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Analiza zmienności rytmu pracy serca na podstawie elektrokardiogramów, sejsmokardiogramów i żyrokardiogramów

Rozprawa na stopień doktora nauk inżynieryjno-technicznych

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Abstract of the PhD Thesis by Szymon Sieciński: "Heart rate variability analysis based on electrocardiograms, seismocardiograms and gyrocardiograms"

Cardiovascular diseases are the main cause of death in Poland, Europe and worldwide. Early diagnosis and start of therapy may reduce the mortality and improve the life expectancy. Heart rate monitoring is a common diagnostic method of cardiovascular diseases. Electrocardiography (ECG) is a gold standard of heart rate variability (HRV) analysis, although there is ongoing research on heart rate monitoring methods which do not use electrodes, such as seismocardiography (SCG) and gyrocardiography (GCG). Seismocardiography is a non-invasive technique of registration of cardiac vibrations on the chest wall. Gyrocardiography is a technique for assessment of cardiac motions by registering gyration by a gyroscope attached to the chest wall.

The main purpose of this work is **to propose the heart beat detection algorithms and examine the usefulness of heart rate variability analysis on seismocardiograms and gyrocardiograms**. The main research hypothesis states that **the differences between HRV analysis results performed on electrocardiograms, seismocardiograms and gyrocardiograms are statistically insignificant and the time of aortic valve opening can be determined based on seismocardiograms and gyrocardiograms**. The analysis was performed on 35 recordings of electrocardiograms, seismocardiograms and gyrocardiograms which consist of 29 recordings from the "Mechanocardiograms with ECG reference" database available on IEEE DataPort and 6 recordings acquired using a recorder which consists of Arduino Micro, ECG module AD8232 and 3-axis IMU LSM9DS1.

Heart beats were detected independently on lead II of the electrocardiogram, Z axis of the seismocardiogram and the Y axis of the gyrocardiogram. The next step was calculating heart beat intervals and performing HRV analysis in two variants: on signals divided on overlapping windows of a constant width and on entire signals.

The mean length of the inter-beat intervals calculated on ECG, SCG and GCG signals are very similar. Calculated mean values and standard deviations, linear correlation coefficients, absolute errors and Bland-Altman plots indicate high agreement of HRV indices calculated on electrocardiograms and seismocardiograms as well as electrocardiograms and gyrocardiograms. For both analyzed variants of the the HRV analysis, the mean and standard deviation of HRV indices for ECG, SCG and GCG signals are similar. Slightly stronger correlation and improved agreement of HRV indices were observed while comparing the results of whole signal HRV analysis than by analyzing HRV in overlapping windows with a fixed width.

The result of the work are the analyses of HRV indices which confirm the feasibility and reliability of HRV analysis on seismocardiograms and gyrocardiograms and the development of an ECG, SCG and GCG recorder based on Arduino.