Comprehensive Approach to Covid-19 Detection and Severity Assessment

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Abstract

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has significantly impacted global health systems, economies, and societies worldwide. Rapid and accurate detection of COVID-19 infections, as well as the timely assessment of disease severity, are crucial for effective disease management, resource allocation, and public health interventions. This study presented a two-step methodology for identifying the presence of COVID-19 infection in lung CT scans and assessing the severity of the patient's condition. Feature extraction is performed by utilizing pre-trained models, and the features from AlexNet, DenseNet-201, and ResNet-50 are combined through analysis. The identification of COVID-19 is conducted by the utilization of an Artificial Neural Network (ANN) model. Once the COVID-19 infection is diagnosed, a process of assessing the severity of the infection is carried out. To do this, visual characteristics are integrated with the clinical data and categorized using Cubic Support Vector Machine (SVM) into three categories: High, Moderate, and Low. Patients with a high risk might receive increased attention by categorizing them into three severity levels.

Keywords: Severity detection, Classifier, Sensitivity, Accuracy, Precision

I. Introduction

The appearance of the novel coronavirus SARS-CoV-2 and its related disease COVID-19 has triggered an unparalleled global health emergency, unlike anything witnessed in recent history. Since its first detection in December 2019 in Wuhan, China, the virus has swiftly disseminated across continents, resulting in millions of global illnesses and fatalities. The complex and diverse nature of the COVID-19 pandemic has presented significant difficulties for healthcare systems, economies, and society, requiring prompt and efficient actions to reduce its effects. At the core of these endeavors is the creation and execution of tactics to identify COVID-19 infections and evaluate the seriousness of the disease. Prompt and precise identification of SARS-CoV-2 is essential for timely separation, tracking of contacts, and execution of control strategies to hinder additional spread. Furthermore, evaluating the seriousness of a condition is crucial for directing medical treatment, distributing resources, and forecasting patient results. The main technique used to identify COVID-19 is reverse transcription-polymerase chain reaction (RT-PCR), which identifies the presence of viral RNA in respiratory samples. RT-PCR is extensively used as the benchmark for detecting SARS-CoV-2 infection because of its exceptional sensitivity and specificity. Nevertheless, the scalability and accessibility of the system have been hindered by difficulties such as supply chain interruptions, laboratory capacity limits, and turnaround times, especially during periods of increased case numbers. In order to tackle these difficulties, alternative diagnostic methods have been created, such as rapid antigen assays. These tests identify viral proteins and provide fast results that are appropriate for point-of-care testing. Although antigen tests are not as sensitive as RT-PCR, they have been crucial in increasing testing capacity and detecting asymptomatic and presymptomatic infections, therefore decreasing the spread of the virus. Serological assays, which identify antibodies generated as a result of SARS-CoV-2 infection, are useful for evaluating previous exposure and immunological status. However, they are not appropriate for early diagnosis because there is a delay in antibody generation. In addition, imaging modalities such as computed tomography (CT) scans have been employed to identify distinct lung abnormalities linked to COVID-19, especially in situations when RT-PCR test outcomes are uncertain or not accessible.

Aside from identifying COVID-19 infections, it is crucial to evaluate the gravity of the illness in order to appropriately direct clinical treatment and allocate resources. COVID-19 presents a broad range of clinical symptoms, varying from no symptoms or mild illness to severe respiratory failure and death. Various criteria have been recognized as indicators of the seriousness of an illness, including older age, pre-existing conditions like diabetes and cardiovascular disease, and specific aberrant laboratory results such as increased inflammatory markers. Several scoring systems and prognostic models have been created to combine these criteria and forecast the advancement of the disease, aiding doctors in prioritizing care and distributing resources accordingly. Biomarkers such as C-reactive protein (CRP), interleukin-6 (IL-6), and D-dimer have demonstrated a correlation with the severity of the disease and clinical outcomes, offering useful information about the inflammatory response and coagulopathy linked to severe COVID-19. Furthermore, imaging examinations, specifically chest radiography and CT scans, are essential for evaluating lung involvement and identifying complications such as pneumonia, acute respiratory distress syndrome (ARDS), and thromboembolism. These studies are vital for directing clinical decision-making and monitoring the evolution of the disease.

Machine learning algorithms and artificial intelligence (AI) approaches have become increasingly valuable for assessing clinical data and imaging investigations, assisting in the timely identification and categorization of COVID-19 patients. These algorithms possess the ability to detect patterns and correlations within extensive datasets, thereby assisting clinicians in making well-informed decisions and accurately predicting patient outcomes. Moreover, the utilization of telemedicine and digital health technology has made it possible to remotely monitor individuals with COVID-19, so facilitating prompt intervention and alleviating the strain on healthcare institutions. Nevertheless, it is crucial to tackle difficulties such as data privacy, interoperability, and algorithm bias in order to guarantee the ethical and fair utilization of these technologies in pandemic response endeavors.

