OriginalArticle

Development of the new Aquicnn algorithm for an augmentation of CT scans images for COVID-19 Patients

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Abstract

The world is restoring life balance after the global Covid-19 pandemic. This situation, giving birth to new problems, arose as an outcome of pre-and post pandemic scenarios. Healthcare system was under tremendous burden during this pandemic. Government bodies, scientists, drug discovery and drug registration were working in cooperation to fight the situation and to save lives. Out of all such activities, one healthcare domain is a key player, and that is the radiological department of hospitals. As discovery made those Covid-19 effects on lungs, the pressure on CT scan activities rose. To generate a CT scan quickly and to diagnose lung condition is the need of hour. Furthermore, that became a challenge for early detection of lung conditions. Hence, this paper presents the proposed research to develop iterative techniques using deep learning computation. Paper presents the proposed lung image acquisition and augmentation algorithm developed using a convolution neural network named “AquiCNN”. This proposed algorithm will be useful for quick and enhanced lung CT image analysis.

Keywords:CNN, deep learning, covid-19, CT scan, Lung, Radiology

1.INTRODUCTION

The COVID-19 pandemic has currently overtaken every other health issue throughout the world. There are numerous ways in which this will impact existing public health issues. Here we reflect on the interactions between COVID-19 and tuberculosis (TB), which still ranks as the leading cause of death from a single infectious disease globally [1].Major adverse outcomes were found to affect different body systems: immune system, respiratory system (lung fibrosis and pulmonary thromboembolism), cardiovascular system, and neurological system, impaired hepatic and renal function [2]. Much recent peer-reviewed radiology literature has introduced thoughtful solutions to mitigate disparities interfacing with radiology. Abundant opportunities exist for radiology practices to craft new approaches for addressing multidimensional access barriers [3].

Early diagnosis allows for timely infection prevention and control measures. Patients with mild disease do not require hospitalization, unless there is concern for rapid deterioration. Thus, in the short term, a more systematic way to help healthcare professionals identify cases and assess the risk of progression to severe or critical conditions, or from acute to subacute conditions, can help better manage scarce resources in hospitals [4]. Numerous sources of medical images (e.g., X-ray, CT, and MRI) make deep learning a great technique to combat the COVID-19 outbreak. Motivated by this fact, a large number of research works have been proposed and developed for the initial months of 2020 [5]. In this paper, we depicted efficient use of deep CNN model and further proposed “AquiCNN” algorithm is tested for fast iterative image analysis and augmentation lung CT images. In this paper, Section-2 gives latest literature review, Section-3 provides proposed research methodology, Section-4 reveals the result and analysis and Section-5 concludes the paper.

2.Literature Review

The COVID-19 continues to have a negative impact on healthcare systems around the world, though the vaccines have been developed and national vaccination coverage rate is steadily increasing. At the current stage, automatically segmenting the lung infection area from CT images is essential for the diagnosis and treatment of COVID-19 [6].Chest X-Ray (CXR) and Computed Tomography (CT) imaging modalities are widely used to obtain a fast and accurate diagnosis of COVID-19. However, manual identification of the infection through radio images is extremely challenging because it is time-consuming and highly prone to human errors [7].

Image data categorization and segmentation algorithms have been developed to help doctors save time and reduce manual errors during the diagnosis. Over time, CNNs have consistently outperformed other image segmentation algorithms. Various architectures are presently based on CNNs such as ResNet, U-Net, VGG-16, etc[8].Radiological image analysis, both X-ray and CT, help to diagnose COVID-19 and provide more details of patient conditions combined with virus' nucleic acid by real time reverse transcription polymerase chain reaction (RT-PCR) tests. Moreover, CT scan analysis can achieve up to 98% sensitivity in diagnosing COVID-19 [9].

Author has used machine learning techniques to diagnose and classify the COVID-19 and normal patients from chest X-ray images using a machine learning technique. The proposed system involves pre-processing, feature extraction, and classification. The result analysis shows that the SVM achieved the highest accuracy of 96% and provide a better result than logistic regression (92%) [10].However, it remains unclear whether various non-COVID19 lung lesions could contribute to segmenting COVID-19 infection areas and how to better conduct this transfer procedure [11].Imaging techniques are used to capture anomalies of the human body. The captured images must be understood for diagnosis, prognosis and treatment planning of the anomalies. Medical image understanding is generally performed by skilled medical professionals [12].

3. Research Methodology

Convolutional neural networks, specifically artificial neural networks, are a branch of deep learning methods that are inspired by the natural visual perception mechanism of living organisms. CNNs are nothing but stacked multilayered neural networks. There are three major categories of layers, namely, convolutional layers, pooling layers and fully connected layers. The first layer of any CNN model is an input layer, where the width, height and depth of the input image are specified as the input parameters [13].

