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V.T. LAZURIK, DSci (Ph.-Math.), Professor,
V.N. Karazin Kharkiv National University,
6, Svobody Sq., Kharkiv, 61022, Ukraine,
mst@karazin.ua

M.G. STYERVOYEDOV, DSci (Eng), Associate Professor,
V.N. Karazin Kharkiv National University,
6, Svobody Sq., Kharkiv, 61022, Ukraine,
keus@karazin.ua

N.V. VARLAMOVA, Doctoral Student,
V.N. Karazin Kharkiv National University,
6, Svobody Sq., Kharkiv, 61022, Ukraine,
natess123@gmail.com

INFORMATION PROCESSING SYSTEM FOR PSYCHOPHYSICAL RESEARCH WITH TWO- AND THREE-DIMENSIONAL PRESENTATION OF TEST SIGNALS

The importance of creating psychodiagnostic equipment, taking into account modern informational capabilities, is considered. The purpose of the work is to develop a conceptual model of an information processing system with the ability to represent two- and three-dimensional test signals, remote control of the testing process, data collection and storage on a remote server. The use of the IoT concept is proposed to create a conceptual model of an information processing system with a remote control function. The structure of an information processing system containing a control unit, a testing unit, an unit for receiving and transmitting data, and an unit for processing and storage data is considered. The components of the testing unit and their interaction with each other and the components of receiving and transmitting data are considered. A description of the devices for 2- and 3- dimensional test signals is given. A model of the device "Cube" for three-dimensional representation of light signals has been created. The structure of the information processing system database has been developed and presented.

Keywords: *IoT, microcontroller, information processing system, psychophysical research, 3-dimensional representation of test signals, WiFi, GPRS.*

Introduction

Understanding the importance of the influence of the psychological and psychophysical state of a person on his workability, his performance of work at various rates and types of complexity, requires obtaining high-quality information

about these states [1–3]. Prompt obtaining of objective data on the psychophysical capabilities of a person or the psychological compatibility of a group of people is provided by psychodiagnostic information processing systems. The development of such psychodiagnostic information processing systems involves the

creation of a set of methods for psychophysical diagnostics, algorithms for the testing procedure, the structure and functional model of the system, as well as significant experience in working with information technologies. Therefore, the creation of a model of such a system is of a complex multidisciplinary nature [4].

Formulation of the problem

The principle of operation of an information processing system presupposes, on the one hand, its consideration as a system consisting of components with built-in modern technologies and interacting with each other and the real world, that is, it uses the *IoT* concept. On the other hand, it is assumed that this system contains new diagnostic tools for a deeper study of the functional state of a person.

The Internet of Things (*IoT*) currently has a list of standards and recommendations for conceptual and architectural solutions for measuring systems projects.

Therefore, when developing a model of an information-measuring system, were used the recommendations of ITU-T Y.2060 and the project of the European integration project *IoT-A* (Internet of Things – Architecture), which developed reference *IoT* models, their components and used technologies. Based on the *IoT* architecture [5–7] built according to these recommendations, the structure of an information processing system for psychophysical research with a volumetric representation of test signals was developed and shown in Figure (1). Such a structure requires a detailed description of the interaction of its components.

The development of new diagnostic equipment is due to the need to maximize the approximation of the test material to real conditions. The most traditional diagnostic tools for psychophysical indicators are devices for two-dimensional representation of light stimulus or imitation volumetric techniques. At the moment, physiological differences have been identified in perception of objects in two-dimensional space, three-dimensional presented on the monitor and real three-dimensional space.

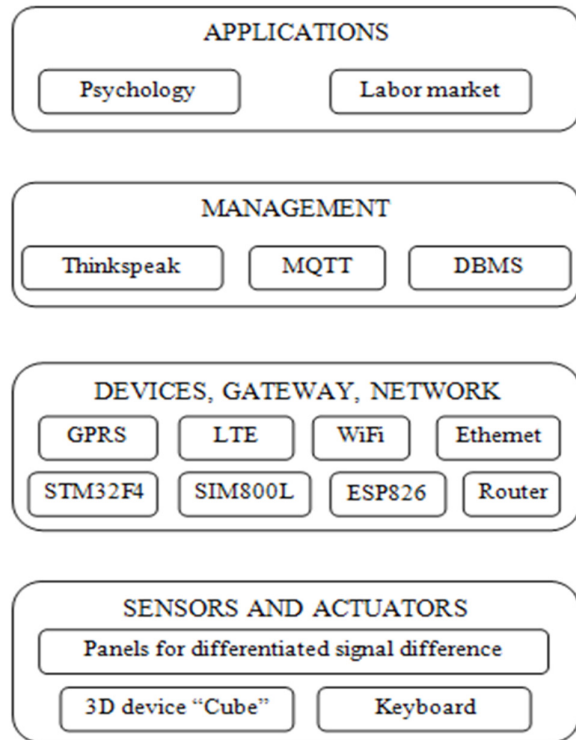


Fig. 1. Compliance of the psychodiagnostic information-measuring system with the *IoT* structure