Efficient identification and accurate evaluation of the seriousness of COVID-19 are crucial elements of plans to combat the pandemic. These measures allow for prompt actions to reduce the spread of the virus, improve medical treatment, and ultimately, prevent loss of life. Although there has been notable advancement in the creation of diagnostic tests, prognostic models, and digital health solutions, continuous research and innovation are necessary to tackle remaining obstacles and enhance the utilization of these tools in practical situations. Through the utilization of diverse methodologies and cooperation among relevant parties, we can improve our capacity to identify and control COVID-19 infections with great efficacy, hence lessening the impact of the pandemic on individuals, communities, and healthcare systems globally.

II. Review Of Literature

Abbasi, Wajid Arshad et al., (2021) In the absence of inadequacy of a specific vaccination, early detection of Coronavirus disease 2019 (COVID-19) is critically vital to advise quarantine and halt the spike of this deadly sickness. The majority of people infected with COVID-19 do not experience any symptoms at all, and those who do often have similar symptoms to those of other respiratory diseases, making a definitive diagnosis difficult. There is a critical need for an alternative, non-invasive, quick, and affordable automated screening method for COVID-19 because of the high expense and lengthy wet-lab diagnostic testing. An alternate method that has been helpful in detecting and diagnosing COVID-19 infections is a chest CT scan. We introduce COVIDC, an automated approach for diagnosing and predicting the severity of COVID-19 using CT scans, which employs deep feature maps extracted from chest CT scans. Using deep feature maps and various shallow supervised classification algorithms like SVMs and random forest to deal with data scarcity, our newly proposed system can detect COVID-19 and forecast its severity in two phases: COVID vs. non-COVID and COVID-19 severity. Under the guidance of a seasoned radiologist, we conducted a comprehensive test of COVIDC's performance in a real-world environment, in addition to using an external validation dataset and 10-fold crossvalidation. With an F1 score of 0.94 on the validation dataset, COVIDC surpassed all previous state-of-the-art methods developed to detect COVID-19 in all evaluation settings. It also rationalized its use for effective COVID-19 diagnosis in real-world scenarios by correctly classifying 9 out of 10 COVID-19 CT scans.

Qiblawey, Yazan et al., (2021) In order to lower the risk of patient mortality, early detection of COVID-19 is crucial. This paper presents a cascaded approach for lung segmentation, COVID-19 infection detection, localization, and quantification using CT scans. An extensive collection of studies was conducted utilizing several forms of DenseNet and ResNet, with backbone (encoder) topologies varying in Encoder-Decoder Convolutional Neural Networks (ED-CNNs), UNet, and Feature Pyramid Networks (FPN). Experiments on segmenting the lung region using the U-Net model and the DenseNet 161 encoder demonstrated a Dice Similarity Coefficient (DSC) of 97.19 percent and an IoU of 95.10 percent. In addition, by utilizing the FPN with DenseNet201 encoder, the suggested system accomplished a sophisticated performance for COVID-19 infection segmentation, achieving a DSC of 94.13% and an IoU of 91.85%. Recent research has neglected tiny infection sites, but the suggested approach can accurately pinpoint infections of any form or size. In addition, the suggested approach demonstrated excellent performance in detecting COVID-19, with a sensitivity of 99.64% and a specificity of 98.72%. Lastly, the system successfully distinguished between mild, moderate, severe, and critical levels of COVID-19 infection using a dataset of 1,110 individuals; the corresponding sensitivity values were 98.3%, 71.2%, 77.8%, and 100%.

Zhao, Wentao et al., (2021) Worldwide, COVID-19 has had a devastating effect on healthcare providers and their patients. Combined with reverse transcription-polymerase chain reaction testing, computed tomography images can be a powerful tool. In order to test for COVID-19, this research used a convolutional neural network. We found that bigger, out-of-field datasets increase the testing power of the models when we compared the performance of several pre-trained models on CT testing. That means you can use your past understanding of the models from out-of-field training on CT scans as well. In comparison to the existing methods mentioned in the literature, the suggested transfer learning strategy achieves better results. In terms of identification, we think our method has reached the cutting edge. Our model performs satisfactorily in studies using training datasets that are randomly sampled. In order to help clinical practitioners with manual screening, we looked at the important visual aspects of the CT scans used by the model.

III. Research Methodology

The objective of this research is to distinguish COVID-19 infection from other lung infections or normal cases, and thereafter assess the severity of the infection by analyzing the features of the pictures and clinically relevant symptoms. Distinguishing between COVID-19 infection and other diseases in the lungs is challenging due to the inclusion of several non-COVID pictures in the COVID-CT data set. Feature extraction is crucial for applications involving image classification. Currently, CNN surpasses all other statistical feature extraction methods that rely on color, texture, and intensity in effectively portraying visual input. Pre-trained networks offer significant benefits for feature extraction in the field of medical imaging.

