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COVD-19 Detection Platform from X-ray Images using Deep Learning

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Abstract

Since the early days of 2020, COVID-19 has tragic effects on the lives of human beings all over the world. To combat this disease, it is important to survey the infected patients in an inexpensive and fast way. One of the most common ways of achieving this is by performing radiological testing using chest X-Rays and patient coughing sounds. In this work, we propose a Convolutional Neural Network-based solution which is able to identify the positive COVID-19 patients using chest X-Ray images. Multiple CNN models have been adopted in our work. Each of these models provides a decision whether the patient is affected with COVID-19 or not. Then, a weighted average selection technique is used to provide the final decision. To test the efficiency of our model we have used publicly available chest X-ray images of COVID positive and negative cases. Our approach provided a classification performance of 88.5%.

Keywords: *COVID-19, CT-Images, Deep Learning, CNN Algorithm.*

1. Introduction

In recent years, the globe has seen tremendous technological advancements. Education, business, marketing, military, communications, engineering, and health care are all reliant on innovative technological applications nowadays. From identifying symptoms to precise diagnosis and computerized patient triage, the health care center is a critical area that urgently requires the use of new technology. Coronavirus-2 (SARSCoV-2) causes severe respiratory infections and problems in people, leading to the new coronavirus disease in 2019 (COVID-19). SARS-CoV-2 expanded globally, infecting millions of people, prompting the (WHO) to declare the epidemic a global pandemic, citing the fact that the number of infected individuals continues to rise on a daily basis (Mahmood, et al., 2020).

Total (global) coronavirus cases were estimated to be about 73,806,583 as of December 16, 2020, with 1,641,635 deaths recorded (Pasupuleti, Tsai, Ponnusamy, & Pugazhendhi, 2021). The new coronavirus was discovered in Wuhan, China, in December 2019, and (W.H.O.) announced it on December 31, 2019. On February 11th, 2020, the World Health Organization designated the virus as COVID-19,

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indicating that it posed a worldwide threat (Wu 2020). There is no exact medication that contracts straight with COVID-19 (Mahmood, et al., 2020). Artificial intelligence and deep learning algorithms have demonstrated the ability to accurately diagnose COVID-19, which can be considered a helpful factor. (Pasupuleti, Tsai, Ponnusamy, & Pugazhendhi, 2021).

Using an artificial intelligence/machine learning-based method to evaluate COVID-19 literature, it is possible to determine if the study generated meets the goal of the existing knowledge gaps or not (Doanvo, et al., 2020). As a result, the primary benefit of these AI-based platforms is the speed with which they diagnose and treat COVID-19 illness (Naseem, Akhund, Arshad, & Ibrahim, 2020), demonstrating a tremendous potential to dramatically increase and improve health care research (Jamshidi, et al., 2020). The rapid spread of the pandemic has created massive health-care problems, necessitating immediate responses to limit the effects. Artificial Intelligence (AI) has a lot of potential in dealing with the problem from a variety of perspectives (Tayarani-N, 2020). COVID-19 is a global epidemic that has posed a threat to human lives. Machine learning ML training methods and statistical models that are utilized by computers to execute different tasks without explicit instructions were discovered through systematic studies (Bishop, 2006). Because of their accuracy, machine learning techniques are now used for predictions all over the world. Machine learning (ML) methods, on the other hand, face a number of difficulties, such as the online availability of a new, inadequate database. One of the difficulties in training a model or choosing the optimal Machine learning model for prediction, for example, is deciding on the right parameters. Using the best Machine learning model that fits the dataset, researchers were able to make predictions based on the given data (Shinde, et al., 2020). Hidden patterns and data analytics can be discovered using machine learning techniques (Khan, et al., 2020). Machine-learning algorithms are intended to find complex patterns and interfaces in data, particularly in the setting of unknown and intricate risk factor correlation patterns (Hossain, et al., 2019) (T. Kanan et al., 2019&2020).

