
DEEP LEARNING MODEL FOR DETECTING COVID-19 THROUGH COUGH SOUNDS

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ABSTRACT:

Increased potentiality in screening and early testing for a disease can significantly support extinguish its spread and impact. The research work is to develop a deep learning based audio file clustering system for easy and fast diagnosis of COVID-19 cases. We are establishing deep learning AI models to analyze cough sounds as a prescreening tool for COVID-19. Cough-based analysis is non-invasive, cost-effective, scalable, and, if approved, could be a potential game-changer in our fight against COVID-19.

Our expected practical AI models will learn convoluted acoustic features to differentiate between cough sounds from Covid-19 positive patients and other healthy patients. This is beneficial because, while someone may not have observable symptoms, the virus may still cause exquisite changes in their body that may be detected by distinct algorithms connecting audio signal processing and machine learning. Our system can take cough samples from any audio devices like phones or mobile phones also. When any one call us on a given number for COVID-19 diagnosis, the system will pass on the cough sample file to Deep Learning based clustering model. The model will attach it to a cluster if the assigned cluster has some COVID-19 positive patents then an alarm signal will be generated for that person. So our proposed system will make sample collection and infection detection very fast and automated. Anyone can get its diagnosis by just giving his/ her cough sample over phone call.

Keywords: - Deep learning, COVID-19, Sound

INTRODUCTION

Again and again, experts have appealed that we need more and faster testing to have control on the corona virus pandemic and many have recommended that artificial intelligence (AI) can help. Coughing and sneezing were accepted to be the symptoms of the bubonic plague pandemic that demolished Rome in the late sixth century. The flu-like symptoms associated with the plague co-occur during the current Covid-19 pandemic as well to the extent where “normal” coughs have drawn immediate alarm and concern. We can now build sophisticated and refined AI models that learn complex audile features to differentiate between cough sounds from Covid-19 positive and otherwise healthy patients.

Since the dawn of the Covid-19 pandemic, multiple AI research teams have been working towards leveraging AI for enhancing screening, contact tracing, and diagnosis. Most of the foundation work involved CT or X-ray scans to diagnose Covid-19 faster and, in some cases, for better efficiency the RT-PCR test is taken. Recently, AI researchers have started testing cough sounds for initial diagnosis or a prescreening technique for Covid-19 detection in asymptomatic individuals. This is valuable because, while someone may not be having observable symptoms, the virus may still cause slight changes in their body that may be detected by specific algorithms merging audio signal processing and machine learning. This technology might also prove to have better efficiency than the standard strategy of prescreening for Covid-19 on the basis of temperature, especially for asymptomatic patients.

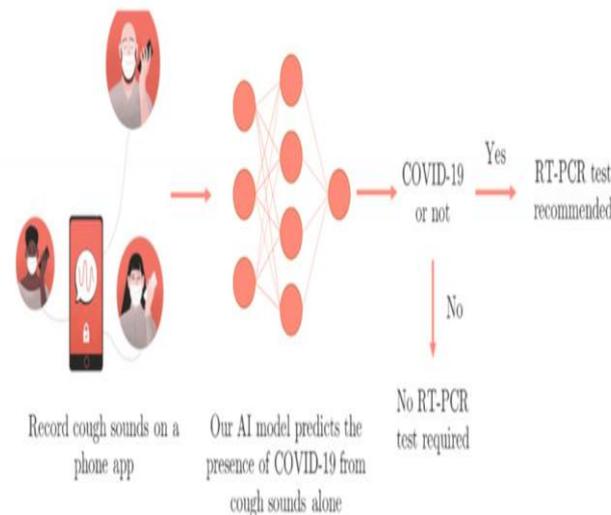
Cough is, unfortunately, a common symptom of many respiratory and non-respiratory diseases which are mentioned below. Hence, an AI model must also learn how to differentiate between the coughs related to Covid-19 from the coughs caused by other respiratory ailments. The prediction of such AI

models could be considered as such or could be further demonstrated by other clinical tests, for instance, an RT-PCR screening test.

Non-COVID-19 medical conditions that can cause cough.

