Singaporean Journal of Scientific Research(SJSR)
An International Journal (AIJ)
Vol.16.No.1 2024,Pp.43-47
ISSN: 1205-2421
available at :www.sjsronline.com
Paper Received : 04-08-2024 Paper Accepted: 05-10-2024
Paper Reviewed by: 1.Prof. Cheng Yu 2. Dr.Yarab Baig
Editor : Dr. Chen Du Fensidal

Croup Cough Detection and Classification by using Cough Sound using Deep Learning Methods- A Survey

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Abstract

Reliable and rapid non-invasive testing has become essential for COVID-19 diagnosis and tracking statistics. Recent studies motivate the use of modern machine learning (ML) and deep learning (DL) tools that utilize features of coughing sounds for COVID-19 diagnosis. In this paper, we describe system designs that we developed for COVID-19 cough detection with the long-term objective of embedding them in a testing device. More specifically, we use log-mel spectrogram features extracted from the coughing audio signal and design a series of customized deep learning algorithms to develop fast and automated diagnosis tools for COVID-19 detection. Croup cough is an infection in the upper airway typically occurs in children from age six month to 3 years. Symptoms of croup cough begin with a normal cold, fever and loud barking makes the child difficult to breath. These symptoms are relatively similar with a recent pandemic SARS-CON2. So, the common symptoms of croup cough and SARS-CON2 is urges the physicians to diagnose the infection at early stage. Typically, clinical professions Computer Aided Diagnose system (CADS) for detecting the abnormalities from chest X-Ray (PA Niew) and CT images of infants. Most of CADS adopted the deep learning technique for classification of radiograph images due to the its ability in term of accuracy rate. Classification accuracy of deep learning techniques like Deep Neuro Fuzzy Logic highly relays on the weights of convolution filters and fully connected layer. In this work, we propose the optimized Deep Neuro Fuzzy Logic using Genetic algorithm (GA) for classification of croup cough images. This work includes optimizing weights of Deep Neuro Fuzzy Logic (DNFL)with different batch size and iterations using genetic algorithm to identify the best weights for the classifier to generate maximum accuracy.

Keywords: Deep Learning, Croup Cough, Classification, respiratory diagnosis, Fuzzy Logic Algorithm

1. Introduction

Kids with laryngotracheobronchitis (Croup) is caused by a virus that causes the airways to inflate. Those who have a peculiar “barking” cough (commonly equated to the sound of a seal's bark) as well as a scratchy voice, and when they inhale, they emit a high-pitched, squealing noise. Breathing becomes much more difficult if the bronchi remain to enlarge. Stridor is a high-pitched or squeaking sound made by children when they breathe in. They may also have rapid breathing or retractions (when the skin between the ribs pulls in during breathing). Leading to a shortage of oxygen, a kid may seem pale or have a blue tint around the mouth in the most acute cases. The importance of addressing this disease by taking consideration of the increasing trend of CONID-19 among pediatrics around the world and coughing is the early sign of both Croup cough and CONID-19[1]. Although reverse transcriptase-polymerase chain reaction (RTPCR) testing is generally adopted, coughing sounds have been found to reveal useful signatures pertaining to COVID-19 which can be used to facilitate rapid, non-invasive, and reliable screening methodologies [2]. For example, the authors of [3] curated the Coswara dataset consisting of cough samples collected from subjects who either tested positive or negative for COVID- 19.

2. Related work

In this section, related works of CNN based medical image Classification methods and optimization technique using genetic algorithm. Han J, Brown C & co Brown et al. [18] used ML based algorithms to distinguish between healthy and COVID-19 cough sounds using crowdsourced data. The authors gathered data using their own “COVID-19 Sounds” web and Android app where 141 COVID-19 samples and 350 healthy samples were selected for training. Classical audio features including root mean square energy (RMSE), mel-frequency cepstral coefficients (MFCCs) and spectral centroids were used for training logistic regression/ support vector machines (SVMs) classifier models. The authors report an average AUROC metric of 80% for the different tasks reported in their study.

