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A Systematic Review and Analysis on Deep Learning Techniques Used in Diagnosis of Covid-19

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ABSTRACT—

Contagious diseases are very common and dangerous. To find out if they are infected, people must go to doctors directly or indirectly. Coronavirus disease and its different forms have had a big effect on the world in the last few years. In this work, a deep learning model is put into place that can use cough sounds to find COVID-19. You can find out if someone has a disease without having to touch them. For this study, more than 60 research articles are considered from various indexing sources. After several selection steps, finally a 31 quality research articles are included for detailed analysis. From this study, it is observed that majority of the research articles focused on DL techniques with cough audio signals. The classification of cough sounds helps doctors figure out what's way off the mark with the respiratory system. The COUGHVID dataset, which has cough sound files, is used. The sound is turned into spectrogram images, and then an auto encoder with an attention mechanism is used to pull out the features. The features are then fed into an algorithm that uses deep learning to figure out if a person is COVID positive or not. This model is utilized by either the medical professionals or the patients in order to do the initial disease diagnosis.

Keywords— COVID-19, Attention Mechanism, Spectrograms, Deep Learning, Contagious Diseases.

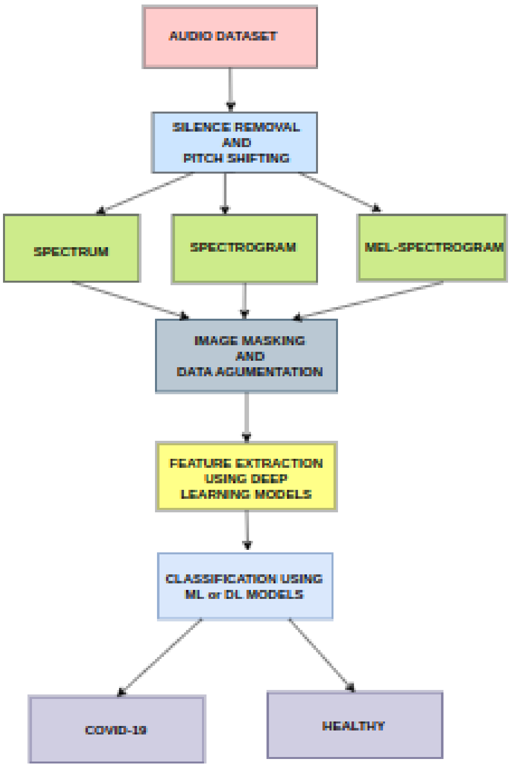
LITERATURE SURVEY

Skander Hamdi et al. [1] The major objective of this study was to predict the COVID-19 in the people by using audio signals and diagnosing the viruses without any human intervention. The COUGHVID dataset was used for this study which contains nearly 27550 samples of healthy, symptomatic, COVID-19 and other categories.The silence parts are removed from cough noises and Pitch-Shifting is applied on the audio files and then they are converted into mel spectrogram images.The features are extracted using CNN and then fed into Attention based LSTM which then passes through a convolutional layer to classify the cough noises. The study offers some important insights for the prediction of COVID-19 using cough at early stage and also it is used by doctors and patients for preliminary test. Despotovic et al. [2] This research describes the preliminary detection of COVID-19 from different feature sets which are extracted from cough patterns.The sound data for this study were collected from the human mouth using five vocal tasks which is proposed from COVID-19 Detection by Cough and Voice Analysis.The different feature sets are acoustic feature sets, wavelet scattering features and deep audio embedding's extracted from low-level feature representations (VGGish and OpenL3).The extracted features are then fed into random forests, boosted and bagged decision trees and Multi-Layer Perceptron (MLP) models for classification. Aly et al. [3] there are mainly two phases of this study 1. Sound-to-image transformation, which is improved by the Mel-scale spectrogram approach 2. Extraction of features and classification using nine deep transfer models.The Coswara dataset is used for this study which contains the audio samples collected in .wav format from 1600 people all over the world.The data augmentation is performed as there are limited samples available which contain the comparable properties of original data.This research implies that it may potentially be possible to successfully use deep learning to identify various respiratory disorders by using discrete hidden features of cough and breath tones.Tena et al. [4]The major objective of this study was to design a freely available, quick and efficient methodology for the automatic detection of COVID-19 in raw audio files.In this paper, a supervised machine-learning technique is utilized to automatically extract time-frequency cough variables and choose the most important ones to be employed in the diagnosis of COVID-19.The synthetic dataset and three additional publicly available datasets such as University of Cambridge, Coswara, Virufy datasets and also Pertussis dataset were used.The total of 39 time-frequency features are extracted and a set of features are selected which obtain best accuracy by first applying RFE and then auto encoder to each classification model.Fitting an RF model with the collection of time-frequency features chosen by RFE for differentiating COVID-19 coughs produced excellent results.Islam et al. [5]This research mainly uses cough sound samples and a deep neural network to create an algorithm for automatic and noninvasive diagnosis of COVID-19. There are mainly three primary parts of the suggested technique (a) extracting acoustic features from the cough sound samples, (b) creating a feature vector, and (c) classifying the cough sound samples using a deep neural network. Three acoustic feature vectors such as time-domain, frequency-domain, and mixed-domain are taken into consideration in this research. The considerable discrepancies for the frequency domain features suggest that the proposed approach can also be used to distinguish COVID-19 from cough samples from people with asthma and bronchiectasis. Sharmaet al. [6] This paper suggests that completing a detailed audio texture analysis of COVID-19 sounds may aid in carrying out the initial COVID-19 screening. The 5 classes were used for the textural analysis of cough and breath sounds: A healthy individual with and without a cough, a COVID-19 positive with and without a cough, a cough associated with asthma. 