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A SURVEY ON IMPLEMENTATION FRAMEWORK FOR COVID-19 SCREENING FROM CHEST CT SCAN IMAGES USING ARTIFICIAL INTELLIGENCE

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ABSTRACT

Corona virus Disease (COVID19) is a fast-spreading infectious disease that is currently causing a healthcare crisis around the world. Due to the current limitations of the reverse transcription-polymerase chain reaction (RT-PCR) based tests for detecting COVID19, recently radiology imaging based ideas have been proposed by various works. Recognition of COVID-19 in Chest CT Scan images is a challenging task. Identification of disease in a human organ demands expert's opinion and the patients medications are completely dependent on the results given by that expert. However, there might be situations where experts may not be available or too busy. To tackle the emergencies, which arise due to lack of experts, it is necessary to screen inputs image of Chest CT to classify whether the chest CT scan image is COVID-19 infectious or non-infectious i.e. healthy. In this paper, we present a taxonomy of the state-of-the-art machine learning based disease detection systems. This research aims to survey a Machine-Learning-System (MLS) to detect the COVID-19 infection using the CT scan Slices (CTS) with effective feature extraction by various researchers.

Keywords: Covid-19, CT Scan, Machine Learning, Medical Images

INTRODUCTION

In the recent years, medical CT Images have been applied in clinical diagnosis widely. It assists physicians to detect and locate pathological changes with more accuracy. Computed tomography images can be distinguished for different tissues according to their different gray levels. Lung diseases can be caused by infection, an exposure at the workplace, medications and various disorders. X-ray chest radiography and computer tomography (CT) are two common anatomic imaging modalities that are routinely used in the detection and diagnosis of a variety of lung diseases. Medical images play a vital role in patient diagnosis, therapy, surgical, medical reference, and training. The Digital Imaging and Communications in Medicine (DICOM) standard allows storing textual descriptions, known as metadata, along with the images. It was the most important breakthrough since the discovery of the X-rays, and CT has remained a cornerstone of diagnostic radiology throughout the years.

The World Health Organization (WHO) estimates that there are 300 million people who suffer from asthma, and that this disease causes around 250 thousand deaths per year worldwide. In addition, WHO estimates that 210 million people have COPD. This disease caused the death of over 300 thousand people in 2005. Recent studies reveal that COPD is present in the 20 to 45 year-old age bracket, although it is characterized as an over-50-year-old disease. Accordingly, WHO estimates that the number of deaths due to COPD will increase 30% by 2015, and by 2030 COPD will be the third cause of mortalities worldwide. For the public health system, the early and correct diagnosis of any pulmonary disease is mandatory for timely treatment and prevents further death. From a clinical standpoint, diagnosis aid tools and systems are of great importance for the specialist and hence for the people's health. The COVID-19 pandemic, caused by severe acute respiratory syndrome corona virus 2 (SARS-CoV-2), has lead to a global public health crisis, and continues to spread worldwide. Medical imaging, especially Computed Tomography (CT), has been playing an important role for clinical diagnosis and monitoring of patients with the disease infections. However, the growth rate of COVID-19 suspicious cases has overloaded the public health service capacity and manifested shortage of trained radiologists. Therefore, developing effective computational methods for automated COVID-19 CT image analysis is highly demanded towards improving the diagnosis outcomes and patient management, as well as helping clinicians on tedious image interpretation workload for releasing their precious time which can otherwise be dedicated to more urgent things on the frontline.

The most common test technique currently used for COVID-19 diagnosis is a real-time reverse transcription-polymerase chain reaction (RT-PCR). Chest radiological imaging such as computed tomography (CT) and X-ray have vital roles in early diagnosis and treatment of this disease. Due to the low RT-PCR sensitivity of 60%–70%, even if negative results are obtained, symptoms can be detected by examining radiological images of patients. It is stated that CT is a sensitive method to detect COVID-19 pneumonia, and can be considered as a screening tool with RT-PRC. CT findings are observed over a long interval after the onset of symptoms, and patients usually have a normal CT in the first 0–2 days. In a study on lung CT of patients who survived COVID-19 pneumonia, the most significant lung disease is observed ten days after the onset of symptoms. The chest CT scan images of normal and covid19 patients are shown below in figure 1.