Analysis of recent research and publications

The modern existing technical devices of psychophysical and cognitive diagnostics contain several types [8–10]:

- stationary (hardware and software complexes, controlled directly by a psychologist present, testing data is stored in the memory of a PC, a separate unit or a CD-ROM),
- remote (systems that transmit data over short distances (for example, using an infrared data exchange channel) or carry out diagnostics using an ultra-wideband radar).

No information was found about information processing systems that allow remote control of the diagnostic process (selection of a technique, management of the procedure, etc.), collecting and transmitting data to a cloud server for subsequent storage and processing.

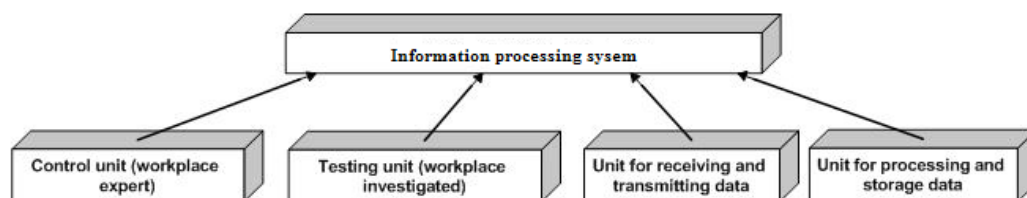


Fig. 2. Information processing system for psychophysical research

Also, existing psychophysical complexes are mainly equipped with well-known two-dimensional panels for the diagnosis of visual components. No volumetric objects of diagnostics were found.

The current task of this work is to develop a conceptual model of an information processing system, given modern information capabilities, namely, the ability to three-dimensional represent of test signals, remotely control the testing process, collect data and store information on a remote server. The object of study is automated process of diagnostics of psychophysical state of a person. The subject of study is methods for collecting, transmitting and storing information of psychophysical research, remote control.

Statement of basic materials

In the process of developing a model of system, functional and technical requirements were formed for the system itself and for its components. Requirements for the information processing system presuppose: systems-structures that have their own functional capabilities and interact with each other as a whole; functionality — using a mobile application for diagnostics, realization test tasks to study the psychological and psychophysical state of a person, collecting responses received, transmitting data, sending data to a cloud server, storing data in a database, using a mobile application for expert assessment of the state of the investigated.

The structure of the information processing system, as shown in Fig. 2, includes four units interacting with each other: a control unit (an expert's workplace), a testing unit (a stand for presenting control stimuli to a person under study), an unit for receiving and transmitting data, and an unit for processing and storage data [11, 12].

The control unit, as shown in Fig. 3, consists of a PC and a mobile application, interacting through the interface of the mobile application. The control unit can be used by an expert (to select a methodology, start a testing procedure and create an expert review) and an engineer (to control the correctness of a testing procedure). Due to the fact that the Thing speak cloud server uses the MQTT protocol, an expert and an engineer can be informed about the arrival of new data, which allows them to quickly process them.

The testing unit consists of the following components:

- panels for the presentation of two-dimensional light, sound, tactile and combined signals;
- devices for three-dimensional presentation of signals such as LED-cube or LED-ball;
- keyboard and microphone for recording responses;
- appropriate microelectronic support and software.

The panel of light signals and the device for three-dimensional representation of signals are made in the form of two- and three-dimensional arrays of multicolor LEDs. Due to their size,