1141 samples of cough signals, 392 samples of breath signals, and 893 samples of speech signals were employed in this research. The local binary patterns (LBP) and Haralick's characteristics were derived from the signal's spectrogram in order to examine the audio textural behavior of COVID-19 sounds. Pahar et al. [7] The main purpose of this study is to perform an experimental research into the performance of transfer learning and bottleneck feature extraction in identifying COVID-19 from cough, breath, and voice recordings.The five datasets without COVID-19 labels are utilized for pre-training. The classification process made use of three sets of datasets of coughing audio with COVID-19 labels. The inner loops of the layered k-fold cross-validation technique were used to optimize the hyper-parameter optimization and evaluate performance.Our findings demonstrate that a pre-trained Resnet50 classifier that is either fine-tuned or utilized as a bottleneck extractor offers optimal or almost ideal performance across all datasets and all three audio classes**.** Mouawad et al. [8] The aim of this study is to automatically detect the COVID-19 using symbolic recurrence quantification measures with MFCC characteristics in healthy and sick people's cough sounds. The models are developed using the data gathered for the Corona Voice Detect project, collaboration between Voca.ai and Carnegie Mellon University.Symbolic RQAS are taken from the MFCC vectors that have been VMO-symbolized to make up the feature set. This research shows great promise for analyzing and automatically detecting COVID-19 from web-based audio samples of a person's vocalizations and coughs.Nguyen et al. [9] The aim of this study is to use a two-stage vision-based framework, namely Fruit-CoV, is introduced for detecting SARS-CoV-2(named Delta) infections through recorded cough sounds. Specifically, audio signals are converted into Log-Mel spectrograms. A mobile application that offers quick deployment and delivers precise outcomes in any circumstance. Therefore, a novel vision-based framework (namely Fruit-CoV) is proposed to tackle this problem in this study. A high average AUC score of 92.8% has been achieved with the proposed method. Loey et al. [10] The main objective of this study is to introduced a model that takes into consideration of two major steps. The first step is the transformation phase from sound to image that is optimized by the scalogram technique. The second step involves feature extraction and classification based on six deep transfer models. The accuracy is promising enough for a wide set of labeled cough data to test the potential for generalization. The outcomes show that ResNet18 is the most stable model to classify the cough sounds from a limited dataset. Dentamaro et al. [11] The net can fine-tune the features extraction stage and accepts raw audio files as input. Additionally, AUCO ResNet has been tested on the well-known Urban Sound 8K dataset, achieving cutting-edge accuracy without the need of any data preprocessing or data augmentation methods. The accuracy and AUC scores of AUCO ResNet consistently exceed all other methods, however transfer learning is the only method that can provide the highest generalization performance. Sobahi et al. [12] The main objective is to investigate the deep Yet another Mobile Network (YAMNet) model. The produced images are divided into COVID-19, healthy, and symptomatic classes using a pre-trained vision transformer (ViT) model. This work makes use of three publicly accessible cough sound datasets, COUGHVID, VIRUFY, and COSWARA. Lella et al. [13**]** For the automated diagnosis of COVID-19, the author of this research proposed a deep convolutional neural network (DCNN). For respiratory sounds (breath + cough), the crowd sourced covid-19 benchmark dataset is utilized. The deep features are extracted from enhanced data using multi-feature channels, such as the data De-noising Auto Encoder (DAE) methodology, GFCC (Gamma-tone Frequency Cepstral Coefficients), and IMFCC (Improved Multi-frequency Cepstral Coefficients) techniques. Asthma, COVID-19, pertussis, bronchitis, and healthy classes are classified using the features provided to the CNN algorithm. Han et al. [14] The author of this study used DNN to categorize the classes of healthy and COVID