Poster Abstract: A Mobile-Cloud Service for Physiological Anomaly Detection on Smartphones

Dezhi Hong[1], Shahriar Nirjon[1], John A. Stankovic[1], David J. Stone[2], Guobin Shen[3]
[1]Department of Computer Science, University of Virginia, USA
[2]School of Medicine, University of Virginia, USA
[3]Microsoft Research Asia, Beijing, China
{dh5gm, smn8z, stankovic, djs4v}@virginia.edu, jackysh@microsoft.com

ABSTRACT

There is a growing number of examples that use the microphones in phone for various acoustic processing tasks as mobile phones become increasingly computationally powerful. However, there is no general physiological acoustic anomaly detection service on smartphones. To this end, we propose a physiological acoustic anomaly detection service which contains classifiers that can be used to detect irregularity and anomalies in lung sounds and notifies the user. We also present and discuss on some preliminary results.

Categories and Subject Descriptors

C.3 [**Special-Purpose And Application-Based Systems**]: Real-time and embedded systems

General Terms

Performance, Experimentation

Keywords

Physiological Sound Classifier, Anomaly Detection, Mobile Service

1. MOTIVATION

As mobile phones become increasingly computationally capable and powerful, m-Health has been in rapid development in the past years. Mobile health platforms could free users from frequenting doctors as well as enable remote diagnosis. A daily acoustic footprint of a user's heart and lung can be referred to in later medical consultations. Smartphones have begun to use their microphones for various acoustic processing tasks, some state-of-the-art examples include: emotion and stress detection [2, 5], cough detector [1], heart beats counter [4]. However, these are generally limited to voice and environmental sounds detection, and specifically, MusicalHeart [4] only delves into heart beats. Currently, there is no general physiological acoustic anomaly detection service on smartphones. To this end, we propose a physiological acoustic anomaly detection service based on the mobile-cloud platform [3]. Our service contains classifiers that can be used to detect irregularity and anomalies in lung sounds and notifies the user. Such a service could provide promising opportunities for early pulmonary problems detection. There are multiple parts in our work. First, is to perform an analysis of lung sounds as sounds acquired on different parts of body will vary case-by-case in their intensity, pitch and inspiration-expiration temporal ratio (detailed in Section 2.1). Second, to explore what features in lung sounds can be used to build a classifier for recognizing or matching any irregular patterns in respiratory cycles and differentiating between various adventitious lung sounds. Third, such a cloud-based service could get more users involved thus contributing to a larger repository of sound samples.

IPSN'13, April 8–11, 2013, Philadelphia, Pennsylvania, USA.
ACM 978-1-4503-1959-1/13/04.

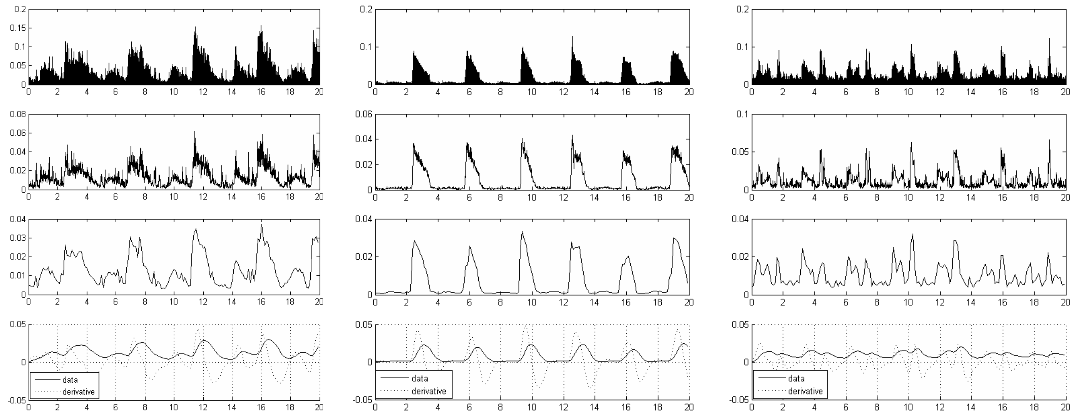
2. LUNG SOUNDS BACKGROUND

In this section, we give a brief introduction to a few typical normal and abnormal lung sounds.

2.1 Normal Lung Sounds

Normal lung sounds can be heard from different positions on body and the sounds vary a lot in terms of intensity, pitch and inspiration-expiration temporal ratio.

