THE INTELLIGENT STETHOSCOPE

P. Hult*, C. Ahlstrom*, L. Rattfält*, C. Hagström**, N-E. Pettersson** and P. Ask*

* Department of Biomedical Engineering, Linköping University, Linköping, Sweden
** Biomedical Engineering, Örebro University Hospital, Örebro, Sweden

peras@imt.liu.se

Introduction.

We are developing the intelligent stethoscope as a powerful instrument in distributed health care. Taking advantage of the rapid development in computer technology we intend to improve the nearly two hundred year old stethoscope. Advanced signal processing is used to relate the sounds to specific pathologies of the heart and lungs. Implemented preferably in a PDA we can store and process acoustic recordings from the patients and, if necessary, communicate the signal for external expert advice.
Our aims are to:

1. Develop tailored signal processing methods to extract clinically relevant information.
2. Develop telecommunication solutions to transfer obtained data to a centrally placed database or electronic health record.

Methods and Results

Most of our bioacoustic research has been concentrated in two fields: lung sound analysis and heart sound analysis. This is a short review of our previous and ongoing research within the scope of the intelligent stethoscope.

Automatic detection of the third heart sound: The 3rd heart sound is clinically important due to its relation to heart failure/myocardial insufficiency. Our automatic method for detection of the 3rd heart sound was based on a tailored wavelet approach [1], capable of utilising both time and frequency information from the signal at the same time. The method was verified in a study on heart failure patients and proved capable of detecting a majority of the 3rd heart sounds.

Automatic timing of respiration phases: The aim of this work was to develop a method for respiration monitoring, where the start and stop of the respiration phases could be timed accurately [2]. A microphone applied over trachea measured sounds induced by turbulent airflow, and the method is hence based on a direct measurement of the flow. The analytical method used was a moving FFT summation and could accurately detect and separate inspiration and expiration.

*Characterisation of heart murmurs:*The main reasons for generation of murmurs are high rates of flow through the valves, flow through constricted valves (stenosis) or backward flow through incompetent valves (insufficiency). A more turbulent blood flow induces a more chaotic sound, which is reflected in the recorded acoustic signal. The degree of self-similarity, and hence chaos, is represented by the object's fractal dimension - a measure of a signals complexity in terms of morphology, entropy, spectra or variance in the time domain [3]. Preliminary classification of various heart murmurs has been conducted.

Analysis of adventitious lung sounds: We have investigated the nonlinear properties of adventitious lung sounds (wheezes and crackles) in comparison with normal lung sounds. Wheezes are musical lung sounds common in patients with obstructive airway diseases such as asthma or COPD. Crackles are discontinuous, explosive and transient in character. Typical diseases where crackles are present are alveolitis, emphysema and COPD. Our investigations show that different adventitious lung sounds can be characterised and visualized in a phase space plot. The intention of the project is to find relevant discriminating features to classify different diseases such as heart failure and COPD based on their lung sounds.

Conclusions

Our new signal processing algorithms gives us a powerful tool for relating bioacoustic signals to specific cardiac and pulmonary pathologies. The data from an intelligent stethoscope can be stored as an acoustic patient record, for diagnostic support and for external expert advice in a distributed and home heath care system.

References

[1] HULT P., FJALLBRANT T., WRANNE B., ASK P. (2004): 'Detection of the third heart sound using a tailored wavelet approach', *Med Biol Eng Comput*, **42** pp. 253-8.
[2] HULT P., FJALLBRANT T., WRANNE B., ENGDAHL O., ASK P. (2004): 'An improved bioacoustic method for monitoring of respiration', *Technol Health Care*, **12** pp. 323-32.
[3] KINSNER W. (1994): 'Batch and real-time computation of a fractal dimension based on variance of a time series', *Dept. of Electrical & Computer Eng., University of Manitoba*, pp. 1-22.

ISSN: 1727-1983