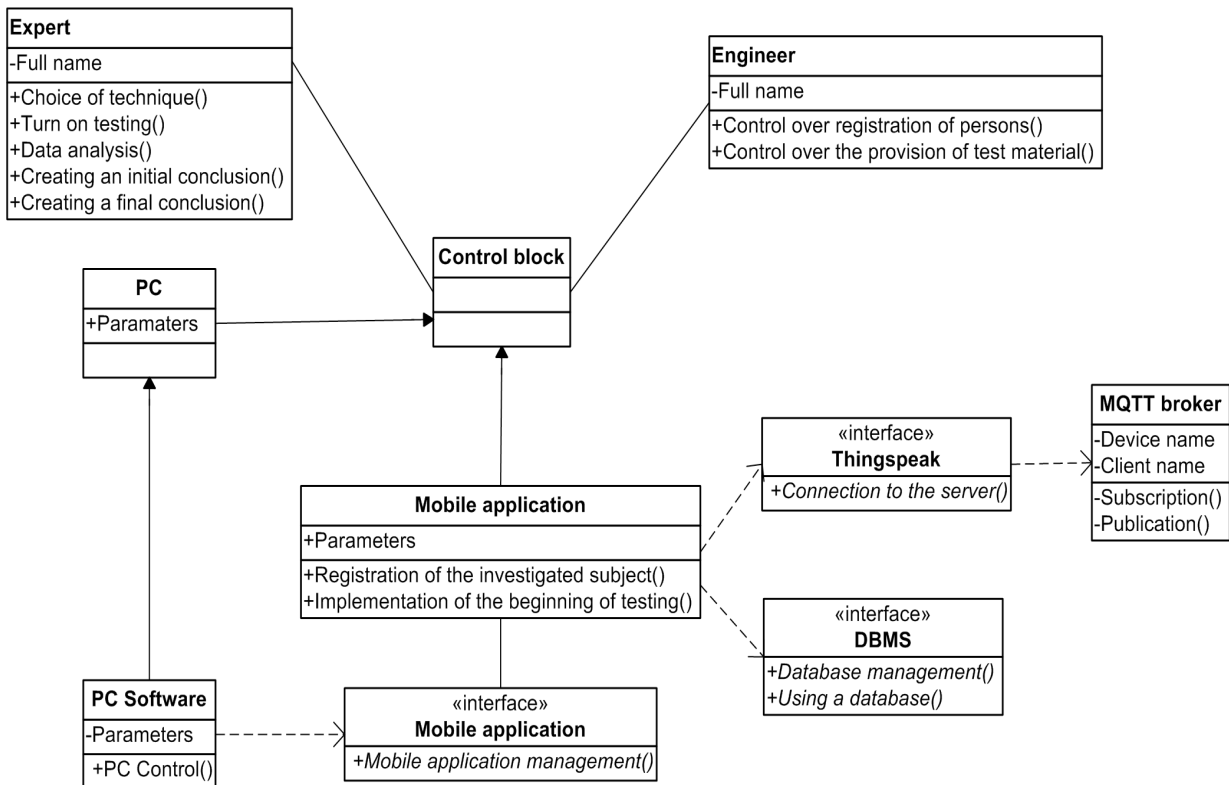


Fig. 3. Control unit class diagram

brightness, low energy consumption and cost, they are the optimal solution for using them as sources of visual stimulus, including, to use in the field conditions.

For the implementation of linear and two-dimensional light stimulus arrays, the optimal solution was the use of three-color addressable digital RGB LEDs WS2812B with a built-in controller. Simple sequential control over one wire by turning on all RGB LEDs WS2812B makes it easy to type panels of any size, as shown in Fig. 4, and rich libraries – to program any combination of light and color effects for investigated.

The electronics of the testing unit is based on the STM32F4 Discovery microcontroller [13].

The unit for receiving and transmitting data is shown in Fig. 5 in the form of a diagram classes. It includes the following components: STM32F4 microcontroller on TM32F4Discovery develop-

ment board, ESP8266 WiFi module, SIM800L GSM module and router. ESP8266 modules for wireless WiFi connection with the server and SIM800L for GSM/GPRS communication with the server are connected to the microcontroller pins and interact with it using AT-commands. Also, both modules support the TCP/IP stack, through which the connection to the global network is established. If it is impossible to transfer information through the WiFi network, the SIM800L module is used, which transfers data to the subsystem of base stations that support packet data transmission, and then through the gateway to the global network.