Shuja *et al.* [10] had surveyed the most relevant papers that employed artificial intelligence for analyzing COVID-19 from CT-scan image, cough sound and x-ray to create a database for diagnosing and preventing the disease. Also, their research compared the relevant work and set challenges and future direction in the field. They recommended that most of the health providers use technology like image scanning and cough sound analysis via application to protect the forefront workers and find a way to protect the privacy of the patients who shared their data.

Imran et al. [2] developed tools that utilize CNNs trained with mel spectrograms for cough detection followed by model ensembling to determine whether or not the sample belonged to a COVID-19 patient. In this study, the authors gathered cough samples from patients diagnosed with COVID-19, bronchitis, and pertussis. 48 COVID-19, 102 bronchitis, 131 pertussis, and 76 healthy samples were used in order to train their algorithm. The algorithm consisted of three separate classifiers, namely, a deep learning-based multi class classifier, classical ML based multi class classifier, and deep learning based binary class classifier. The authors report accuracies of 93.56%, 94.06%, and 88.89% for these classifiers, respectively. They also developed an app, “AI4COVID-19”, in order to allow users to interface with their AI-based COVID-19 detection algorithm

Rao S, Katoch S and co by MIT’s Open Voice Team has further validated the practicality of detecting COVID-19 using cough samples powered by deep neural networks and have reported significantly higher sensitivity and specificity metrics. Their model was trained and verified using 2,600 COVID-19 positive audio samples and 2,600 COVID-19 negative audio samples. The authors extract MFCC features which are then passed through a CNN architecture built upon the designs in [39,40]. At a sensitivity of 98.5% and a specificity of 94.2%, the authors achieved and AUROC metric of 97%.

Esposito M, Rao S & co , we use an ensemble of four deep models namely CNNs, Recurrent Neural Networks (RNNs), Gated CNNs (GCNNs), Gated Convolutional Recurrent (GCRNNs) for COVID-19 cough detection on the DiCOVA 2021 dataset. However, the average validation accuracy obtained using the stacked approach was only 65%. In this paper however, we find that in addition to model ensembling or fusion strategies, the careful choice of loss functions and meaningful data augmentations was critical in improving the overall generalization performance (improved accuracies and AUROC scores on the validation folds and the blind test dataset) of the VGG-13 convolutional architecture under limited data scenarios.

Xiaowei Xu & co ,The deep learning techniques are utilized to monitor distinguishes between corona virus pneumonia using Computed Tomography (CT) images [20].

Mesut To˘gaçar & co, COVID-19, pneumonia, and X-ray image data classes are applied to fuzzy coloring technique for preprocessing step. The preprocessing datasets are trained with DL models such as MobileNetV2, SqueezeNet. Finally the support vector machine is used to classify and extract the data feature result of COVID-19 virus detection up to 99.27 % accurately [21].

Ali Abbasian Ardakani & co ,To distinguish between corona virus and Non corona virus group the 10 convolution neural network techniques are utilized. Among all these networks ResNet-101 and Xception both was achieved better performance with an AUC of 0.994. But the radiologist performance is moderate with an Area Under the Curve (AUC) of 0.873 [22].

Shuja J & co In a recent survey [23], numerous studies and open source datasets on CT have been examined. According to [23], it is reported that open cough-based COVID-19 datasets are few and their sizes are small.

Tawfik et al. (2022) [18] proposed a smart system based on deep learning to detect COVID-19 patient's using cough sounds. The suggested system is divided into three phases: noise reduction in audio pre-processing, segmentation, feature extraction, classification, and model deployment. Eight characteristics, including 573 COVID-19 positive and 1062 COVID-19 negative coughs, were retrieved from 1635 sound subjects. The authors used Convolutional Neural Network model to detect Covid-19 and achieved an accuracy of 0.985. After deployment, the models were 6 assembled to function as a flask-based web service. The cough model takes in the sound of a cough via a mobile app or online interface and determines whether it is present before passing it on to the coivd1-9 model to determine whether the cough is positive or negative. Then return the outcome to the mobile application.

