Design of COVID-19 Disease Detection Framework for Medical Health Care System

Kamlesh Kumar Yadav[1], Deshmukh Vaishnavi Jaikumar[2]

[1]*Assistant Professor, Department of CS & IT, Kalinga University, Raipur, India.*
[2]*Research Scholar, Department of CS & IT, Kalinga University, Raipur, India.*

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ABSTRACT

Due to practical challenges in data collecting and the efficacy of testing methods, the recognition and diagnosis of COVID-19 using traditional image processing and ML algorithms is a laborious and time-consuming task. Thus, Deep Learning (DL) algorithms are being developed to diagnose COVID-19 instances of pneumonia globally. Due to the fact that deep learning algorithms have recently been developed for clinical diagnosis on image datasets such as brain MRI, chest X-ray, retina, and CT scans with high precision Lately, suggested deep learning techniques have demonstrated limitations, such as their ability to precisely identify a small number of COVID-19-associated pneumonia cases and their symptoms. A reliable forecasting technique for COVID-19 and pneumonia that makes use of CT scans is necessary. Therefore, the emphasis of this study is on the DL-based approach that uses lung CT images to precisely detect and classify the COVID-19 severity level.

1. Introduction

The family Coronavirides includes a broad range of viruses that affect both humans and animals and are distinguished by their distinct appearance. Viruses come in three different shapes: disc, spherical (coronaviruses), rod-shaped (toroviruses), or enclosed. A fringe or circle of the bulbous distal ends of glycoproteins from an implanted cover surrounds each element. Up until 2003, members of this group were only thought to cause mild respiratory illnesses in humans and in the livestock industry; other coronaviruses were shown to have a considerable impact [1]. But the emergence of the Severe Acute Respiratory Coronavirus (SARS-CoV) prompted extensive research into these illnesses and resulted in the identification of multiple additional coronaviruses with the potential to cause devastating human disease outbreaks through zoonotic transmission. Middle Eastern Respiratory Syndrome CoronaVirus (MERS-CoV) is a novel virus that has emerged recently. The largest positive-sense RNA chromosome is found in coronaviruses (COVID-19); these chromosomes are typically identified by the complex process that produces nested mRNA transcripts, which regulates the expansion of the reproduction cycle [12]. Dust and fly particles can spread the coronavirus, which also affects those who are in close contact with the ill individual. Compared to COVID-19, previous pandemics like swine influenza, bird influenza, and SARS are more difficult to diagnose. This is a reference for assessing COVID-19 in light of the diseases and pandemics that reshape the world [2]. The rest of the paper is organized as follows: Section 2 provides the classification scheme for the survey; Section 3 provides an overview of proposed architecture. Section 4 provides a summary and comparison of the results of the various papers discussed in this taxonomy. Finally, Section 5 concludes the paper.

2. Related Works

The country's death ratio is increasingly being caused by the COVID-19 infection; at its peak, the causality rate is 244K. When the new CoV enters a person's respiratory system, it has a significant impact on the pulmonary system and causes a critical stage in contrast to previously recognised pneumonia [3]. Since the COVID-19 symptoms are difficult to recognise and there aren't many testing options available, it's imperative to find other ways to diagnose the illness. While many efforts are being made to find a strong prognosis for COVID-19, social isolation and the closure of multiple communities nationwide remain the most effective preventative measures. However, it also affects the GDP and well-being of the populace. Globally, the number of COVID-19 victims experiencing discomfort is increasing at an exponential rate [4]. The US, Italy, and France are among the most severely impacted countries; China was defeated. Additionally, they negatively and horribly impact the universal revenue. From this angle, the detection and management of COVID-19 by DL is an important matter that must be handled and avoided in the current pandemic scenario. Therefore, in order to prevent this natural pandemic, it is crucial to develop medical systems based on AI that can accurately and swiftly identify COVID-19 patients [5]. The development of DL frameworks [6] over the course of several centuries completely changed the parameters of numerous enquiries. Using deep learning frameworks, image datasets such as lung X-rays, eye images, and so on, offer promising results with higher accuracy, especially in healthcare systems. This may stimulate the development of sophisticated deep learning frameworks for the identification and diagnosis of COVID-19 and pneumonia patients around the globe [14]. Radiologists interpret the categorisation, segmentation, and analysis of current COVID-19 algorithms, which are trained and optimised for particular datasets obtained using CT equipment with certain factors [7]. Hence, these frameworks are insufficient for information on datasets from other equipment and are always dataset-specific. Many traditional systems have experience classifying COVID-19 cases; however, especially during the outbreak, these do not offer the segmentation and analysis of the afflicted individual with the aid of a large amount of data [8].

