Research Article

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Filtering of Fluctuations of the Basic Electropotential in Complex Signals of a Contactless Electrocardiogram

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ABSTRACT

The proposed article presents the results of the authors' application of a complex electrical signal filtering algorithm developed by them, registered as a non-contact, non-invasive, abdominal ECG of a pregnant woman containing an ECG of a pregnant woman and a fetus. The previously proposed registration scheme allows you to register signals that are practically "unnoticed" by traditional ECG circuits, but it reacts very "sensitively" to changes in the basic electrical potential – the ECG baseline. It is shown that the proposed algorithm for filtering low-frequency components not only effectively eliminates the fluctuations of the baseline, but also improves the visualization of the studied cardiocomplexes necessary for the diagnosis of the condition of the pregnant woman and fetus.

Keywords: Personalized Medicine; ECG Baseline; Abdominal ECG; ECG Measurement; The Quality of Registration of ECG Special Treatment of ECG

Introduction

Continuing the studies of non–standard electrocardiograms started in [1-6], we were forced to pay attention to the fact that the proposed schemes of "contactless" ECG registration by both of us [3,4] and a number of other researchers [7-10], along with the possibility of accurate registration of small electrode potentials (ECG), have a high sensitivity to changes in the "basic" electro potential - ECG baseline. In some cases, hypotheses have been formulated about the diagnostic potential of these changes [2-6], but for the analysis of cardio complexes, these variations are clearly negative. There are several diagnostic areas in which this problem cannot be circumvented. A striking example is the diagnosis of the fetal condition in the intrauterine state by abdominal ECG, which a number of scientists have been doing for many years, trying to introduce the method into widespread practice.

Formulation of the Problem

Figure 1 shows examples of three abdominal ECG intervals of a pregnant woman registered more than 15 years ago to diagnose her condition. Currently, the signals are identified and do not represent information of an individual nature. On the blue diagrams, you can track the cardio complexes of the pregnant woman and the fetus. Significant fluctuations in the baseline significantly complicate the analysis of the received ECG – both the calculation of the heart rate of the mother and fetus, and the analysis of the cardio complexes themselves. The red diagrams in Figure 1 are the same ECGs after using traditional low–pass filters to compensate for the movements of the ECG baseline. This operation has a significant effect, but it introduces distortions into cardiocomplexes. This is easily explained – the spectrum of the cardio complex is 10-100 Hz, and the spectrum of baseline changes is 1-10 Hz, it is quite difficult to exclude their mutual influence. The method of registering an abdominal ECG is non–invasive and non-contact, and it is not able to stabilize the baseline in a "natural" way - by connecting electrodes, as is customary in electrocardiography. As follows from Figure 1, low-frequency filters allow to reduce the influence of baselines, but

do not allow to study the details of cardio complexes. It should be noted that for screening the fetal condition, it is usually sufficient to register variations in fetal heart rate, which the filter affects very weakly. But for the consideration of the details of cardio complexes, its influence can be very significant. Within the framework of this article, we want to show the possibilities of filtering technologies developed recently, the details of which, for obvious reasons, are not disclosed.