In the case of using a WiFi network, data transfer is carried out thanks to the ESP8266 module and the router, interacting through the TCP/IP protocol. Using the MQTT protocol based on TCP/IP, data is sent to the Thing speak cloud server, which has its own DBMS

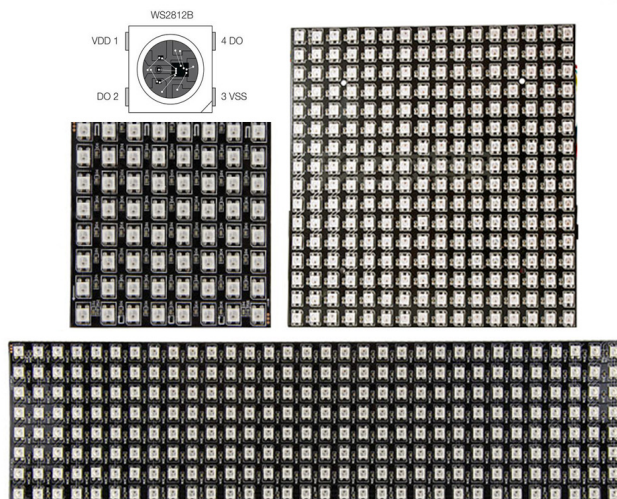


Fig. 4. Two-dimensional panels of WS2812B addressable RGB LEDs

[14]. The use of the MQTT protocol for the development of a system model is due to the provided opportunities for integrating new devices into the structure of the system, its operation in conditions of unstable data transmission and when using different levels of quality of service.

Results

The model of the LED cube for the presentation of volumetric stimulus in size 8x8x8 was made using conventional LEDs and shown in Fig. 6. The main function of the device is to provide visual light signals, according to the procedures for conducting techniques for assessing cognitive abilities in conditions close to real (3-dimensional representation instead of 2-dimensional).

For the investigated subject's answers used color and black and white keyboards with dynamic interrogation of pressed keys and their combinations.

To store data and form an expert conclusion, a database structure was developed, including a database about each subject. In turn, the subject's database consists of four units and allows

you to store general information about the subject (name, age, position, etc.), quantitative indicators of the subject for each method of initial and re-testing, initial and final expert conclusions, as shown in Fig. 7.

The unit "Expert conclusions" contains data on the main and additional indicators of techniques, the number of errors, Whipple coefficient, the probability of completing the required task (Bayes equation), pair correlation coefficients, indicators of multicollinearity and other indicators of the dependence of the test subject's criteria (in depending on the goal set by the client). The unit of final expert conclusion contains the interpretation of the obtained test results and statistical data processing.

Conclusion

The urgent problem of development a conceptual model of an information processing system with remote control capability and volumetric presentation of test signals is solved.

The scientific novelty of the developed model lies in the fact that for the first time a method for diagnosing psychophysical parameters of a per-

