QUCoughScope: An Artificially Intelligent Mobile Application to Detect Asymptomatic COVID-19 Patients using Cough and Breathing Sounds

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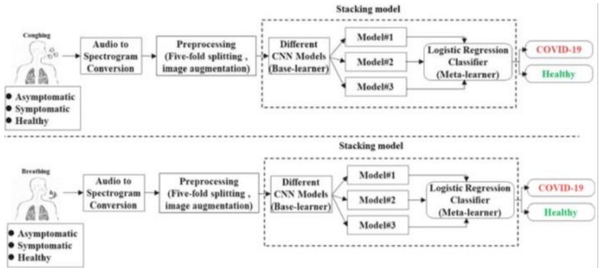
INTRODUCTION



The COVID-19 pandemic has made mass testing crucial to reduce the spread of the virus, as many infected individuals may not display symptoms. The primary diagnostic tool, RT-PCR, is invasive and resource-intensive.
Recent research suggests that asymptomatic patients cough and breathe differently from healthy individuals. This paper aims to use machine learning to detect COVID-19 patients (symptomatic and asymptomatic) from home, reducing the burden on the healthcare system and minimizing the spread of the virus.

METHODS

A research group from Cambridge University has shared a dataset of cough and breath sound samples from healthy and COVID-19 patients to develop a real-time deep learning- based backend server with a web application to screen for COVID-19 infection from the comfort of the user's home. The proposed system includes two different pipelines for screening asymptomatic and symptomatic patients, using a stacking CNN model based on spectrograms generated from breath and cough sounds.

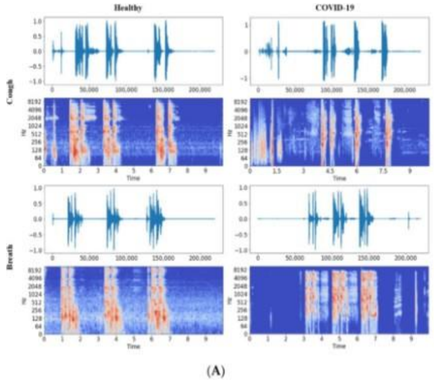


Figure 1 Cough and breath sound waveforms and spectrograms for **(A)** symptomatic and **(B)** asymptomatic healthy subjects and COVID-19 patients.

METHODS

Several public datasets are available such as Coswara [50], CoughVid [60], and Cambridge dataset [57]. However, the Cambridge dataset was not completely public, the team has made it available upon request. Among the accessible dataset, the Cam-bridge dataset was most reliable as that was acquired in a well-designed framework. Moreover, the authors have collected a similar coughs and breath dataset from COVID-19 infected and healthy patients with our proposed framework.

Experiments	Healthy		COVID-19	
	Cambridge	QU	Cambridge	QU
Symptomatic (Cough/Breath)	264	32	54	18
Asymptomatic (Cough/Breath)	318	213	87	78
Total	582	245	141	96

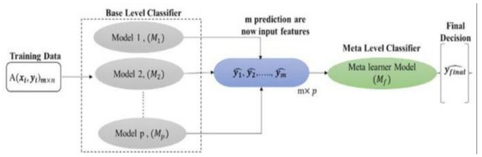


Figure 4 Stacking model architecture.

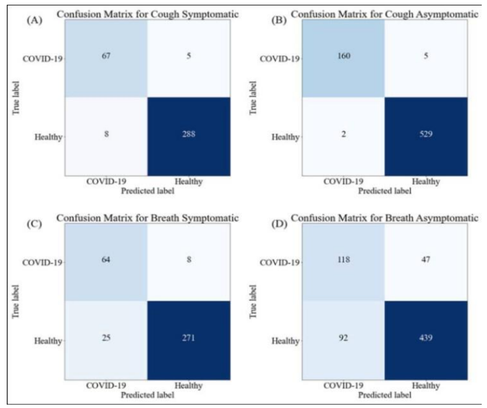


Figure 2 Confusion matrices for healthy and COVID-19 classification using cough sounds for **(A)** symptomatic patients and **(B)** asymptomatic patients, and using breath sounds for **(C)** symptomatic patients and **(D)** asymptomatic patients using best performing stacking CNN models.