RESPIRATORY	NON-RESPIRATORY
Upper respiratory tract infection (mostly viral infections)	Gastro-esophageal reflux
Lower respiratory tract infection (pneumonia, bronchitis, bronchiolitis)	Drugs (angiotensin converting enzyme inhibitors; beta blockers)
Upper airway cough syndrome	Laryngopharyngeal reflux
Pertussis, parapertussis	Somatic cough syndrome
Tuberculosis	Vocal cord dysfunction
Asthma and allergies	Obstructive sleep apnea
Early interstitial fibrosis, cystic fibrosis	Tic cough
Chronic obstructive pulmonary disease (emphysema, chronic bronchitis)	Smoking
Postnasal drip	Foreign body
Croup	Mediastinal tumor
Laryngitis	Air pollutants
Tracheitis	Tracheo-esophageal fistula
Lung abscess	Left-ventricular failure
Lung tumor	Congestive heart failure
Pleural diseases	Psychogenic cough
Interstitial lung disease	Idiopathic cough

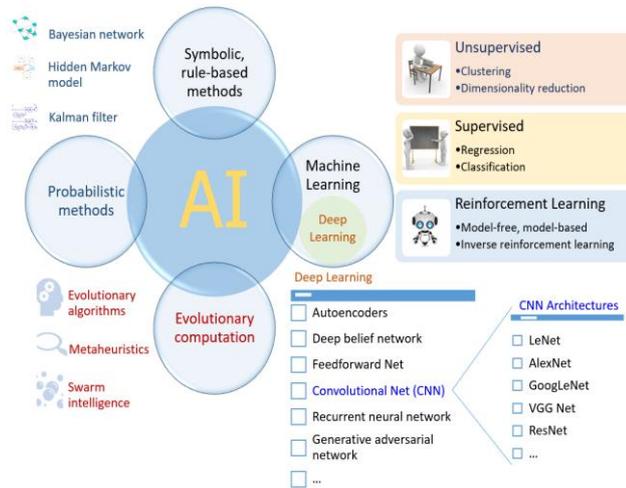
An overview of AI pre-screening App by “cough against Covid-19” project is shown below:



LITERATURE SURVEY

In a paper published recently in the IEEE Journal of Engineering in Medicine and Biology, the team reports on an AI model that differentiating asymptomatic people from healthy individuals through forced cough recordings, which people have willingly submitted through web browsers and devices such as laptop and cell phones. On the other hand, MIT researchers have also found that people who are asymptomatic may differ themselves from healthy individuals only in the way that they cough. These differences are not noticeable from the human ear. But it turns out that they can be picked up by Artificial Intelligence. So as a result of above mentioned researches and many other researches, the researchers have trained the model on tens of thousands of samples of cough as well as spoken words. It has also accurately identified 98.5% of coughs who were confirmed to have COVID -19, including 100% of coughs who were asymptomatic, with 83.2 percent success identifying negative cases. The team is also working on incorporating the model into a user-friendly app, which if FDA approved and adopted on a larger scale be free, convenient, non-invasive pre-screening tool to identify people who are likely to be asymptomatic for COVID-19. “The effective implementation of this group diagnostic tool could diminish the spread of the pandemic if everyone uses it before going to a classroom, a factory, or a restaurant,” says co-author Brian Subirana, a research scientist in MIT’s Auto-ID Laboratory. Back in June, Imran and colleagues were able to develop an AI model to

identify asymptomatic coughs and sift through those confounding factors to distinguish COVID -19 coughs from the cough sounds of bronchitis, whooping cough, and asthma with overall 90 percent accuracy. Sound-based tools could also be used as an early warning system, in which coughs across a population are detected via hospital recordings or home smart speakers to pick up early signs of infection of a new disease.



PROBLEM DOMAIN

AI has contributed in dealing with the corona virus diseases (COVID-19) pandemic, which has been happening around the globe. The novel corona virus disease has created tremendous chaos around the world, affecting people lives and causing a large number of deaths. Government of many countries has proposed intervention policies to mitigate the impacts of the COVID-19 pandemic. To overcome the pandemic and chaos created by corona virus researchers are facing two major issues which are mentioned below:-

- Limited access to COVID -19 coughs events.
- Clinical data acquisition is currently unrealistic.

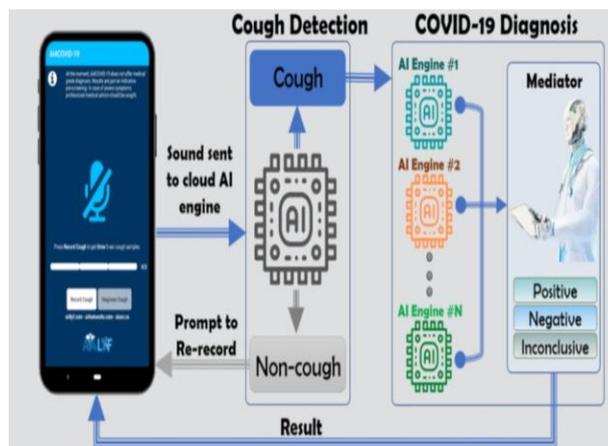
Limited access is available because this virus is highly transferable and cannot be controlled without following social distancing. On the other hand, to access the clinical reports and to study the patient’s symptoms clinical reports and data should be studied which are not available in the current scenario. To control this spread of virus Novel Corona Virus Cough Database should be collected for the deep learning process for creating cough detecting machine algorithm. One of the significant challenges is the availability of the right quantity and quality of data to build an AI model that can make robust predictions about the underlying medical ailment based on cough sounds.

