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Advanced Medical Images Recognition and Diagnosis of Respiratory System Viruses

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Abstract

Detection of respiratory viruses is a perplexing task which regularly requires taking a quick look at clinical images of patients on and on. Hence, there is a need to propose a model to predict the respiratory viruses (COVID- 19) cases at the earliest possible to control the spread of disease. Deep learning makes it possible to find out that Covid-19 can be detected in an efficient way using its classification tools. MFCC is a very common and efficient technique for signal processing. In this research, a MFCC – CNN learning model to accelerate the prediction process is proposed that assist the medical professionals. MFCC is used for extracting the image's features concerning existence of COVID-19 or not. Classification is performed by using convolutional neural network. This makes the time-consuming process easier and faster with more accurate results for radiologists and this reduces the spread of virus and save lives. Experimental results show that a CNN using CT image converted to Mel-frequency cepstral coefficient spectrogram images as input can achieve high accuracy results; with classification of validation data scoring an accuracy of 99.46% correct classification of COVID and NOT_COVID labeled images. Hence, it can be used practically for detection of COVID-19 from CT images. The work here provides a proof of concept that high accuracy can be achieved with a moderate dataset, which can have a significant impact in this area.

Keywords: Biomedical Imaging, COVID-19, Computed Tomography, Feature Extraction, MFCC, Image Classification, CNN

Background

Respiratory viruses are the most numerous contributory agents of disease in humans, with considerable impact on morbidity and humanity globally, that leads to significant cause of illness and death around the world. Roughly one-quarter of all deaths worldwide are related to Covid-19 (corona virus) respiratory infections, particularly in impecunious populations across the world wide where Covid-19 cases are fatality remarkably higher than before. Corona-Virus is presently an extensive infective worldwide disease. Corona-virus 2019 (COVID-19), which was caused by a virus named SARS-CoV-2, was very first apprised in Wuhan, China in December 2019 and later in many parts all over the world; on 3 January 2020, the World Health Organization declared that COVID-19 is a Public Health Emergency of International Concern (PHEIC), and confirmed it as an epidemic on 11 March 2020 [1]. This pandemic has imposed tremendous loss to life so far; also has spread and prompted momentous side effects, with 86,159,886 cases of confirmed corona virus and 1,861,764 deaths on 5 January 2021. The virus is a strain of cruel sharp respiratory Covid-19 which cause a harass to the respiratory system and therefore causes symptoms such as coughing, ageusia, anosmia, breathing difficulties, as wellas fever and fatigue based upon World Health Organization (WHO). Researches efforts are in progress into diverse aspects of COVID-19 including vaccine research, anti-viral treatments and diagnostic tools for determining who has the virus at early stages. In this research, the achievability of high accuracy image classification is scrutinized of COVID-19 Computed Tomography (CT-Scan) images. This a scope diagnostic software application that would be available for more accurate detection of Covid-19 infection.

The virus is transmitted largely via close contact and through respiratory droplets delivered when the patient sneezes or coughs. The symptoms of this virus are fever, difficulty in breathing and coughing. Dilemma in breathing is a sign of plausible pneumonia and needs a punctual medical deliberation. No antibiotics, antibodies or precise treatment for COVID-19 infectivity is presented. The health trade is fervently looking for new methods, technologies and techniques to follow and control the escalation of corona virus epidemic in this intercontinental health catastrophe. One of the superlative uses worldwide technologies right now is Artificial Intelligence (AI), which can scrutinize the rapidity and detection of the growth rate of Covid-19 virus, and categorize the risk and cruelty of Corona virus on patients.AI can also expect the possibility of death by effectively analyzing earlier patient's data and also can give a hand in battling the virus by examining individuals, data, information, medical assistance and recommendations concerning disease control. Thus to resolve miscellaneous problems in our lives, AI is a wide umbrella that consists of many sub-areas. These sub-areas include thinking, learning, preparation, representation of information, and searching. Deep Learning (DL) and Machine Learning (ML) are a subset of AI areas that consist of several algorithms that provide intelligent models to identify or cluster particular tasks.