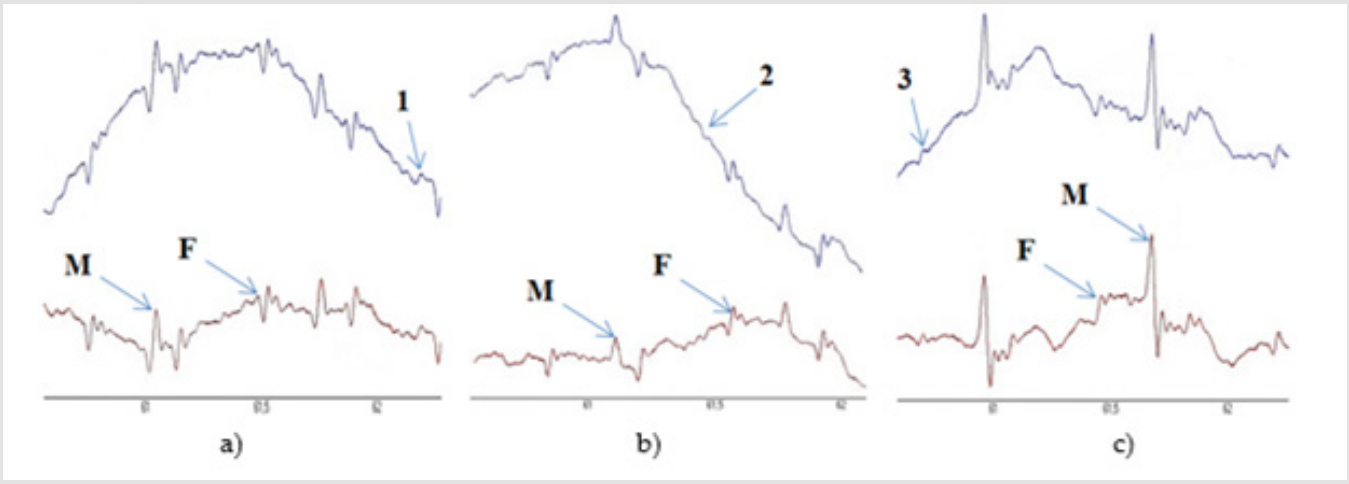

Figure 1: Filtering of the baseline of the abdominal ECG signal using traditional filters: initial signal (blue); signal after filtration (red), "F" - fetal cardiocomplex, "M" - pregnant cardiocomplex.

Research Methods

Obviously, the influence of the baseline is completely excluded. The fetal and pregnant cardiocomplexes retained their shape, the main proportions of positive and negative segments and time intervals, and in some cases were "corrected" from distortions by baseline variations.

Discussion

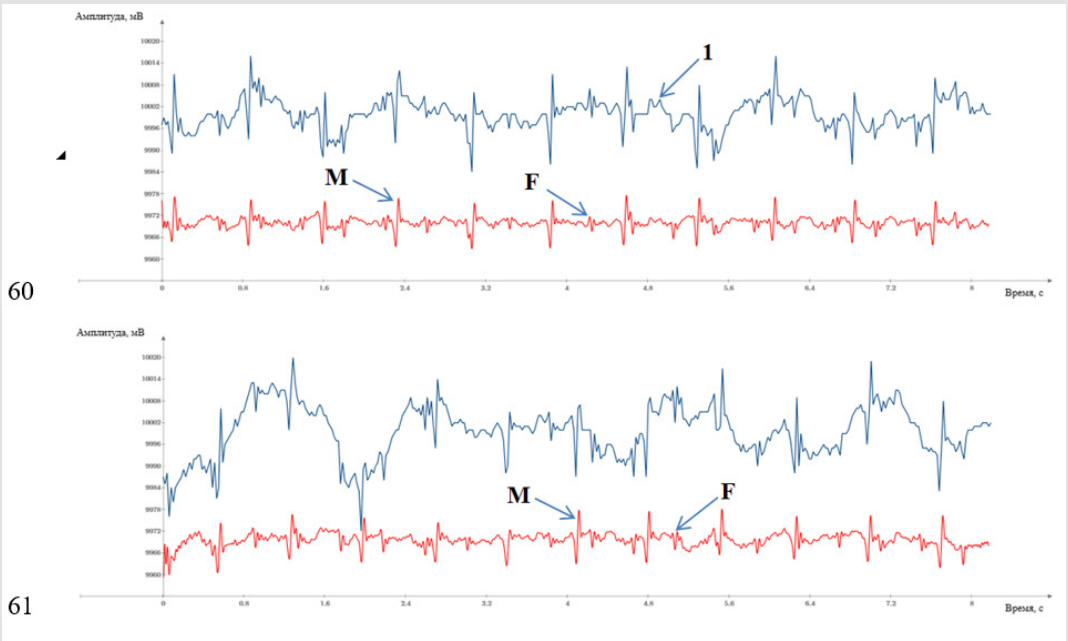

Figure 2: Enhanced scale of "complex" sections of diagrams: initial signal (blue); signal after processing (red), "F" - fetal cardiocomplex, "M" - pregnant cardiocomplex.

