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Predicting COVID-19 Patients Using Deep Machine Learning

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Abstract – Coronaviruses are a family of viruses that can cause respiratory illness in humans and are diagnosed with laboratory tests, such as RT-PCR and Antigen tests which have limitations. To overcome these limitations, in this study, a model based on deep CNN was designed the identification whether an X-ray image has COVID-19 or does not. We extracted the deep learning feature and analyzed the performance of the CNN model. The Inceptionv3 reached an accuracy and Specificity of 90% in all performance measures. Further studies on a larger scale can confirm the accuracy of these results and use this method to diagnose Covid 19 patients using artificial intelligence in X-ray analysis of patients. Also, we aimed to identify which symptoms, at the time of notification, were associated with a positive RT-PCR result for SARS-CoV-2. The results of our studies didn't show a significant correlation between these prognostic symptoms.

Keywords – Predicting, COVID-19, Patients, Deep Learning, Machine Learning

I. Introduction

Coronaviruses are a family of viruses that can cause respiratory illness in humans. They are called "corona" because of the crown-like spikes on the surface of the virus [1]. The new strain of coronavirus (SARS-CoV-2) was first reported in Wuhan, China in December 2019 [2]. It has since spread to every country around the world. COVID-19 symptoms vary from person to person. Some infected people don't develop any symptoms (asymptomatic) [3]. The Covid-19 disease has a wide range of symptoms similar to the common cold and flu, the most important of which are: Tiredness, Diarrhea, Cough, Fever, loss of taste or smell, runny nose, Sore throat, Shortness of breath or difficulty breathing, body aches and, Headaches [4]. COVID-19 is diagnosed with laboratory tests, such as RT-PCR and Antigen tests [5]. RT-PCR tests always have their limitations, and to overcome these limitations and create new measures to control the prevalence of Covid disease, several machine learning methods using lung scans such as chest X-ray (CXR) images, have been proposed [6]. Deep learning is a subset of machine learning in artificial intelligence (AI) that has networks capable of learning unsupervised from data that is unstructured or unlabeled [7]. One of the most popular algorithms for deep learning, is a CNN (convolutional neural network), a type of machine learning in which a model learns to perform classification tasks directly from the text, image, etc. [8]. In this study, a model based on deep CNN was designed the identification the whether an X-ray image has COVID-19 or does not. Also, this study aims to better understand the clinical presentation of COVID-19 cases at the time of notification in Iran. We aimed to identify which symptoms, at the time of notification, were associated with a positive RT-PCR result for SARS-CoV-2.

II. Material and methods

2.1 Statistical population

In this study, we used a dataset that contains 35 patients with valid positive SARS-CoV-2 PCR test results. All of these patients underwent X-ray imaging and 35 Normal X-ray images were prepared for negative control (Fig.1). The dataset was examined in the proposed model. We use this dataset for deep feature extraction based on deep learning architectures such as VGG16 and

InceptionV3. We used InceptionV3 as a transfer learning approach for the identification of COVID-19. Finally, we trained, validated and evaluated the performance of the proposed model. The symptoms of all patients who had an X-ray image and their disease was confirmed by the Rt-PCR test were asked one week before and, after the positive test. The key characteristics of the study population for those reporting symptoms are summarized in Table 1.

Figure .1. (A): Normal X-ray images, (B): X-ray imaging Belonging to Covid-19 patients**.**

Table.1. The key characteristics of PCR-positive cases in study population.

Variable	**Value (n** = 35**)**
Gender	
Male	**19** (**54**%)
Female	**16** (**46**%)
Smoking history	
Never-smoker	**18** (**52**%)
Current smoker	**17** (**48**%)
History of Covid-19	
Previously infected	**16** (**46**%)
Never infected	**5** (**14**%)
Unknown history	**14** (**40**%)
Age	
1-15 years old	**3** (**8**%)
16-35 years old	**18** (**52**%)
36-60 years old	**10** (**29**%)
61-85 years old	**4** (**11**%)

2.2 Creating the CNN model

To evaluate the performance of the model on X-Ray images, four metrics including the accuracy, sensitivity, specificity, and Positive Prediction Value (PPV) were calculated as follows: Accuracy = true predictions/total number of cases, Sensitivity (Recall) = true positive/positive, Specificity = true negative/negative, Positive Prediction Value (PPV) (Precision) = True Positive/(True Positive + False Positive. In this developed model: The True Positive (TP) is the number of correctly predicted COVID-19 pneumonia cases/images, The False Positive (FP) is the number of mistakenly predicted COVID-19 pneumonia cases/images, The Positive is the number of cases/images of COVID-19 pneumonia patients, The True Negative (TN) is the number of correctly predicted non-COVID-19 pneumonia cases/images, The False Negative (TN) is the number of mistakenly predicted non-COVID-19 pneumonia cases/images and The Negative is the number of non-COVID-19 pneumonia cases/images enrolled.

