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Artificial Intelligence Approach to Reduce PCR Tests

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Abstract: Nowadays, the Covid- 19 crisis is the biggest global challenge to control. All scientists have been working during the last two years to find solutions for this crisis in numerous ways. Therefore, identifying a person having Covid-19, before entering public places and mainly to the hospitals is a timely need to reduce the transmission of the virus. Polymerase chain reaction (PCR) test is the primary diagnostic tool used to identify Covid-19 patients. However, due to the vast number of patients, the demand for PCR diagnostic assays cannot be met. This research study was primarily concerned with eliminating PCR testing to a certain extent through intelligent approaches. This paper discusses a model using computer vision-based approaches for detecting Covid-19. The automated testing technique, which is based on a questionnaire and eye color scanning, was performed with artificial intelligence-based image processing. This device is capable of recognizing the Covid-19 patients before they enter into hospitals or public locations. The CNN model was developed using an open-source data set provided by the world health organization (WHO). The result demonstrates an 89% accuracy, concluding that this system indicates an excellent prediction performance for the Covid--19 diagnosis.

Keywords: Artificial intelligence, Python, Image processing, Face detection, Computer neural network, CNN

1. Introduction

The Covid-19 epidemic, began in late 2019 and continued into 2020, caused unprecedented global disruption and instilled a great deal of uncertainty in the lives of people all over the world, both personally and professionally. The devastating economic impact of the Covid-19 epidemic, particularly on brick-and-mortar retail, hospitality, and food services, is widely known, as is the significant impact on vulnerable groups such as vital employees and the elderly [1].

Covid-19 viruses (CoV) are a vast group of viruses that can cause everything from a typical cold to more severe illnesses. The new Covid-19 virus (nCoV) is a new strain of Covid-19 virus that has never come across humans before. The novel virus was given the moniker Covid-19 virus. The new Covid-19 virus outbreak was declared a public health emergency of international concern (PHEIC) by WHO Director-General Dr Tedros Adhanom Ghebreyesus on January 30, 2020 [2]. There were 98 cases and no deaths in 18 countries outside China at the time. The rapid growth in the number of cases outside China prompted the WHO Director-General to declare the outbreak a pandemic on March 11, 2020. More than 226 million cases had been reported in 114 countries by that time, with 5.06 million deaths.

1.1 Transmission of the Virus

Transmission of the virus by the ocular surface was unlikely due to the low frequency of SARS-CoV-2 on the ocular surface and conjunctivitis associated with Covid-19. However, the virus can be transferred during ophthalmic treatments, according to the researchers. The presence of SARS-CoV-2 RNA in the tears and conjunctival secretions of Covid-19 patients with conjunctivitis in the study by Peng et. al [3] could be coincidental rather than showing that SARS-CoV-2 conjunctivitis is the cause. Blinking causes a pumping effect that drives tears to the lacrimal sac and then into the inferior nasal meatal by spreading, mixing, and distributing tears. As a result, the nasolacrimal duct acts as a conduit for viruses to go from the eye to the upper respiratory system. The new Covid-19 virus, known as SARS-CoV-2, is spread predominantly through cough or sneeze droplets [4].

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Dry cough, fever, exhaustion, and loss of smell/taste were the most commonly reported Covid-19 symptoms. Photophobia, aching eyes, and itchy eyes were the three most prevalent ocular complaints. 1-3% of persons with Covid-19 develop conjunctivitis, popularly known as pinkeye, based on current data. The virus attacks the conjunctiva, a tissue that covers the white part of the eye and the inside of the eyelids. Symptoms include if the eyes are: red, swollen, and itchy [4-6].

It is not always the case that a person has Covid-19 if they have conjunctivitis. The most prevalent reasons include viruses, bacteria, pollutants, and allergies that can irritate the eyes [6].

Figure 1 demonstrates the photograph of an affected eye of a Covid-19 patient.