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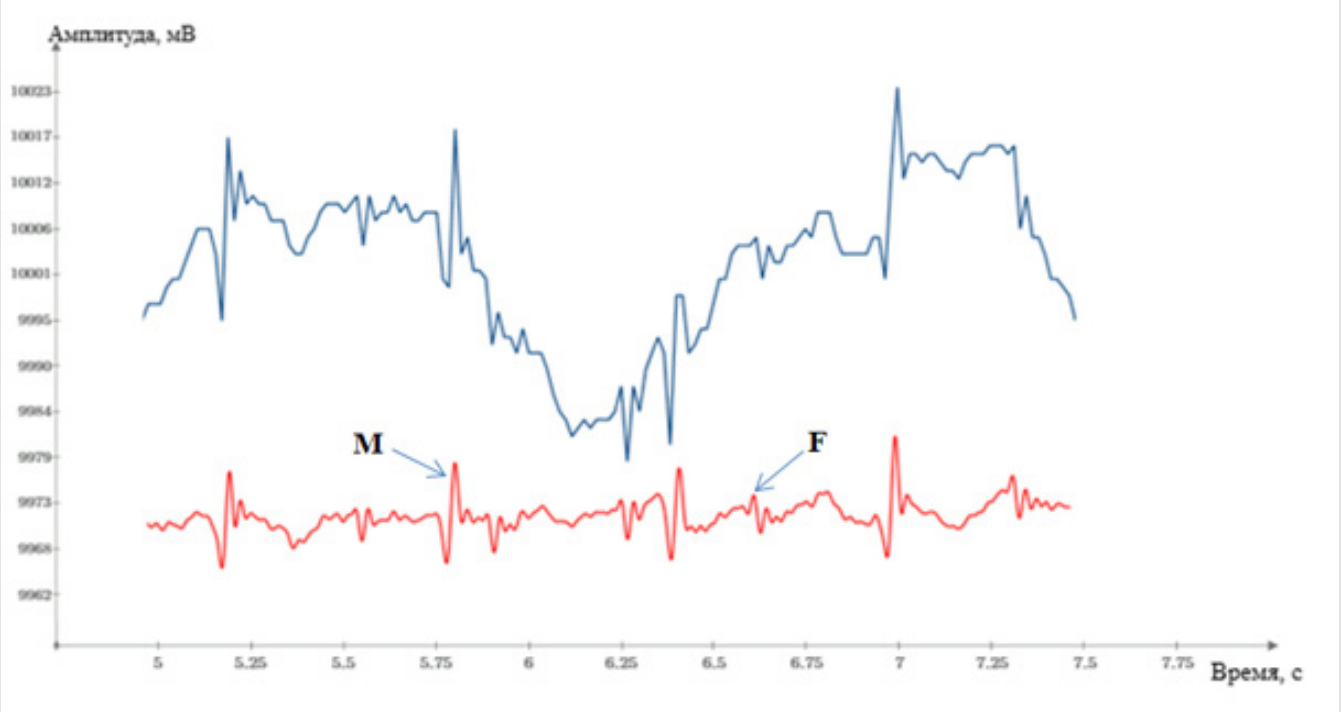

Figure 3: Enhanced scale of "complex" sections of diagrams: initial signal (blue); signal after processing (red), "F" - fetal cardiocomplex, "M" - pregnant cardiocomplex.

