technique uses a deep-learning (CNN) Ref.[12].

Grenze ID: 01.GIJET.9.1.512_3

II. Review of Literature

As proposed in 'An automated eye disease recognition system from visual content of facial images using machine learning techniques', different algorithms and techniques are used which will automatically cut out the eye part of the given facial image and then these eye parts are used for learning. Following image processing, the characteristics are then applied to D-CNN and SVM models [Figure 1]. Along with the above mentioned methods we also apply Principal Component Analysis (PCA) and t-Stochastic Neighbor Embedding (t-SNE). For feature selection of the model the methods used are PCA and t-SNE. After completion of feature selection on the system, the next step is to classify the model. For classification SVM is used which has a differential kernel called RBF based kernel of SVM.the system is then tested with visually observable seven eye diseases - cataracts, conjunctivitis, trachoma, ectropion, corneal ulcer, periorbital cellulitis, and Bitot's spot.

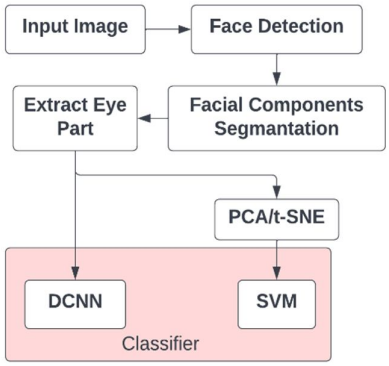

Figure 1: Proposed methodology

The proposed system got an accuracy of 98.79%. While on the other hand the system also has high sensitivity and specificity. Hence the result of the proposed D-CNN model for all seven distinct diseases has an average accuracy of 98% Ref.[1] .

Syed Md. Galib and Juyel Rana insist on development of an Android Application since an Android provides a better platform with fine features for developers. It also consists of some libraries making the development work easy for the programmers.

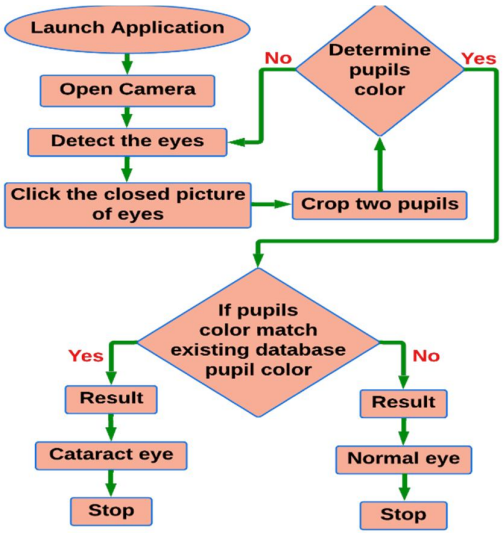

Figure 2: Flow diagram for Cataract Detection using application

Initially [Figure 2], the patient or the user will launch the application. After the launch, the user will see a camera icon. By clicking on the icon, it will open a customized camera that will provide an OpenCV library. The ideal distance or the maximum distance must be around 30 cm. Here, firstly the camera will detect the patient's face

with a highlighted followed by two eyes which will be also shown in two different rectangular views. The focus will only be on the eyes that are framed so that the patient can see his own eye problem on the screen clearly. Then, both the frames will detect and cut the pupil using a Cascade Classifier. (a library having the functionality to detect pupils). After detecting the pupil's image, the image will further be stored in a temporal matrix which stores the values of the image in RGB format. This application will allow users universally to detect cataracts just by using a Smartphone with a good-quality camera. It will solely permit the user to self-screen which can be performed, anytime and at any remote location. In this research work, Android Studio, Software Development Kit, Native Development Kit, and OpenCV are used. Research has shown that such an approach is possible Ref.[2].

Image acquisition, image preprocessing, feature extraction, and classification are the four main sections of the following study [Figure 3].

