EVALUATION OF RESPIRATORY PARAMETERS FROM PNEUMOGRAM

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Abstract

Automatic calculation of signals parameters are very often used methods in a biomedical engineering research. This paper describes algorithms in Matlab usable to calculate or detect specified parameters of pneumogram signals. The described algorithms are suitable to objective evaluation of pneumogram signals. The pneumogram signals used to test proposed algorithms were acquired by equipment own production.

1 Introduction

Pneumogram is one of the oldest methods to provide information about respiration technique during speaking and singing. A pneumogram consists of the person's voice, the movements of the chest and the movements of the abdominal wall. The measure conceptual scheme is presented in Fig.1. The inputs of the pneumograph are connected to a pair of strain gauges and a microphone. The processed signals are transmitted to PC software in real time via USB bus, which makes it possible to show the curves from the sampled signals in real-time and archive data to evaluate the respiratory parameters.

Currently, the pneumography method is not very widespread and is not used in medical practice, having been replaced by pneumotachography (there is no equipment manufacturer in the present market). However, the pneumography method is more suitable for diagnostic purposes, because it provides direct information about the muscle movements participating in the respiration process. Pneumography is also used in cases when a voice teacher needs to gain information about the pupil's breathing technique.

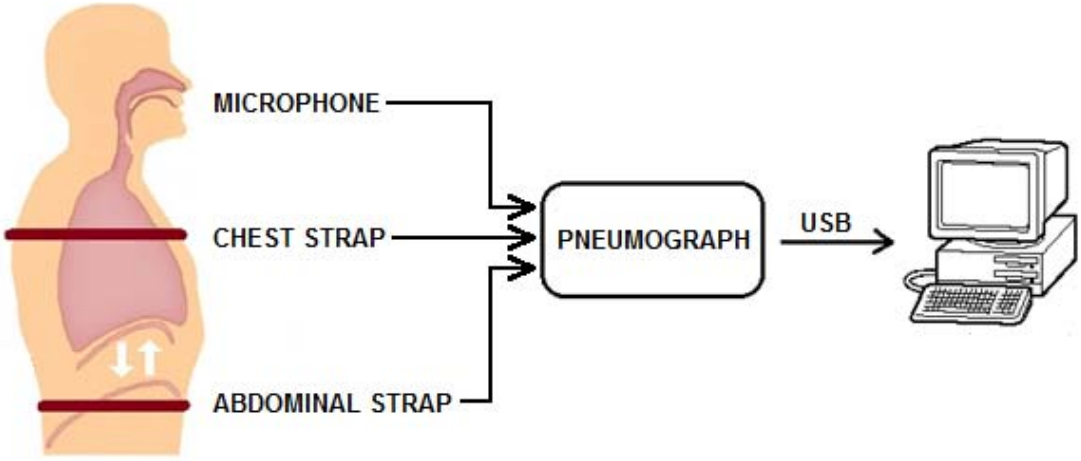

Figure 1: Conceptual diagram of pneumogram measure

2 Description of the analyzed signals

The pneumogram signals were acquired by equipment own production. The sampling frequency is 500 Hz and the A/D converter has 10-bit resolution; since the voice recording is used only to detect the voice's presence, this sampling frequency is therefore sufficient. Pneumography signals are used to measure the respiratory rate, to detect pathological phenomena, to calculate the ratio between the time of inspiration and expiration and to calculate the ratio between the time of speaking and silence.

Further, the asymmetry and relationship between the curves of the chest movements and abdominal wall are evaluated with this method. The example of pneumogram signals used to propose automatic algorithms to evaluation of respiratory parameters is presented in Fig. 2. Example presents signals recorded during still breathing, deep breathing, extended phonation and speaking.