DL is a subclass of ML that focuses on constructing a deep structural neural network (NN) models that learn from data using algorithms of feed-forward and back- propagation. The DL outperformed in the last two decades in various activities. However, it takes a huge amount of data to understand. DL algorithms usually involve Deep Belief Networks (DBN), Deep Neural Network (DNN), and Deep Convolutional Neural Networks (Deep CNN).

Favorably, research works in medical, technological, and military sectors have successfully introduced advanced AI-based ML and DL methods in the COVID-19 battle within a short period after the explosion of COVID-19 and achieved generous progress. Adding up, on a large-scale, COVID-19 case data and AI intelligent models that are based on ML and DL learn to construct disease detection models that accurately predict outbreaks. ML and DL are also vastly used in epidemic protection and public monitoring, such as security check-ups in airports, patient tracking, and epidemic detection.

Chest Ct Scan Image Detection

The role of COVID-19 in research now a days is growing to improve imaging for treatment and diagnosis. The infection triggers an enormous spectrum of CT scan imaging discoveries, most commonly lung periphery consolidations and ground-glass opacities. The sensitivity of Chest CT to diagnose COVID-19 is found to be appreciably higher with good resolution and can occur prior to a positive viral lab test. Therefore, hospitals with large quantities of admissions use CT for the fast emergency of patients with conceivable COVID-19 disease in epidemic territories, where the basic healthcare system is under pressure. Chest CT plays an important role in the estimation of COVID-19 patients with rigorous and compound respiratory symptoms. Based on CT scans, it is possible to determine how defectively the lungs are compromised and how the sickness of the individual progresses, which is effective in making medical

decisions. There is a growing consideration of the sudden occurrence of lung defects that are such as abdominal CT scans for bowel disorders or patients without respiratory symptoms [2]. In this pandemic, by reducing the strain onclinicians, the evaluation of AI may become the most significant factor. AI can analyze the images in 10 s [3].

Therefore, advanced image processing with MFCC and artificial neural network has the possibility to significantly improve the function of CT in COVID-19 detection by allowing a large proportion of patients to identify disease easily and rapidly with accuracy. A chest CT image is shown in Figure 1.

Figure1: Chest CT scan Image

Methodology

In this paper we propose a MFCC-CNN model to further quicken the prediction process of Covid-19 recognition method based on the Mel- frequency cepstral coefficients (MFCCs) for extracting features composite with wavelet transform from MFCC composite with wavelet transform of the image will assist in achieving a higher recognition rate by passing it to a CNN. Covid-19 CT image is producing sufficient information for good Covid-19 discrimination. Capturing this information in a form and size which allows efficient modeling is efficient. Several features extraction techniques are used in signal recognition system such linear prediction coefficients.

Extraction of CT Image Features by MelFrequency Cepstral Coefficient

Feature extraction can be defined as the process of reducing the amount of data present in a given image sample while retaining image discriminative information. The concept of feature extraction contributes to the goal of identifying Covid-19 CT image based on producing sufficient information for good Covid-19 discrimination, capturing this information in a form and size which allows efficient modeling. Several features extraction techniques are used in signal recognition system such linear prediction coefficients (LPC), linear predictive cepstral coefficients (LPCC), perceptual linear predictive analysis (PLP), and Mel Frequency Spectrum Coefficients (MFCC) which is currently the most popular and it is discussed in this paper. Mel-frequency Cepstral coefficients (MFCCs) are coefficients that have been usedto represent signal distribution. MFCCs are commonly used as features in speech recognition systems. MFCC features are derived through cepstral analysis and are warped according to the Mel-scale which emphasizes low frequency components over the higher frequency components. The steps from image to coefficients by MFCC (Figure 2) are:

1. Slicing of the original waveform into predeterminedwindow size.
2. Performing Fourier Transformation (FFT) on thesliced signal.
3. Mapping the log amplitudes of the spectrum onto the Mel scale, using triangular overlapping filters.
4. Performing Discrete Cosine Transformation (DCT) on the Mel log amplitudes.
5. The resulting amplitudes of the spectrum are the MFCCs.

