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Automated Deep Learning-Based Network for Detecting COVID-19 from a Lung CT Scan

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Abstract: The corona virus disease 2019 is an emerging worldwide threat to public health. Early detection and diagnosis are critical factors to control the COVID-19 Spreading. For the diagnosis of COVID-19 Computed tomography has an important role in the early diagnosis of COVID-19 as it provides both rapid and accurate results. The lung infection due to COVID-19 has affected a larger human community globally. The COVID-19 disease has adverse effects on the respiratory system, and the infection severity can be detected using a imaging modality. As the COVID-19 continues to spread rapidly across the world, CT has become essentially important for fast diagnosis. Hence it is very important to develop an accurate computer-aided method to assist medical experts to identify COVID-19 infected patients by CT images. Early identification of severely ill patients can enable easy intervention, prevent disease progression and help reduce mortality. The study aims to develop the Artificial intelligence-assisted tool using CT imaging to predict disease severity and further estimate the risk of developing severe disease in patients suffering from COVID-19. CT images can effectively complement the reverse transcription polymerase chain reaction testing. Early and accurate diagnosis of coronavirus disease is essential for patient isolation and contract tracing so that the spread of infection can be limited.

1. INTRODUCTION

The World Health Organization (WHO) got the first update related to Corona virus disease 2019 (COVID-19) on December 31, 2019. On January 30, 2020, WHO announced the COVID-19 spread as a global health emergency. Corona virus is a zoonotic virus, which means it began in animals before spreading to humans. The transmission of the virus occurred in humans after coming into contact with animals. Corona virus can transmit from one person to another through respiratory droplets when a person exhales, coughs, sneezes, or chats with others. It is also believed that the virus may have transferred from bats to other species, such as snakes or pangolins, and then to humans. Multiple COVID-19 complications leading to liver problems, pneumonia, respiratory failure, cardiovascular diseases, septic shock, etc. have been promptedby a condition called cytokine release syndrome or a cytokine storm. This occurs when an infection activates the immune system to leak inflammatory proteins known as cytokines into
the bloodstream which can kill tissues and organs in human beings These people were associated with the local wild animal market, which indicates the possibility of transmitting the virus from animals to humans. The severe outbreak of the new coronavirus spread rapidly throughout China and then spread to other countries. The virus disrupted many political, economic, and sporting events and affected the lives of many people worldwide. The most important feature of the new coronavirus is its fast and wide-spreading capability. The virus is mainly transmitted directly from people with the disease to others; It is transmitted indirectly through the surfaces and air in the environment in which the infected people come in contact with it . As a result, correctly identifying the symptoms of people with the disease and quarantining them plays a significant role in preventing the disease. New coronavirus causes viral pneumonia in the lungs, which results in severe acute respiratory syndrome. The new coronavirus causes a variety of changes in the sufferer. The most common symptoms of new coronavirus are fever, dry cough, and tiredness. The symptoms of this disease vary from person to person. Other symptoms such as loss of sense of smell and taste, headache, and sore throat may occur in some patients, but severe symptoms that indicate the further progression of COVID-19 include shortness of breath, chest pain, and loss of ability to move or talk. There are several methods for the definitive diagnosis of COVID-19, including reverse transcriptase-polymerase chain reaction (RT-PCR), Isothermal nucleic amplification test, Antibody test, Serology tests, and medical imaging. RT-PCR is the primary method of diagnosing COVID- 19 and many viral diseases. Besides, the lack of diagnostic kits in most contaminated areas around the world is leading researchers to come up with new and easier ways to diagnose the disease [9]. Due to the availability of medical imaging devices in most treatment centres, the researchers analyse CT scans and X-rays to detect COVID19. In most patients with COVID- 19, infections are found in the lungs of people with new coronavirus that can help diagnose the disease. Analysis of CT scans of patients with COVID-19 showed pneumonia caused by the new coronavirus. with the approval of radiologists for the ability to use CT scans and X-rays to detect COVID-19, various methods have been proposed to use these images. Most patients who have COVID-19 symptoms at least four days later have X-rays and CT scans of

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their lungs, showing infections that confirm the presence of a new coronavirus in their body. Although medical imaging is not recommended for definitive diagnosis, it can be used for early COVID-19 diagnosis due to the limitations of other methods. Some patients with early-onset COVID-19 symptoms were found to have new coronavirus infections on their CT scans. At the same time, their RT-PCR test results were negative, then both tests were repeated several days later, and RT-PCR confirmed the CT scan's diagnostic results.