3. Methodology

The realistic problems in data collecting and the efficacy of testing tools make it more difficult to recognise and diagnose COVID-19 using typical image analytics and computer vision approaches [10]. A fast and accurate partition and quantification technique is used to address this problem. Using this strategy, lung CT images were first provided into the embedding space by means of preprocessing. Next, a well-defined partitioning framework was applied to the conventional embedding space, such as 2.5D U-net. Additionally, a brand-new training simulation method that simulates the dynamic alteration of COVID-19-infected areas was created [11]. However, it takes a long time to learn and uses a lot of memory. Consequently, a weighted sum rule-based deep TL known as Enriched 2.5D U-Net (E2.5D U-Net) was developed to improve the accuracy of the 2.5D U-Net segmentation process. Therefore, rather than carrying out the drawn-out learning process using the random main weights, pre-trained structures in the TL are encountered as an initial step for a few specific activities. Consequently, it helps to reduce the need for significant processing and storage capacity while creating deep learners. Ultimately, this newly created segmentation framework is put into practice, and the effectiveness of it is assessed in comparison to the traditional partition frameworks. The results show that compared to the other models, our E2.5D U-Net-based segmentation model performs better.

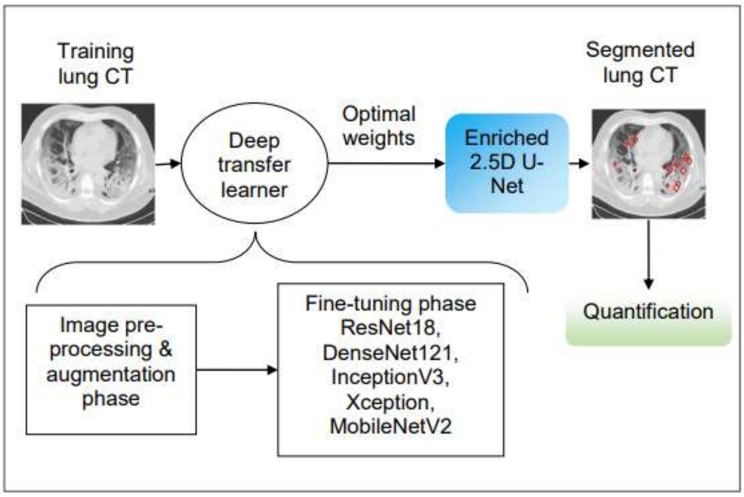
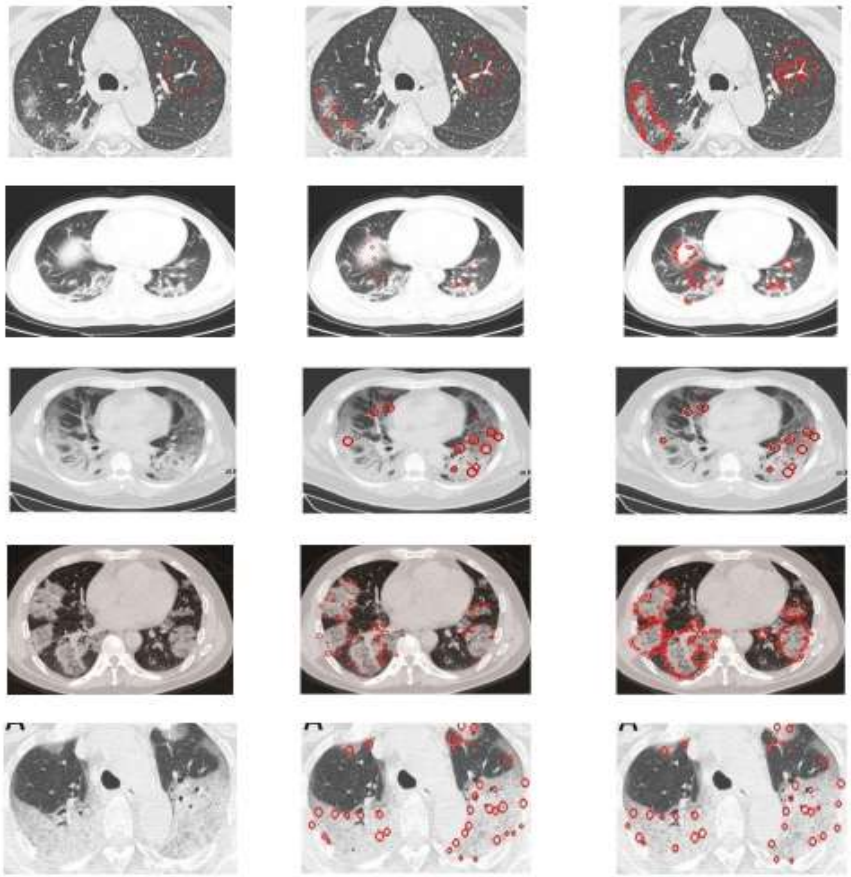