- **Tracheal**: Heard over the trachea as harsh, high-pitched and discrete sounds. This originates from turbulent air flow in the upper airways of the body and cover a wide range of frequency from 100 Hz to 1500Hz. In general, the expiration phase is slightly longer than inspiration.
- **Bronchial**: Mostly heard from over the manu-brium or upper part of the sternum and usually consist of high-pitched and large amplitude sounds similar to the sound of air blowing through a tube. There is a brief pause between expiration and inspiration, where expiration is longer than inspiration.
- **Bronchovesicular**: Heard near the main stem bronchi, i.e., the median upper chest. They contain pitch and intensity characteristics between vesicular and bronchial sounds. They can be heard during the inspiratory and expiratory pass, which each last for approximately the same period and do not have a pause in between them.
- **Vesicular**: Heard over majority of the lung during the shallow breathing of normal respiration. They possess low-pitched and soft sounds which are generated as a result of changing airflow patterns in the lungs. There is no pause in between the two phases and the inspiration is longer than expiration.



(a) A normal lung (b) A lung with asthma (c) A lung with rhonchi

Figure 1: Sound recording samples of lungs

2.2 Adventitious Lung Sounds

Adventitious sounds usually signify a pulmonary disorder or disease in patients. Here are several adventitious lung sounds commonly encountered in clinical auscultation:

- **Crackles**: Are discrete and explosive popping sounds and generally heard during inspiration. They are caused by air passing through moist airways and alveoli. Short duration (5-10 ms duration) crackles are called fine crackles and long duration (20-30 ms) ones are called coarse crackles. They are associated with lung disease such as pneumonia as well as with heart disease.

- **Wheezes**: They are high-pitched sounds that are more prominent in expiration with a duration longer than 100 ms. They are caused by air flowing across obstructed passages and create a few sharp spectral peaks around 400 Hz. These sounds indicate diseases such as pneumonia, asthma and emphysema.

- **Rhonchi**: They are continuous and low-pitched sounds with causes similar to those for wheezes. They occur at frequencies lower than 300 Hz and usually come with bronchitis and chronic obstructive pulmonary disease (COPD).

3. PRELIMINARY RESULTS

We perform preliminary processing on some lung sound recording samples [6] to identify the respiratory cycle which is a basic feature of lung sounds. The samples range from normal lungs to lungs with wheezes, crackles and bronchi. Several steps of processing (from top to bottom in the figure) includes: 1) down sample to extract the envelope, 2) denoise and further down sample, 3) apply a low pass filter, 4) take the derivative of the signal in 3). The zero-crossing points in the derivative help locate the peaks on the original signal and the interval between two adjacent peaks is used to calculate the respiratory cycles per minute, i.e., cpm. Clear differences are seen in Figure 1: the cpm increases from normal lung (a) to diseased (b) and (c); the amplitude ratio of inspiration to expiration (I/E) also varies from (a) to (c). Parameters such as cpm and amplitude ratio of I/E can act as indicators of how well a user's lung functions on a daily basis and these fingerprints can be referred to in our service.

We will next compare the power spectral density (PSD) of the signals to see if it helps better distinguish between abnormal lung sounds. We will also examine the likelihood of simply using the microphones built in phone to reliably collect physiological sound clips and determine if a new accessory is needed.

4. REFERENCES

[1] E. C. Larson, T. Lee, S. Liu, M. Rosenfeld, and S. N. Patel. Accurate and privacy preserving cough sensing using a low-cost microphone. UbiComp '11, New York, NY, USA, 2011.

[2] H. Lu, D. Frauendorfer, M. Rabbi, M. S. Mast, G. T. Chittaranjan, A. T. Campbell, D. Gatica-Perez, and T. Choudhury. Stresssense: detecting stress in unconstrained acoustic environments using smartphones. UbiComp '12, New York, NY, USA, 2012.

[3] S. Nirjon, R. F. Dickerson, P. Asare, Q. Li, D. Hong, J. A. Stankovic, P. Hu, X. Jiang, and G. Shen. Auditeur: A mobile-cloud service platform for acoustic event detection on smartphones. In Submission, 2012.

[4] S. Nirjon, R. F. Dickerson, Q. Li, P. Asare, J. A. Stankovic, D. Hong, B. Zhang, X. Jiang, G. Shen, and F. Zhao. Musicalheart: a hearty way of listening to music. SenSys '12, New York, NY, USA, 2012.

[5] K. K. Rachuri, M. Musolesi, C. Mascolo, P. J. Rentfrow, C. Longworth, and A. Aucinas. Emotionsense: a mobile phones based adaptive platform for experimental social psychology research. Ubicomp '10, New York, NY, USA, 2010.

[6] StethoGraphics. http://www.stethographics.com/.