2. RELATED WORKS

Arora's research work aims to identify COVID-19 through deep learning models using lung CT-SCAN images. The experimentation has been carried out using benchmark datasets like SARS-COV-2 CT-Scan and Covid-CT scan. To mark COVID19 as positive or negative for the improved CT scan, existing pre-trained models such as Exception-Net, Mobile-Net, InceptionV3, Dense-Net, ResNet50, and VGG (Visual Geometry Group)16 have been used. The Mobile-Net model produced better results as compared to its peer models. On the benchmark datasets, viz. Covid-CT scan and SARS-COV2 CT-Scan, for the Mobile-Net model, the sensitivity scores were found to be 96.11% and 100% respectively; precision scores were 96.11% and 100% respectively; F-1 scores were recorded as 96.11% and 100% respectively; and accuracy was to the tune of 94.12% and 100% respectively. The proposed work can be customized further by stacking hybrid pre-trained algorithms. CT scans were taken from two benchmark datasets for this research study; and all the images were enhanced in the pre-processing phase using super resolution deep neural networks. Transfer learning models were employed to label the images as positive and negative for COVID19.[1]

The UDL-VAE model involved adaptive Wiener filtering (AWF) based pre-processing technique to enhance the image quality. Besides, Inception v4 with Ada grad technique is employed as a feature extractor and unsupervised VAE model is applied for the classification process. In order to verify the superior diagnostic performance of the UDL-VAE model, a set of experimentation was carried out to highlight the effective outcome of the UDL-VAE model. The obtained experimental values showcased the effectual results of the UDL-VAE model with the higher accuracy of 0.987 and 0.992 on the binary and multiple classes respectively.[2]

An Efficient Deep Learning Technique for the screening of COVID-19 with a voting-based approach. In this approach, the images from a given patient are classified as group in a voting system. The approach is tested in the two biggest datasets of COVID-19 CT analysis with a patient-based split. A cross dataset study is also presented to assess the robustness of the models in a more realistic scenario in which data comes from different distributions. The cross-dataset analysis has shown that the generalization power of deep learning models is far from acceptable for the task since accuracy drops from 87.68% to 56.16% on the best evaluation scenario. These results highlighted that the methods that aim at COVID-19 detection in CT images have to improve significantly to be considered as a clinical option and larger and more diverse datasets are needed to evaluate the methods in a realistic scenario.[3]

A Deep Learning Based Multi-Modal Fusion technique called DLMMF for COVID-19 diagnosis and classification from Computed Tomography (CT) images. DLMMF model operates on three main processes namely Weiner Filtering (WF) based pre-processing, feature extraction and classification. The proposed model incorporates the fusion of deep features using VGG16 and Inception v4 models. Finally, Gaussian Naive Bayes (GNB) based classifier is applied for identifying and classifying the test CT images into distinct class labels. The experimental validation of the DLMMF model takes place using open-source COVID-CT dataset, which comprises a total of 760 CT images. The experimental outcome defined the superior performance with the maximum sensitivity of 96.53%, specificity of 95.81%, accuracy of 96.81% and F-score of 96.73%.[4]

Methods such as segmentation, data augmentation and generative adversarial network (GAN) are Combined to increase the effectiveness of deep learning models. A method that generates synthetic chest CT images using the GAN method from a limited number of CT images. It tests the performance of experiments (with and without GAN) on internal and external dataset. when the CNN is trained on real images and synthetic images, a slight increase in accuracy and other results are observed in the internal dataset, but between 3% and 9% in the external dataset. It is according to the performance results that the proposed method will accelerate the detection of COVID-19 and lead to more robust systems.