Figure 1. Proposed framework

Initially, a transfer learning strategy is suggested to improve the DL models' ability to precisely handle picture segmentation. In this approach, extensive training with randomly initialised weights is replaced by pre-trained deep learning models (DL) such as ResNet18, Xception, InceptionV3, DenseNet121, and MobileNetV3. The suggested approach contributes to the reduction of the significant resources needed to create DL models for segmentation. Analysis is done on the COVID-19 quantification in the segmented picture [9][13].

4. Results and Discussion

This section uses the Radiopaedia-COVID-19 CT Cases-2020 dataset, which can be found at www.radiopaedia.org, to demonstrate the effectiveness of the E2.5D U-Net-based segmentation model that has been discussed. MATLAB 2017b was used for this implementation. A comparative study is conducted between the suggested and current segmentation models with respect to dice, recall, and worst-case dice. By comparing the segmented diseased ROI and the ground truth sick ROI that the radiologists have annotated, dice and recall are calculated.



(a) (b) (c)

Figure 2. Segmented Findings (a) input image (b) 2.5D U-Net (c) E2.5D U-Net Partition Frameworks

As can be seen in Figure 2, the proposed E2.5D U-Net-based deep learner model outperforms the current 2.5D U-Net segmentation model in accurately segmenting the COVID-19 contaminated patches from the CT images. Thus, in comparison to other traditional deep learner-based segmentation models, it is evident that the E2.5D U-Net architecture can be useful for efficiently dividing CT scans.

