Hardware and software for road user`s functional state research

Oleg Furman

Transport Technology Department, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: oleg.furman6@gmail.com

Abstract – The work describes the features of studying the functional state of road users by recording an electrocardiogram. Reviewed different methods of research. Presented requirements for modern cardiographs and devices that meet these requirements. Also was conducted a brief description of the software for the processing of research results.

Keywords – electrocardiogram, cardiograph, functional state.

I. Introduction

The development of technology facilitates human work in all spheres of its activities. It also affected the scope of research. So, for example, earlier, to find out the level of alcohol in the blood of the driver, was conducted a blood test. This process took a lot of time. Instead, modern devices can do this in less than 1 minute. The speed and quality that modern devices and programs provide is a very important factor in conducting various types of research.

II. The driver's functional state and methods of its research

Functional state (FS) – indicator that shows the level of vital activity of the organism and the level of its adaptation to the environment [1]. If consider the FS, as an indicator of the reliability of the work of road users, including drivers, it can reflect their effect on road safety and the ability to perform their duties.

There is a significant number of electrophysical methods for evaluating FS. The most common of them is [2]:

- electrocardiogram (ECG)
- electroencephalogram (EEG);
- electromyogram (EMG);
- galvanic skin response (GSR);
- electrooculogram (EOG);

In transport research, the most commonly used method is ECG analysis. Electrocardiogram – a graphical record of the appearance and change of electrical phenomena that arise in the heart muscle during its activities.

The first experiment, which became a prerequisite for the emergence of modern techniques for recording ECG carried out in Cambridge in 1912 by professor Willem Einthoven [3]. There are 2 methods for recording ECG at the moment:

1. The method of short records;
2. Holter's method;

The method of short records is made in a darkened room and the subject under study are asked to stop any activity during 15 minutes before the experiment starts. Registration itself lasts 5 minutes (300s) [4].

It should be noted that the modern cardiograph should meet the next requirements [4]:

- the presence of an analog-digital converter for digitizing the ECG signal;
- to ensure the highest accuracy of the location of the peak of the R wave at the level of 0.5 ms, the quantization frequency should be at least 1000 Hz;
- The software tone localization algorithm R should be sufficiently reliable to avoid inaccuracies, especially in the case of low-quality ECG recording, presence of network drives (50.0 Hz), artifacts and other obstacles;
- Should be anthremore and other filters of high and low frequency. They serve to eliminate network cues, electrical signals from muscles and other noises;
- the construction of a software algorithm for calculating heart rate variability (HRC) parameters should be carried out in accordance with the standards;
- the program should provide access to manual correction of records in order to exclude from the analysis, if necessary, individual extrasystoles;
- The program should be easy to use and have an accessible interface so that medical personnel can easily read the recording data of short ECG periods regardless of the level of skill.

Holter's method, named after the American researcher Norman Holter. He was the first ho conducted a long-term ECG registration. This method made possible to detect disturbances in the work of even a healthy heart through the influence of harmful factors. As a rule, monitoring is carried out from 1 to 7 days. For this moment, there are two methods of this research [5].

1. Full-scale monitoring;
2. Fragment method.

With full-scale monitoring, the measurement lasts from 24 to 72 hours. Today it is used most often and is quite informative. It enables the most complete assessment of the cardiovascular system. It enables the most complete estimate of the cardiovascular system work.

The fragment method is used when there are failures in the work of the heart and they are irregular in nature. Then measurements can be made longer, or only at a time when the subject is feeling discomfort. In such cases, the patient clicks the button by activating record by himself. It is also used during research when measurements are made in certain periods of time. It is this method that is used in the research of FS of road users. Because it gives a detailed description of the heart rate variability (HRV) changes and the moments when it departs from the norm.

III. Hardware and software for research of functional state

When ECG is recorded by method of short records next devices are used: Mobile ECG «Mosquito» (Fig. 1. a), Digital 12- channel electrocardiograph (Fig. 1. b) etc.

Mobile ECG «Mosquito» – created for personal use by patients and doctors. It is compact and synchronized with any phone on the Android operating system [6].