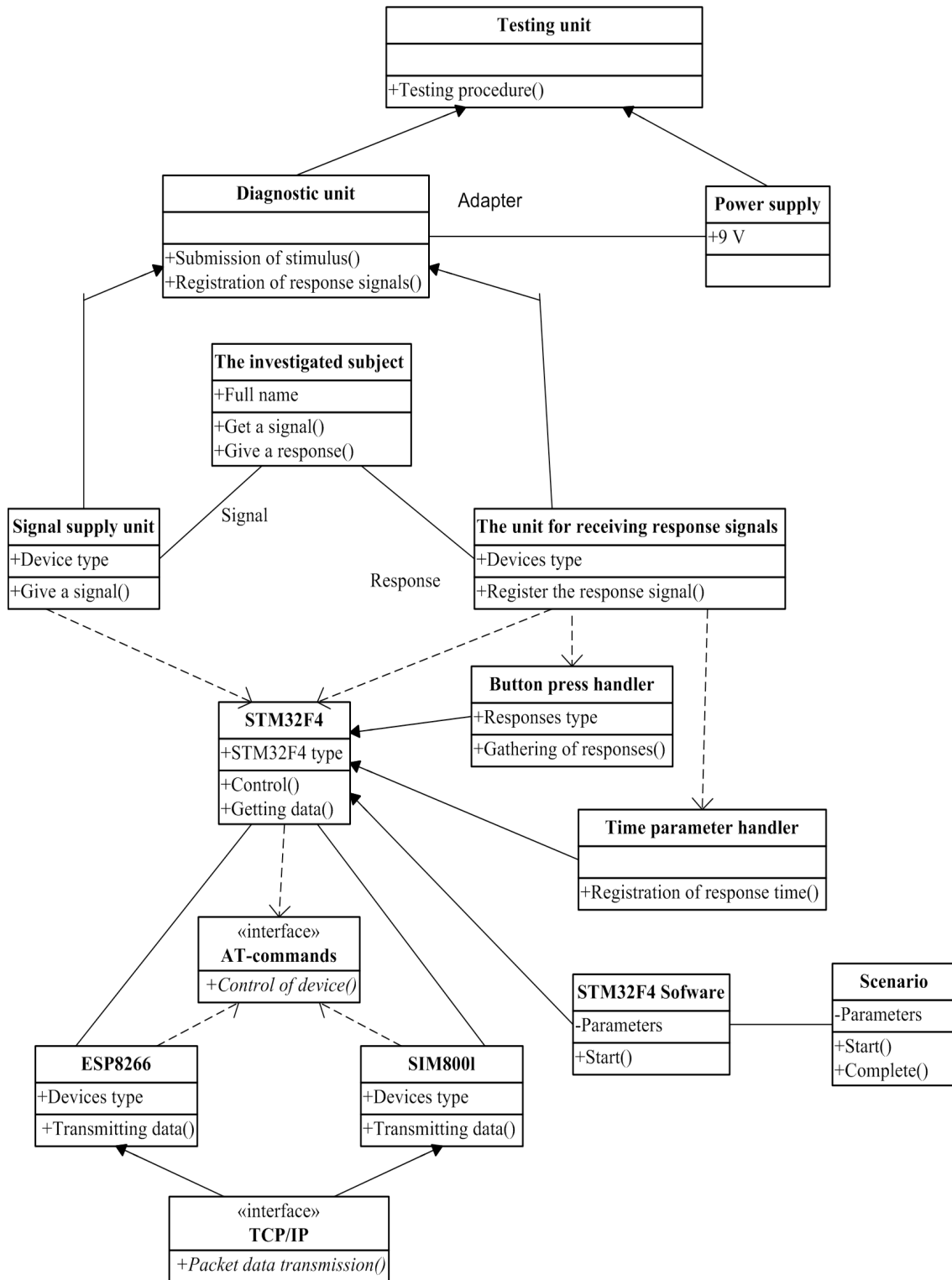


Fig. 5. Class diagram of the testing unit and the data processing and transmitting unit

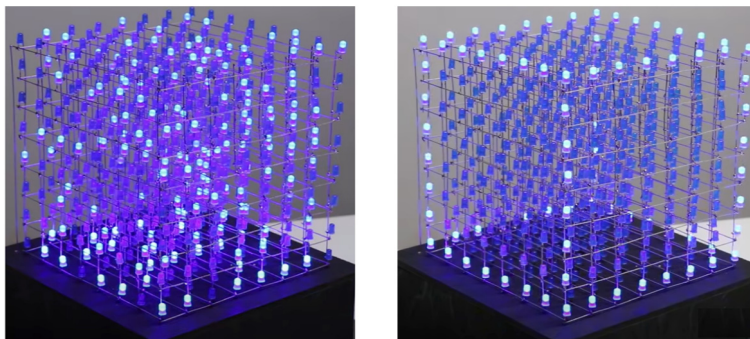


Fig. 6. Model of the LED cube for representing volumetric stimulus with the size of 8 8 8 LEDs

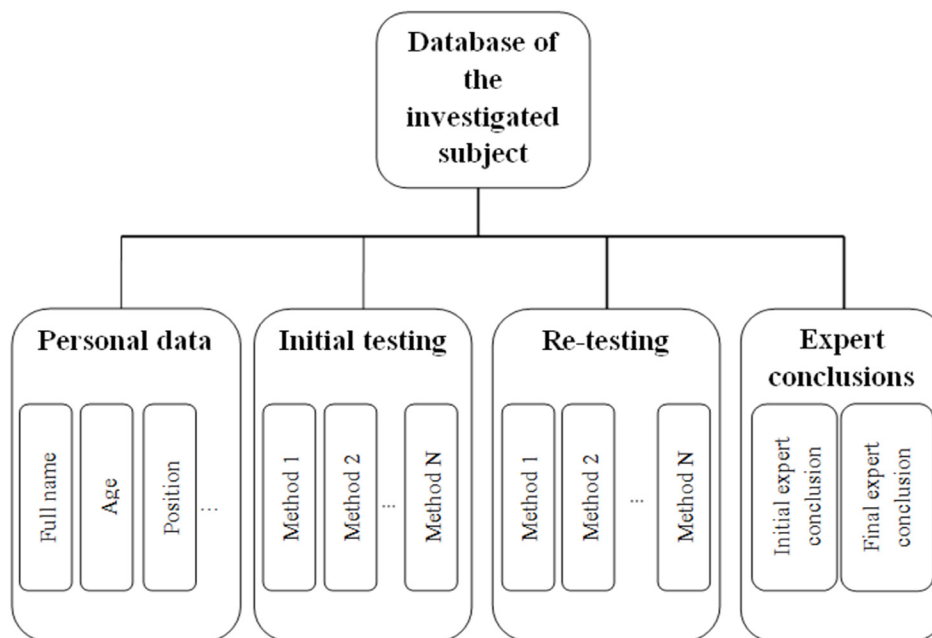


Fig. 7. Structure data base of the investigated subject

son using a real volumetric figure is proposed. It is aimed at making the experiment more consistent with real-life situations. This similarity contributes to more accurate research results.