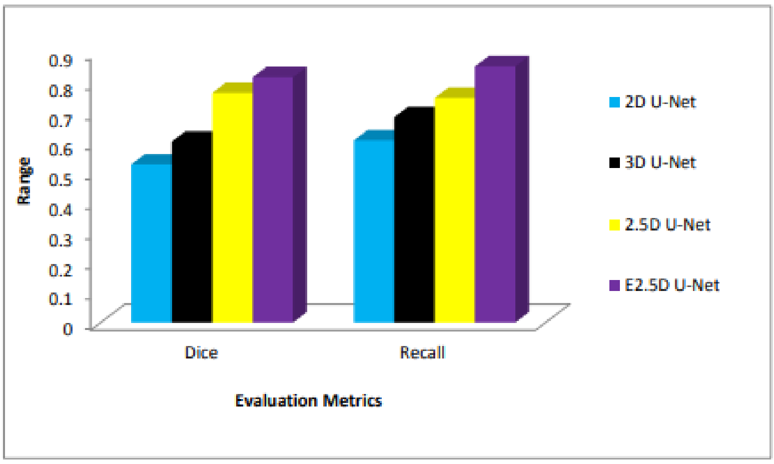


Figure 3. Comparison of Segmentation Efficiency

It is clear from Figure 3 that the E2.5D U-Net-based segmentation outperforms the 2D, 3D, and 2.5D U-Net-based segmentation models in terms of efficiency. In summary, the E2.5D U-Net model outperforms all other models in terms of recall (0.815) and is able to segregate the majority of COVID-19 infected ROIs from CT images. Furthermore, it is robust in terms of the worst-case dice coefficient in addition to being effective.

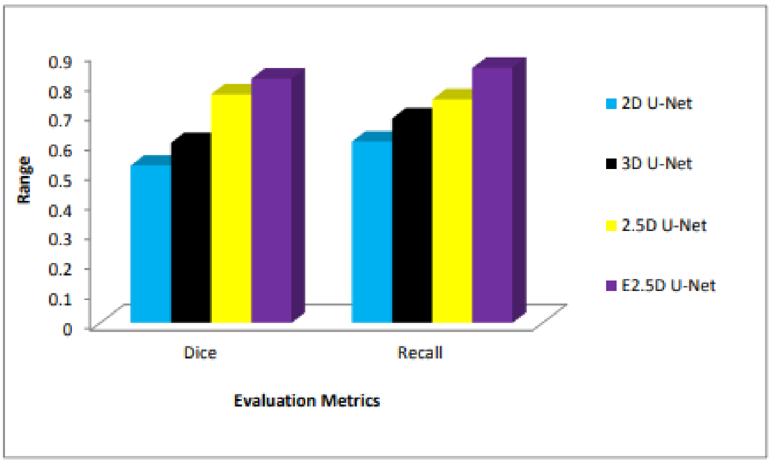


Figure 4. Comparison of Quantification Performance

As a result, Figure 4 illustrates how the E2.5D U-Net-based segmentation provides extremely accurate disease level quantification with a mean loss of roughly 1.8%, which is lower than all other models. This is as a result of its exact segmentation and capacity to distinguish between the infected and pulmonary tissues, such as arteries and veins.

Table 1. Performance Comparison

References	Accuracy	Sensitivity	Specificity
RNN	93.01	89.13	96.8
CNN	91.02	92.7	89.05
DBN	91.95	89.5	93.8
MLP	92	90.9	93
DCNN	91.41	89.06	93.75
Proposed-3D-CNN	97.7	95.3	96.8

The suggested classifier's attained accuracy is 94.7%. Table 1 displays the suggested accuracy, sensitivity, and specificity performance metrics when compared to the current model. The deep learner introduces multi-modelling. In order to distinguish between COVID-19 coronavirus pneumonia and healthy CT lung pictures, it combines the extraction of deep characteristics with manually created features. Through the modification of the Inception framework, the new classifier is designed to efficiently learn mixed characteristics. After learning, the model assigns severity degrees to the test images. The MATLAB tool is used to implement the suggested procedures. The DCNN COVID-19 CT cases 2020 dataset is used to assess several classification performance measures that indicate how effective the suggested technique.

5. Conclusions

An E2.5D U-Net-based profound TL framework was created in this work to efficiently partition ROIs of COVID-19 infections from CT scans. The weighted sum coefficient was employed in this model to fuse the outputs of five distinct pre-learned deep learner structures, hence enriching the 2.5D U-net structure. As a result, there was an improvement in segmentation accuracy and a decrease in memory usage throughout the training stage. In summary, the results demonstrated that the E2.5D U-Net-based segmentation model outperformed the current segmentation frameworks for COVID-19 detection and diagnosis, achieving 0.018 of RMSE and 0.971 of PCC. The sensitivity, specificity, and accuracy of the 3D-CNN classifier which is utilised to identify the COVID-19 stages are computed, measured, and contrasted with those of other suggested techniques. When compared to other suggested strategies, better outcomes are achieved. 97.7% accuracy is achieved by the suggested classifier.

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