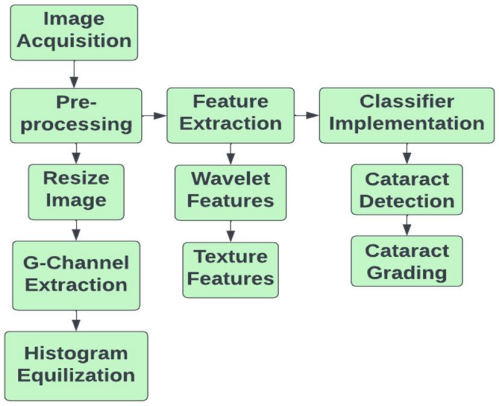

Figure 3: Block diagram for the task of detecting and grading cataracts

The hence described study-Cataract Detection and Grading with Retinal Images Using SOM-RBF Neural Network, represents an automated system for cataract detection and grading specifically based on retinal images to enhance the retinal images, top-bottom hat transformation, histogram equalization methods and green channel extraction methods are used while preprocessing. SOM (Self-Organizing Maps) and RBF (Radial Basis Function) neural network have been combined together to gain accurate results. SOM helps in identifying initial centers and RBF helps in grading and classifying the cataract. This method has gained 95.3% and 91.7% of accuracy for these activities of cataract detection and grading tasks and hence it shows that these methods outpass the traditional ways Ref.[3].

As proposed in 'Automatic Cataract Detection Using Sobel and Morphological Dilation Operation', since we know, due to similar gray levels, ophthalmologists and pathologists can get confused manually identifying cataracts, here in this case it is capable of quickly and accurately detecting cataracts from a given input.

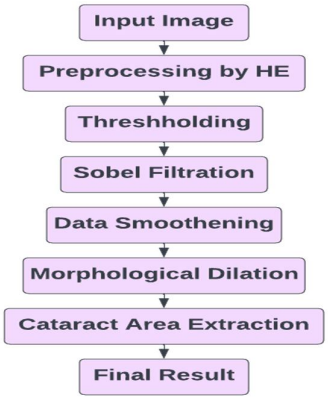

Figure 4: Block diagram illustration

To identify cataracts, firstly, an image as input must be obtained and converted into an image pixel through the HE, which will help reduce the background noises. Further, we apply the threshold method which is the Sobel edge finding method, and morphological dilation to find the borders of the object. Finally, we get the result we wanted, which is the presence or absence of cataracts [Figure 4]. This Sobel-based technique for segmenting cataracts from the input image combines an inverse matrix, smoothing, and morphological dilation algorithm. It is also capable of distinguishing between a cataract-affected eye and a healthy eye. Therefore, the affected area of the eye can be accurately extracted using this proposed system Ref.[4].
The proposed model of Chi-Ju Lai , Ping-Feng Pai , Hsiao-Han Hung, Si-Han Wang and Din-Nan justifies the aim to design a convolutional neural network (CNN) to detect cataracts present in the eye with their digital camera images. The designed CNNDCI system (CNN with digital camera images) assures to perform the cataract identification process accurately and efficiently by collecting the digital images through mobile camera and train the CNN classifier to detect presence of cataract [Figure 5]. This study shows that the presented CNNDCI architecture is a user-friendly, effective and efficient way of detecting cataract Ref.[5].

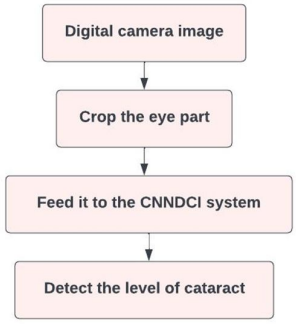

Figure 5: Flowchart for CNNDCI model

Very similar to what commented by Raghavendra Chaudhary and Arun Kumar - Cataract Detection using Deep Learning Model on Digital Camera Images where CNN is used with DCI Ref. [10].
Further, the hence developed model [Figure 6] is completely based on CNN. CNN uses pattern recognition which helps to automate the image classification. They show great increase in accuracy of about 88% by increasing the number of epochs. A CNN model has three layers : convolution layer, pooling layer and a fully connected layer which helps in pattern recognition. The complexity increases as we go from first layer to the last layer of the CNN model Ref.[6].