An information processing system for psychophysical research with a volumetric representation of test signals is proposed, which is a

project based on the *IoT-A* standard model. The system consists of hardware and software modules that allow diagnosing the psychological and psychophysical state of a person in real time, transferring data using WiFi or GPRS connections to remote experts and other users. The use of statistical analysis and other methods for pro-

cessing the results allows the system to be a universal tool for diagnosing the psychological and psychophysical state of a person.

The practical significance of obtained model and devices is the possibility of their high-quality processing using statistical data analysis. Data processing makes it possible to assess the fatigue of the subjects when performing a specific technique, taking into account cognitive and psychophysical indicators. In cases of impossibility of long-term study of the subject's parameters, which are often small samples, it is rational to use analysis of variance, which allows to determine significant differences between sample variances. In cases of

the development of new methods for studying the cognitive process based on an information processing system, the calculation of the correlation dependence between two or more random variables is provided.

Modeling the data processing process allows you to give a high-quality expert assessment not only on the results of existing methods, but also to provide significant assistance in the development of new ones.

Prospects for further research are to develop various scenarios of customer requests for psychophysical and cognitive diagnostics and their mathematical and statistical processing.

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В.Т. Лазурик, доктор фіз.-мат. наук, професор, декан факультету комп'ютерних наук, Харківський нац. університет імені В.Н. Каразіна, 61022, м. Харків, майдан Свободи, 6, Україна, mst@karazin.ua

М.Г. Стервоєдов, кандидат техн. наук, доцент, зав. кафедрою електроніки і управляючих систем, Харківський нац. університет імені В.Н. Каразіна, 61022, м. Харків, майдан Свободи, 6, Україна, keus@karazin.ua

Н.В. Варламова, аспірант кафедри електроніки та управляючих систем, Харківський нац. університет імені В.Н. Каразіна, 61022, м. Харків, майдан Свободи, 6, Україна, natess123@gmail.com

ІНФОРМАЦІЙНО-ВИМІРЮВАЛЬНА СИСТЕМА ДЛЯ ПСИХОФІЗИЧНИХ ДОСЛІДЖЕНЬ ІЗ ТРИВИМІРНИМ ПРЕДСТАВЛЕННЯМ ТЕСТОВИХ СИГНАЛІВ

Вступ. Розглянуто важливість створення психодіагностичного обладнання з урахуванням сучасних інформаційних можливостей. Запропоновано використання концепції *IoT* для створення концептуальної моделі інформаційно-вимірювальної системи з функцією віддаленого управління.

Мета статті. Об'єктом дослідження є автоматизований процес психофізичної діагностики людини. Мета роботи — розробка концептуальної моделі системи обробки інформації зі здатністю тривимірного представлення тестових сигналів, дистанційним керуванням процесом тестування, збором даних та збереженням їх на віддаленому сервері.

Результати. Розглянуто структуру інформаційно-вимірювальної системи, що містить блоки управління, тестування, отримання й передачі даних та блок обробки і збереження даних. Описано компоненти блоку управління. Представлено діаграму класів блоку управління. Розглянуто компоненти блоку тестування та їхня взаємодія між собою та компонентами збору і передачі даних. Наведено опис пристроїв для 2-вимірної та 3-вимірної подачі тестових сигналів.

Створено модель пристрою «Куб» для об'ємного подання світлових сигналів. Розроблено та наведено структуру бази даних інформаційно-вимірювальної системи.

Висновки. Розроблено концептуальну модель інформаційно-вимірювальної системи з функціями дистанційного керування, 2- та 3-вимірної подачі тестових сигналів та діагностування психофізичного стану людини в режимі реального часу. Принцип роботи системи передбачає передачу даних за допомогою *WiFi* або *GPRS*-з'єднання. Застосування статистичного аналізу та інших методів обробки результатів дозволяє здійснювати якісне діагностування психофізичного стану людини.

Ключові слова: *IoT*, мікроконтролер, інформаційно-вимірювальна система, психофізичні дослідження, 3-вимірне представлення тестових сигналів, *WiFi*, *GPRS*.