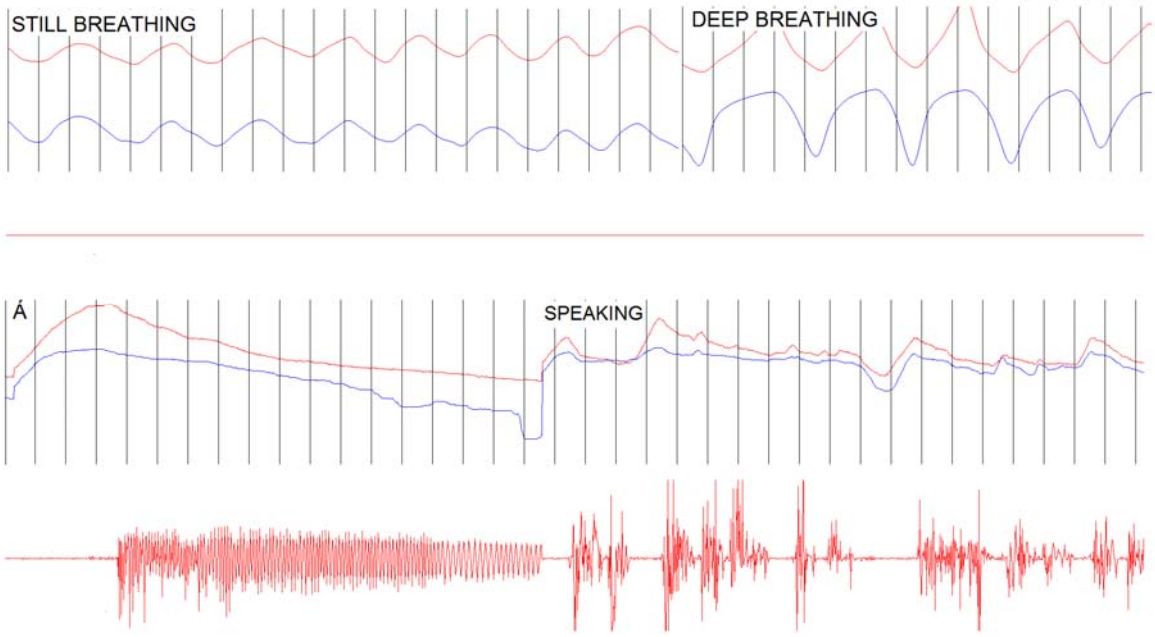

Figure 2: The example of pneumogram signals used to propose algorithms

3 Description of algorithms for evaluation of respiratory parameters

Design of algorithms was implemented in software MATLAB. The pneumogram signal is always first low-pass and high-pass filtered and normalized before further processing. The calculation of the ratio between time of inspiration and expiration is based on signal segmentation. From the signal derivation are determined inspiration and expiration segments. The segments with small length are let out. The segmented signal is used to calculate time ratio and respiratory rate. In the Fig. 3 are presented signals acquired at processes. The signal of pneumogram is the blue curve on the left, red curve is the segmentation signal calculates from the signal derivation. The calculated ratio between time of inspiration and expiration is shown on the ride side.

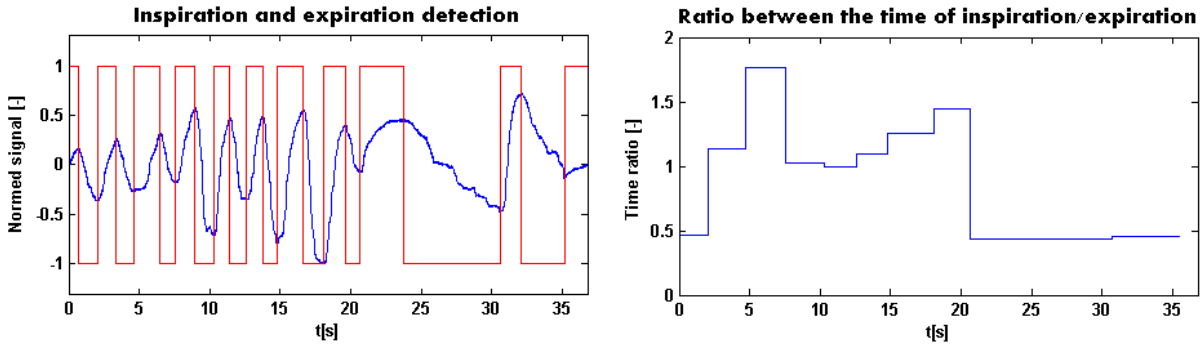

Figure 3: The pneumogram signal segmentation and ratio calculation

The ratio between the time of speaking and silence is calculated from the microphone signal. Microphone signal is squaring and by thresholding is segmented into section speaking and silent. The optimal treshold is set on twenty percent of the maximum microphone signal. The calculation of ratio between the time of speaking and silence from segmentation signal is provided by the same method as in the previous case. In the Fig.4 is presented the result of detection of ratio between the time of speaking and silence. The microphone is shown on the left side, in blue color, signal and segmentation signals with red color. On the right side is the curve of calculated time ratios of speaking and silence.

