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Functional diagnostics of the state of health using an express test for changing the critical flicker fusion frequency

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Функціональна діагностика стану здоров'я молоді за допомогою експрес-тесту заміру критичної частоти злиття мерехтінь

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Резюме. У статті розглянуто новий програмно-апаратний комплекс для визначення втоми людини, який забезпечує високу точність і гнучкість проведення діагностичної операції. Цей комплекс характеризується зручністю та простотою у використанні, має можливість дистанційно змінювати частотно-імпульсні та кольоро-світлові характеристики і складається з простої електронної бази компонентів. *Мета.* Створення програмно-апаратної системи для визначення функціонального стану та втоми людини. *Методи.* Аналіз науково-методичної літератури, тестування. *Результати.* Залучення технології мікроконтролера з бездротовим інтерфейсом дозволяє значно спростити компонентну базу електронної частини розробленого комплексу та розширити функціональність інструменту для діагностики втоми людини. Використання мобільних смарт-інструментів сприяє впровадженню методу дистанційного управління та плавності регулювання ключових параметрів діагностичного процесу. Встановлено, що вимірювання точності зросло на 67 % порівняно з попередньою моделлю. Пропоноване програмне забезпечення робить цю процедуру доступною та простою для більшості операторів діагностики. Комплекс для визначення зорової втоми людини протестовано і рекомендовано для промислового впровадження. Заявлене технічне рішення може бути використане в галузі безпеки життєдіяльності, виробничої санітарії, зокрема в системі визначення рівня втоми програмістів, операторів персональних комп'ютерів, диспансерного спостереження за станом зору школярів, студентів, спортсменів.
Ключові слова: програмно-апаратний комплекс, електронно-компонентна основа, програмний продукт, частота пульсацій, мерехтіння.

Abstract. The article considers a new software and hardware complex for determining human fatigue, which provides high accuracy and flexibility of diagnostic surgery. This complex is characterized by convenience and ease of use, has the ability to remotely change the frequency-pulse and color-light characteristics and consists of a simple electronic database of components. *Objective.* Creating a software and hardware system to determine the human functional state and fatigue. *Methods.* Analysis of scientific and methodological literature, testing. *Results.* The involvement of microcontroller technology with a wireless interface can significantly simplify the component base of the electronic part of the developed complex and expand the functionality of the tool for diagnosing human fatigue. The use of mobile smart tools contributes to the introduction of the method of remote control and smooth adjustment of the diagnostic process key parameters. It was found that the measurement of accuracy increased by 67% compared to the previous model. The proposed software makes this procedure accessible and easy for most diagnostic operators. The complex for determining human visual fatigue has been tested and recommended for industrial implementation. The claimed technical solution can be used in the field of life safety, industrial sanitation, in particular in the system for determining the level of fatigue of programmers, personal

computer operators, dispensary monitoring of the state of vision of schoolchildren, students, athletes.
Keywords: software and hardware complex, electronic component base, software product, pulsation frequency, flicker.

Introduction. The formation of the modern society is marked by the rapid development of communication technologies and information. They are an integral part of the whole structure of society. The stability of the operation of these technologies largely determines the stability of its existence. Their activity generates a significant for modernity effect – the virtualization of social relations, which takes place against the backdrop of the globalization. An Integration of all mankind into a single supersystem is carried out with the active use of information and communication technologies. They serve as a condition for the formation of a global information civilization. Despite the fact that technological forms accompany a person during all stages of his evolution, they have become the subject of special theoretical research relatively recent. From the standpoint of social and philosophical discourse, the phenomenon of technology began to be conceptually considered from the middle of XX century. Constructive understanding of technology provides an active-communication approach which is oriented towards interacting between man and technology. This approach allows us to consider the unity of the emerging socotran system, as it encompasses the dominant activity in their beginning, is in the form of communication [1, 2]. Relying on the indicated concept of the interaction of technology and human, the science of human health is actively developing with the dynamic development of scientific and technological progress. The health of each person is determined by the correlation of external and internal influences on her body [3, 4]. In recent years, the detioritation [5]. Automation of the educational process of higher educational institutions of Ukraine is directly related to the introduction of computer systems [6]. The volume of information is growing at a fast rate. The problem of preservation and purposeful formation of young people's health is extremely significant and relevant at this stage of society's development, since it is directly related to the problem of security and independence. For the present, the criterion of health is a certain level of functional state, which characterise its reserve capabilities and the quality of their regulation. The urgency of the study is determined by the fact that its evaluation is related not only to the ability of a person to work, but also with such physiological concepts as exhaustion, overstrain, tiredness, fatigue and recovery of the body.