A pandemic is an infection or a large-scale epidemic of any infectious illness that may quickly raise mortality and morbidity rates on a big scale and over a broad region. Even crossing international borders, which may create enormous social, economic, and political disruption for a huge portion of the world's population. According to previous research, the likelihood of pandemics has increased throughout the centuries (Andreadakis, et al., 2020). When a new virus is discovered to be capable of circulating or spreading quickly worldwide, a pandemic outbreak may occur, with an epidemic occurring in a particular area or city. In one or more instances, a severe disease is present that may swiftly spread from one person to another. The mortality rate of an epidemic is usually lower than that of a pandemic outbreak, according to evidence. The Spanish flu, for example, was a devastating epidemic that killed over a hundred million people (Mo, et al., 2020). The genetic sequence of SARS-CoV-2 revealed an 80% similarity to SARS-CoV-1 and a 50% similarity to the Middle East Respiratory Syndrome (MARS-CoV), both of which are bat-borne. Coronavirus is sufficiently related to SARS-CoV, according to phylogenetic studies and genomic sequencing. (GÜNER, Hasanoğlu, & Aktaş, 2020). High and persistent fever, persistent dry cough, and respiratory

syndromes such as breathing problems and breath shortness are also typical symptoms of Coronavirus infection (Filatov, Sharma, Hindi, & Espinosa, 2020). The Coronavirus infection spread like wildfire and evolved into a worldwide pandemic in which no therapeutic vaccine or medication has been discovered, as of yet. Because of the seriousness of this problem.

Because of the growth and enhancement of many digital technologies, they may be used and utilized to handle various illnesses and significant clinical issues. These are sophisticated technologies that are being utilized in many areas of healthcare (Kushwaha, et al., 2020). How might AI expertise improve the diagnosis of this Coronavirus? By using a unique set of radiographic pictures. CT and X-ray scans may both be used to diagnose pneumonia. There have been created AI-based automated CT or X-ray image processing methods for identifying, monitoring, and measuring Coronavirus (Kassania, Kassanib, Wesolowskic, Schneidera, & Detersa, 2021).

Because of its serial interval (5 to 7.5) and reproduction rate (2 to 3), CoV has emerged as the deadliest infection for respiratory disorders (Nishiura, Linton, & Akhmetzhanov, 2020). The CoV is a member of the single-stranded RNA virus (+ssRNA) family, which is usually found in animals (Perlman & Netland, 2009). According to current research, the viruses have no species barrier and may cause serious illnesses such as MERS and SARS. (Chen, Liu, & Guo, 2020).

COVID-19 testing is now challenging due to widespread unavailability of the diagnostic system, which is creating concern. We must rely on alternate finding measures due to the limited availability of COVID-19 testing devices. We may use Xray to check the strength of our lungs since COVID-19 destroys the epithelial cells that lining our respiratory system. X-ray pictures are often used by doctors to identify various lung disorders.

Many types of study based on clinical aspects have been conducted in the present condition of COVID-19's fast proliferation (Yang, et al., 2020). Deep Learning is a collection of machine learning techniques aimed at automatically extracting and classifying features from pictures. The two primary tasks where deep learning is used are object detection and categorization. Machine learning advancements have a significant impact on clinical decision-making and the creation of computer-assisted solutions (Greenspan, Van Ginneken, & Summers). Because the available data set is in the hundreds, which is quite tiny for a transfer learning technique, it raises concerns about the classification model's robustness.

The Xray pictures of COVID19, pneumonia patients, and healthy persons are classified using a classification model. The objective of study is to distinguish between healthy persons and pneumonia patients. Because they arrived from another country or previously lived in a COVID-19-affected region, the healthy persons are in question. Again, the symptoms of pneumonia and COVID-19 are similar to various extents, and both are lung disorders. As a result, it must additionally check COVOD-19 for the pneumonia patient. As a result, we created a dataset including Xray pictures of COVID-19 patients, pneumonia patients, and healthy persons for this investigation. There are 127 verified COVID-19 photos, Dr. Joseph Cohen, posted the COVID-19 X-ray photos on his GitHub account (Cohen, Morrison, & Dao, 2020).