The initial part of the approach involves utilizing transfer learning from pre-trained networks, including AlexNet, DenseNet-201, and ResNet-50, to assess if COVID-19 infects the damaged lung. Artificial Neural Networks (ANN) are employed to extract the characteristics, combine them, and subsequently train the model to provide accurate predictions on COVID-19. Both the visual attributes and the indicative traits are employed to conduct the assessment of severity once the illness has been recognized. Three classifications, namely high, moderate, and low severity, are considered in this context. The system is evaluated using metrics such as Sensitivity, Specificity, Accuracy, and F1-Score. The main aim of this study is to assess the severity of the patients' problems.

IV. Results And Discussion

<u>COVID-19 detection</u>

We performed the study using characteristics that were taken from a number of different pre-trained models in order to determine which particular pre-trained models were the most effective. The pre-trained models, such as Xception, GoogleNet, and ResNet-18, are studied in a variety of different combinations. There is a display of the accuracy of the COVID-19 detection that was acquired in Table 1.

Table 1: Results of COVID-19 detection method

Pre-trained networks	Sensitivity (%)	Specificity (%)	Precision (%)	Accuracy (%)	F1-Score (%)
AlexNet+DenseNet-201+ResNet-50	95.8	88.5	87.1	91.9	91.2
DenseNet-201+ResNet-50	90.1	90.7	88.3	90.4	88.6
AlexNet+DenseNet-201	87.7	90.8	90.5	89.0	89.3
DenseNet-201	85.4	89.2	85.4	87.9	85.6
ResNet-50	81.0	92.7	92.2	86.5	86.3
AlexNet	80.6	90.5	85.8	84.0	83.2
MobileNetV2	79.9	88.3	85.7	84.2	82.6

Upon evaluating the results, it has been shown that utilizing characteristics from only one pre-trained model and then passing them to a classifier does not produce adequate results. The standalone accuracy of ResNet-50 was determined to be 86.5%, whereas the accuracy of AlexNet was determined to be 84.0%, and the accuracy of DenseNet-201 was revealed to be 87.9%. The combination of these model properties resulted in a confirmed accuracy of 91.9%.

COVID-19 severity detection

In the majority of the works that have been reported, the binary severity condition is being detected. This is either a severe or a non-severe condition. Three different severity classifications are taken into consideration in this work. It was determined how severe the problem was by analyzing the performance of a number of different classifiers. The results of the performance analysis of several classifiers are presented in Table 2.

Table 2: Accuracy of several classifiers for detecting severity

Classifier	Accuracy (%)
Cubic SVM	90.3
Linear SVM	73.5
Naive bayes classifier	67.3
Ensemble Classifier	88.8
Naive bayes classifier with Gaussian Kernel	80.4
Tree	85.4
KNN	77.8

It may be deduced from this that the support vector machine (SVM) that utilizes the cubic kernel is producing superior outcomes. A level of accuracy of 88.8 percent is being provided by the ensemble classifier. Random photos were acquired for the purpose of testing. Class 1 is used to represent very severe cases, class 2 is used to represent moderately severe cases, and class 3 is used to represent very low cases. Table 3 presents the findings that were obtained following the implementation of the suggested COVID-19 severity detection technique for three different classes.

Table 3: Results of COVID-19 severity detection method

Classes	**Sensitivity (%)**	**Specificity (%)**	**Precision (%)**
High Severity	89.2	95.8	89.2
Moderate Severity	90.4	82.7	92.1.
Low Severity	89.8	96.2	97.4

With a sensitivity that ranges from 89.2% to 90.4%, a specificity that ranges from 82.7% to 96.2%, and a precision that ranges from 89.2% to 97.4%, the detection approach displays high performance across all severity classes. Based on these findings, it appears that the technique is capable of accurately identifying COVID-19 instances throughout a range of severity levels, with a particularly high degree of precision in the Low Severity class.

V. Conclusion

Efficient identification and precise evaluation of the extent of seriousness are crucial elements in the worldwide effort to combat the COVID-19 epidemic. During this crisis, the creation and execution of several diagnostic techniques have been essential in detecting patients, monitoring the spread of the disease, and guiding public health actions. A variety of methods, including the highly accurate RT-PCR tests, fast antigen assays, and serological tests, have been used to address the changing needs of testing infrastructure and availability. Simultaneously, the evaluation of the seriousness of a condition has been crucial in directing clinical decision-making, allocating resources, and devising patient treatment methods. Biomarkers, scoring systems, and imaging investigations have yielded vital information about the course of diseases, allowing healthcare practitioners to efficiently prioritize patients and give personalized treatment. The combination of machine learning and artificial intelligence has enhanced our ability to predict patient outcomes and improve treatment plans, providing healthcare providers with powerful tools.

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