patients using audio recordings of healthy and COVID patients. Cough noises are used to extract three types of characteristics: time-driven features, frequency-driven features, and mixed features. The deep neural network model for classification trains and evaluates all the features. Pancaldi et al. [15] In this study, the author used VECTOR software to compile the lung sounds of 28 patients that were recorded in the emergency room of the university hospital of Modena (Italy) in December 2020. From audio signals frequency vs. time images are developed and LPC to extract features. Then the features are given to a binary classification algorithm using neural networks. Rao et al. [16] Convolutional neural network architectures, including the VGG-13 architecture and other recently suggested baselines on the DiCOVA 2021 COVID-19 cough audio dataset, were used in this investigation. Results demonstrate that a distinct ensemble of the VGG-13 architecture was learned using a mix of binary cross entropy and focal losses with data augmentation. With an average AUROC of 82.23%, this method can identify COVID19. Researchers successfully identified COVID-19 samples with an 80% accuracy rate and a 17% false positive rate. Aly et al. [17] The Coswara dataset, which contains recordings of 9 various types of noises, including coughing, breathing, and speaking and is tagged with the COVID-19 status, was employed in this study to improve performance in addition to respiratory sounds. A combination of models trained on numerous noises can diagnose COVID-19 more precisely than a single model trained on only breathing or coughing. The results show that simple binary classifiers may achieve an AUC of 96.4% and an accuracy of 96% by averaging the predictions of a number of models that were trained and evaluated separately on distinct sound types. Soltanian et al. [18] The Virufy dataset, one of the standards for Covid-19 cough detection and recognition, was employed by the author in this work. To extract features from audio signals, MFCCs are created from the record; they serve as the input layer for classification models. The proposed lightweight separable-quadratic convolutional network receives the MFCCs for classification of healthy and covid19. Kumar et al.[19]An approach for using hybrid deep fusion learning models for the early diagnosis of COVID-19 patients is proposed in this paper. Based on samples of chest X-ray images and Coswara cough (sound) samples of persons who may be infected, the framework conducts early patient categorization. After applying speech signal processing techniques to pre-process the recorded cough samples, deep convolutional neural networks are employed to extract Mel frequency cepstral coefficient characteristics from the data. Hoang et al. [20] In this paper, Light GBM model is used on the Coswara dataset. Light GBM is a gradient boosting framework based on decision trees to increases the efficiency of the model and reduces memory usage. Mel-frequency cepstral coefficients (MFCC) and delta features were retrieved in this. The Light GBM model with handcrafted, TRILL-based embedding features has an AUC score of 81.21. The sensitivity, precision, and F1 score for this Light GBM were 48.33, 59.18, and 53.21, respectively. Coppock et al. [21] For feature extraction and classification in this paper, conventional neural networks (CNN) and spectrum extraction are utilized. A subset of the dataset is employed, including 247 healthy persons, 226 bronchitis patients, and 70 COVID-positive individuals (Crowd-sourced data). Finally ,CIdeR has obtained a high AUC-ROC of 0.846. Pahar et al. [22] In this paper, the dataset is balanced by technique called synthetic minority over-sampling technique (SMOTE). Coswara dataset and sarces dataset are the two datasets utilized in this. By using the Leave-p-out cross validation approach, features are extracted. And MFCC, Fram, and seg are the hyper parameters utilized for extraction. The model introduced in this paper is LSTM+SFS(Sequential Forward Selection) and also obtained specificity of 96%, sensitivity of 91%,ACC of 92.91% and AUC of 0.938. Andreu-Perez et al. [23] The objective of this study is to assess the efficacy of a primary screening method for Covid-19 utilizing clinically validated sample cough sounds and laboratory molecular tests (qRT-PCR) from accredited laboratories. The suggested technique uses an Empirical Mode Decomposition (EMD)-based algorithm to identify cough sounds, followed by classification using a tensor of audio sonograms and the 30'DeepCough3D' deep artificial neural network classifier. Results from the "Cough Detect" online application we've suggested indicate good AUC (Area under Curve) values of 98.80% 0.83%, sensitivity values of 96.43% 1.85%, and specificity values of 96.20% 1.74%. The suggested approach performs better than comparable studies and other cutting-edge approaches, and it has the potential to dramatically slow the Covid-19 epidemic. The study also explores