Deep learning has provided exceptional performance in image classification tasks in computer vision, leading to a recent explosion in popularity. Similarly, its application to connectomic analyses holds great promise. In this study, author introduceddeep neural network architecture, Fusion Net, with a focus on its application to accomplish automatic segmentation of neuronal structures in connectomics data [14]. Noisy images reduce the classification performance of convolutional neural networks and increase the training time of the networks. In this paper, a Noise-Robust Convolutional Neural Network (NR-CNN) is proposed by author(s) to classify the noisy images without any preprocessing for noise removal and improve the classification performance of noisy images in convolutional neural networks [15]. But, to get blur-free images with exact identification of pixel sets, CNN can be modified. Hence, this paper presents a new deep CNN algorithms called “AquiCNN” which can also enhances the image visibility by de-blur the unnecessary pixels. The iterative execution of proposed algorithm runs recurrently which can increase the speed of image augmentation. The lowered size of Epoch gives details of images at the end of iteration. Fig 1 shows the proposed AquiCNN Algorithm framework.

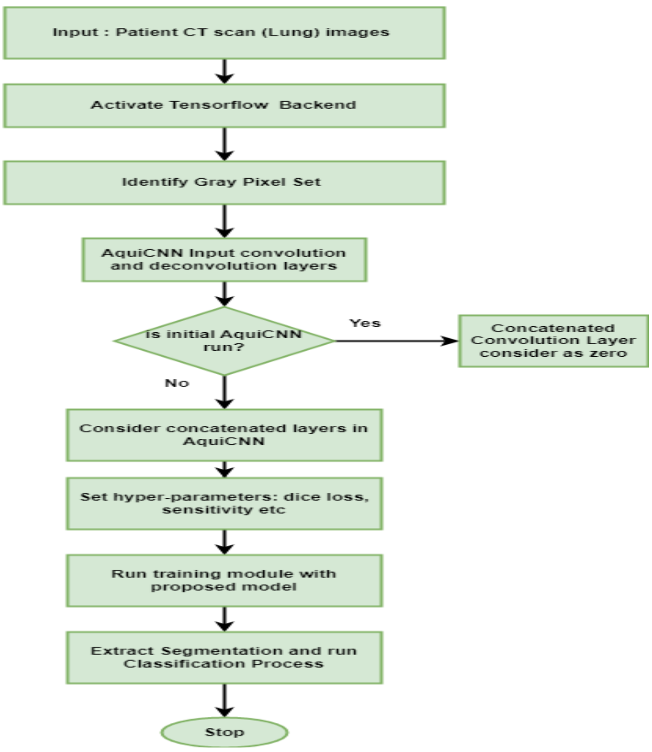

Fig. 1: Proposed AquiCNN Algorithm Framework

The output is segmented and classified by fully connected layer. Finally, a classification is conducted by using softmax activation functions. The proposed system can classify lung CT images as a Covid-19 or Non-Covid-19 patient. The pseudo code for proposed algorithm is shown below:

Algorithm: AquiCNN

Input: Lung CT images of Covid-19 and Non-Covid-19 patients
Output: Augmented lung CT images
1.*Create* $Incremental\_CTimage\_batch\_0\ (M\ ,N)$*:* $Incremental\_CTimage\_batch\_n\ (M, N) +\ X_{ct}$
Where, $X_{ct} = 0$ *# Concatenation status*
2. $Incremental\_CTimage\_batch\_n\ =\ (Incr\_aquicnn\_0\ (X, P) +\ ConcatLayer)$ *# Train using Concat Layer for identification of hyper parameters*
Where, $X_{ct}! = 0$
3. while *(*$X_{ct}\ ! = 0$*)* ***do***
4. *Add NewConcatLayer*
$Incremental\_CTimage\_batch\_n = X_{cl} +\ Incremental\_CTimage\_batch\_n(M, N) - losses$ *# remove losses*
while *(*$X_{ct}\ ! = 0$ && $Y! = 0$*)* ***do***
5. *Activate ReLu for* $Incr\_aquicnn\_n_{relu()}$
6. *Adding a new batch (M, N) with* X_{ct} *and Y:* $Incr\_aquicnn\_batch\_n\ (X, P) + X_{ct} +\ Y$
7. $Incr\_aquicnn\_batch$ *(0 to n) =* $\sum_0^n Incr\_aquicnn\_n_{relu()} + X_{ct} + Y$
8. end while
As per the proposed algorithm execution, the proposed system is tested for patient's lung CT scan images and next section 4 shows the results.

4. Result and Analysis

The proposed research is tested with RadiAnt DICOM Viewer to display medical images (CT lung images) in a DCOM format. Following Fig.2 shows the DCOM results of CT scan classification for non-covid-19 and covid-19 patients.
Fig 2 shows the Classification results of proposed system.