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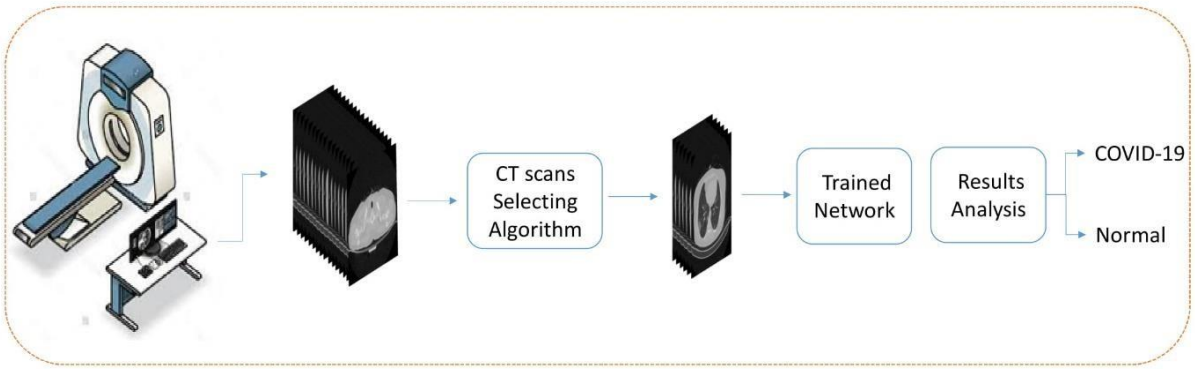
3. SYSTEM DESCRIPTION

General view of the proposed method for automated patients' classification



4. EXPERIMENT & RESULTS

4.1 Materials and methods

COVID-CTset1 is our introduced dataset. It was gathered from Negin radiology located at Sariin Iran between March 5th to April 23rd, 2020. This medical centre uses a SOMATOM Scope model and syngo CT VC30- easy IQ software version for capturing and visualizing the lung HRCT radiology images from the patients. The format of the exported radiology images was 16-bit grayscale DICOM format with 512*512 pixels resolution. As the patient's information was accessible via the DICOM files, we converted them to TIFF format, which holds the same16-bit grayscale data but does not conclude the patients' private information. One of our novelties is using a 16-bit data format instead of converting it to 8bit data, which helps to improve classification results. Converting the DICOM files to 8bit data may cause losing some data, especially when few infections exist in the image that is hard to detect. even for clinical experts. Also, original 16-bit CT scan images may contain information that human eyes can not distinguish, but the computers notice them while processing. The pixels' values of the images differ from 0 to 5000, and the maximum pixel values of the images are considerably different. So scaling them through a consistent value or scaling each image based on the maximum pixel value of itself can cause the mentioned problems and reduce the network accuracy. So each image of COVID-CT set is a TIFF format, 16-bit grayscale image. In somestages of our work, we used the help of clinical experts under the supervision of the third author,a radiology specialist, to separate those images that the COVID-19 infections are clear. To make these images visible with standard monitors, we converted them to float by dividing eachimage's pixel value by the maximum pixel value of that image. This way, the output images had 32-bit float type pixel values that could be visualized by standard monitors, and the qualityof the images was good enough for analysis. COVID-CT set is made of 15,589 images that belong to 95 patients infected with COVID-19 and 48,260 images of 282 normal people.

4.2 Results

In this section, we report the results into two sections. The Image classification results sectionincludes the results of the trained networks on the test set images. The Patient condition identification section reports the results of the automated system for identifying each person asnormal or COVID-19. We implemented our algorithms and networks on Google ColaboratoryNotebooks, which allocated a Tesla P100 GPU, 2.00 GHz Intel Xeon CPU, and 12 GB RAM on Linux to us. We used Keras library [8] on Tensor flow backend [1] for developing and running the deep networks.