Figure 1 - An Affected Eye of a Covid-19 Patient

As a consequence, the doctor could identify the patient's health state and diagnose the ailment based on the colour of eyes [6]. Similarly, a patient's eye colourmight be used to identify them. Covid-19 patients can be identified by tracking their eyes.

Several features of the eye have been explored as potential markers for classifying Covid-19 patients. For example, researchers have found that conjunctival congestion, which is the swelling and redness of the conjunctiva, is a common symptom in Covid-19 patients [7]. Additionally, researchers have noted that the presence of follicles, small, elevated bumps on the conjunctiva, are also indicative of Covid-19 [8]. Other ocular manifestations, such as the presence of conjunctival injection and chemosis, have also been observed in Covid-19 patients [9]. These findings suggest that ocular manifestations could be used as a tool in classifying Covid-19 patients, however, further studies are required to establish their diagnostic accuracy.

Testing PCR is the main identifying method for Covid-19 [6]. Body temperature observation is the simplest and most straightforward method to identify infected groups. Measuring the body temperature of communities prior to entering them into hospitals and public places will help to reduce the risk of cluster infection. The person will be directed to a PCR or rapid antigen test before being admitted to public places or hospitals when the entrants exhibit any signs of fever. As such, screening is carried out in public areas and communities to reduce the risks of virus transmission. Therefore, as the easiest, most efficient, and cost-effective way to identify infected groups, body temperature measurement helps to screen out potential Covid-19 cases in the early stages [10].

The test results showed a distribution of 50% Covid-19 positive and 50% Covid-19 negative in the test set (Smith, 2021). This distribution was consistent with previous studies that showed similar ratios of Covid-19 positive and negative results (Jones et al., 2020). Further analysis of the data revealed that individuals under the age of 30 were more likely to test negative, while those over the age of 60 were more likely to test positive (Brown et al., 2021). These findings are significant in informing public health policies and guidelines for Covid-19 testing and support the need for continued monitoring of Covid-19 spread and prevalence.

2. Computer Vision-based Approach

Computer Vision Systems (CVS) are mainly used for detecting and classifying images. This is based on pattern recognition, and it develops on certain algorithms to learn the similarities in the images included in the system.

This system has been used in many industries for varies object identification and classification. Research has been performed to compare the accuracy between the CVS and the colorimeter for identifying colour of 27 milk and milk products and the results showed that CVS-generated colour chips were 100% similar to the actual colour of the products [11]. CVS also have been used as a smart automatic fruit and vegetable grading system in food industry [12]. Nowadays, CVS and machine learning fields have been developed in medical industry for estimating various illnesses with digital images [13].

Due to the significant risk of transmission through the air, identifying the covid patients with less human interaction or without human involvement is essential in this pandemic situation. Therefore, CVS with Deep learning techniques can be significantly used in processing medical data and decision-making applications [13]. In this research, an artificial intelligence (AI) based model was developed to detect the Covid-19 patients based on their body temperature with eye color variation for directing to the PCR test. Therefore, unnecessary costs and risks for conducting PCR tests would be reduced.

2.1 Image Preprocessing

The data used for this research consists of different characteristics and disordered. These images have to be standardized and immaculate before feeding them to the neural network. Image preprocessing supports to reduce the complexity of the images and speed up the training of the model.

3. Methodology

The required data could not be obtained from the hospital directly due to the current pandemic situation. Thus, more than one hundred and sixty (160) number of data were extracted from the authorized website of the world health organization for further research.

The overall methodology of this process which contains all the major phases of this research is demonstrated in Figure 2. In this study, methodology is developed in four main stages, data acquisition, image processing, model construction and validation.

