TECHNICAL REPORT

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The phonocardiographic data recording & processing system: an effective approach

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Abstract

Some results obtained in recording and processing of phonocardiograms are presented herein. To process phonocardiographic signals, a cascade filtration method has been used that allows detecting tones of the cardiovascular system in the background noise. The effectiveness of the proposed processing method is demonstrated by the results of visualization.

Keywords

Cardiovascular system, Phonocardiogram, Phonocardiac signal, Recording, Processing, Visualization

Imprint

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Introduction

As is known, the phonocardiographic method for diagnosing diseases of the cardiovascular system is relevant today in modern healthcare. The phonocardiographic method for recording the sound vibrations occurring during the work of the muscular and valvular apparatus of the heart makes possible to identify them using a microphone, an amplification unit, a specialized filtration unit and a visualization device [1]. However, the proper identification of phonocardiographic tones of the cardiovascular system is greatly complicated by an interference caused by random ambient sound vibrations at the time of signal recording [2]. To identify the relevant diagnostic tones of the cardiovascular system against the background of interference, a problem of an increase in the accuracy of detecting the phonocardiographic signal should be formulated. An increase in the accuracy of the identifiability of the tones produced by the cardiovascular system mainly depends on the choice of the method used for filtration (processing) of the phonocardiographic signals. To solve this problem nowadays, there are several approaches [3–7], which have the following drawbacks:

– when passing the filter units, the shape of the phonocardiographic signals is distorted by noise that takes place due to a narrow bandwidth of the signal;

– smoothing the amplitude and time parameters of the signal and clipping the phonocardiographic signal may lead to crackling of the identifiable tones of the cardiovascular system.

With the aim of eliminating the identified drawbacks of the known approaches, proposed is a cascade filtration of the phonocardiographic signals for sequential detection of the cardiovascular tone. This fresh approach allows eliminating noise on the extended frequency bands and thereby clearly identifying the tones of the cardiovascular system.

Aim

The aim of our research was to confirm the possibility of applications of the cascade filtration of phonocardiographic signals in sequential detection and visualization of the tones of the cardiovascular system.

Materials and methods

Recording and processing of the phonocardiographic signals were carried out in a human individual, aged twenty-five, in the absence of any physical activity. The signal was recorded via a microphone, built into the head of a stethoscope, at certain points in the auscultation of the heart. The head of the stethoscope was used to improve recording of the phonocardiographic signal on the surface of the chest. Processing was performed by the cascade filtration of the phonocardiographic signals utilizing 2 cascades, each of them containing the stable Butterworth filters of the second order and operational amplifiers. The Butterworth filters were selected because of their capability to have a small flatness of amplitude and frequency characteristics in the bandwidth of the signal and suppress noise [2]. The frequency boundaries of the cascade filters were selected in such a way that the filter sequence passed only the fundamental frequency of the phonocardiographic signals. Visualization of the processed signals was realized using the Proteus software product. The 3D model of the recording and processing system was also implemented using the above software (see Figure 5 herein).

Results and Discussion

This paper section presents the results obtained in processing of the recorded phonocardiographic signals, based on the cascade filtration method. To illustrate the effectiveness of the developed method, conducted was a simulation of the system recording and processing of the phonocardiographic signals. Figures 1 - 4 herein show some visualization graphs in the simulation of our system used for recording and processing of the phonocardiographic signals.

The obtained simulation results have shown that the proposed processing method allows properly identifying the tones of the cardiovascular system in an individual under examination. When compared with the recorded real phonocardiographic signals, we can see that the cascade of filters largely eliminates the interference and increases the diagnostic value thereof.

Visualization of the processed phonocardiographic signals has demonstrated that no pathology has been detected and that the identified tones fully correspond to the cardiac cycle of the vascular system. For a better illustration, we present herein a 3D model of the system designed for recording and processing the phonocardiographic signals.

Conclusions

The paper has discussed our original solution of the problem of processing the phonocardiographic signals. It is proposed to use the cascade of the bandpass filters for the operational amplifiers. Such circuit improves to a large extent the identifiability of the tones against the background interference and thereby allows increasing the efficiency of diagnosing diseases of the cardiovascular system.

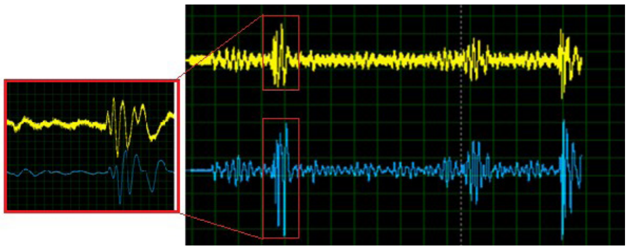

Figure 1. Recorded (yellow) vs. processed (blue) phonocardiogram of the aortic point of auscultation. In both cases: the amplitude is plotted on the ordinate, and the time is laid off as the abscissa.

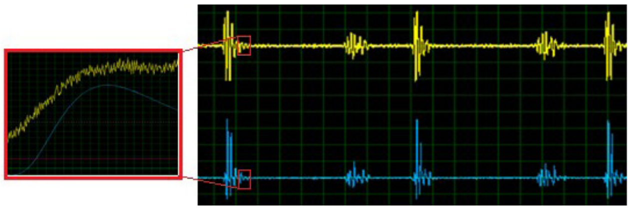

Figure 2. Recorded (yellow) vs. processed (blue) phonocardiogram of the pulmonary point of auscultation. In both cases: the amplitude is plotted on the ordinate, and the time is laid off as the abscissa.

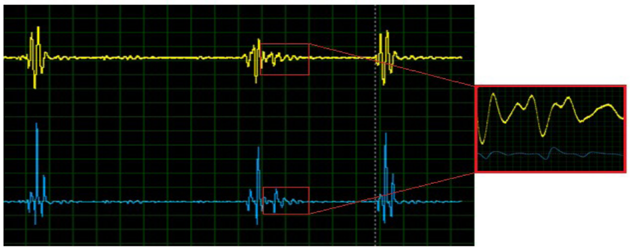

Figure 3. Recorded (yellow) vs. processed (blue) phonocardiogram of the mitral point of auscultation. In both cases: the amplitude is plotted on the ordinate, and the time is laid off as the abscissa.

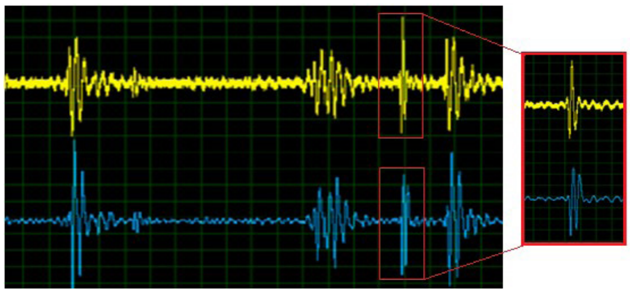

Figure 4. Recorded (yellow) vs. processed (blue) phonocardiogram of the tricuspid point of auscultation. In both cases: the amplitude is plotted on the ordinate, and the time is laid off as the abscissa.

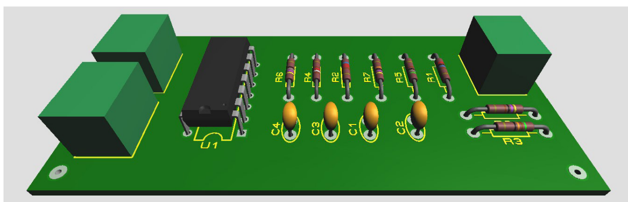

Figure 5.Our 3D model of the system designed for recording and processing of the phonocardiographic signals.

Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest

None declared.

Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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