4.3 Image classification results

In this section, we present the main results of our work. CT scan data is not like many other data like X-ray images, which can be evaluated by investigating one single image. CT scans are sequences of consecutive images (like videos), so for medical diagnosis, the system or theexpert person must analyse more than one image. Based on this condition, for proposing an automatic diagnosis system, the developers must evaluate their system differently than single image classification

If our proposed fully-automated system wants to check the infection of COVID-19 for a patient, it takes all the images of the patient CT scans as input. Then it processes them with the proposed CT scan selection algorithm to select the CT scans that the lung is visible in them. Those chosen images will be fed to the deep neural network to be classified as COVID-19 or normal. For indicating the condition of a patient, we must set a threshold. For each patient, if the number of CT scan images, which are identified as COVID-19, be more than the threshold, that patient would be considered as

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infected; otherwise, his condition would be normal. This threshold value depends on the precision of the model. In trained models with high accuracy, the threshold can be set to zero, meaning if at least one CT scan image of a patient (between the filtered CT scans by the selection algorithm) is detected as COVID-19, that patient would be considered being infected.

5. CONCLUSION

In this paper, we have proposed a fully automated system for COVID19 detection from lung HRCT scans. We also introduced a new dataset containing 15,589 images of normal persons and 48,260 images belonging to patients with COVID-19. At first, we proposed an image processing algorithm to filter the proper images of the patients' CT scans, which show inside the lung perfectly. This algorithm helps increase network accuracy and speed. At the next stage, we introduced a novel deep convolutional neural network for improving classification. This network can be used in many classification problems to improve accuracy, especially for the images containing important objects in small scales. We trained three different deep convolution networks for classifying the CT scan images into COVID-19 or normal. Our
model, which utilizes ResNet50V2, a modified feature pyramid network, and the designed architecture, achieved the best results. After training, we used the trained networks for running the fully automated COVID-19 identifier system. We evaluated our system in two different ways: one on more than 7796 images and the other one on almost 245 patients and 41,892 images with different thicknesses. For single image classification (first evaluation way), our model showed 98.49% overall accuracy. Our model obtained the best results at the patient condition identification stage (second evaluation way) and correctly identified approximately 234 patients from 245 patients. We also used the Grad CAM algorithm to highlight the CT scan images' infection areas and investigate the classification correctness. Based on the obtained results, it can be understood that the proposed methods can improve COVID-19 detection and run fast enough for implementation in medical centres.

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7. REFERENCES

[1] Arora, V., Ng, E. Y. K., Leekha, R. S., Darshan, M., Singh, A. (2021). *Transfer learning-based approach for detecting COVID-19 ailment in lung CT scan*. Computers in biology and medicine, 104575.

[2] Mansour, R. F., Escorcia-Gutierrez, J., Gamarra, M., Gupta, D., Castillo, O., Kumar, S. (2021). *Unsupervised deep learning based variational autoencoder model for COVID-19 diagnosis and classification*. Pattern Recognition Letters, 151, 267- 274.

[3] Silva, P., Luz, E., Silva, G., Moreira, G., Silva, R., Lucio, Menotti, D. (2020). *COVID- 19 detection in CT images with deep learning: A voting-based scheme and cross-datasets analysis. Informatics in medicine unlocked*, 20, 100427.

[4] Subhalakshmi, R. T., Balamurugan, S. A. A., Sasikala, S. (2021). *Deep learning based fusion model for COVID-19 diagnosis and classification using computed tomography images*. Concurrent Engineering, 1063293X211021435

[5] Acar, E., S¸ahin, E., Yılmaz, ˙I. (2021). *Improving effectiveness of different deep learning-based models for detecting COVID-19 from computed tomography (CT) images.* Neural Computing and Applications, 1-21.