Related works. Numerous works in the area of diagnostics of the functional state are known, as well as a significant number of patents and copyright certificates, which indicates a great interest in this problem. The work of the scientists Baevsky R. M., Berseneva A. P., Budchenko L. L., Garkav L. X., Gorodka M. A., Rayevskaya N. D., Danko Yu. I., Dembo A. I., Dibner R. D., Zabelyn S. I., Ivanovsky Yu. A., Ignatiev V. R., Jordan X. A., Karpman V. D., Krasnovoy A. F., Kryachko I. A., Kuznetsova T. I., Logunova S. P., Moshkova V. P., Muraveva A.V., Protasova A. I., Stupniikogo Yu. A. and others are devoted to solve the problems of determining the functional state. A large number of methods for determining the functional state and fatigue of a person are considered in the domestic and foreign literature, but the processes of adaptation to the load are not sufficiently studied (if the individual characteristics of a particular organism are taken into account) taking into account the individual characteristics of a particular organism. There is no simple and obvious instrumental method of making a decision about the moment of fatigue and fatigue. Actual problem of the method of integral evaluation of the functional state, easy to use and comfortable for the subject. An analysis of literary sources has shown that such a method can be called the method of critical frequency of flicker merging (CFFM). The development of devices for calculating CFFMs that provide the required accuracy and accuracy of measurements remains relevant in connection with the choice to determine the functional state of the CFFM method.

Purpose of the work. The purpose of the work is to create a software-hardware complex to determine the fatigue of a person, which would ensure high accuracy and flexibility of the diagnostic operation to determine the functional state of a person, characterized by convenience and simplicity in its use, had the opportunity to remotely change the frequency pulse and color-light characteristic, consisted of a simple electronic component base.

The following tasks are set to achieve the goal:

1. To study the impact of health-saving technologies on the general condition of youth.
2. To analyze statistical data on the causes of visual fatigue and its consequences.
3. To study the principles of the operation of existing devices for the measurement of CFFM.

4. To develop and put into exploitation an individual software and hardware complex for measuring visual fatigue.

Object of research: modern devices and software complexes for the measurement of CFFM.

Subject of research: software and hardware complex for determining the visual fatigue of a person.

Material of research: scientific researches of scientists, materials of conferences, personal data of students. The chronological framework of the study from the beginning of studying the fatique by the athor covers the period from the beginning of study by the author and the development of the "Photospectrum-1" device (2011) [10, 11] to the creation of a new hardware and software complex (2018).

The following research methods were used to achieve the set goal and to solve the specified tasks, in particular: 1. Problem-chronological – to establish the chronology of scientific study of fatigue; 2. Sociological – to study medical and social aspects of the spread of pathological changes on the part of the autonomic nervous system among young people; 3. Analytical – to determine the scientific guidelines for the use of radioelectronics and microelectronics in the measurement of CFFM; 4. Method of terminological analysis, which allowed to ensure the disclosure of the essence of the phenomena under investigation; 5. The method of scientific extrapolation, which allowed to determine the possibility of creating and using the device as an optimal synthesis of theoretical and practical knowledge; 6. Methods of multivariate statistical analysis and forecasting – for data processing.

Scientific novelty and theoretical significance: the basis of the useful model is the principle of creating a software and hardware complex for determining visual fatigue based on the indicators of the critical frequency fusion blinks, which has the ability to remotely change the frequency pulse and color-light characteristics, consists of a simple electronic component base.

Practical meaning. The declaired useful model can be used in the sphere of human life safety, industrial sanitation, particularly, in the system of determining the level of fatigue of programmers, operators of personal computers, regular medical check-up of eyestate of health of pupils and students.

A plan for our research and experimental study was drawn up before proceeding with the task of setting ourselves: 1. To study the influence of the educational workload on the visual fatigue of youth on literary sources; 2. To analyze statistical data on this issue in the Poltava region during the last 5 years; 3. To study the element base of the devices for measuring the CFFM that are already in operation; 4. To create a software and hardware complex for measuring the CFFM and put it into operation.