the potential use of qRT-PCR and lymphocyte count to quantify the amount of the Covid-19 infection. Dash et al. [24] in this paper, the datasets used are coswara, crowd-sourced, virufy, COUGHVID and recorded interviews from online platforms in telephone quality speech. The feature extracted from Spectral Features, Cepstral features, Spectral Descriptors and Periodicity Features. Light GBM was utilized as the classifier in this study, and the stratified K-fold cross-validation test showed that the suggested model performs 97% accuracy. This model's performance matrices have AUC values of 0.989, F2 values of 0.983, and PR values of 0.983. Grant et al. [25] the proposed model in this paper is Multilayer perceptron model. The dataset consists of 11 participants with 5 COVID-positive and others are COVID-negative (Crowd sourced dataset). The features that were extracted for feature extraction were Mel-frequency cepstral coefficients (MFCC) and Relative Spectral Perceptual Liner Prediction (RASTA-PLP). The suggested model had a low complexity AUC-ROC of 0.79. Hasan et al. [26] This paper focuses on how artificial intelligence might help battle the COVID-19 epidemic. AI-based algorithms incorporated into wearable technology were successful in detecting and anticipating COVID-19. The paper investigates different AI models for COVID-19 prediction, including supervised, unsupervised, and few-shot learning. The accuracy and sensitivity performances of COVID-19 prediction models, object identification approaches, and picture segmentation methods are demonstrated in thorough comparisons. In this work, COVID-19 analysis was carried out using transfer learning techniques such as ResNet, DenseNet, VGG, Inception, AlexNet, and CNN. In the fight against COVID-19, future research should concentrate on examining AI methodology, enhancing the fairness of frameworks and large-scale datasets, and combining low latency, low power consumption, and strong privacy for AI applications. Sharan et al. [27] In this paper, a hybrid model called SincNet-BiGRU is suggested, where BiGRu is a model for sequence processing made up of two GRUs. one processing the information forward and the other processing it backward. Only the input and forget gates are present in this bidirectional recurrent neural network. The features extraction is done by MFCC and ERB. And the dataset consists of 400 audio recordings, containing more than 72,000 cough and non-cough frames. When the MFFC and ERB features of the model were processed independently, SincNet-BiGRU with ERB obtained higher accuracy and AUC than MFCC. SincNet-BiGRU (ERB) has an accuracy of 0.9496 and an AUC of 0.9866. Wang et al. [28] The COVID-19 pandemic demands early discovery as a practical means of limiting the virus's transmission. There are issues with existing diagnostic techniques like RT-PCR and LFIA, such as insufficient samples and mistakes in detection. Accurate, quick, and visually appealing COVID-19 detection techniques need the use of splitting materials and technology. This study gives new instances based on various output signals, outlines current approaches for SARS-CoV-2 diagnosis, and analyses limitations. Future test development should concentrate on overcoming restrictions and enhancing the COVID-19 diagnostic techniques' accuracy, speed, and usability. Kranthi Kumar et al. [29] In this paper, Deep CNN (with Max-Pooling) and Deep CNN (without Max-Pooling) are proposed models. KDD-data, ComParE2021-CCS-CSS Data, and NeurlPs2021-data are the datasets utilized in this. MMFCC (Modified Mel-Frequency Cepstral Coefficients), Log-Mel Spectrum, and Soft-Mel Spectrum are the features channels that are employed. Deep CNN with MMFCC (without Max-Polling) provides greater accuracy than the other. The suggested model has a 97% accuracy rate. Vijayakumar et al. [30] This study provides a foundation for thinking beyond the usual clinical diagnosis and identifying the condition at least in the early stages in a matter of seconds, considering the accumulation of COVID cough data. In order to determine hacks, our suggested machine learning-based framework is ready to use 8 COVID hack tests, 28 pneumonia, 15 pertussis, and 30 common hack noises. This has fairly been used as a validation of the idea to give the applicability of the machine learning and deep learning techniques in the preparation of diagnosing COVID. Deshpande et al. [31] in this paper, an overview of studies on human auditory signals using 'Artificial Intelligence' techniques to detect, monitor, and raise awareness of COVID-19 is provided. The various algorithms are employed in audio processing created for the C19 screening and diagnosis. Based on the clinical validation of the data gathered and analyzed, all efforts are classified as “non-clinical” and “clinical”. This model will be helpful for creating automated systems that can support COVID-19 by utilizing unobtrusive and simple to use bio-signals transmitted in human non-speech and speech audio creations.