In this thesis, the classification will be based on a deep learning algorithm through which the classification will be made based on the coughing sound, as well as the CT scans of the patient in the diagnosis. So that there will be some audio clips of coughing sounds for patients infected with Corona virus and also a lot of CT images of patients so that this will be the training data for the algorithm, the car algorithm was chosen because it is high accuracy in the binary classifications that consist of only two classifications and the classifications here are infected or not injured.

2. Literature

In this section, we have chosen papers for evaluation of literature that have evaluated ML and DL deployed in medical imaging to address a clinical issue and compared each method in terms of output and performance.

The COVID-19 virus, which is a contagious disease caused by the SARS-COV-2 virus. (Hashem, et al., 2020). Despite this, due to the difficulty in discriminating between positive and negative COVID19 persons based on the many symptoms of COVID-19, all of these efforts are restricted in their effectiveness. (Brinati, et al., 2020). Among the most beneficial and vital modalities used for diagnostic COVID-19 stage and risks on the patient's lungs, chest CT scan is one of the most often utilized and most effective (Day 2020). Early detection of COVID-19 is critical for reducing the risk of human-to-human transmission and improving patient treatment (AlZubi, 2021). Recently, it has been discovered that the isolation and quarantine of healthy individuals from those who are afflicted or who are suspected of having the virus is the most effective strategy for preventing the spread of COVID-19 (Deng, Shao, Shi, Wang, & Xie, 2020). Using machine-learning techniques, researchers were able to gain a better understanding of the COVID-19 diagnosis, and the differences between COVID19 pneumonia and other viral pneumonia using CT scan of the lungs (Kassania, Kassanib, Wesolowskic, Schneidera, & Detersa, 2021).

Approaches like the Support Vector Computer, logistic regression, clustering, and so on are all examples of artificial intelligence (AI) techniques that concentrate on how a machine can learn from prior data (Gupta, Gupta, Jaiswal, & Ansari, 2018), (Sharma, Gupta, & Jaiswal, 2016) composed of multiple processing layers for learning data representation and extracting features at multiple abstraction levels. This model is composed of multiple processing layers for learning data representation (Nagendran, et al., 2020) (S. AlZu'bi, et al., 2018).

In (Apostolopoulos & Mpesiana, 2020) which the author proposes a deep learning-based approach referred to as deep transfer learning, which may identify patients with Coronavirus sickness on an automated basis. A dataset of 50 patients with Coronavirus who had X-ray pictures collected from a common GitHub repository was used, while a dataset of 50 healthy persons who had X-ray photos acquired from a Kaggle repository was used. The findings of this investigation revealed that the pre-trained model, ResNet50, outperformed the other three models in terms of accuracy by a factor of 98 percent. Additionally, in individuals with Coronavirus infection, early detection of the infection may help to prevent the illness from progressing rapidly. (Alhoori et al., 2015)

(Xu, et al., 2020) developed a deep learning paradigm for detecting Coronavirus patients at an early stage in their illness. The primary goal of this article is to utilize computed tomography images to identify Coronavirus viral pneumonia from Influenza-A viral pneumonia and normal patients. CT samples were collected from three hospitals in Zhejiang Province, China, that had been certified as Coronavirus treatment centers. The results of this study's studies revealed an overall accuracy of 86.7 percent when viewed from the perspective of all CT instances combined.

The authors of another research developed an automated technique for detecting Coronavirus illnesses by combining Deep Learning Convolutional Neural Networks with chest X-ray pictures. Using X-ray pictures, the authors have developed three distinct CNN-based models for the detection of Coronavirus cases in this study. Data from 50 Coronavirus patients was obtained from an open-source GitHub repository (Dr. Joseph Cohen), and 50 photos of normal chest X-rays were collected from an online resource in the Kaggle competition (Chest X-Ray images). (Korkut, Kiliç, & Hazer, 2019).