Personal Contribution by the Author. Directly the author of this scientific work software and hardware complex for measuring CFFM was designed, as well as justified the theoretical and practical expediency.

The ability to perceive the human eye of the pulsating visible light radiation is the basis of the work of the complex: at low frequency ripples the eye takes a series of light flashes, and at high frequency, the signal is perceived as equal to the glow. The limiting value after which the eye ceases to distinguish between flashing is set by adjusting the frequency of the ripples. The value of the indications varies in one and the same subject during the day due to the fatigue of the visual system, which leads to a decrease in the result by several units.

The objective is solved by the fact that in the software and hardware complex, which includes the power supply unit, a light emitter with discrete sources of visible light with constant wavelengths and the intensity of electromagnetic radiation, contains a microcontroller with a built-in hardware and software multichannel generator of discrete electrical pulses, under the connected to a microcontroller a wireless Bluetooth interface module that provides communication with a smart smartphone, where a special light-box program is specified in the special program shell, changing its frequency and color-light characteristics, while the light emitting diode itself is made in the form of a single-housing multi-crystal LED three semiconductor emitters of red, green and blue and blue.

As the basis of the hardware part, the Arduino platform is chosen, the choice is conditioned by the simplicity of hardware realisation and a a huge amount of additional modules. Hardware blocks are shown in Exhibit 1.

The work of the program part is depicted in the form of UML diagrams in the drawings. Exhibit 2, Exhibit 3. The software is implemented for the Android platform. In the future, we are planning to implement software for other platforms.

Software-hardware complex for determining the fatigue of a person works as follows, the method of work on the software and hardware complex is protected by the Patent of Ukraine [7, 8].

Measuring the complex of the critical frequency of twinkling is performed in such a consequence.

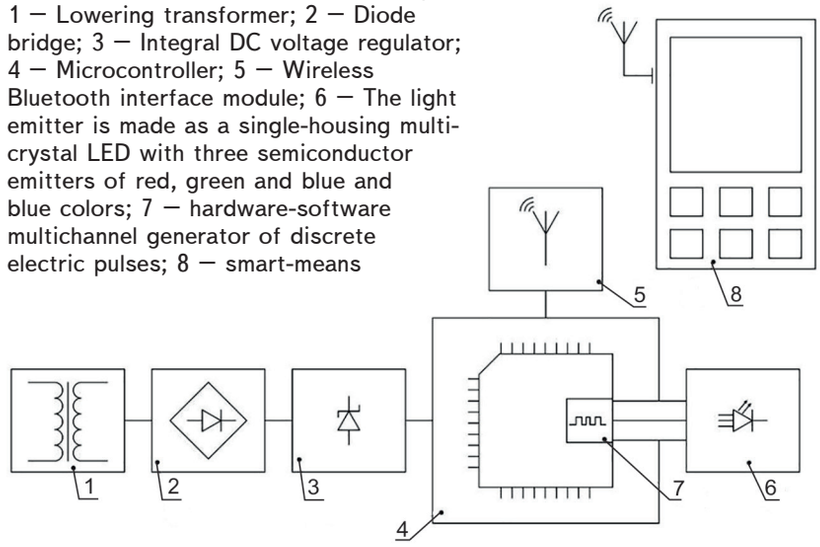

Exhibit 1 — Scheme of the hardware part: 1 — Lowering transformer; 2 — Diode bridge; 3 — Integral DC voltage regulator; 4 — Microcontroller; 5 — Wireless Bluetooth interface module; 6 — The light emitter is made as a single-housing multi-crystal LED with three semiconductor emitters of red, green and blue and blue colors; 7 — hardware-software multichannel generator of discrete electric pulses; 8 — smart-means

At the first stage of measurements, the subject is presented with light flashing with increasing frequency until the determination of the superconductive value. At the second stage of measurements, the subject is presented with light flashing, which decreasing to the specified threshold value. At the third stage of the measurements, the subject is presented with light flashing with a frequency equal to the arithmetic mean of the frequencies recorded by him at the first two stages of the measurement by means of a sequential discrete increase or reduction of the frequency of light flashing, the actual value is determined. Studies have shown that the average value of the critical frequency of visual flashing in healthy children aged 5 to 15 varies between 45 ... 55 Hz. The threshold of perception of flashing below 26 ... 37 Hz testifies to the pathology or the presence of overwork of the body. Values can change in a person during the day and the fatigue of the visual part leads to a drop of a few units, which indicates the functional state of the body as a whole.