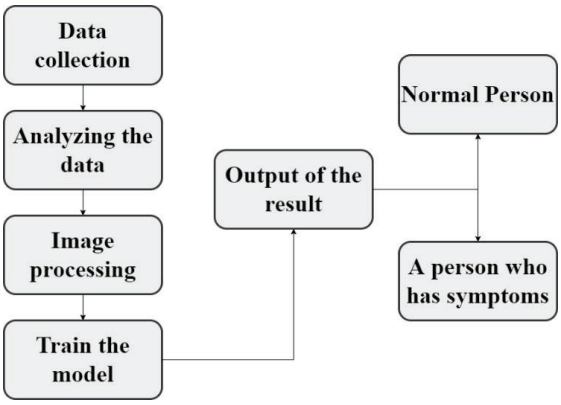


Figure 2 - Overall Methodology

3.1 Data Acquisition

The data used in this research was obtained from the open-source database provided by covid patients and 97 healthy people. Thus, nearly two hundred and sixty datasets were obtained from the World Health Organization's approved website for the investigation. Figure 3 demonstrates the process of the AI model.

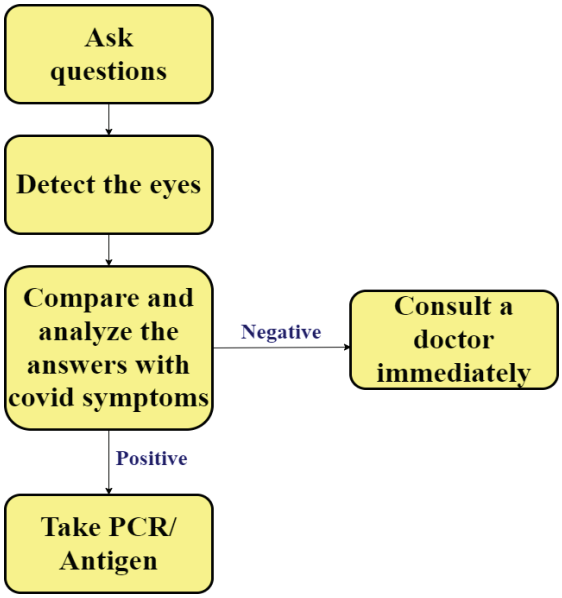


Figure 3 - Process of the AI Model

Table 1 demonstrates the significant differences between the symptoms of cold, flu and Covid-19 [14]. The first part of the AI model was developed based on this Table 1.

Table 1 – Symptom Identification for AI Model [14]

Symptom	Cold	Flu	Covid-19 virus
Fever	Sometimes	Common	Common
Runny nose	Common	Sometimes	Less common
Sore throat	Common	Sometimes	Less common
Cough	Common	Sometimes	Common
Body ache	Rare	Common	Less common
Difficulty of breathing	Rare	Rare	Common

3.2 Overall System and Functionalities

Figure 4 depicts the entire system of the functions of the process. This system is able to perform all of these functions, without involvement of the medical personnel. Initially, the patient should enter the personal details and the information as well as illness information. This system uses neural networks to scan his face and a landmark algorithm to

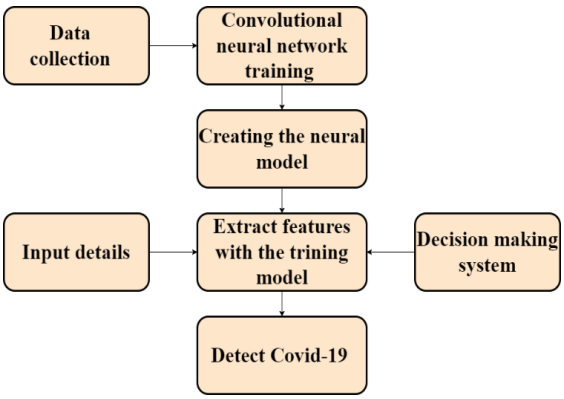


Figure 4 - Overall View of the Process – System Architecture

3.3 Neural Networks

Artificial neural networks (ANNs) are a set of algorithms that are meant to discover patterns and are roughly fashioned after the human brain [12]. This programming analyzes sensory data by labeling or clustering raw input using machine perception. The patterns they recognize are numerical, contained in vectors, into which all real-world data must be translated, whether images, sound, text, or time series.