Calculation of MFCC features proceeds similarly to the Cepstral transformation process: the input converted image is firstly framed and windowed. The Fourier Transform is then taken and the magnitude of the resulting spectrum is warped by the Mel-scale. The log of thisspectrum is then taken and a Discrete Cosine Transform isapplied [4]. The Mel is a unit of measure of perceived pitch or frequency of a tune. The Mel- scale is therefore a map-

ping between the real frequency scale (Hz) and the perceived frequency scale (Mels). The name Mel comes from the word melody to indicate that the scale is based on pitch comparisons [5]. The Mapping is virtually linear below 1 KHz and logarithmic above. A popular formula toconvert f hertz into m Mel is given as in (1):

$m = 2595 \log_{10} ((f/700) + 1)$

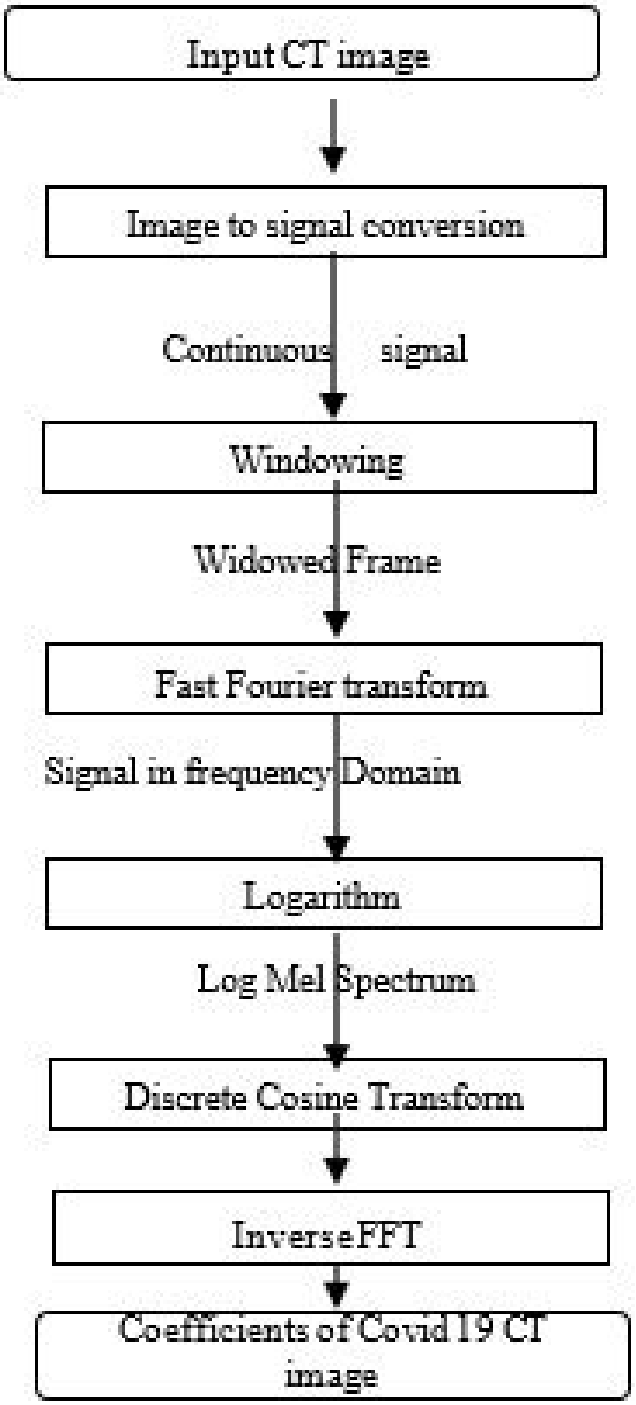

Figure 2: MFCC stages diagram

Mfcc-Cnn Classification

MFCC-CNN architectures are very effective for classifying image data. Images extracted from MFCC is usually represented as an image as shown in Figure 3, we can use an image classifier - already a highly developed area of machine learning - for classification of the image [6,7]. We used a deep convolutional neural network, shown in with multiple hidden layers and a binary dense output layer for label classification. The layers are:

