A Mobile Base Application for Cataract and Conjunctivitis Detection

Anupama Soysa
Information Technology
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
anupamasoysa@gmail.com

Dilshan De Silva
Computer Science and Software Engineering
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
dilshan.i@sliit.lk

Abstract — **With time the life patterns of humans have evolved at a rapid space. Today, it has come to a point where people are opting to put their health status behind other priorities in life. A contemporary example is the spreading of the COVID-19 virus. One of the other significant health issues faced by the present-day community is illnesses related to the eyes. However, unlike other health issues, most of the eye diseases can be cured with proper attention. Cataract and Conjunctivitis are identified as two of the main eye diseases faced by a mass amount of people around the world. If left untreated, these diseases can even lead to blindness. As a matter of fact, Cataract has been reported as the first cause of blindness by the world health organization. Typically, the detection of these diseases is done by an ophthalmologist with the use of a special medical equipment. Thus, the channeling of an ophthalmologist has become a mandatory requirement for the detection of these diseases. In addition, the availability of medical equipment and medical officers is deficient in rural areas. Thus, as a solution for the above-mentioned issues, it was decided to propose a mobile-based application, Eye Plus, for the detection of Cataract and Conjunctivitis diseases. Using Eye Plus, one would be able to test his/her eyes at a convenient time in any place for a zero cost. In addition, it provides additional information related to Cataract and Conjunctivitis diseases. Another special feature of the application is the ability to operate it without the help of another party. At present, the application achieved a success rate of 83.3% for a collection of 150 images.**

Keywords — Cataract, Conjunctivitis, Image Processing, CNN, Keras, TensorFlow

I. INTRODUCTION

Due to the rapid increment in technology, most modern society people suffer from eye illnesses. Nevertheless, patients are reluctant to wait in the queues in hospitals because of their busy schedules. To minimize eye illnesses, we introduce a mobile application where users can check their eye illnesses on their own at home. This application is mainly focusing on two illnesses, namely Conjunctivitis and Cataract which tries to identify those illnesses by using Image Processing and Deep Learning techniques. Currently, Sri Lanka can find a few localized web and mobile applications to detect eye illnesses. Most of the existing applications (such as Eye test, Eye Exercises-Eye Care Plus, and Macular Test) mainly focus on improving the user's medical and scientific skills. They mainly focus on detecting color blindness, eye exercises, Shortsightedness, and Nearsightedness. For Shortsightedness and Nearsightedness patients are required to read Jaeger charts placed in measured distance away from them. In smartphone solutions, the user cannot maintain that distance. Thus, it is hard to get an accurate result from a mobile application for such diseases.

II. OBJECTIVES

The main objective of the research is to introduce a mobile based application to detect Cataract and Conjunctivitis diseases of a person. Accordingly, the sub-objectives of the research as follows:

1. To allow a user to test for Cataract and Conjunctivitis illnesses:
   - At a convenient time for him/her.
   - From home or any preferred place without having to go to the eye-clinic or hospital.
   - Without having to pay additional charges such as channeling and doctor fees.
2. To provide additional information related to Cataract and Conjunctivitis diseases.
3. To provide a user with the ability to operate the application without the help of another party.

III. METHODOLOGY

Image processing and deep learning methods are used for the detection of eye illnesses. Deep learning is a branch of machine learning, and deep learning methods can generate results better than human experts. Convolutional Neural Networks and Deep Neural Networks are some of the main deep learning methods used in various fields like medical imaging and search engines [6]. Google's TensorFlow is one of the main libraries that can be used to build deep learning models. This system builds the TensorFlow model by using Keras library. Keras consists of an interface for use cases. Google's TensorFlow provides good performance using Keras high-level APIs and fast debugging. This process is used for classification, understanding, and prediction. The methodology that was used to obtain the desired output can be broken down into the three stages as follows:

A. Image preprocessing and segmentation.

This concept is used to remove the noise from images. The mobile application captures the user's eye images and uploads that image to the server. In order to detect and crop eyes, Haar-Cascade files were used. At first, the server-side needs to remove the noise of the image. A clear eye retina images need for data extraction [1]. Noise is a random variation of the image intensity and noise visible as part of the grains in the image. The image can be affected due to light or thermal energy of the heat. This heat can occur with image sensors. In this research, eye image capturing is done by a mobile camera.