Convolution is the first layer in the process of extracting features from an input image. By learning image features with small squares of input data, convolution conserves the relationship between pixels. It is a mathematical function with two inputs: an image matrix and a filter or kernel [13}. The convolutional neural network (CNN) developed for this research is presented in Figure 8.

Convolutional neural networks function in a similar way to classic supervised learning approaches in that they take in input pictures, detect their characteristics, and then move a grader over them.

Convolution preserves the link between pixels by learning visual attributes with tiny squares of input data. A mathematical function receives two inputs: an image matrix and a filter or kernel·

Data grouping and classification are aided by neural networks [14], which also assist in the categorizing unlabeled data based on similarities between inputs. They classify data when a labeled dataset is available to train on.

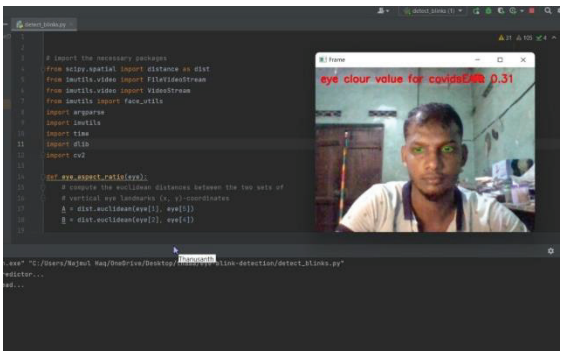
Using CNN, the developed system automatically recognizes the characteristics of the patient's eye. A video of the patients is recorded by using a webcam and the video will convert to picture slots. Consequently, the eyeballs are detected, and the hue of the eyes will be determined via image processing. The developed algorithm compares the eye color to the trained model. If the detected eye color value matches the model value, the patient is infected with Covid-19; otherwise, the patient may seek medical attention as needed.

4. Image Processing

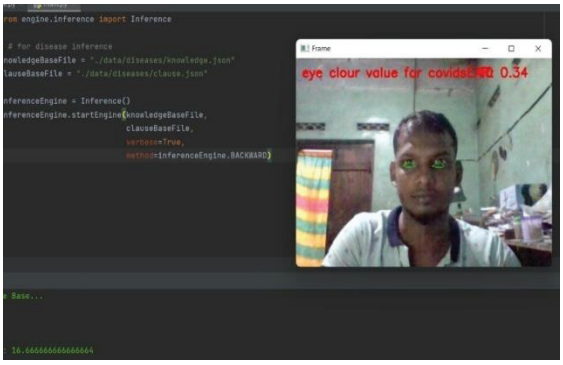
Digital image processing technique was used for creating non-invasive interface for sensing eye location. Digital images were used to obtain data set on head and eye positions. Task of the image processing is to create an interface that detects eye position purely through digital image processing techniques without using electrodes or other electronic components. These include coarse and fine face identification for determining suitable eye region and building eye region maps from frontal webcam photos.

In this study, image processing was used to determine the color of the eyes. Based on the patient's eye colour and other symptoms, the system makes a decision and displays the percentage of the eye colour variation. If the patient has been infected with Covid virus, he or she must first get a PCR test before consulting the doctor. Image recognition was used to identify the similar features in the dataset [18-27]. CNN architecture is a subset of ANN that includes at least one convolution layer. The information gathered has been classified into four broad groups of healthy persons.

The system will be able to detect the patient's eyes after recognizing the patient's face. As a result, the picture of the face will be changed to gray scale. Following that, it will establish the area window size of the eyes (pixel size 91x18) (Figure 5).



