Breath Sound Analysis via Smartphones

Application of contemporary smartphone technology for diagnosing breathing disorders

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Aim: To examine if current smartphone technology can be used to detect wheeze in breathing sounds

Objective: The objective of this study is to examine current smartphone technology in relation to:
- If it can be used for practical analysis of breathing sounds
- How its recording capabilities compare to certified medical devices such as stethoscopes
- The possibility of combining it with a method of automatic wheeze detection that has been developed by other studies

Introduction: Breathing disorders such as asthma are a worldwide problem that generally results in various breathing difficulties like wheeze. This problem exist at the same time as public smartphone usage increases rapidly and offers new possibilities of diagnostic methods for detecting breathing disorders. By taking advantage of the smartphones’ mobility, it could offer patients with respiratory diseases easier and more flexible way of monitoring their symptoms.

Materials:
- An iPhone 5 was used as a main smartphone type and was compared to a Littmann Electronic Stethoscope Model 3200
- A custom made rubber seal, handcrafted out of a bicycle tire was used in some parts of the study (see Figure 1)
- The software Matlab was used for all numerical calculations and data manipulation

Methods: The experimental implementation of the study can be divided into four steps:
1. Make sure that an iPhone is capable of recording frequency components that are dominant in wheeze, namely 100-4000 Hz [1]. The iPhone was configured so it would be recording while an audio file was playing close by and emitted sound that contained frequencies within the relevant frequency interval. The recording from the iPhone was then transferred to a computer where it was analysed and checked if the frequencies between 100 and 4000 Hz had been successfully detected by the iPhone.
2. Record identical breathing cycles on both the iPhone 5 and the Littmann stethoscope at the same time. The microphones of both devices were placed on each side on the front part of the neck, more accurately on the trachea (see Figure 2). The recording of each device had already been started before they were placed on appropriate spots so the subject was asked to speak before doing the actual breathing demonstration. The spoken sound could then be used to synchronize and identify the demonstration part between the recordings from both devices. The subject was then asked to breath normally for several breathing cycles. This pattern of recording with iPhone 5 and stethoscope was repeated few times. In some cases a rubber seal was placed on the iPhone and the idea was to protect the microphone from picking up skin flakes and perhaps decrease effect of background noise (see Figure 2b)
3. The recordings from the iPhone and the stethoscope were transferred to a computer and processed. The relevant parts of the recordings, i.e. the breathing demonstration were extracted from the original recordings and filtered with a bandpass filter that had a passband between 100-4000 Hz. The frequency components and the magnitude-squared coherence of the signals were analysed.
4. The recordings were processed by an automatic wheeze detection algorithm [7]

Results:
- The iPhone 5 showed a good response throughout the frequency interval that is dominant in wheezy sounds
- Spectrogram of the recordings from the iPhone 5 (without seal) and the Littmann stethoscope can be found in Figure 4
  - The coherence got worse if the rubber seal was used
  - The automatic wheeze algorithm was able to detect some traces of wheeze in a breathing sound sample that beforehand was suspected to have some amount of wheezy components

Conclusions: The iPhone seems to be able of capturing characteristics of breath disorders by detecting wheezy characteristics in breath sounds. The comparison of the signals recorded by the iPhone and the stethoscope resulted in decent coherence on frequencies lower than 1000 Hz. It also turns out that the stethoscope only detects frequency components up to 2000 Hz so it begs the question if it is unnecessary to analyse any frequencies above that value.