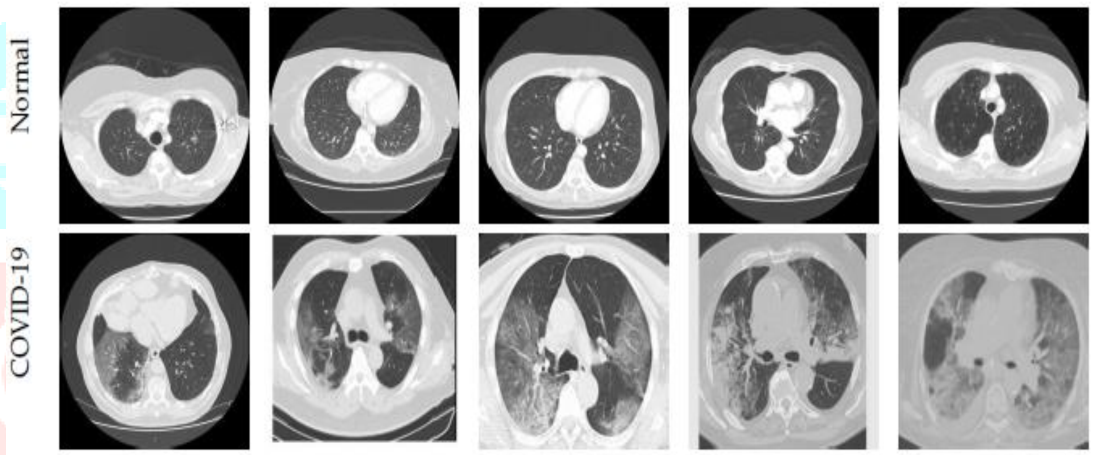

Fig 1: CT Scan Images of Normal or Covid-19 Patients

The use of medical imaging tools is the second approach of COVID-19 virus detection. These tools are playing an important role in the management of patients that are confirmed or suspected to be infected with the virus. It is worthy of note that without clinical suspicion, findings from X-ray, or CT images are nonspecific as many other diseases could have a similar pattern. Thoracic CT scan is the imaging modality of choice that plays a vital role in the management of COVID-19. Thoracic CT has a high sensitivity for diagnosis of COVID-19 which makes it a primary tool for COVID-19 detection. CT scan involves transmitting X-rays through the patient's chest, which are then detected by radiation detectors and reconstructed into high-resolution medical images. There are certain patterns to look out for in a chest CT scans which present themselves in different characteristic manifestations. Interpretation of these findings by expert radiologists does not have a very high sensitivity. Artificial Intelligence (AI) has been employed as it plays a key role in every aspect of COVID-19 crisis management. AI has proven to be useful in medical applications since its inception, and it became widely accepted due to its high prediction and accuracy rates. In the diagnosis stage of COVID-19, AI can be used to recognize patterns on medical images taken by CT. Other applications of AI include, but not limited to, virus detection, diagnosis and prediction, prevention, response, recovery, and to accelerate research. AI can be used to segment regions of interest and capture fine structures in chest CT images, self-learned features can easily be extracted for diagnosis and other applications as well. A recent study showed that AI accurately detected COVID-19 and was also able to differentiate it from other lung diseases and community acquired pneumonia.

RELATED WORK

Research work presented by various authors related to COVID-19 diagnosis using artificial intelligence techniques majorly based on machine learning and deep learning techniques are described given below.

Zhao Wang proposed a novel joint learning framework to perform accurate COVID- 19 identification by effectively learning with heterogeneous datasets with distribution discrepancy. They build a powerful backbone by redesigning the recently proposed COVID-Net in aspects of network architecture and learning strategy to improve the prediction accuracy and learning efficiency. They aim to develop a highly-accurate model for COVID-19 CT diagnosis by exploring the benefits of joint learning from heterogeneous datasets of different data sources. Their joint learning framework explicitly mitigates the inter-site data heterogeneity by conducting separate feature normalization for each site. A contrastive training objective is further explored to enhance the learning of domain-invariant semantic features to improve the identification performance on each dataset. Experiments on two large-scale public datasets demonstrates the effectiveness and clinical significance of our approach. They develop and evaluate our method with two public large-scale COVID-19 diagnosis datasets made up of CT images. Extensive experiments show that our approach consistently improves the performances on both datasets, outperforming the original COVID-Net trained on each dataset by 12.16% and 14.23% in AUC respectively, also exceeding existing state-of-the-art multi-site learning methods. The future works include improving the generalization capacity of our model, extending it into a wider multi-site setting, as well as employing transfer learning from other large-scale datasets to further enhance the diagnosis accuracy.