Software-hardware complex for determining the fatigue of a person in such a performance compares favourably with the already known, because it reduces the error caused by the influence of subjective and objective factors and expands the functional capabilities and scope of use.

Comparison of opportunities and analyzed the disadvantages of the methods used to determine the functional state and fatigue rights. For the diagnosis of individual systems of the human body a complex of methods for determining their state is used as:

1) an integral assessment of the human functional state of the CFFM;

2) the time of the sensorimotor reaction;

3) the temperature and electrical conductivity of the skin.

And other parameters that will be laid by us in the next software and hardware complex to determine the functional state of man.

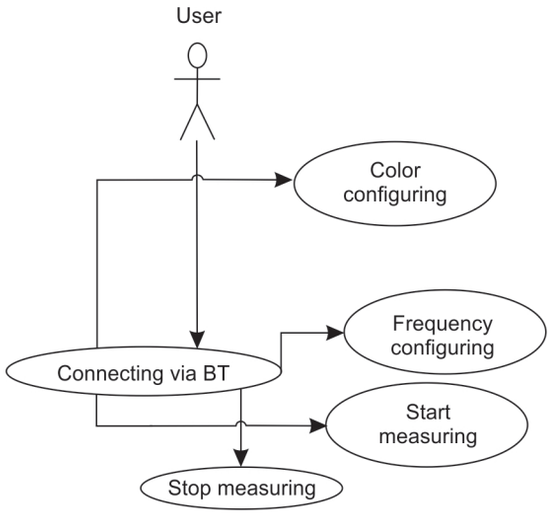

Exhibit 2 — Case diagram precedent

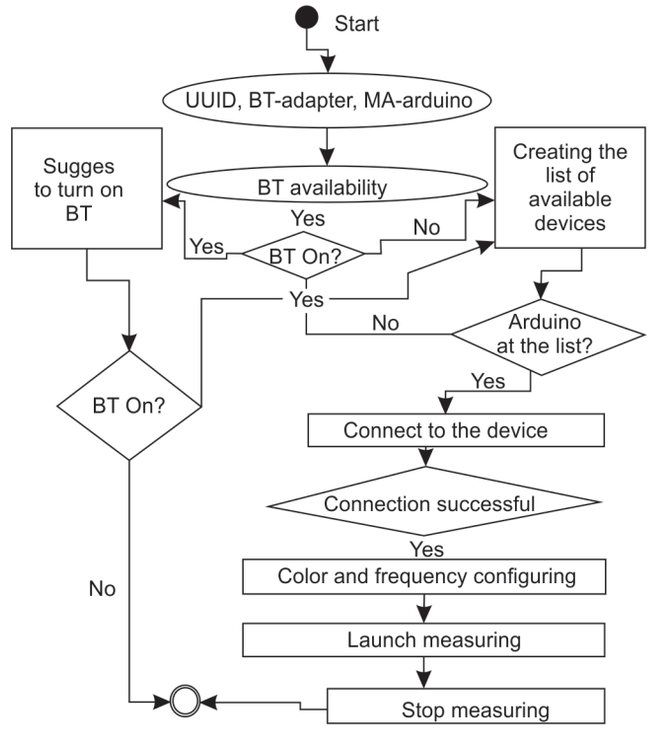

Exhibit 3 — Activity and Status Chart

TABLE 1 — **Mobile application parameters fixed on different models of smartphones**

The name of the mobile device	Android version	Number of RAM	The size of the attachment to fit	The size of the application after placement	Using RAM
HTC Desire 820	6.0.1	2ГБ	1МБ	1,93 МБ	32 MB
Huawei HONOR 8	8.0.0	4ГБ	1МБ	8,92 МБ	32 MB
Huawei HONOR 6	4.4.2	3ГБ	1МБ	5,76 МБ	32 MB

In view of all the above arguments for expediency and relevance of mobile control of the human's functional state, we worked with the Android platform, which allowed us to write a code in Java abstracting from the core. And create a mobile application to measure human fatigue based on the CFFM. At work, we noted that this operating system has such advantages as: a framework that has a wide set of APIs for the creatures of various types of applications and enables the reuse and replacement of components offered by the platform and other applications. And also the presence of Dalvik virtual machine, which provides the launch of applications. In addition, Android tools include SQLite database, 2D and 3D graphics, Media Player, communications, exchange protocols and various libraries.

