At present, cardiotocographic monitoring (CTG) plays an essential role in the diagnosis of the fetus, the main element of which is the analysis of fetal heart rate changes (FHR) on the background of the uterus muscle activity and fetal movement activity. The most common technique of recording the FHR signal is the ultrasound Doppler method, which, due to averaging the measurements, makes difficult to correctly estimate the instantaneous heart rate variability playing a crucial role in the diagnosis of fetal condition. For many years, increasing interest in monitoring the bioelectric activity of the fetal heart has been noted, as analysis of the fetal electrocardiogram (FECG) provides high efficiency and accuracy of the heart rate determination. The FECG signal can be recorded invasively – by direct recording of the signal from the fetal head during delivery, and indirectly – by means of measuring electrodes placed on the maternal abdominal wall. The advantage of the indirect method is non-invasive procedure and the possibility of applying both during pregnancy and delivery.

The main aim of the dissertation was to carry out a comprehensive research to develop the optimal methods of extraction and analysis of FECG signal recorded noninvasively. The research focused on two main aspects: suppression of the maternal electrocardiogram MECG, which dominates in the abdominal signals, and development of the detection algorithm of the fetal QRS complexes, which enables determination of the instantaneous FHR values. Real signals recorded during pregnancy and delivery were used in the work, that were collected using a dedicated signal recorder developed by the author.

As part of the research, the original method of maternal electrocardiogram suppression was developed, which can be used even in the case of a small number of abdominal signals. The method is based on precise centering and subtraction of the maternal signal pattern (covering the whole maternal cardiac cycle). During the work, several important problems related to coincidence of maternal and fetal QRS complexes were solved, as well as to pattern adaptive scaling in the subtraction process.
Effective and accurate detection of individual fetal QRS complexes is the basis for the correct determination of instantaneous FHR values. The original method of detection of fetal QRS complexes has been developed, in which the detection function is based on matching filtering. By applying normalization, the sensitivity of the detection function to muscle disturbances has been significantly reduced. At the same time, it enabled the application of decision rules based on the minimization of the cost functions. These rules allowed for proper detection of fetal QRS complexes, even if their amplitude is below the noise level.

In the final stage, a metrological evaluation has been carried out where the proposed methods of bioelectric analysis of fetal heart activity registered non-invasively were related to the reference method – direct recording of the electrocardiogram. High accuracy of the determination of instantaneous fetal heart rate values as well as lack of their influence on the values of the clinical indicators for description of the instantaneous FHR variability have been demonstrated.