Muskan Lawania proposed a productive strategy to identify the lung malignancy and its stages effectively and furthermore means to have progressively precise outcomes by utilizing KNN and Image Processing systems. Proposed work has several steps, CT scan, Preprocessing, morphological operation, cancer area segmentation, cancer area feature extraction, classification, output. There are many classification algorithms are available and some classification algorithm that are given below is KNN. KNN gave great outcomes with high precision.

Seifedine Kadry presented a Machine-Learning-System (MLS) to detect the COVID-19 infection using the CT scan Slices (CTS). This MLS implements a sequence of methods, such as multi thresholding, image separation using threshold filter, feature-extraction, feature-selection, feature-fusion and classification. A two-class classifier system is implemented to categorize the chosen CTS into normal/COVID-19 group. In this work, the classifiers, such as Naive Bayes (NB), k-Nearest Neighbors (KNN), Decision Tree (DT), Random Forest (RF) and Support Vector Machine with linear kernel (SVM) are implemented and the classification task is performed using various feature vectors. The experimental investigation of this study confirms that, the classification accuracy of SVM is 89.80% when 2 FFV is considered to train, test and validate the classifier. This confirms that, when the proposed MLS is equipped with the SVM classifier, a better classification is attained with the considered CTS database.

Arnab Kumar Mishra explored various Deep CNN based approaches are explored for detecting the presence of COVID19 from chest CT images. An experimental evaluation of existing Deep CNN based image classification approaches is presented in order to identify COVID19 positive cases from chest CT scan images. Moreover, a decision fusion based approach is also proposed, which combines the predictions of each of the individual Deep CNN models, in order to improve the predictive performance. A decision fusion based approach is also proposed, which combines predictions from multiple individual models, to produce a final prediction. Experimental results show that the proposed decision fusion based approach is able to achieve above 86% results across all the performance metrics under consideration, with average AUROC and F1-Score being 0.883 and 0.867, respectively. From the extensive experimentations, it is observed that the proposed approach can achieve very impressive results, with above 86% in terms of every performance metric under consideration, while having a good reduction of the number of False Positives. From the experimental observations, it is clear that Deep CNN based approaches can potentially have a huge impact on the spread control of COVID19 by providing fast screening. With DL based approaches being used widely in other medical imaging tasks, it is high time for such approaches to be used in the screening process of the current pandemic as well.

Andreas Christe proposed a preliminary evaluation of an integrated pipeline for the automatic classification of IPF. A multistep approach is used for the segmentation of anatomical structures of the lung cavity, the segmentation of lung pathological tissue, and finally the classification into a radiological diagnostic CT pattern. In summary, we found that a machine learning-supported computer-aided detection algorithm was able to classify IPF with similar accuracy to a human reader. Moreover, the computer algorithm delivered results comparable to those of radiologists when grouping fibrosis patterns according to the Fleischner Society's newest recommendation.

Tulin Ozturk presented new model for automatic COVID-19 detection using raw chest X-ray images is presented. The proposed model is developed to provide accurate diagnostics for binary classification (COVID vs. No-Findings) and multi-class classification (COVID vs. No-Findings vs. Pneumonia). Our model produced a classification accuracy of 98.08% for binary classes and 87.02% for multi-class cases. The Dark Net model was used in our study as a classifier for you only look once (YOLO) real time object detection system. We implemented 17 convolutional layers and introduced different filtering on each layer. Our model can be employed to assist radiologists in validating their initial screening, and can also be employed via cloud to immediately screen patients.