Java Development Kit is a multiplatform interactive package developed for Java developers. The kit consists of several components, such as the java compiler, standard libraries, examples and templates, as well as utilities required for work. You need to install an IDE application that helps programmers write code. This program provides a brief set of tools such as debuggers, compilers, and more. Such integrated development environments are used by seasonal developers and novices who want to create an application.

There are many IDEs on the Internet, I recommend using the free Eclipse software, due to the fact that Google provides a plug-in to integrate it with the Android SDK. When you download the executable file, you must start the installation. Android Software Development Kit consists of documentation, utilities, a wide range of tools and various examples. The SDK includes a debugger, a memory and performance profile that is needed to for detecting memory leaks and find inefficient codes, device emulators, utilities needed to communicate with devices, and create packages. After all the necessary applications and plug-ins have been installed, the program code was written. Upon completion of the program code development and testing of the program on several mobile phones, a table of basic parameters was compiled (Table 1).

The results of mobile devices are shown in Exhibits 4–7.

Exhibit 4 — Work on the HTC Desire 820 Exhibit

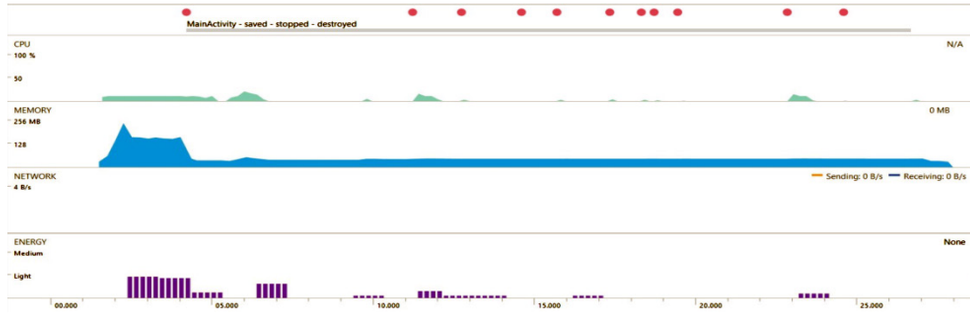

Exhibit 5 — The work of the application on Huawei HONOR 8

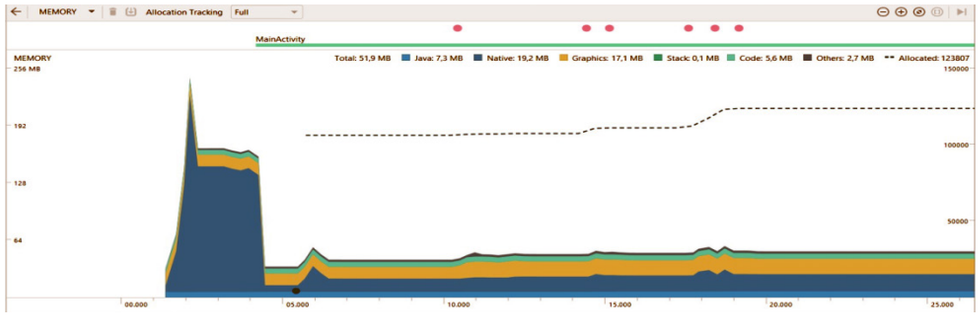

Exhibit 6 – The work of the application on Huawei HONOR 8

Exhibit 7 – Work of processor in the exchange of data with the microcon-troller

Conclusions

The enlisting of microcontroller technology with a wireless interface makes it possible to substantially simplify the component base of the electronic part of the developed complex and expand the functional of the human fatigue diagnostic tool.

The mobilization of smart-tools facilitates the introduction of a remote control method and the smoothness of the control of the key parameters of the diagnostic process.

The measurement accuracy increased by 67 % compared to the previous model.

The proposed software makes this procedure affordable and easy for the majority of diagnostic operators.

The proposed complex for the determination of visual fatigue was tested and recommended for industrial implementation. The stated technical solution can be used in the field of life safety, industrial sanitation, particularly in the system of determining the level of fatigue of programmers, operators of personal computers, dispensary observations on the state of view of students, athletes.

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