Gupta et al. (2022) [19] studied early detection of COVID-19 based on cough sounds and machine learning algorithms. They tested the effectiveness of 10 different machine learning methods for the automatic detection of COVID-19. For cough sounds of new patients, the suggested stacked ensemble of machine learning models performs best, with an accuracy of 0.7986 and an area under the area under curve of 0.797. For the validation of the research, the authors used COUGHVID dataset. More than 25,000 cough recordings are available in the COUGHVID collection, which primarily includes participants from different sexes, COVID-19 statuses, age groups, and geographical areas [20].

Han et al. (2021) [24] proposed a voice-based framework to detect Covid-19 positive cases automatically and evaluated its performance on a subset of data crowdsourced from the 'Covid-19 Sound App.' The InterSpeech 09 Computational Paralinguistics Challenge (COMPARE) set, openSMILE toolkit, MFCCs features, and SVM with linear kernel as the classifier were used by the authors. Users were asked to record information in the App by submitting their breathing, coughing, and voice samples, as well as reported symptoms, if any, and providing some basic demographic and medical information while using the App. The authors reported an AUC of 0.79 on 828 samples (326 Covid-19 positives and 502 Covid-19 negatives), with a sensitivity of 0.68 and a specificity of 0.74. Other studies highlight the use of common machine learning classifiers, 8 such as Neural Networks (NNs), Support Vector Machines (SVM), Random Forest (RF), and Logistic Regression, in addition to handcrafted features (LR).

Methods

Since the deficiency of data can cause overfitting, we increased the data (data augmentation) to be learned by artificial intelligence with a standard method. According to the data augmentation standard, the data should be changed in such a way that the quality and nature of the data do not change, because it can cause a fundamental change in the data. In the data used in model training, the speed of the audio signal was changed with different rates (0.8–1.10 times) and the pitch Frontiers in Artificial Intelligence 02 frontiersin.org Askari Nasab et al. 10.3389/frai.2023.1100112 of the audio signal was changed with different steps (−2.5 to 2.5 times). There was no change in the test data.

Data collection

From January 2021, data related to cough of people with COVID-19 was recorded and collected using the online site "sorfeh.com/sendcough/en." In order to increase the number of data, the contact information of patients with COVID-19 was received through laboratories, hospitals and infectious specialists. During this process, the data was collected after the patient's consent and having the required conditions. The conditions for the patient to enter the study include a positive PCR test, or CT Scan diagnosis of lung involvement by CT scan, or a definite diagnosis of corona virus by a physician based on clinical examinations, and no more than 8 days have passed since the definite diagnosis of COVID-19. People admitted to the hospital were excluded from the study because usually more than 8 days have passed since the duration of the illness of the hospitalized people and their coughs could be pulmonary complications after COVID-19 and not related to COVID-19.

Experimental Designs

The importance and benefits of conducting this study include reducing the workload of medical and health staff, especially during the peak of the outbreak of COVID-19, identifying more patients and reducing diagnostic and treatment costs, especially in less developed countries. Diagnosis and screening in this method is very simple and people will not have any worries about doing it, so more patients can be identified and prevent the spread of the disease. Also, according to the diagnostic method of this study, the workload of health and treatment staff is reduced and the staff can devote their time and energy to treating patients, which can also have a positive effect on increasing the number of recoveries of COVID-19 patients.

Conclusions

Recent advances in the healthcare domain demand revolutionized practices. There is an unprecedented interest towards data-driven processes to unleash the computing power that AI can provide. Machine Learning-based frameworks are being leveraged for the general diagnosis of virulent maladies. By gathering these studies, this survey provides a comprehensive study on the existing literature on detection and preliminary diagnosis of the respiratory diseases with the aid of cough sounds and AI- based models. Moreover, this survey presented methodologies, data collection procedures, and analyzed objective assessment algorithms, that are employed in the reviewed studies. Additionally, it also analyzed the studies in the broad categories, i.e., detection and diagnosis using cough acoustic and then by using similar sounds (lungs sounds, breathing, auscultations, and snoring). The study concludes that AI-powered solutions demonstrate promising potential for developing innovative clinical decision assistance and diagnostic tools that can help the healthcare community and policy makers to revitalize the existing healthcare practices.

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