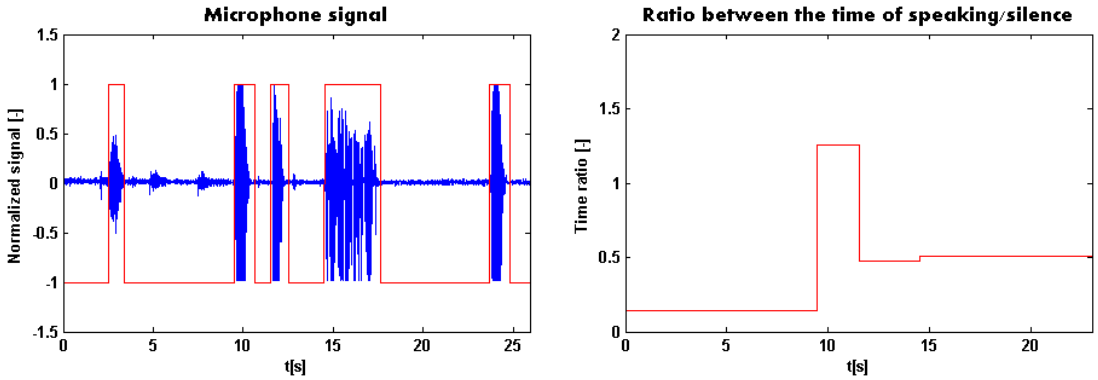

Figure 4: The microphone signal segmentation and ratio calculation

The asymmetry and relationship between the curves of the chest movements and abdominal wall are evaluated from preprocessing signals with adding ones offset. Asymmetry is calculated as the ratio of signals. In the Fig. 5 is on the right side presents the result of asymmetry detection.

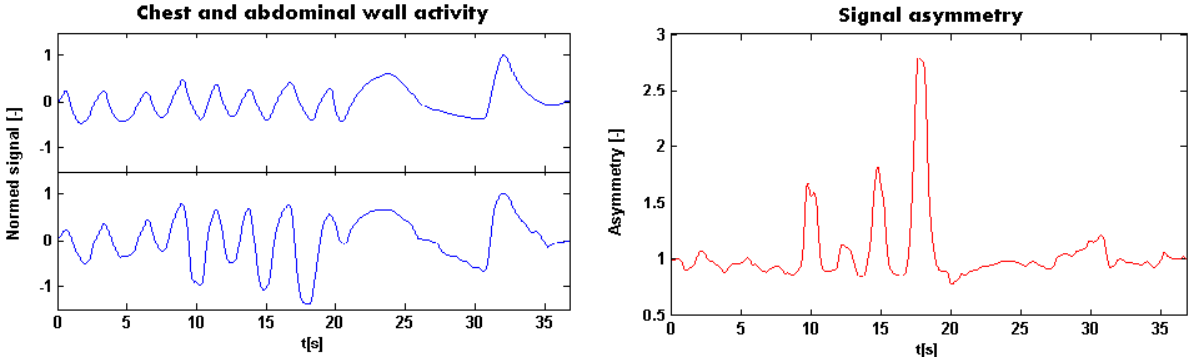

Figure 5: The calculation of chest and abdominal wall activity asymmetry

The detection of pathological phenomena, especially such as hard voice beginnings, is based on using difference, which well describes the fast changes in pneumogram signals. Another possibility provides using of correlation pneumogram signal with signal segment with pathological phenomena patterns.

4 Results

The designed algorithms were tested by many purchased records. The evaluation of time ratio of speaking and silence and asymmetry of signal provided stable results for all recorded signals. The calculation stable of the ratio between time of inspiration and expiration is susceptible on the act during the examination. The evaluation during speaking is the most difficult process, because the signal is more complicated. Automatic evaluation method for respiratory parameters detection provides director additional information which are useful for phoniatric specialists during patients diagnostics.

References

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