RESULTS

The proposed stacking CNN model showed the best classification performance for binary classification using cough sound spectrogram images, with high accuracy, sensitivity, and specificity for both symptomatic and asymptomatic patients. However, the metrics were lower for breath sound spectrogram images, particularly for asymptomatic patients.

The proposed stacking CNN model achieved an accuracy of 96.5%, sensitivity of 96.42%, and specificity of 95.47% for symptomatic patients, and an accuracy of 98.85%, sensitivity of 97.01%, and specificity of 99.6% for asymptomatic patients using cough sound spectrogram images. For breath sound spectrogram images, the model achieved an accuracy of 91.03%, sensitivity of 88.9%, and specificity of 91.5% for symptomatic patients, and an accuracy of 80.01%, sensitivity of 72.04%, and specificity of 82.67% for asymptomatic patients. The dataset used for the study included 582 healthy and 141 COVID-19 patients, of which 87 were asymptomatic and 54 were symptomatic. An additional dataset was collected from 245 healthy individuals, 78 asymptomatic COVID-19 patients, and 18 symptomatic COVID-19 patients using the web application.

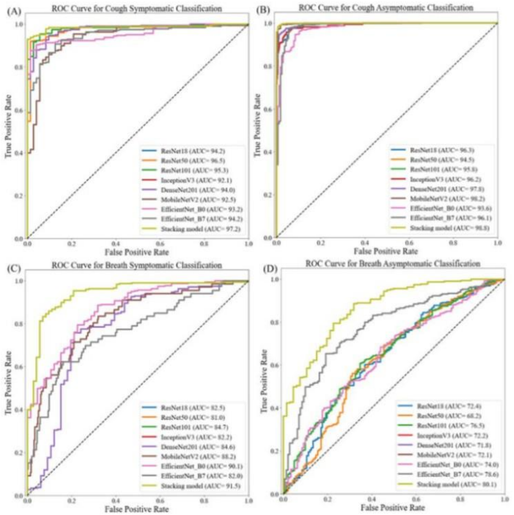


Figure 3 ROC curve for healthy and COVID-19 patients' classification using cough sounds for **(A)** symptomatic patients and **(B)** asymptomatic patients, and using breath sounds for **(C)** symptomatic patients and **(D)** asymptomatic patients.

RESULTS

Our pipeline is divided into two parts: symptomatic (who has cough) and asymp-tomatic user (no symptom). Once the spectrogram is generated, our AI-enabled server checks whether the user has a cough or not, based on which two separate pipelines are carried out. If the user has entered that he/she has a cough symptom, the symptomatic pipeline is activated. It was observed that for differentiating COVID-19 and healthy with symptomatic and asymptomatic patients cough sounds play an important role than breath sounds.

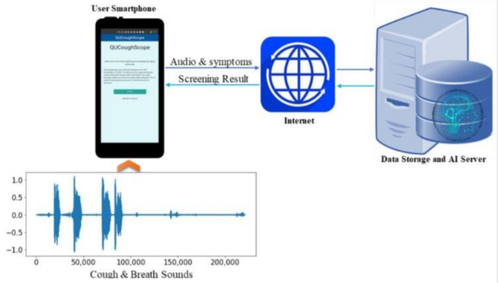


Figure 5 Illustration of a generic framework for the QUCoughScope application.

CONCLUSION

The web-application QUCoughScope records coughing and breathing sounds, converts them to a spectrogram, and applies the best- performing machine learning model to classify the COVID-19 patients and healthy subjects.
The result is then reported back to the test user in the application interface. Therefore, this novel system can be used by patients in their premises as a pre- screening method to aid COVID-19 diagnosis by prioritizing the patients for RT-PCR testing and thereby reducing the risk of spreading of the disease.

ACKNOWLEDGEMENTS

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