A NOVEL END-TO-END MACHINE LEARNING APPROACH FOR COVID-19 DETECTION BASED ON ECG IMAGES

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Introduction

With the emergence of new strains of Covid-19 with high prevalence rates that are resistant to the available vaccines, there is an urgent need to find rapid diagnostic methods to break the cycle of virus spread. Various diagnostic methods have been used, including the WHO recommended laboratory procedure "reverse transcription polymerase chain reaction RT-PCR" [1]. However, due to the slow pace of this method and the limited availability of the equipment needed to perform the test in some countries, medical radiographic imaging methods such as X-rays and computed tomography have been used [2][3], these methods "if they are available", are expensive for patients and expose them to radiation.

Recent medical research has shown that Covid-19 uses the ACE2 protein as a functional receptor to enter cells, and because heart muscle expresses this protein on the surface of its cells, the virus can use this protein as a pathway to directly invade and destroy heart muscle cells. This effect of the virus stimulates damage to the heart, which can be detected on an ECG [4]. In our article, we propose a machine learning system that can diagnose Covid infection using fast, cheap, and safe ECGs.

ECG image dataset preprocessing

In our article, we use the only dataset that contains ECG images of COVID-19 patients [5]. The data set consists of 1937 images distributed into five different categories. To train our model, we use only two categories: Covid-19 patients with 250 images, and Normal ECG with 859 images.

In the pre-processing stage, we subject each image from the formed sub data set to three processing operations before passing it to the model as follows:

- Cutting the area of interest from the image to remove explanatory phrases and words.
- Automatically thresholding the image using Otsu's method to remove the background.
- Resizing the image.

Proposed model

To distinguish normal ECG images from those showing COVID-19, we used a pre-trained deep residual network (ResNet-50) in which we fixed the model weights trained on ImageNet, and replaced the final fully connected neural network with one of the most popular classifiers in the field of machine learning (Support vector machine). The processed images are transferred to the ResNet network, whose task is to perform the process of extracting features from each image without any training, and then pass these features to the classifier, which will be trained to perform the classification process. The parameters of the classifier were experimentally adjusted to obtain the best performance, and accordingly, the regularization coefficient value was chosen to be 15 and the nonlinear kernel to be radial basis function (RBF). Between the feature extractor and the final classifier we reduced the high dimension space using PCA. Fig. 1. shows the proposed model.
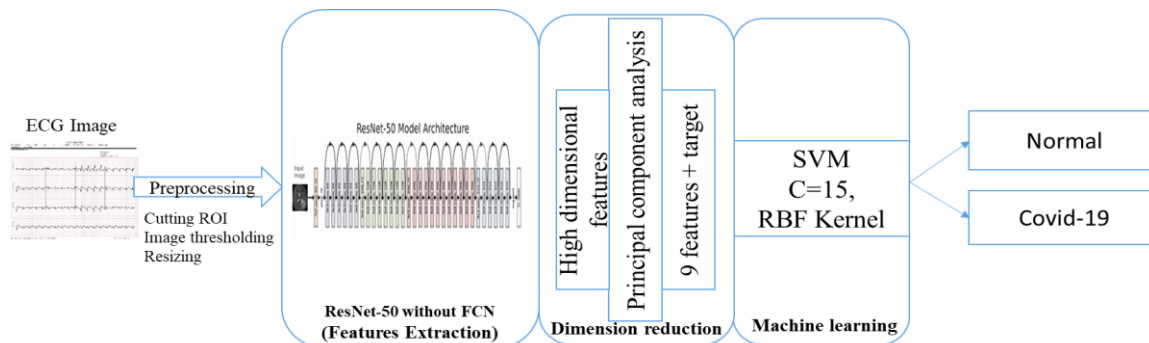

Fig. 1. Proposed model

Performance evaluation

We tested our previous model using the 10-fold cross-validation method after shuffling the data, which ensures that the result is not biased towards a specific part of the data. The confusion matrix in Fig. 2. shows that we have achieved a high accuracy of 99.5%.
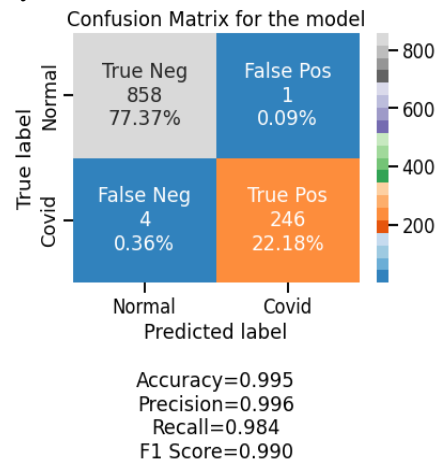

Fig. 2. Confusion matrix for the proposed model

Conclusion

In our paper, we proposed an intelligent model for diagnosing Covid-19 infection using processed ECG images with an accuracy of 99.5%. Despite obtaining unprecedented results, the main objective of the paper is that we have demonstrated the possibility of using ECG images to diagnose Covid-19 infection quickly, safely, easily, and at a low cost.

References
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