According to recent research, an auxiliary tool is being developed to improve the accuracy of Covid-19 diagnosis, using a novel model of Automatic COVID-19 detection that is based on a deep learning algorithm (Deebak & Al-Turjman, 2021). With outstanding performance accuracy, binary class accuracy of 98.08 percent, and multi-class accuracy of 87.02 percent, we have achieved a wonderful result. (Sun, et al., 2020)

Researchers discovered eleven key relevant indices in clinical blood samples from Wuhan, which can be used as a judgement tool for doctors to help diagnosis patients (Wu, et al., 2020). The results of the research reveal that the Random Forest method may be used to extract 11 important indices with an overall accuracy of 95.95 percent and specificity of 96.97 percent, respectively.

The use of CT scans to evaluate the condition of a patient's lungs has become necessary since COVID-19 affects the epithelial cells that line our respiratory system (Li, et al., 2020). In light of the fact that practically all hospitals are equipped with CT scan or X-ray imaging equipment, it may be feasible to test for COVID-19 using CT scan or X-ray pictures. CT scan and X-ray image processing are time-consuming and need the expertise of a radiology professional (Kooraki, Hosseiny, Myers, & Gholamrezanezhad, 2020), which is inconvenient when patients need to be tested for COVID-19. As a result, the creation of an automated analysis system is required in order to save significant time while serving a greater number of patients. The goal of this project is to develop point-of-care screening models for the diagnosis of COVID-19 utilizing deep neural network methods.

A technique to categorize large-scale screening of patients infected with COVID-19 differently was proposed by Wang Yunlu et al. in (Wang, M, Zhang, Zhai, & Yao, 2020). This work may be utilized to distinguish diverse breathing patterns, and we can put this technology into practical usage in the real world. For the purpose of identifying six clinically significant breathing patterns, the researchers initially deployed bidirectional neural networks, such as the GRU network attentional tool (BI at GRU). The study findings demonstrate that the suggested model can identify six discrete respiratory patterns with precision, accuracy, recall, and recall rates of 94.5 percent, 94.4 percent, 95.1 percent, and 94.8 percent,

respectively, precision, accuracy, recall, and recall rates of 94.8 percent. When compared to current state-of-the-art models, the newly obtained BI at GRU model tailored to the categorization of respiratory patterns surpasses them.

An experimental technique for tracking the health condition of persons wearing masks was suggested by Jiang Zheng and colleagues in (Jiang, et al., 2020) and examined aspects of the respiratory system. This gadget is primarily composed of a thermal imaging camera using FLIR (Forward-looking infrared) technology and an Android smartphone. Pre-screening at institutions and healthcare facilities. In this study, the researchers used a mix of thermal and RGB films from DL architecture-based cameras to conduct health screenings on subjects. They achieved 83.7 percent accuracy in classifying the respiratory health conditions of a diseased patient.

We hypothesize that COVID-19 signatures can be detected by analyzing the movements of the vocal folds, as proposed by (Al Ismail, Deshmukh, & Singh, 2021). Because most symptomatic COVID-19 patients have mild to severe impairment of respiratory functions, we hypothesize that COVID-19 signatures can be detected by analyzing the movements of the vocal folds. Only the recordings of patients who were reported within seven days of being medically evaluated were chosen from this group. Only 19 citizens were able to meet this condition. There were 10 girls and nine men among them. Five women and four men were positive for COVID-19, while the others tested negative. The effectiveness of logistic regression on extended vowels and their combinations is 91.20 percent.

3. Methodology

Figure 1 shows the of the proposed method of CT-images which reviews the model mechanisms. The input to the classifier is a set of images of two classes, COVID-19, and normal cases, Image Segmentation, Deep Feature Extraction, CNN Classifier and Diagnostic Result.

