Listen-to-Nose: A low-cost system to record nasal symptoms in daily life

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ABSTRACT
This paper proposes Listen-to-Nose, a phone-based system that detects and records when and where a person's nose-related symptoms, such as sneezing and runny nose, occur in everyday settings. It is hoped that this system can be used to collect reference data for doctors to diagnose the cause of these symptoms.

Author Keywords Nasal symptoms detection, allergic rhinitis, location, smartphones, sensing.

ACM Classification Keywords H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms Design, Experimentation

INTRODUCTION
The respiratory system is one of the most vital biological systems in the human body because it supports the function of other systems by absorbing oxygen and emitting carbon dioxide. In the process of exchanging air, the nose plays an important role as the gateway of the entire process. However, studies have reported that many people have nose-related problems [1]. Some illnesses such as colds or allergies may cause a runny nose, nasal congestion, sneezing, and so on. Even if these symptoms are mild, they impair the normal function of the respiratory system and reduce people's quality of life [2, 3]. Moreover, the number of people with nasal problems is not negligible. Statistical evidence shows that allergic rhinitis affects approximately 20% of adults and 40% of children, and 3% to 20% of people contract a cold every year in the United States [4, 5]. Because there are numerous causes of these symptoms, accurate diagnoses may be difficult, particularly for complex allergens. Therefore, the frequency and location of where these symptoms occur is valuable information for assisting proper diagnosis.

Previous studies have focused on other health-related symptoms such as coughing [6, 7]. Although coughing is commonly a reference for diagnosing a cold, it is insufficient for diagnosing hay fever. Other studies [8, 9] have recorded and analyzed human respiratory patterns, but the test environments are more likely to be limited to hospitals and laboratories, and they do not record the symptoms happening locations. Therefore, the "Listen-to-Nose" system is presented as a cost-efficient system that uses smartphones to record these symptoms daily. With advances in technology and the increasing use of smartphones, it is possible for people who have nasal problems to use our system to generate data for future diagnosis.

SYSTEM DESIGN
Listen-to-Nose is an audio-based mobile application that detects nasal symptoms such as a runny nose, stuffy nose, and sneezing. To sense which symptoms the user has, the application recognizes sound patterns corresponding to blowing or sneezing.

Figure 1 presents the Listen-to-Nose system design. On the client-side, the application records sounds using a phone's microphone and periodically classifies the audio data using an acoustic recognition model. The acoustic recognition model classifies sounds as blowing the nose or sneezing, and discards other audio data such as silence and speech. When nose-related events are detected, the system also obtains contextual information, including location (using the phone's GPS) and time of occurrence. These contexts may help the system detect when and where the user experiences allergic reactions. On the server-side, the application uses a support vector machine (SVM) to identify the audio source

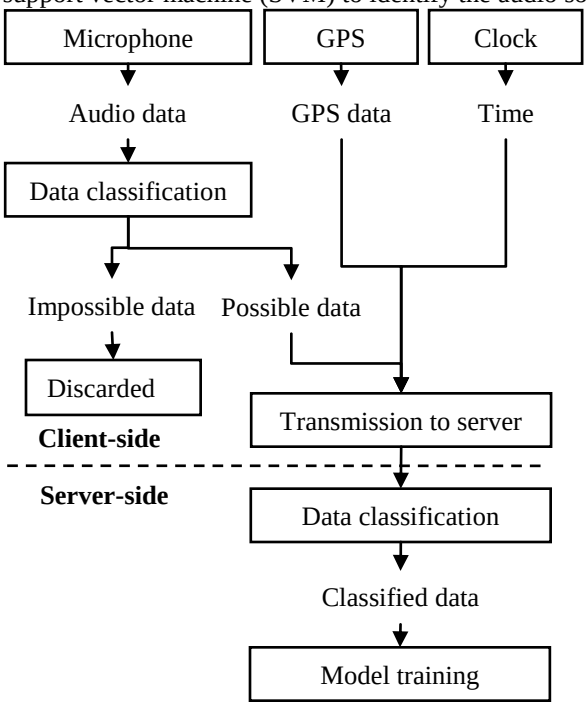

Figure 1. Listen-to-Nose system design

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(nose blowing, sneezing, or a mistaken event) and potential associated symptoms such as a runny or stuffy nose. The system stores the classified data and uses it to enhance the accuracy of future occurrences.

PRELIMINARY PROTOTYPE AND EXPERIMENTS

To test the feasibility of the Listen-to-Nose system, we deployed a mobile application to collect ground-truth data for analysis using Matlab software. Figure 2 shows data collection application user interface. Users press the red button to start collecting data. If users blow their nose or sneeze, they the bottom-right button is pressed to label a nose blowing event, and the bottom-left button is pressed for sneezing events. To achieve greater audio signal clarity, the mobile phone should be deployed in proximity to the user (e.g., placing the mobile phone on a desktop while the user is working).

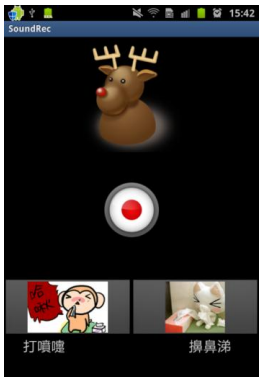

Figure 2. Data collection application interface

PILOT STUDY

In our pilot study, 21 audio samples were recorded from 21 participants (primarily university students). These participants were suffering from a cold or hay fever. The recordings came from real environments where participants blew their noses, sneezed, coughed, conversed, or performed other activities at libraries, classrooms, hospitals, and so on.

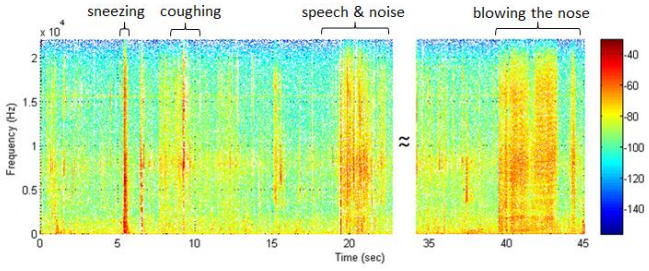

Figure 3. Spectrogram image of the acoustic data

Figure 3 shows the spectrogram of one audio sample, in which the red and blue represent high and low amplitude values, respectively. It is possible to distinguish audio events corresponding to nose-blowing and sneezing from other events such as speech, coughing, and silence. For example, nose-blowing has lower amplitude and a longer duration than coughing. Additionally, sneezing has unique amplitude duration that is approximately 500 ms long. Preliminary analysis shows potential for developing an audio-based recognition model that detects nose-related events.

FUTURE WORK

We anticipate prototyping the Listen-to-Nose system and conducting experiments to collect real data from users' phones to evaluate the accuracy of our recognition system.

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