PROPOSE METHOD

Prior to the pandemic’s onset, research groups already had been training algorithms on cell phone recordings of coughs to precisely diagnose conditions such as pneumonia and asthma. In similar manner, the MIT team was developing AI models to analyze forced cough recordings to see if they could detect signs of Alzheimer’s, a disease associated with not only memory loss but also neuromuscular deterioration such as weakened vocal cords. They first trained a general machine-learning algorithm, or neural network, known as ResNet50, to differentiate sounds associated with different degrees of vocal cord strength. Researchers trained the neural network on an audio book dataset with more than 1,000 hours of speech, to pick out the word “them” from other words like “the” and “then.” The team trained a second neural network to distinguish

Emotional states visible in speech. The researchers developed an opinion speech classifier model by training it on a large dataset of actors presenting emotional states, such as neutral, calm, happy, and sad. The researchers then trained a third neural network on a database of coughs in order to determine changes in lung and respiratory performance. Finally, the team combined all three models, and superimposed an algorithm to detect muscular degradation. With their new AI framework, the team fed in audio recordings, including of Alzheimer’s patients, and found it could identify the Alzheimer’s samples better than existing models. The results showed that, together, vocal cord

strength, sentiment, lung and respiratory performance, and muscular degradation were effective biomarkers for diagnosing the disease. In the month of April, the team set out to collect as many recordings of coughs as they could, include those from Covid-19 patients. They developed a website where people can record a series of coughs, through their cell phones or other web-enabled device. Participants also fill out a survey of symptoms they are experiencing, whether or not they have Covid-19, and whether they were detected through an official test, by a doctor's assessment of their symptoms, or if they have self-diagnosed it. To date, the researchers have collected more than 70,000 recordings, each containing several coughs, approximately to some 200,000 forced-cough audio samples. Around 2,500 recordings were submitted by people who were confirmed to have Covid-19, including those who were asymptomatic. The team have used the 2,500 Covid associated recordings, along with 2,500 more recordings that they randomly selected from the collection to balance the dataset. They used 4,000 of these samples to train the AI model. The remaining 1,000 recordings were then fed into the model to see if it could accurately determine coughs from Covid patients versus healthy individuals. The AI model is not meant to diagnose symptomatic people, as far as whether their symptoms are due to Covid-19 or other conditions like flu or asthma. The tool's strength lies in its ability to detect asymptomatic coughs from healthy coughs. The team is working with a company to develop a free pre-screening app based on their AI model. They are also partnering with several hospitals around the world to collect a larger, more diverse set of cough recordings, which will help to train and strengthen the model's accuracy. Once an AI model is trained, it can be integrated into a user-friendly app where users can log in and submit their cough sounds via their phones to get instant results. The model prediction can be used to ascertain whether a user might be infected and follow-up to confirm with a formal test like RT-PCR.\



The above figure shows an overview of the architecture developed by the AI4covid-19 team. It includes a cough detection model to check the quality of the cough sound and prompts the user to re-record in case of noisy recording or non-cough sound. The detected cough is then sent to Covid-19 diagnosis model to differentiate between a cough from a Covid-19 positive and negative patient.

CONCLUSION

The preliminary results of most of the teams look promising and confirm the assumption that cough sounds contain unique information and latent features to aid diagnosis and prescreening for Covid-19. The MIT lab has collected around 70,000 audio samples of different coughs with 2,500 coughs from confirmed Covid-19 positive patients. The trained model has correctly identified 98.5% of the people with Covid-19 and has correctly ruled out Covid-19 in 94.2% of people without the disease. For asymptomatic patients, the model correctly identified 100% of people with Covid-19, and correctly ruled out Covid-19 in 83.2% of people without the disease. Cambridge's Covid-19 sounds project reported an 80% success rate in July 2020. In spite of the similar audible modeling pipeline and deep learning approaches, it is difficult to compare these preliminary results across these projects as each AI model is trained using distinct datasets. Since cough also co varies with age and gender, it

is important to collect diverse data to make any AI solution generalized across patient populations around the world and accepted as a standard non-invasive prescreening tool for Covid-19.

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