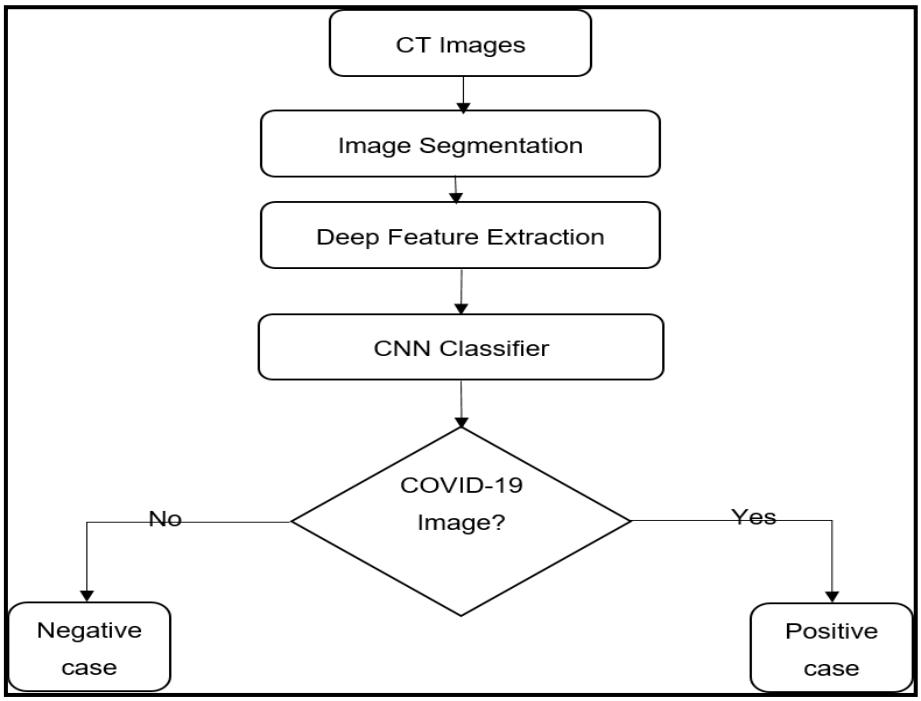

Figure1. Proposed methodology.

3.1 CT Images

To aid the worldwide battle against COVID-19, one major strategy is to create a record of CT scans and accompanying medical symptoms. As noted in the Related Work section, many datasets for COVID-19-related research have been created and are available to researchers, clinicians, and data scientists. The restricted patient demographic variety is a possible drawback of employing COVIDx-CT for CNN. CNN would become more diversified and comprehensive as the quantity and diversity of patients increased, making them more generalizable and relevant in a variety of clinical settings throughout the globe. To identify COVID-19, we employ CT slides as input images, making the COVID-19 detection issue an image classification problem. The CT pictures are 512x512 pixels in size.

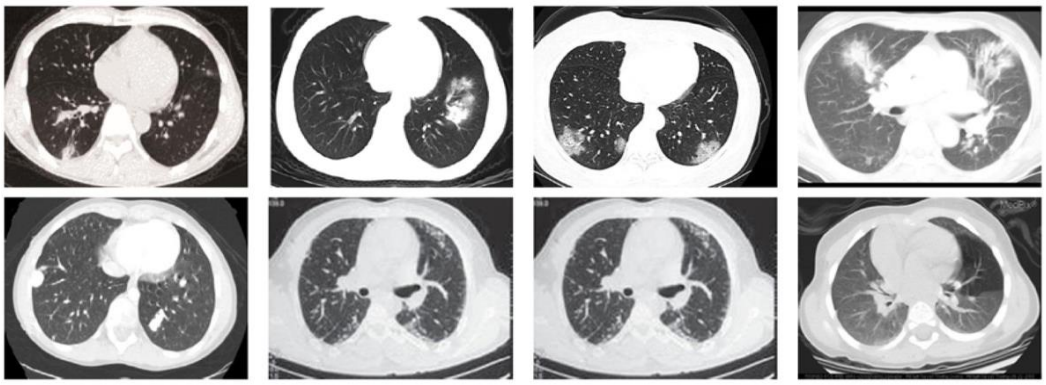

Figure 2. Relevant examples of CT images in COVIDx CT-2

We used COVIDx CT-2A for COVID-19 testing in this research because of the comparison with earlier functioning models and the availability of the data. Figure 2 shows the relevant cases from the COVIDx CT-2A dataset, which include three kinds of CT scans: SARS-CoV-2-infected new coronavirus pneumonia (NCP) and normal controls.