Varalakshmi Perumal appliedthe transfer learning technique to clinical images of different types of pulmonary diseases, including COVID-19. They propose a transfer learning model to quicken the prediction process and assist the medical professionals. The proposed model outperforms the other existing models. This makes the time-consuming process easier and faster for radiologists and this reduces the spread of virus and save lives. The proposed model produces precision of 91% , recall of 90% and accuracy of 93% by VGG-16 using transfer learning, which outperforms other existing models for this pandemic period.

Lin Li designed and evaluated a three-dimensional deep learning model for detecting corona virus disease 2019 (COVID-19) from chest CT scans. A 3D deep learning framework was proposed for the detection of COVID-19. This framework can extract both two-dimensional local and 3D global representative features. On an independent testing data set, we showed that this model achieved high sensitivity (90% [95% confidence interval [CI]: 83%, 94%]) and high specificity (96% [95% CI: 93%, 98%]) in the detection of COVID-19. The areas under the receiver operating characteristic curves for COVID-19 and community-acquired pneumonia were 0.96 (95% CI: 0.94, 0.99) and 0.95 (95% CI: 0.93, 0.97), respectively.

Ramalho Geraldo proposed a novel method for lung disease detection based on feature extraction of ACACM segmented images within the co-occurrence statistics framework. The spatial interdependence matrix (SIM) synthesizes the structural information of lung image structures in terms of three attributes. Finally, we perform a classification experiment on this set of attributes to discriminate two types of lung diseases and health lungs. We evaluate the discrimination ability of the proposed lung image descriptors using an extreme learning machine neural network (ELMNN) comprising 4-10 neurons in the hidden layer and 3 neurons in the output layer to map each pulmonary condition. This network was trained and validated by applying a holdout procedure.

Lal Hussain employed an automated supervised learning AI classification of texture and morphological- based features on portable CXRs to distinguish COVID-19 lung infections from normal and other lung infections. The major finding was that the multi-class classification was able to accurately identify COVID-19 from amongst the four groups with a combined AUC of 0.87 and accuracy of 79.52%. AI classification of texture and morphological features of portable CXRs accurately distinguishes COVID-19 lung infection in patients in multi-class datasets. Deep-learning methods have the potential to improve diagnostic efficiency and accuracy for portable CXRs.

Xiaohong Gao developed an enhanced Res Net deep learning network, depth-ResNet to classify the five types of Tuberculosis (TB) lung CT images. Depth-ResNet takes 3D CT images as a whole and processes the volumetric blocks along depth directions. It builds on the ResNet-50 model to obtain 2D features on each frame and injects depth information at each process block. As a result, the averaged accuracy for classification is 71.60% for depth-ResNet and 68.59% for ResNet. The datasets are collected from the Image CLEF 2018 competition with 1008 training data in total, where the top reported accuracy was 42.27%.

Stephanie A. Harmon show that a series of deep learning algorithms, trained in a diverse multinational cohort of 1280 patients to localize parietal pleura/lung parenchyma followed by classification of COVID-19 pneumonia, can achieve up to 90.8% accuracy, with 84% sensitivity and 93% specificity, as evaluated in an independent test set (not included in training and validation) of 1337 patients. Normal controls included chest CTs from oncology, emergency, and pneumonia-related indications. The false positive rate in 140 patients with laboratory confirmed other (non COVID-19) pneumonias was 10%. AI-based algorithms can readily identify CT scans with COVID-19 associated pneumonia, as well as distinguish non-COVID related pneumonias with high specificity in diverse patient populations.

CONCLUSION

An automated approach for classification of the COVID-19 infections using CT scan images by various researchers are reviewed. The proposed summary helps as the assistant in detecting the diseases in the medical field .the motivation for choosing the work is to give the automated way of finding the diseases that affect our community most commonly. The aim of this disease diagnosis is to suggest a computerized system to distinguish the normal and COVID-19 CTS images. To conclude, investigating how artificial intelligence was employed in COVID-19 detection is highly significant to ensure future research will concentrate on the right track, thereby improving the performance of disease detection systems. The presented taxonomy could be used by other researchers to plan their research contributions and activities. The potential future direction suggested could further improve the efficiency and increase the number of AI aided COVID-19 disease detection applications.

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