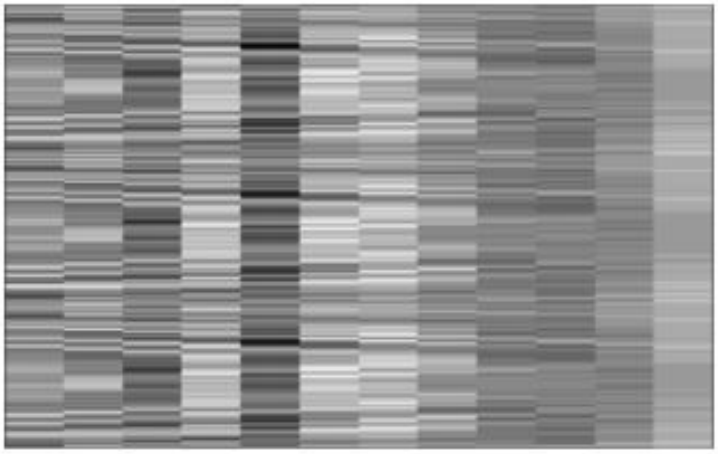

Figure 3: MFCC of Covid-19 image

• Convolutional Layer: It applies 14 5x5 filters (extracting 5x5-pixel sub-regions),

• Pooling Layer: This will perform max pooling with a 2x2 filter for down sampling and stride of 2 (which specifies that pooled regions do not overlap).

• Convolutional Layer: It applies 36 5x5 filters, with ReLU activation function

• Pooling Layer: Again, performs max Pooling with a 2x2 filter and stride of 2.

• 1,764 neurons, with the dropout regularization rate of 0.4 (where the probability of 0.4 that any given element will be dropped in training)

• Dense Layer (Logits Layer): There are ten neurons, one for each digit target class (0-9).