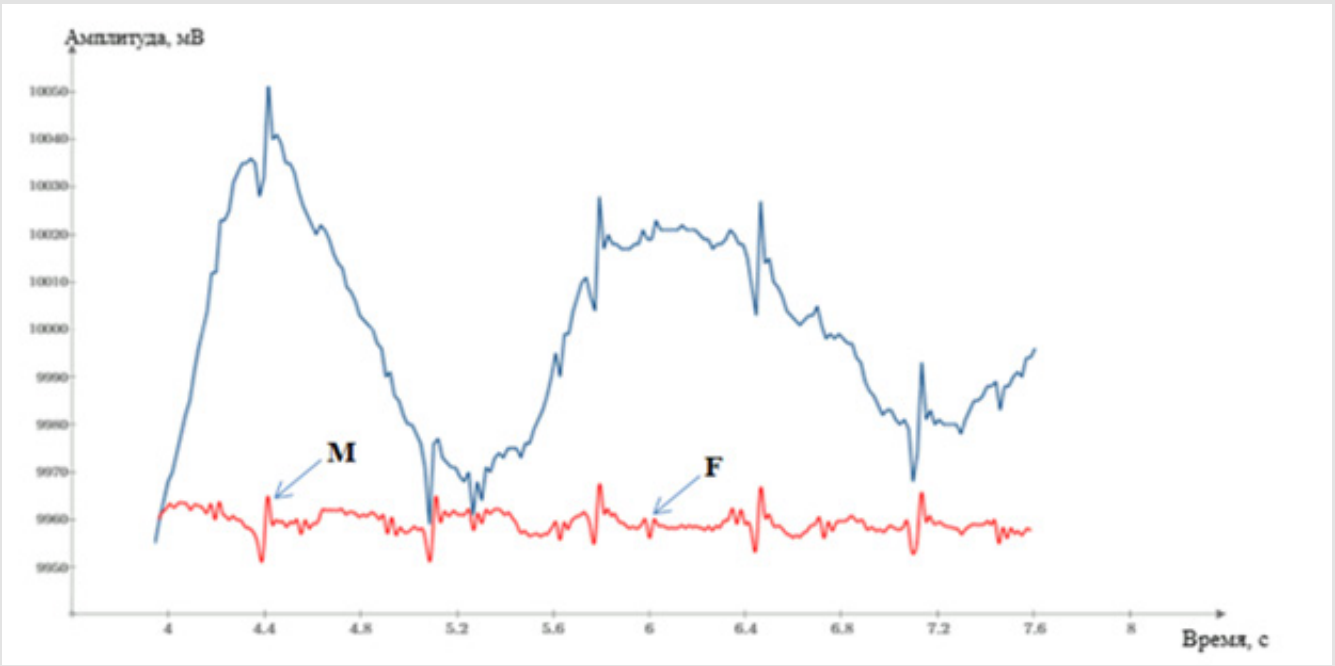

Figure 4: Enhanced scale of "complex" sections of diagrams: initial signal (blue); signal after processing (red), "F" - fetal cardiocomplex, "M" - pregnant cardiocomplex.