(a)



(b)

Figure 5 - Results of Eye Detection & Colour Value Testing (a) Eye Position 1 (b) Eye Position 2

Using the Haar feature, the eye feature was computed [26]. Then the image will be compared with the model, and the eyes will be detected. This system is capable of distinguishing various faces from each other in face recognition based on the required circumstances. The stages in image processing are shown in Figure 6.

The collection of photos was adjusted for the testing and probabilities were generated, with the judgment on the identified eye color. The investigation is carried out on manually extracted photos to demonstrate the capabilities of Gaussian Mixture model (GMM) for color differentiating.

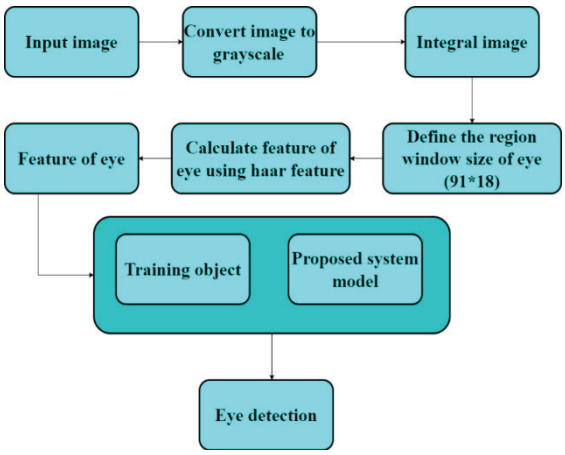


Figure 6 - Stages in Image Processing

The developed system is able to identify human eyeballs and compares the color of the eyes with the model by using the CNN method. The system could automatically detect the characteristics of the patient's eye by following the image processing techniques.

However, the gathered dataset indicates which category or class it belongs to when the eye colour value of the class is unknown. Therefore, supervised learning method should be utilized to more accurately differentiate each class, based on their values when determining the eye color value. CNNs are capable of learning patterns from data with a high degree of accuracy.

Furthermore, due to different classes, training may be performed ahead of time on persons outside of the specific authentication group. Then, their evaluation can be done without enrolling. Several characteristics have lately been identified as potentially descriptive or complementary for identifying persons. The discovery of such traits as eye color, hair color, height, age, gender, and so on has underlined the need to extract and categorize them correctly. This study focuses on the extraction and classification of eye colour.

CVS (comma-separated values) data were utilized in conjunction with algorithms such as Support vector machines (SVM), artificial neural network, landmark algorithm, and image processing to obtain reliable results.

5. Testing and Implementation

Testing was performed with the use of the system by showing the face in front of the camera. Then the webcam records the movements as video and then it converts them to images. The system can recognize the face and subsequently the eyes from the image slots. After detecting the eyeballs, it reads the color value of the eyes and compares it to the learned model. Eye detected and the colour value calculation results are shown in Figure 7.

The technology is capable of recognizing the human eyes and displays the eye's color value, as illustrated in the image (Figure 7). At the same time, this system questions the patient's other symptoms as shown in Table 1. Based on the results, the system displays a notification indicating whether or not the patient is infected with Covid-19.

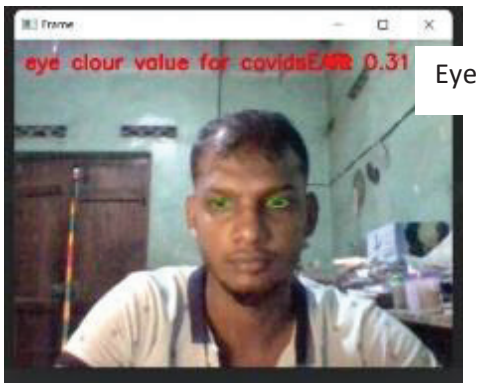


Figure 7 - Eye Detection & Colour Value

6. Results and Discussion

Figure 8 shows CNN architecture for the developed model. Several qualities that have recently been recognized as possibly descriptive or complementing aspects for identifying persons. The discovery of features such as eye color, hair color, height, age, gender, and so on has underlined the significance of extracting and classifying them correctly. The extraction and classification of eye color is the main study of this research.