2.3 Training and testing of the model

For image-based metrics, 35 images containing infection lesions identified by radiologists among patients with COVID-19 pneumonia were used as the positive sample, and 35 X-rays images from patients with non-COVID-19 pneumonia were used as the negative sample. After creating the model based on the algorithm of IncepyionV3, we trained the model for 35 X-rays images in normal and COVID-19 pneumonia patients [9].

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN}$$

$$\text{PPV}(Precision) = \frac{TP}{TP + FP}$$

$$\text{Sensitivity (Recall)} = \frac{TP}{TP + FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

2.4 Real-time quantitative PCR

For all samples, RNA was extracted by Roje RNA extraction kit (Cat, No RN983010). Then, Real-time PCR was performed in a 20-µl reaction containing: 5µ RNA, 9µ enzyme mix, 1µ primer-probe and 5µ water was prepared for each sample. all of samples were checked with positive and negative controls in each real time-PCR running by StepOnePlus™ Real-Time PCR Systems (ABI Applied Bio-systems, Thermo Fisher Scientific, USA). RT-PCR amplifications were done as follows: Reverse Transcription was set to an initial 50°C for 20 min, 95°C for 3 min for initial denaturation and then for a total of 45 cycles, 94°C for 10 seconds and 55°C for 40 seconds (step and hold).

2.5 Statistical Analysis

We used univariate logistic regression to model the risk of testing positive for SARS-CoV-2 as a function of symptoms reported in the week before testing. All statistical analysis was performed using the GraphPad Prism v8 (GraphPad Software Inc., USA). For all tests, a P-value <0.05 was considered statistically significant.

III. Results

3.1 X-rays images analysis by Artificial Intelligence

In this study, we examined the performance of the CNN model based on the algorithm of IncepyionV3, in 35 COVID-19 pneumonia patients by X-rays images. The results are reported in Table 2.

Table.2. analysis of different performance measure of our model using deep learning.

CNN Model	Accuracy	Sensitivity	Specificity	PPV
Inceptionv3	90 %	95 %	90 %	85 %

3.2 Correlation studies between symptoms and clinical features

The symptoms reported in PCR-positive patients are summarized in Table 3. According to the table.2 information, the most reported symptom among PCR-positive cases was headache, shortness of breath, and Cough. The results of the studies didn't show any significant differences between the reported symptoms with any clinical features of patients (P>0.05).

Table.3. symptoms reported in PCR-positive patients.

Variable	Male	Female	Total
Gender	19	16	35
Fever	8	7	15
Sore throat	6	6	12
Cough	9	6	15
shortness of breath	**10**	**7**	**17**
loss of taste or smell	4	3	7
headache	11	9	20

IV. Discussion

In this study, we examined the performance of the model for detecting whether an image has COVID-19 or is Healthy. Our model was measured in terms of accuracy, sensitivity, specificity, and Positive Prediction Value. We extracted the deep learning feature and analyzed the performance of the CNN model. The Inceptionv3 reached an accuracy and Specificity of 90% in all performance measures. Further studies on a larger scale can confirm the accuracy of these results and use this method to diagnose Covid 19 patients using artificial intelligence in X-ray analysis of patients. The proposed model for detecting COVID-19 achieved 100% accuracy. on the other hand, in this study, we also targeted the symptoms of patients with Covid-19 after confirmatory tests to obtain prognostic symptoms. The results of our studies did not show a significant correlation between these prognostic symptoms because the number of patients studied and the study population was limited. On the other hand, the number of patients who had both a PCR test and access to their X-ray results and images was a bit difficult. Therefore, by considering the larger statistical population, more accurate results can be obtained regarding the predictive symptoms of Covid-19 disease.

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