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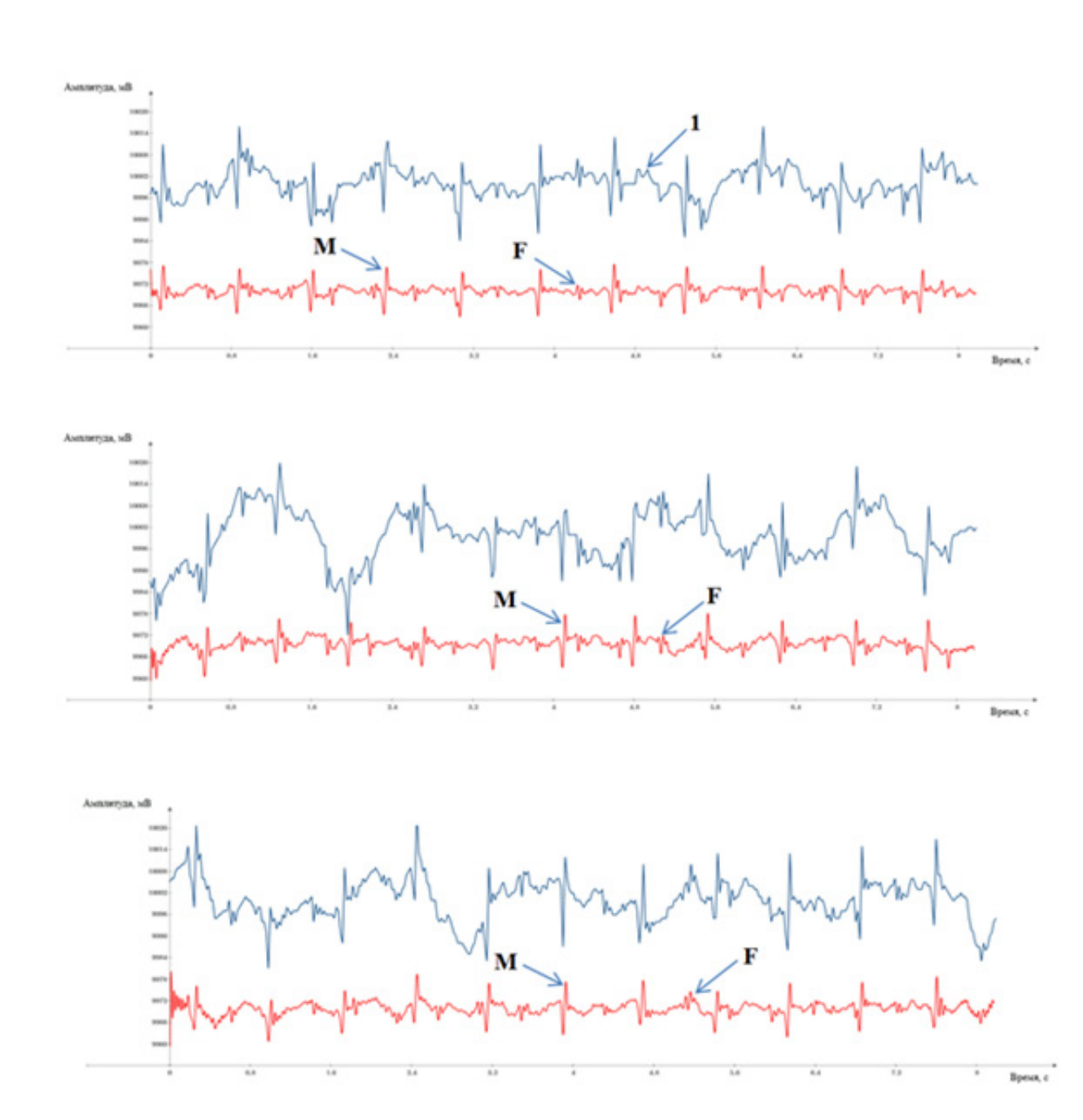

Figure 5: Filtering of the baseline of the abdominal ECG signal using special processing: initial signal (blue); signal after processing (red), "F" - fetal cardiocomplex, "M" - pregnant cardiocomplex.

Figures 2-4 show the most "complex sections of diagrams on an enhanced scale. Attention should be paid to the exact preservation of the time intervals between the cardio complexes of the pregnant woman and the fetus on the original and processed diagrams. In the original blue diagram, the baseline makes significant changes in the cardio complexes of both the pregnant woman and the fetus. On the processed diagrams (red) – the variations of the complexes are much smaller, and in Figure 5 at points 1-3, on the original diagram they do not differ at all or are very "far" from other complexes in shape, and on the processed one at the same time, the fetal cardio complexes are very clear and similar to others.

Conclusion

It should be noted that in such a signal, as in the diagrams after processing (red), it is quite easy to carry out an accurate calculation of the heart rate of the pregnant woman and the fetus and other

diagnostic actions. The digital filtering procedure itself, according to the authors, will allow for refined processing not only to exclude variations in the ECG baseline, but also individual segments and intervals of cardiocomplexes, which will significantly increase the efficiency of contactless ECG registration, which is necessary for the development of personalized medicine, biocybernetic complexes and special cardiodiagnostics, which should include registration of abdominal ECG of pregnant women. There is no doubt that this filtration technology can find application in numerous continuous ECG monitoring complexes currently being developed [11-14].

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