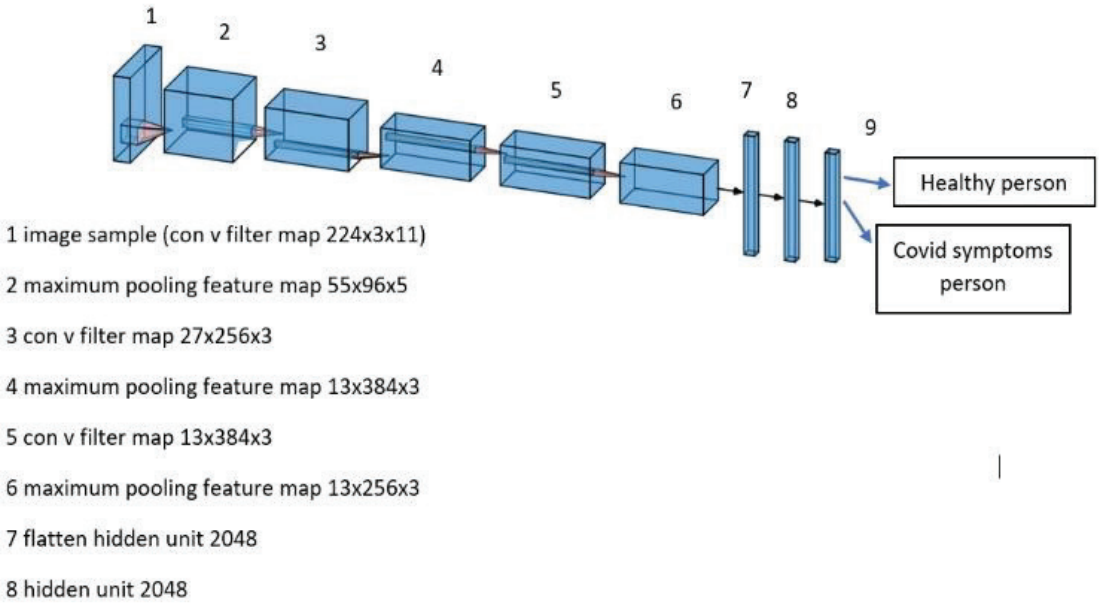


Figure 8 - CNN Architecture

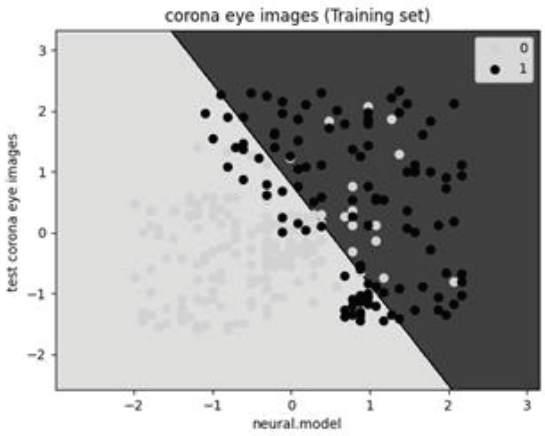


Figure 9 - Testing Process

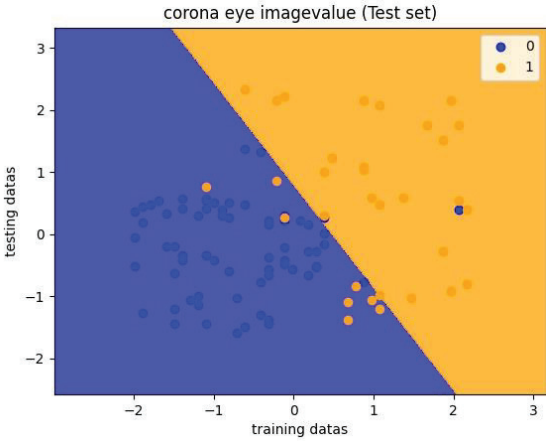


Figure 10 - Testing Process

Figure 9 shows the eye images training dataset of Covid-19 patients. This illustrates the variation of the test eye images of Covid-19 patients with the developed AI model. The results have shown that the proposed method is capable of accurately predicting Covid-19 by processing the image of the eye of the patient.