[6] Ahuja, S., Panigrahi, B. K., Dey, N., Rajinikanth, V., Gandhi, T. K. (2021). *Deep transfer learning-based automated detection of COVID-19 from lung CT scan slices*. AppliedIntelligence, 51(1), 571-585.

[7] Shi, W., Peng, X., Liu, T., Cheng, Z., Lu, H., Yang, S., ... Shan, F. (2021*). A deep learning-based quantitative computed tomography model for predicting the severity of COVID-19: a retrospective study of 196 patients.* Annals of Translational Medicine, 9(3).

[8] Song, Y., Zheng, S., Li, L., Zhang, X., Zhang, X., Huang, Z., ... Yang, Y. (2021*). Deep learning enables accurate diagnosis of novel coronavirus (COVID-19) with CT images*. IEEE/ACM Transactions on Computational Biology and Bioinformatics.

[9] Ravi, V., Narasimhan, H., Chakraborty, C., Pham, T. D. (2021). *Deep learning based meta-classifier approach for COVID-19 classification using CT scan and chest X-rayimages*. Multimedia Systems, 1-15.

[10] Chen, J., Wu, L., Zhang, J., Zhang, L., Gong, D., Zhao, Y., ... Yu, H. (2020). *Deep learning-based model for detecting 2019 novel coronavirus pneumonia on high resolution computed tomography*. Scientific reports, 10(1), 1-11.

[11] Zhao, W., Jiang, W., Qiu, X. (2021). *Deep learning for COVID-19 detection based on CT images*. Scientific

DOI: 10.17148/IJARCCE.2022.11574

Reports, 11(1), 1-12.

[12] Alshazly, H., Linse, C., Barth, E., Martinetz, T. (2021). *Explainable covid-19 detectionusing chest ct scans and deep learning*. Sensors, 21(2), 455.

[13] Wu, D., Gong, K., Arru, C. D., Homayounieh, F., Bizzo, B., Buch, V., ... Li, Q. (2020). *Severity and consolidation quantification of COVID-19 from CT images using deep learning based on hybrid weak labels*. IEEE Journal of Biomedical and Health Informatics, 24(12), 3529-3538.

[14] Shah, V., Keniya, R., Shridharani, A., Punjabi, M., Shah, J., Mehendale, N. (2021). *Diagnosis of COVID-19 using CT scan images and deep learning techniques.* Emergency radiology, 28(3), 497-505.

[15] Singh, M., Bansal, S., Ahuja, S., Dubey, R. K., Panigrahi, B. K., Dey, N. (2021). *Transfer learning–based ensemble support vector machine model for automated COVID-19detection using lung computerized tomography scan data*. Medical biological engineering computing, 59(4), 825-839.

[16] L. Li, K. Ota, M. Dong, *Deep learning for smart industry: efficient manufacture inspection system with fog computing*, IEEE Trans. Ind. Inform. 14 (10) (2018) 4665–4673.

[17] L. Li, L. Qin, Z. Xu, Y. Yin, X. Wang, B. Kong, J. Bai, Y. Lu, Z. Fang, Q. Song, et al.,*Artificial intelligence distinguishes covid-19 from community acquired pneumonia on chestct, Radiology* (2020) page 200905.

[18] T.-Y. Lin, P. Dollar, ´ R. Girshick, K. He, B. Hariharan, S. Belongie, *Feature pyramid networks for object detection*, Proceedings of the IEEE Conference on Computer Vision andPattern Recognition (2017) 2117–2125.

[19] T.-Y. Lin, P. Goyal, R. Girshick, K. He, P. Dollar, ´ *Focal loss for dense object detection*, IEEE Trans. Pattern Anal. Mach. Intell. (2018).

[20] G. Litjens, T. Kooi, B.E. Bejnordi, A.A.A. Setio, F. Ciompi, M. Ghafoorian, J.A. Van Der Laak, B. Van Ginneken, C.I. Sanchez, ´ *A survey on deep learning in medical image analysis*, Med. Image Anal. 42 (2017) 60–88.