Towards Ambulatory Cough Monitoring Using Smartwatches

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Introduction Long term monitoring of cough in individuals with chronic respiratory disease could provide insights into how active their disease is and when it requires medical attention. There are specialized, dedicated cough detection systems currently available to monitor cough, however, they are cumbersome to use and expensive. The purpose of the current study was to determine if smartwatches could accurately and passively monitor cough in ambulatory patients with chronic obstructive pulmonary disease (COPD). Methods Patients with COPD admitted to two hospital networks with acute exacerbations of their disease were provided with Android smartwatches which recorded audio, accelerometer, gyroscope, and heart rate over three months. Data from the smartwatch was transferred daily to a smartphone, from where it was sent to a secure server. Audio files were used to determine cough. To process the files, periods of silence were first automatically removed. The remaining audio was listened to by trained annotators who documented when coughs occurred. They also noted if coughs seemed to come from the smartwatch wearers or other individuals. To build a model for detecting coughs, audio was split into 0.5 second frames and features were computed for each frame. Each frame was labeled with the volunteers' annotations and used to train a random forest classifier with an 80/20 split for training and testing. For each frame, the classifier predicts whether the frame contains a cough or not. Results To date, 16 patients have completed the three-month trial, resulting in over 4,000 hours of data (1,260 hours after removing silence). Annotators have annotated 63 hours of silence-removed audio across seven patients and found 583 coughs. The accuracy of the random forest classifier is shown in Figure 1. The classifier is able to identify coughs with 82.2% sensitivity and 92.3% specificity. An interesting finding from our annotation is that 15% of coughs are not from the patient.

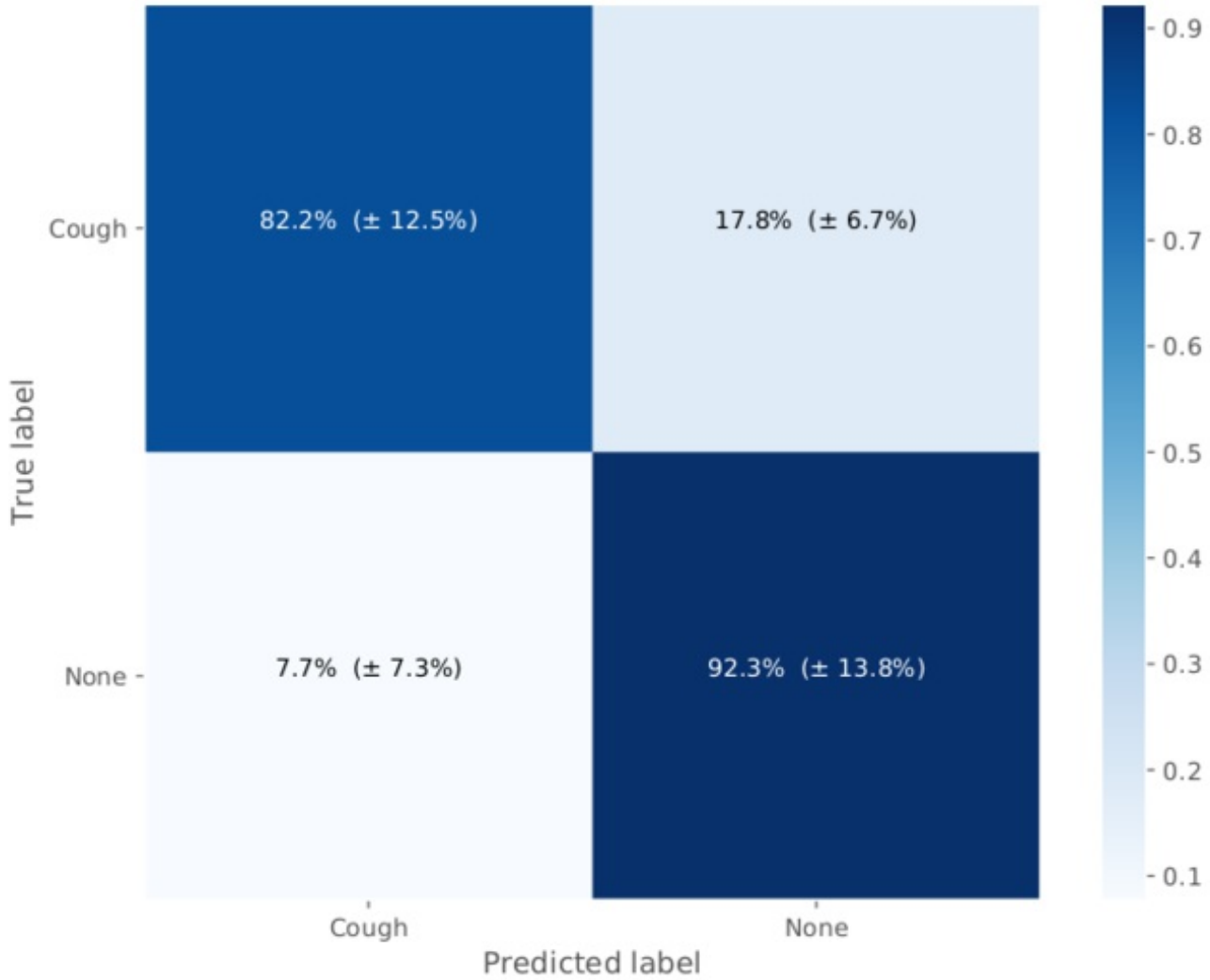

Figure 1: Accuracy of cough detection Conclusions Smartwatches are a promising platform for an ambulatory cough monitor. Our system can currently detect coughs with reasonable accuracy. With further improvements and validation with more users, smartwatches could make cough monitoring highly accessible.

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