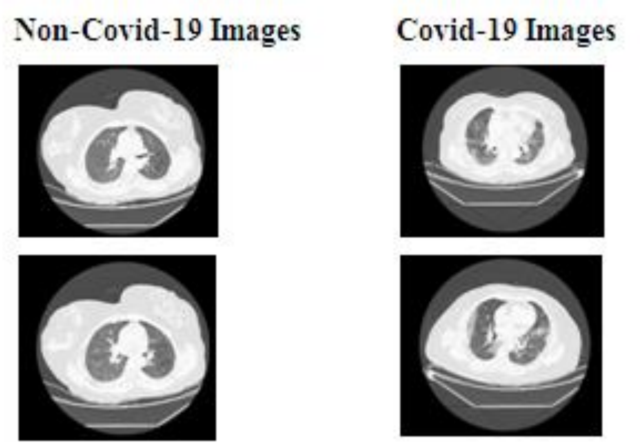

Fig. 2. Classification results of proposed system

Further to classification by proposed algorithm, system is tested to identify min-max values. By means if this testing, as shown in following Fig.3 health professionals can quickly identify the severity by measuring opacity of lung.

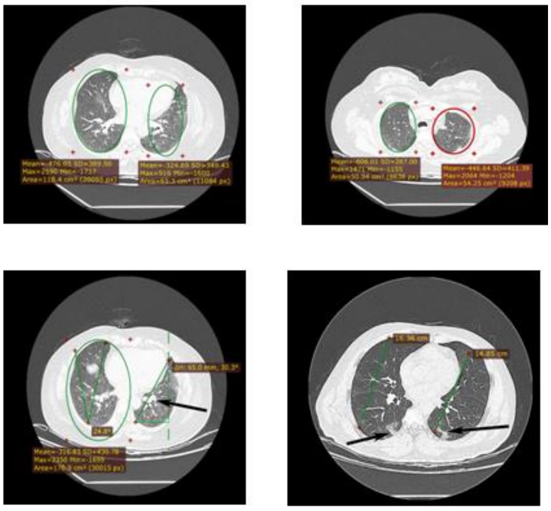

Fig.3. Identification of Max Mean Values for Covid-19 patients

Fig 3 is the Max and Min values for Cocid-19 patients. Severity is identified by CT score (i.e. 0 to 5) which is depends on the each lobe's min-max score. By using HRCT THORAX, following Fig. 4 shows the time intensity curve. This can be identified by 20 lesions collectively.

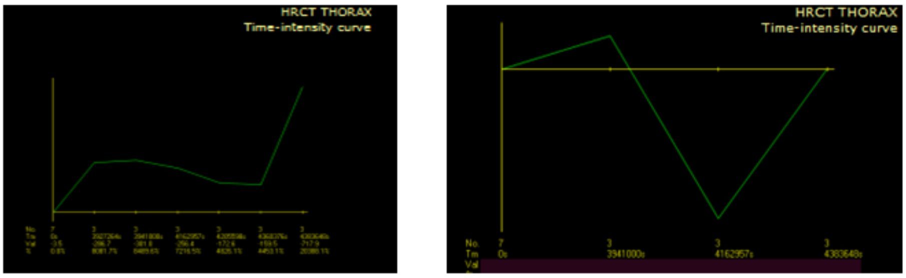

Fig.4. Time intensity curve for proposed system

Based on the training and validation of lung CT scan images, with Epoch size 50, proposed system identified hyper parameters as shown in following table 1.

Table 1: Hyper parameter values for proposed research

	Plateau LR	Cyclic LR	Constant LR
Macro average precession	0.91	0.90	0.92
Macro average recall	0.92	0.88	0.89
Macro average F1 score	0.91	0.91	0.92
Accuracy	0.94	0.90	0.91
AUC score	0.95	0.92	0.93

As per the hyper parameter values, it is clear that proposed system performance is better with AquiCNN algorithm. This is because of the iterative system training and using maximum max-pooling layer. The convolution and de-convolution in a iterative manner gives higher accuracy.

5. Conclusion

The proposed research is focuses on the quick and enhanced visibility of CT scan images. Many times, the blur images give the false diagnosis due to human error or manual visible analysis. Covid-19 has shaken the whole world which led to the higher death rate. In this situation quick analysis of opacity score is the greatest way for doctors to decide the line of action of treatment. The severity score became a buzz word. Hence, the proposed system algorithm enhances CT images by de-blur method which is achieved by using AquiCNN algorithm by image acquisition and augmentation which gives clear visibility with min-max values.The proposed research will be very useful for analysis of lungs not limited to Covid-19 patients but overall identification of lung health. As a future development, this can be broaden to develop human machine interfacing for medical devices.

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