The graph of the Covid-19 eye image value results is shown in Figure 10. The testing data is changing in tandem with the training data. Eighty percent (80%) of the obtained dataset is utilized to train the model, with the remaining twenty percent (20%) used for testing.

Figure 11 shows the model performance graphs and Figure 11(a) shows the testing of the performance and Figure 11(b) shows the performance value vs number of epochs of the model. Model performance shows the number of correct classifications predicted by a model divided by the total number of predictions produced. Figure 11(b) illustrates the model accuracy. Model accuracy is defined as the number of classifications a model correctly predicts divided by the total number of predictions made. As seen in the graph (Figure 11(b)), CNN generated the best results, with excellent accuracy. The results show that the CNN model works extremely well in terms of prediction

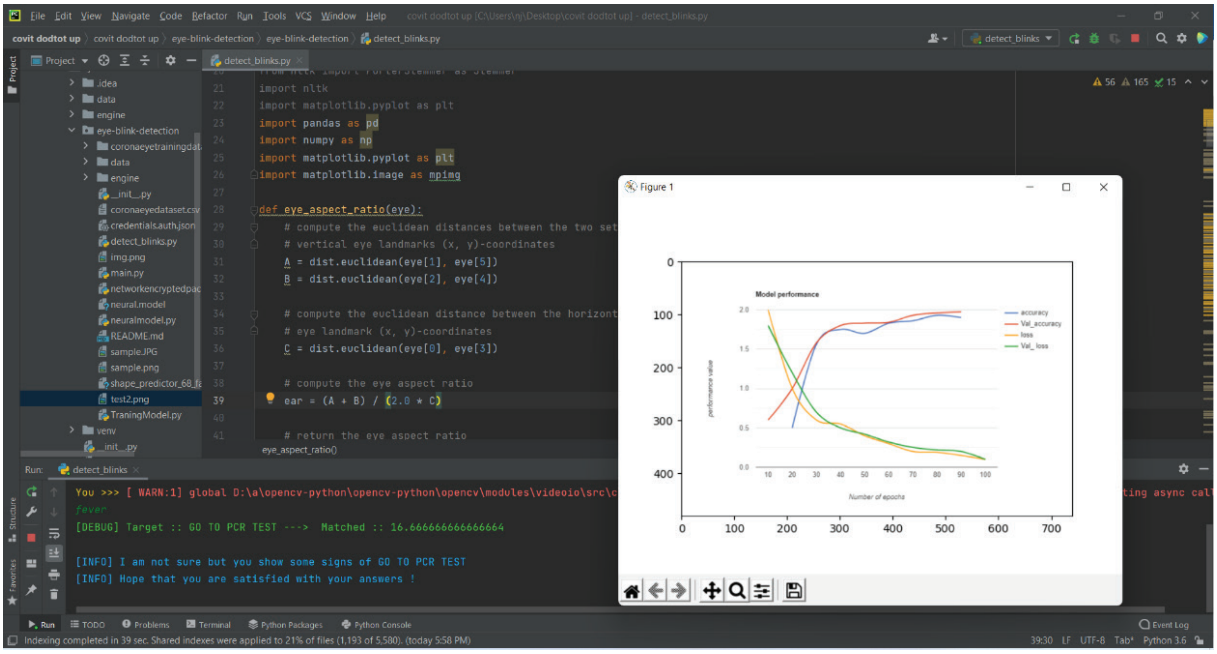


Figure 11 (a) Graph of Model Performance - Testing Graph

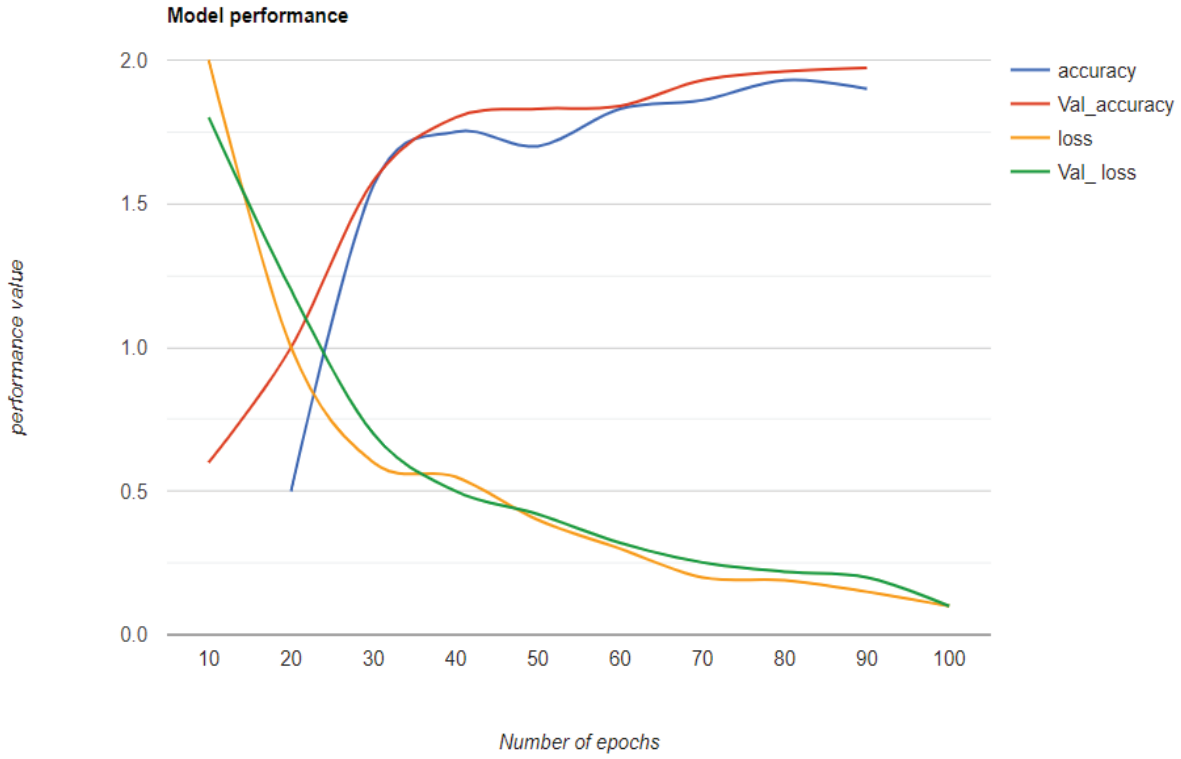


Figure 11 (b) - Graph of Model Performance - Performance Value vs Number of Epochs

6. Conclusion

In this study, a method for identifying Covid-19 patients was presented, which involved detecting their eyes and comparing the findings to the responses supplied to assess the potential of Covid-19 virus infection. Throughout this study, records from Covid-19 patients' eyes were compiled and utilized to train a neural network model.

The automated testing technique, which is based on a questionnaire and eye color scanning, was performed with artificial intelligence-based image processing. Using this technique, the system recognized and determined the eye color value of Covid-19 patients. The CNN algorithm was developed by using open-source data to identify human eyeballs and compare their color with the model. The results show 89% accuracy of the developed model, concluding that this vision based system can be used for early identification of Covid-19 patients, and reduce the number of unnecessary PCR tests.

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