3.2 Image Segmentation

The process of segmenting a picture into sections with comparable attributes such as gray level, color, texture, brightness, and contrast is known as segmentation, see Figure 3. Segmentation is used to segregate items in an image; in the case of medical image segmentation.

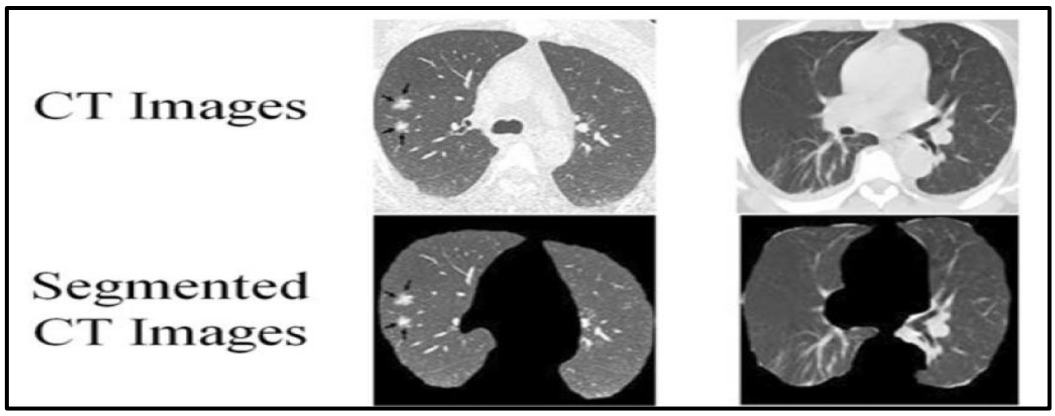

Figure 3. Image segmentation

As we can see in the figure 3, Because CT scans may be collected by various scanners in different medical clinics using varied acquisition techniques, the data pretreatment phase is critical in allowing the convolutional network to learn appropriate and relevant features.

The model was trained using 3D picture patches due to memory constraints. An 11GB GPU was used to train all of the models. To accommodate our hardware, we picked a basic configuration with an input patch size of 128 128 128 and a batch size of 2. The program then automatically adjusts these parameters to suit each dataset's median picture size. We take a look at two distinct approaches:

Low-resolution—the patient picture is downscaled by a factor of two until the median shape of the resampled data has less than four times the number of voxels that can be processed as an input patch. During training, 3D patches are also picked at random. The model contains more background information in this scenario, but it lacks high-resolution details.

3.3 Deep Feature Extraction

In general, the purpose of feature selection is to maximize joint dependency while using the least number of variables necessary to do this. A minimal subset must be obtained by reducing the duplication of the variables used as much as possible while

simultaneously striving to maximize the joint dependency with the goal variable. When it comes to pattern recognition and artificial intelligence difficulties, feature selection is one of the most crucial aspects to consider. The two most frequent methods of selecting features are via filters and wrappers. Techniques for data pre-processing or data filtering are inherently filter-type methods at their core.

The purpose of feature extraction is to reduce the number of features in a dataset by producing new ones from the existing ones (and then discarding the original features). It should be feasible to summarize the overwhelming majority of the information provided in the original set of features after this new, reduced collection of features has been developed.