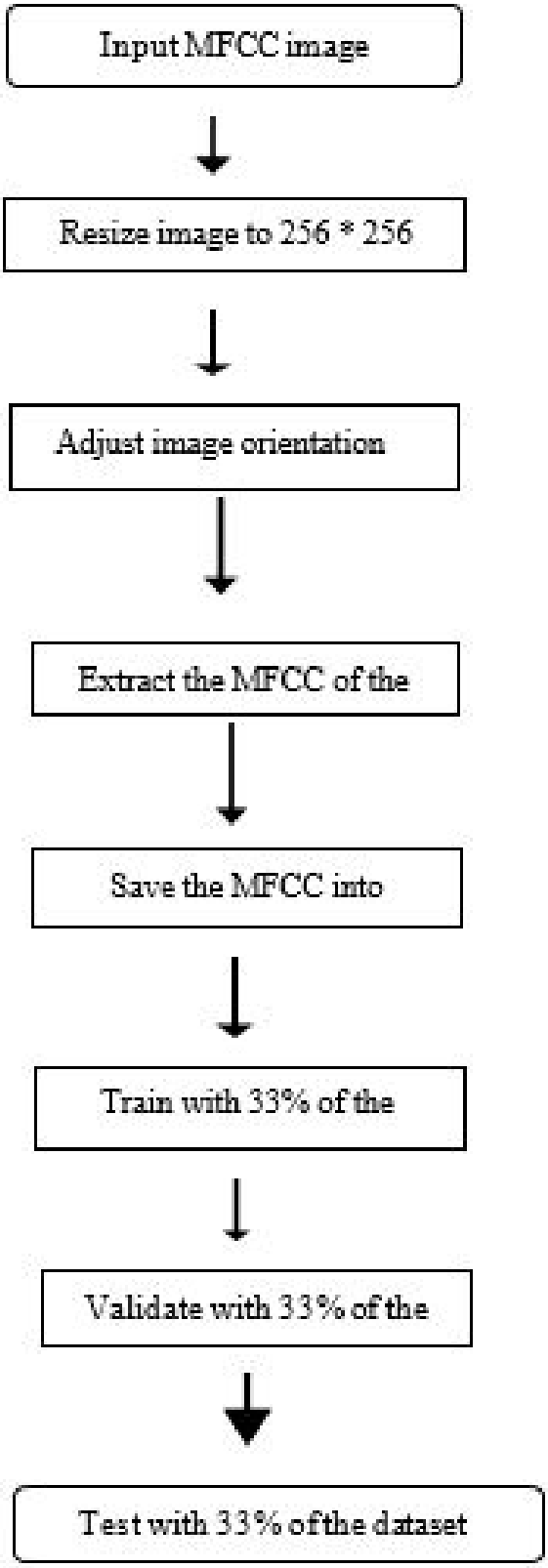

Figure 4: MFCC Feature Extraction Process

Experimental Results

Training the CNN on the training set and evaluating it on the test set for the CNN model yielded 99.46% accuracy with a small dataset, shown in the Figure 5.

```
Epoch 250/250
12/12 [==============================] - 58s 5s/step - loss: 0.0250 - accuracy: 0.9946
772
```

Figure 5: Resultant Accuracy

Testing with the validation dataset, which is data the model has not seen before, yielded an accuracy of 99.46%. Both of the Covid labels for the MFCC images in the validation dataset were correctly classified. The prediction result a Covid-19 MFCC image is shown in Figure 6.

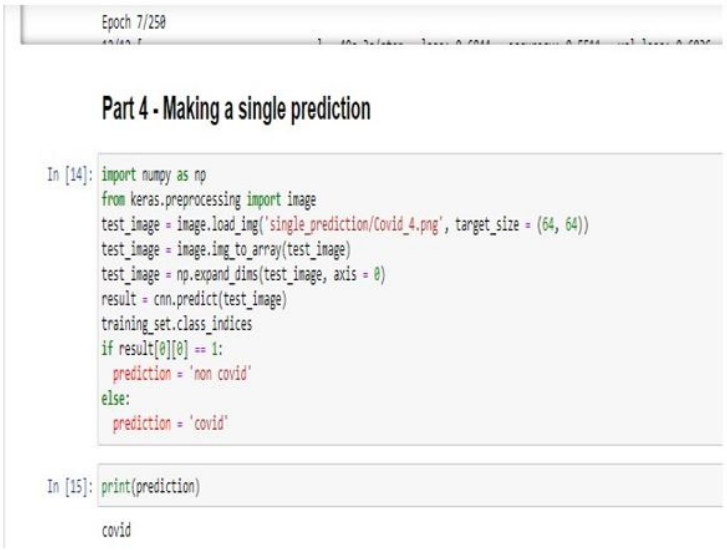

Figure 6. Prediction result

A comparison of our results against similar research workcan be seen in Table 1 below.

Table 1: Table of Comparison against similar research work

Classifier	Accuracy	Reference
Logistic Regression	65%	[6]
Random forest	70%	[7]
SVM	82%	[6]
CNN(Covid images)	96.76%	[8]
CNN (MFCC of coughs)	97.5%	[9]
CNN (MFCC of Covid images)	99.46	This Research

Conclusion

This research presents an advanced method for Covid-19 identification based on converting the Covid-19 image into one dimensional signal, then extracting MFCCs features of this modeled signal in the form of an image. Inthis research paper, the deep learning technique has been applied to clinical images of different types of respiratoryviruses (COVID-19). This shows the knowledge gained by model trained for detecting viral pneumonia can be transferred for identifying COVID-19 [8]. This makes theextraordinary work easier by using existing model for determining COVID-19. It is difficult to detect the abnormal features from images due to the noise impedance from lesions and tissues. For this reason, Mel Frequency Ceptral Coefficient (MFCC) feature extractionis consummated which focus only on the area of interest to detect COVID-19 out of CT image. The classifier used in this research demonstrated a high accuracy of 98.39% compared to the other studies, marginally outperforming a good acceptable results. In the field of biomedicals, Covid-19 detection is an essential and promising technology. Boundless work has been reported on Covid-19 identification and verification although the importance of Covid-19 image features [9]. There are many sole features in a Covid-19 image that can be used for pandemic identification. Covid-19 recognition based on extracting features is tedious work and requires high computational complexities. The obtained accuracy is better than that obtained of Logistic Regression, Random forest, SVM, CNN (applied to Covid images), CNN (applied to MFCC of Covid coughs). The obtained results are highly encouraging and provide further opportunities for researchby the academic community on this important topic.

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