Digital 12-channel electrocardiograph – is one of the newest devices for registration. He is able to record an ECG by the method of short recordings and Holter's method. So, it can be considered multifunctional [6].

a) *b)*

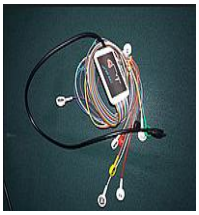

Fig. 1. Devices for recording ECG using the short record method

When ECG is recorded by Holter's method, next devices are used: SDM3, Polar smart H7, ECGpro etc.

"SDM3" – capable of monitoring up to 48 hours. Built-in compatibility with the Android operating system, Allows you to connect this device with a smartphone to recive fast the results (Fig. 2. a) [7].

"ECGpro" – fast, professional, with a complete set of techniques, cardiology complex. It is equipped with a screen for monitoring the change of HRV and edit the way of submitting information before printing (Fig. 2. b) [8].

"Polar smart H7" – combined Heart Rate Monitor, designed to record heart rate during exercise or active rest. Compatible with most programs for HRV analysis , which are working on the basis of the android operating system (Fig. 2. c) [9].

a) *b)* *c)*

Fig. 2. Devices recording ECG by Holter's method

For synchronization with devices such as SDM3, Polar smart H7, can be used next programs: HRVxt, HRV monitor, HRV lite. Characteristics of these programs are listed below [10]:

TABLE 1

SOFTWARE FOR ROAD USER`S FUNCTIONAL STATE RESEARCH [10]

Name	Characteristic	What indicators determine
1	2	3
HRVxt	Output parameters by user choice. Synchronization by using Bluetooth with Polar devices	HR, RR, SDNN, RMSSD, SDSD, pNN50, SD1, ІД2, SD1/SD2, LF, HF, LF/HF
HRV monitor	Ability to export data to different programs Synchronization by using Bluetooth with Polar devices	RMSSD, SDNN, SDSD, pNN50, SD1, SD2, Pulse, Power of LF&HF-Band with FFT Livespectrum, ØLF- & ØHF-Frequency and Poincaré-Plot

CONTINUATION OF TABLE 1

1	2	3
HRV lite	Ability to record HRV without time limit. Also ability to show the level of stress. Synchronization by using Bluetooth with Polar devices	MPB, SDNN, RMSSD, pNN50

All these programs run on the Android operating system.

Conclusion

Results of the literary analysis shows, ECG is one of the ways to study the FS of road users. It is determined that for this kind of research Holtree method of recording ECG is best suited. It allows to get more accurate data in real-world conditions. This is due to the fact that it is ECG that can accurately show the slightest changes in the state of the body of the road user.

References

[1] N. U. Hiuliev, "Osoblyvosti erhonomiky ta psyhofiziolohii v diialnosti vodiia" ["Features of ergonomics and psychofisiology in driver's practice"], 1st ed. Kharkiv, Ukraine: KhNAMH, 2012, pp. 5, 48-49.

[2] T. M. Postranskyy, "Metodyka doslidzhennya funkcionalnogo stanu vodiyiv transportnyx zasobiv", ["Methodology for studying the functional state of e drivers"], Kiev, Ukraine: DP «Derzhavnyj avtotransportnyj naukovo-doslidnyj i proektnyj instytut», 2015, №3, pp. 30 – 34.

[3] https://med-history.livejournal.com/7712.html

[4] O. A. brahamovich, V. O. Sergienko, A. P. Cher-kas, V. A. Abrahamovich, M. A. Abrahamovich, , "Variabelnist sercevogo rytmu" ["Variability of cardiac rhythm"], Lviv, Ukraine: Lviv national medical university, 2014 – 119p.

[5] http://poradu.pp.ua/krasa-zdorovya/28446-dobove-montoruvannya-ekg-za-holterom-holter-ekg-montor-vidi-cni.html

[6] http://www.tredex-company.com/en

[7] http://biomed.ua/ua/produktsiya/kardiologiya

[8] http://ecgpro.ua/

[9] http://polar-ua.com/item/datchik-chastotyi-serdechnyih-sokraschenіy-polar-h7-black-razmer-m-xxl-447

[10] https://play.google.com/store?hl=ru