Input can be an image or sequence of images, and output may be a set of parameters associated with the image. Contrast is one of the main features of image processing. It improves the clarity of objects by enhancing the brightness between the foregrounds and backgrounds. This process accommodates the corresponding brightness and darkness of objects, and it improves object visibility and clarity. The image processing technique's main function is to increase the image quality to make differences in the outcome of the image. Due to high image size fluctuation, all the images

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require to be downsized to a size of width 50 pixels and height 50 pixels. Fig.1 shows the condition of the image before and after pre-processing.

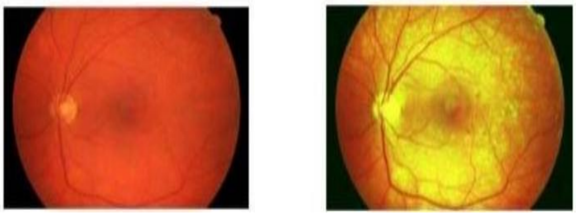

Fig. 1. Image before pre-processing and after pre-procesing

B. Feature Extraction and Classification.

A Convolutional neural network (CNN) is a sub-part of Neural networking, which can introduce as very useful in image recognition and the classification. This application uses a pre-trained models to detect Cataract and Conjunctivitis with Cataract, Conjunctivitis, and normal eye image sets. The trained models include class objects to read images as input [4].

The feature extraction process needs to be cross-checked by using another method called G-filter. The G-filter method is used to overcome the reflection and uneven illumination interference [5]. The model reads the image dataset as input, and subsequent layers of convolutional neural networks process that. The batch technique is used to train the neural networks that standardize the input images batch layer-wise. This process decreases the count of numbering training epochs required to train the network. 2D Convolutional layer implements a convolution kernel that involves with input layer and produces output tensors. Max-pooling process down-samples input image to minimize image dimensions. This process allows making predictions about the features which are contained in the sub-reigns. Pooled map and flattened obtained in the featured map. The matrix of the pooled feature map is transformed into a single column using flattening. Further, for processing, fed to the neural network. Dense layer use for adding a fully connected layer to the neural network. Fig. 2 shows CNN model architecture of the system.

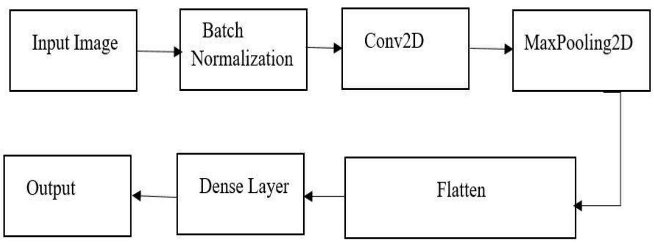

Fig. 2. CNN Model

The model is supposed to detect the class of the input image. The system creates a model or a binary classifier to make predictions. The testing image data set is not the same as the training model dataset. The training model may contain the unimportant features. This situation can make an over fitting issue. To avoid this issue, we need to keep a portion of the dataset separately from the training procedure. After the training phase is completed, the model can make predictions for new images. Fig. 3 describes flow diagram of the model.