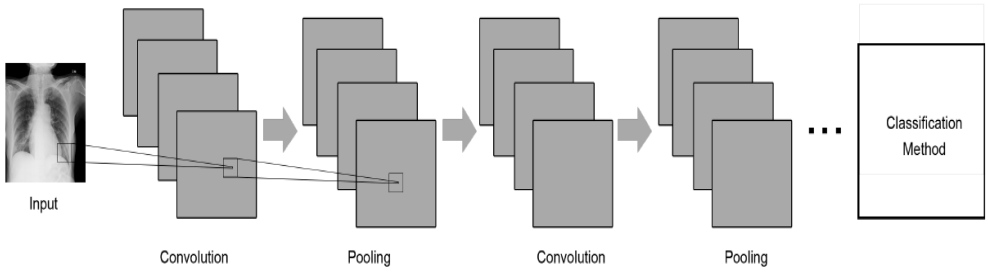

Figure 4. Deep Feature Extraction.

A CNN is a multilayer architecture in which the consecutive layers are intended to learn high-level information in a progressive way, with the last layer being accountable for producing a result. They have been proven to be very accurate in time series analysis and image classification, among other applications. Constantly applying filters to the whole image and so lowering its complexity is what CNN's convolutional layers are responsible for. An image is filtered to produce another picture that may be thought of as a feature map, which indicates whether specified properties (such as borders) were detected in the original image. The process of a convolutional network is shown in Figure 4.

4. Results and Analysis

In our study, to evaluate our classifiers, we use three popular measures used in data mining techniques, which include precision, recall, and F-measure.

Table1. Precision, Recall, and F-Measure Results

	Precision	Recall	F-Score
COVID	0.890	0.880	0.885
Normal	0.920	0.910	0.915

Table 1 shows a comparison of the precision, Recall, and F1-measure results of the CNN method

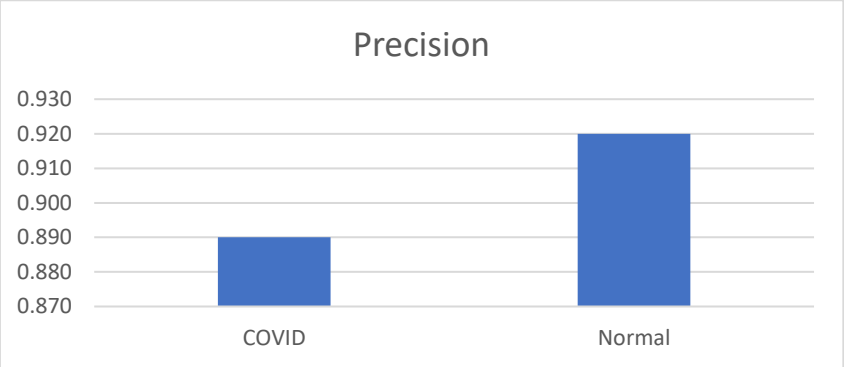

Figure 5. Precision Results

Table 1 and Figure 5 show the precision of the CNN method. The results show achievement of (89 %) for the COVID images and (92% for the normal images).

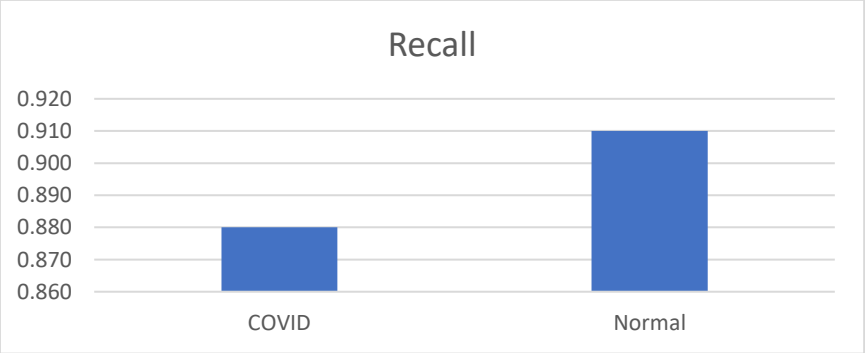

Figure 6. Recall Results

Table 1 and Figure 6 show the Recall of the CNN method. The results show achievement of (88 %) for the COVID images and (91% for the normal images).