METHODOLOGY

The COUGHVID dataset, consisting of approximately 27,550 audio samples, has been used in this study. The dataset contains various categories, including healthy, symptomatic, COVID-19, and others. Empty cough noises were removed from the dataset, and a threshold value was used to compress the audio files. The compressed audio files were subjected to pitch shifting, and then converted into spectrogram images. This process likely helped to enhance the features of the cough sounds and make them more easily distinguishable between the different categories. Further analysis and evaluation of the resulting spectrogram images would be necessary to determine their effectiveness in accurately detecting COVID-19.

After converting the audio files into spectrogram images, image masking was performed to identify the pure points. This process likely involved identifying and masking out any background noise or irrelevant elements in the images to highlight the important features of the cough sounds. Additionally, data augmentation techniques were employed to create slightly modified copies of the images, likely with the goal of increasing the diversity of the dataset and improving the performance of the model. These techniques could include flipping or rotating the images, adjusting the brightness or contrast, or adding noise to simulate different recording conditions. By augmenting the dataset, the model would have more examples to learn from and potentially improve its ability to accurately classify cough sounds. However, the effectiveness of the data augmentation techniques would need to be evaluated through testing and validation.



FLOW CHART FOR THE PROPOSED METHODOLOG

Once the spectrogram images were processed through image masking and data augmentation, they were fed into deep learning models to extract informative features. These features likely capture the key characteristics of the cough sounds and are then passed to a deep learning or machine learning model for classification, specifically distinguishing between COVID and non-COVID cases. The proposed model has the potential to be useful for doctors and patients as an initial screening tool, allowing for early detection and treatment of COVID-19. However, it is important to note that further research and evaluation is needed to assess the accuracy and reliability of the proposed model, as well as its practical application in clinical settings.

CONCLUSION:

Early detection of infectious diseases is crucial in preventing their spread. COVID-19, being highly contagious, is particularly important to identify and treat in its early stages. A proposed approach to detect COVID-19 is through analyzing cough sounds, which would limit the need for human intervention and could be beneficial for both doctors and patients. This method could help control the spread of the virus by allowing for early detection and isolation of infected individuals. However, further research is needed to evaluate the efficacy of this approach.

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