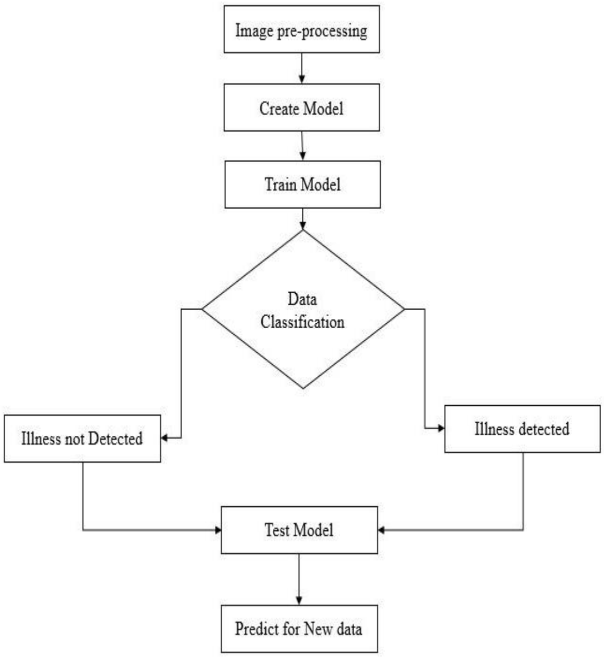

Fig. 3. Model Flow Diagram

C. Finalize output

For the output, finalization considers image extraction output, and the questionnaire answers output. The mobile application provides questionnaire interfaces to users. These questionnaires are based on the physical symptoms of Cataract and Conjunctivitis. Tearing, burliness, and light vision are some of the Cataract's physical symptoms. These symptoms cannot catch by images. An accurate final output always requires both image extracted data and physically gathered data. Eye burning, tearing, itching, and paining are some of the physical symptoms of Conjunctivitis. The eye specialists are involved in organizing support questionnaires. According to the server signal after the data classification analysis, the mobile application provides a user's questionnaire interface. The questionnaire interfaces contain questions about main symptoms like itching, tearing, and eye painting—each of these questions assigned a weight value. By analyzing the user's answers and according to the weights of the questions, finalize the output. The final output depends on these questionnaire output and image feature extraction output. After the image analyzing process completes, the server sends the output signal to the mobile application. The mobile application analyzes both results and finalizes the eye condition.

Additionally, the application provides eye specialist doctor details, some home remedies as well as eye specialist details base on the eye illness. Moreover, it displays relevant nearby hospitals. Fig. 4 shows the overall system diagram including application-side functions and server-side functions.

IV. RESULTS AND DISCUSSION

Measuring the light source option helps the client get a quality image with recommended light energy using a smartphone light sensor. If the mobile phone's light energy is lower than the recommended range (1000lu), it does not capture the image.

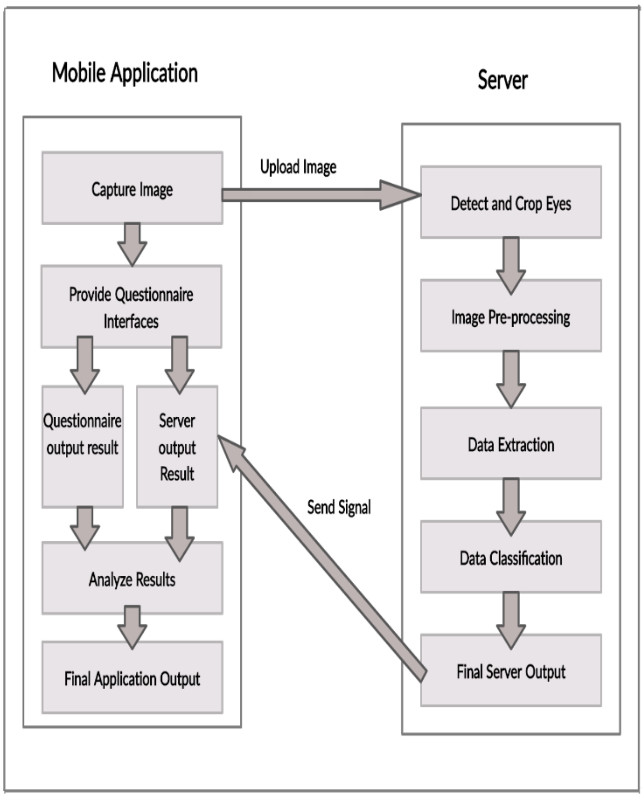

Fig. 4. Model Flow Diagram

Table 1. Unit testing results for data extraction and classification

Image	**Actual Situation**	**Conjunctivitis Positive or Negative**	**Cataract Positive or Negative**	**Correct Output**
	Normal Eye	Negative	Negative	Yes
	Detect Conjunctivitis	Conjunctivitis detected	Positive	Yes
	Detect Cataract	Cataract Detected	Positive	Yes

The distance calibration function guides the user to set the required distance between him/her and the application and thereby preserve the quality of the captured image. When the user zooms the camera, it changes the distance between two eyes. Once the distance requirement is satisfied, the user can capture the image. The system can identify Camera-Flash-Effect, Conjunctivitis, and Cataract with a higher accuracy. About 150 images were used to test the proposed application. Those samples consisted of regular images, Cataract affected images, and conjunctive affected images. Eye Plus achieved a success rate of 83.33% for those images. Table 1 depicts some sample images entered into the system and the corresponding outputs of those.

V. CONCLUSION

This paper presents the development of the eye illness detecting application, an ideal solution for eye illness patients. Researchers proposed an android and IOS mobile applications where it identifies the most prominent eye illnesses using image processing and machine learning techniques. The mobile application provides the users with various benefits over existing applications that are available in the market. Those who use this application can identify the eye illnesses within a short time with mobile device aid. The final output of the application, including home precautions that he/she can take to reduce the illness up to some extent, can finally consult a doctor to cure it completely.

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