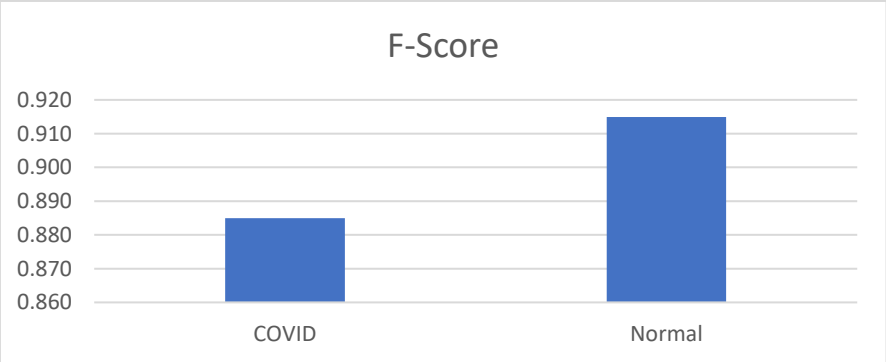

Figure 7. F-Measure Results

Table 1 and Figure 7 show the F-Measure of the CNN method. The results show achievement of (88.5 %) for the COVID images and (91.5% for the normal images).

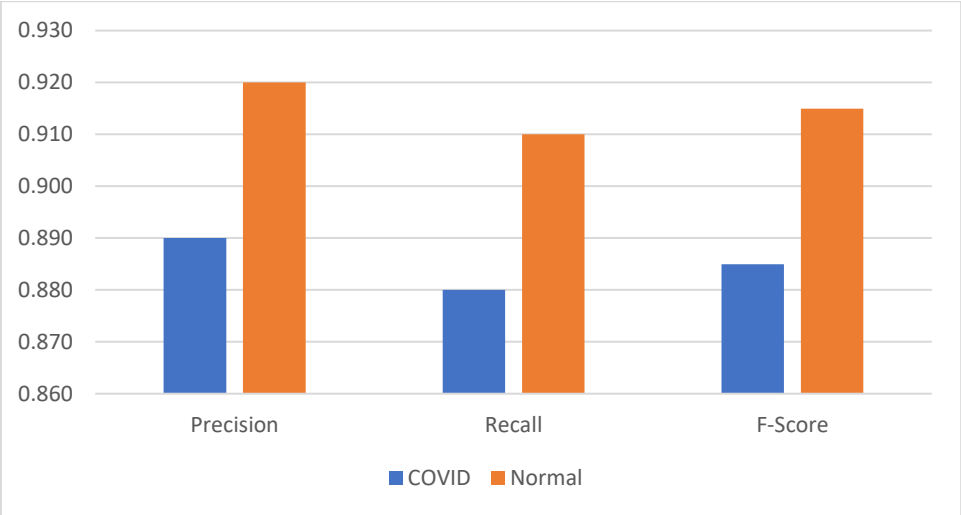

Figure 8. Overall Results

Figure 8 shows the overall results of the CNN method using the three evaluation techniques. The results show better results for the normal images over the COVID images, that's due to number of images available for each dataset.

5. Conclusion

In this study, we proposed a model for detecting COVID-19 from CT scanned patient's images. The proposed idea grants similar outcomes to many recent proposed models. We used convolutional neural network method to classify our data. CNN considered as one of the best performing techniques for this kind of work. Up to our search, there is a few research that produces such outcomes. Our data set contain 20k images, 16k were used to train the model and the rest were used to test and verify our proposed model. We used Recall, Precision, and F-Measure to evaluate our model results. Based on our results we can say that the overall accuracy with f- measure for the normal images was 91.5% and for the COVID-19 images was 88.5%. As a future plan, we intended to extend our model to use coughing sound along with CT images to enhance the model prediction accuracy for detecting COVID-19 patients.

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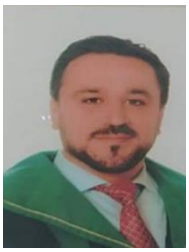
Author Biography



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