Mobile Device for Variability of Heart Rate Monitoring

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***Abstract*—Decision for a mobile device, which is able to make a monitoring of Heart rate variability is described in that article. Authors of the project had constructed such kind of hardware of gadget, which is not similar with others, if we shall speak about algorithms, also databases had been obtained and the results of data analysis you can read in the text below Abstract.**

I. INTRODUCTION

In a resent time interest to the personal health monitoring is at the one of the highest points. Especially it's evident in sports, personal, before-doctoral applications and when medicos have a necessity to forecast adaptational potential. The organism condition, behavior and adaptive potential are the subjects of study of many researches. Too much devices had been constructed to help people with it. And common part of the solutions were made for everyday usage for a wide circle of clients.

Topicality of this theme is confirmed by the large quantity of researches made in clinical and experimental medicine, in which the variability of heart rate (VHR) is commonly used factor for health estimation. According to this fact mobile devices for remoted and distant VHR measurement from the doctor are highly required.

The VHR analysis is the fastest and the cheapest way to estimate the functional status of organism, its adaptive possibilities and can help in early diagnostics of functional derangement. The special methodic of heart rate data processing is used in VHR analysis. So as requirements to the data accuracy are too high, stationary professional equipment is used for recording such kind of information. The programs of Solvag inc, CardioSpectr, monitor CardioLab+ are mostly used to process the data. Great quantity of analysis algorithms are included in holter monitor systems.

It seems to be possible to elaborate a wearable gadget, which could help people and medical specialists to make postoperative health surveillance distantly. For example, it can be useful when patient is traveling and needs monitoring of the doctor. Or when we speak about members of expeditions.

Generally all the pulse waves records are suitable (reogramm, sfigmogramm, photoplethysmogramm etc.) for pulsegramm [1].

At the current time several devices for recording and analysis of VHR: holter monitors, apparatus and complexes for tracking of current heart rate, sports pulse meters are existing.

Holter monitors are used only by medical specialists, who can mount and dismount the device, analyze the records and make a medical conclusion decision.

Devices with data processing are also widely spread. Those devises can make a recording of electrocardiogram with 1000 samples per second and higher. The precision of the measurement of R-R periods is about 1 ms. Many ways are used for distinguish R-peaks in different systems [2]. Such a systems for heart rate tracking are complicated and are heavy to move. In these systems usually 5 minutes of ECG data in two-three derivations is made. The connecting with the personal computer for following data processing is required. These systems can't be used for recording of long duration or outside.

Sports pulsometers it's models, which are oriented on the mobility and are allowed to control the current health state in any time in any place. There is no limitation for getting the coach advises or sportive medical consults through the web-clouds for sportsmen[3]. Such a pulsometers are created for recording the heart rate date, and they do have an option of sending this information then through Bluetooth applications on smartphone and providing after that its analysis.

There are devices, including the sports-ones too, which are used in photoplethysmogramm (PPG), which records the signal from the LED sensors. This devises are convenient because of there is only one sensor, which is required for data recording and it can be mounted in a watch. This devices are not used for medical purpose and than not forced to follow the medical requirements on precision, artifact and

exstrasystole filtration. All this factors do not allow to that gadgets be used for VHR analysis [2,4].

As it was shown above, there is a quantity of different devices for VHR measurements. To compete with them all the new one have to provide the precision of ECG method and the convenience of sports watch style device. The goal of this project is creation of mobile device for tracking of the heart rate variability.

The project is running in Intel-lab in Novosibirsk State University.

II. Main part

Today the hardware is constructed and tested by our group. This devises include the pulse sensors, wireless data transmitter via Bluetooth to the phone and via WiFi to the external server in the web. The first applied algorithms: determination the R-R period and extrasystoles. The project was focused on heart rate analysis and heart rate derangements determination, what is the main advantage for the our devises. Our feature is exclusive algorithmical part. Now researches about accuracy gotten information are in process

A. Heart rate variability analysis.

VHR method opens the possibility for determination the general health state of the regulatory system, but it's not connected to the specified disease. Every day new methods of it's usage are opening. It includes the forecasts for unpredictable heart death or searching for the best medicinal drug treatment. Our device determines the VHR factors (CKO, SDNN, SDANN, RMSSD, NN50, PNN50, CV) and calculates the strain index for regulatory systems [5].

B. Strain index

Determination of the strain index and stress index is the method of the VHR analysis. Strain index can be calculated in equation:

SI = AMo/(2Mo*MxDMn), where

Mo - mode - is the most frequently occurring in this dynamic range value of cardiointervals.

AMo - amplitude of the mode - is the number of cardiointervals, matches a value of the mode, in % of the total volume of the sample.

MxDMn - variation range - the difference between the maximum (Mx) and minimum (Mn) values of cardiointervals.

The extrasystoles have to be removed from the date.

SI characterizes the activity of the sympathetic regulations. In a pathological conditions SI can be increased for a couple of times. For example for the infarction the SI rise up the level of 1000-1500 with the normal level in 80-150 arb.un. In a resent time the interest to the VHR analysis is increased in the many medical spheres: midwifery, nephrology, gastroenterology etc [2, 5–8].

C. Extrasystole calculations

In the VHR analysis its required to remove the artifacts and extrasystoles. The possibility to determine the extrasystoles is also useful for diagnostics cardiovascular diseases.

The quantity of extrasystoles, equal or increase the level of 10% of all the heart beats affects the gemodynamics and requires the medical treatments. In general it's easy to determine the separate extrasystoles on the pulsogramm obtained, but for the statistical analysis it's required external algorithms. This algorithms also can help in following the extrasystoles dynamics and quantity. If the patient take the anti arrhythmic medical treatment, the method can be used to estimate it's effectiveness.

D. Rhythm violation

Additional applications of heart rate analysis include bradycrdia and tachycardia.

E. Arrhythmia

Rhythm with the 10% difference between the heart beat period is called sinus arrhythmia. Influence on sinus node by the nerves is a reason for it. The nerve system can stimulate or depress the node.

Our device allows register the heart rhythm abnormality on its appearance.

III. Equation

We have no information of the patient heart rate, so we use the discrete Fourier analysis to determine the average heart frequency. Using the fast Fourier transformation we get the transform and than multiply each element with the complex conjugated. Than we get the nonzero frequency with highest amplitude, which determine the average heart rate.

To get the strain index the precise period between pulse wave maximums is required. To decrease the noise we remove all the signals with the frequency higher, than doubled average heart rate one. Using the inverse transformation we get the noiseless signal and determine the local maximums and its period required. The periods 1.5 times longer or shorter are removed with 4 aged periods, because of possibility to be affected of extrasystoles. Strain index is calculated as ratio of most

frequent (with 50 ms precision) period to the doubled multiplication of longest and shortest periods.

IV. Conclusion

The device prototype had been constructed. It provides the continuous data record the heart rhythm with the following transmitting of data to the smartphone and external server. The particular signal analysis was realized. The next step planed is prototype improving and real life testing in clinical and home environment.

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