Figure 6: CNN model

Vaibhav Agarwal, Vaibhav Gupta, Vivasvan Manasvi Vashisht, Kiran Sharma, Neetu Sharma insists about a method with following suugestions. The application was created using a variety of tools, including Open CV and Android Studio. The application was developed primarily using the Android Studio environment. For the

support of deep learning and image recognition, many libraries have been employed. The user interface (UI) collects user input and conceals backend processes. There are two ways to get user input into an application: either the user can utilise a photograph already on their phone by utilising the gallery as the input, or they can use the phone's built-in camera to take a picture of themselves to send to the program. The program has a specified set of photos of an eye with a cataract present in them for training the model. The backend processing of the applications is done using Open CV. The eye is recognized by using OpenCV's libraries for image processing and detection, and it is then separated from the original image. The estimated eye feature points are now saved in an array. The points that are close to the pupil of the eye are then saved in a final array after this image has undergone additional processing Ref.[7].

Basant Kumar along with Shashwat Pathak comments that, it is necessary to remove the pupil part from the image in order to do automatic identification of cataract from a digital eye image. The Hough transform is the option for typical circular region recognition algorithms, and since the pupil is circular, we can readily identify it using these methods [Figure 7]. Here, it is used to recognize the distinguishing round pupil. The fundamental approach for a reliable cataract detection algorithm is in three steps: preprocessing, feature extraction, and decision-making Ref.[8].

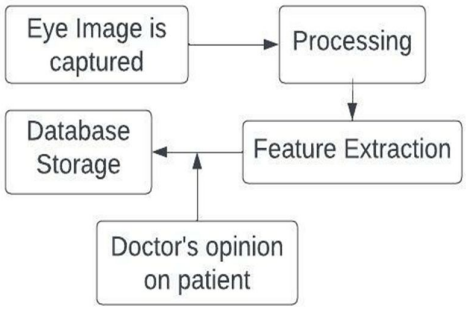

Figure 7: Database creation and parameter hresholding

Using Convolutional Neural Network (CNN) to train the model to diagnose the cataract which uses Image dataset which is publicly available. For optimization, the CNN training cycles takes specific amount of time. In this study the proposed model has two dense layer, three pooling layers, one flatten layer, and three convolutional layers and uses ADAM optimizer. For the selected Digital Camera Images Dataset, the proposed CNN model can detect cataracts with a training accuracy of 0.9980 with a loss of 0.0038 Ref.[9].

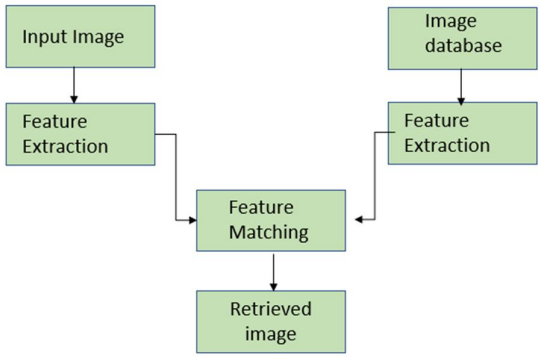

Figure 8: CBIR model

With accordance to above figure [Figure 8] it has been suggested to use feature representation problem Content-based Image Retrieval (CBIR) in their Deep learning for content-based image retrieval study. Here, a framework of deep learning with application to CBIR are examined in accordance with the convolutional neural networks method for CBIR tasks under different settings on a large scale. CBIR involves retrieving similar images based on content similarity from a very large database Ref.[11].

III. CONCLUSIONS

In this paper, we have proposed a Mobile application which will be using the camera to capture images of the eyes of the user and will use the captured image to detect the presence of cataract in the eye. Users can be either People suffering from cataract who need to check the severity and want to know the required precautionary measures to cure cataract or the people who just want to check their eyes to identify any presence of cataract. If the model detects any presence of cataract in the images captured, it will alert the user with their different levels of severity and the required precautionary measures which will help the patient in faster recovery. By using this application all users will be able to detect cataracts just by using a Smartphone with a good-quality camera remotely anytime anywhere. One of the advantages this application has is to permit the user to self-screen which can be performed anytime and at any remote location, it can also be used as a portable screening answer in regions with restricted or fewer medical facilities or skilled staff.

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