ISSN 2522-9818 (print)
Сучасний стан наукових досліджень та технологій в промисловості. 2020. № 1 (11) ISSN 2524-2296 (online)

UDC 612.763:616-71 DOI: https://doi.org/10.30837/2522-9818.2020.11.147

K. SELIVANOVA, O. AVRUNIN, N. KAZIMIROV

DETERMINATION OF THE BASIC PARAMETERS OF SENSOR DEVICES FOR THE IMPLEMENTATION OF PSYCHONEUROLOGICAL RESEARCH WITH THE INTRODUCTION OF MULTITOUCH TECHNOLOGY

The **subject** of the article is the testing process on multi-touch devices for the implementation of psychoneurological studies. The **goal** of the work is development specialized dynamic tests with the introduction of Multi-touch technology to detect carpal tunnel syndrome and hand dysfunction in the early stages of the disease. An **objective** of the work is to conduct a theoretical analysis to determine the optimal parameters of touchscreen devices for the implementation of psycho neurological testing; based on experimental studies to determine the main physical indicators of the test results, indicating the presence of functional disorders of the hand. The constant use of computers, smartphones, gadgets provide multiple identical load on the wrist; constant visual and neuro-emotional stress; sitting position of the body; static tension of the musculoskeletal system caused by the need to maintain a working posture; decreased overall motor activity. The **methods** of computer modeling and visualization of dynamic tests using the multi-platform programming language Python were used. **Results.** The scientific novelty and practical significance of the obtained results is the development of specialized software and algorithmic software for dynamic testing on sensory devices with the ability to video record the movements of the upper extremities in the mode "Rapid". The advantage of this method is its non-invasiveness, ease of implementation, as well as the absence of sensors that can restrict movement. Using the rapid method, one can easily distinguish the pathological state of motor activity of the hand from the established norm. **Conclusions.** A specialized software tool was developed, which was adapted for multi-touch screens that allow identifying functional disorders of the hand by registering the main physical parameters during testing. Dynamic tests are adapted for any age category of participants (patients), have additional modes for individual color perception and different levels of complexity.

Keywords: carpal tunnel syndrome; hand dysfunction; multi-touch devices; dynamic testing; psychoneurology.

Formulation of the problem

The widespread introduction of modern information technologies in all areas of human activity, as well as the global computerization of work processes, has led to a significant increase in the number of cases of such a hand disorder as "carpal tunnel syndrome" or "carpal tunnel syndrome" especially among the young and middle-aged population [1]. Informally, it is called the "computer mouse" syndrome, sometimes the concept is found as a "gamer's hand" among teenagers and the younger generation [1–3]. Often there are concomitant consequences of this disorder in the form of violations of perception by lateral vision, in connection with the continuous processing of visual information on different monitors and screens of electronic devices [4-6]. Determination of professional or functional disorders of human hands of various etiology and pathogenesis, their prevention at the early stages is an urgent scientific and technical problem, especially in Psychoneurology, in order to develop new automated rapid testing tools using interactive sensory devices.

Analysis of recent research and publications

In scientific works [7–8], the touch screen is defined as a coordinate device, which allows you to touch the area of the monitor screen by touching the area of the monitor screen to make the necessary data element, menu or to enter data on different computer systems. It is known that touch screens use only four basic principles of construction: resistive, capacitive, acoustic and infrared; however, various sources [7–9] distinguish six, and sometimes even eight/ten, technologies for the production of touch screens [9–10].

According to the data given in [7-11], two types of displays – resistive and capacitive – have become most widespread at this time. Development of interactive tests for registration of such parameters as speed of sensorimotor reaction, pressure of force, accuracy and time of task fulfillment, determination of level of development of graphic skills, fine motor skills, dysfunction of a hand of a hand require implementation of Multitouch (or multi-touch) technology as it enables to fix several clicks at a time or only one during testing. In addition, the Multitouch screens allow the device to work with several individuals simultaneously, enabling testing to be implemented as an interactive game for children and adolescents [9]. It should be noted that touch screens have a coordinate system independent of the main display. Touch map mapping requires a conversion algorithm from one coordinate system to another. The accuracy of this conversion depends on the stability of the touch point coordinate system and the video coordinates [11].

The analysis of literature sources [1–11] found that:

- the most common types of touch screens are resistive and projection-capacitive, because they have the highest accuracy in determining the touch point;
- infrared sensors are most often used in narrow-profile models of portable electronics;
- the innovation of building sensor devices in the future will only concern the development of a flexible matrix and new protective coatings;
- capacitive sensors are convenient and easy to use for recognizing and entering information;
- for solving research problems in Psychoneurology, the best are Multitouch (multisensory) screens, which also use the click-through process.

A review of the scientific and technical literature

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2020. No. 1 (11)

[1–13] demonstrated the lack of sufficient theoretical and experimental work to determine the basic technical parameters of sensory devices for testing and physical indicators of hand dysfunction, since functional disorders of the upper extremities have neurological, or only psychological component of the pathogenesis of the disease.

Purpose and objectives of the study.

The purpose of the research is to develop specialized interactive tests on Multitouch screens to detect early-stage dysfunction of the hand or tunnel syndrome of the wrist.

To achieve this goal it is necessary to solve the following tasks:

- to carry out theoretical analysis to determine the optimal parameters of sensor devices for the implementation of psychoneurological testing;
- to determine, on the basis of experimental studies, the main physical indicators of the test results, indicating the presence of functional disorders of the hand.

Theoretical analysis to determine the optimal parameters of touch screens for the implementation of psychoneurological testing

Touching the touch screen causes local deformation of the flexible surface layer, resulting in a change in the electrical resistance or capacity of the corresponding cell, depending on the type of sensor. Contact coordinates are determined using two-dimensional matrix sensors. On the basis of matrix tactile sensors, systems of recording the coordinates of touch and fingerprint recognition for biometric identification of the person were created. Most often, resistive and capacitive touch panels are used in electronics [7].

In practice, the capacitance is calculated between the electrodes, in other words the square symmetric matrix of the capacitance of the touch screen is calculated, which determines the relationship between the voltage and the charge on the electrodes of the system.

It is generally accepted [7–9] that the diagonal components of this screen matrix C_{ii} are calculated as an integral of the energy density $\int_{\Omega} W_e$ in the area Ω and the vector of spatial coordinates V_k:

$$C_{ii} = \frac{2}{V_k^2} \int_{\Omega} W_e d\,\Omega\,, \tag{1}$$

where $V_k = \begin{cases} 0,1 & j \neq i \\ V_i & j = i \end{cases}$.

Non-diagonal members of the screen matrix C_{ij} are calculated by the formula using the vectors separately with coordinates V_i and V_j:

$$C_{ij} = \frac{2}{V_k} \int_{\Omega} W_e d\,\Omega - \frac{1}{2}\left(\frac{V_i}{V_j} C_{ii} + \frac{V_j}{V_i} C_{jj} \right), \tag{2}$$

where $V_k = \begin{cases} 0,1 & k \neq i, j \\ V_i & k = i \\ V_j & k = j \end{cases}$.

The principle of operation of the capacitive panel is based on the determination of the point of pressure, while changes in field strength and weak AC signal at the corners of the plate are recorded. Touching any conductive material on the plate will cause the current to be fixed by the sensors at the same angles. The main disadvantage of capacitive technology is the use of sophisticated mathematical processing to determine the contact coordinates and the inability to register the force of pressure on the touch screen, if it is made, for example, through a glove [8].

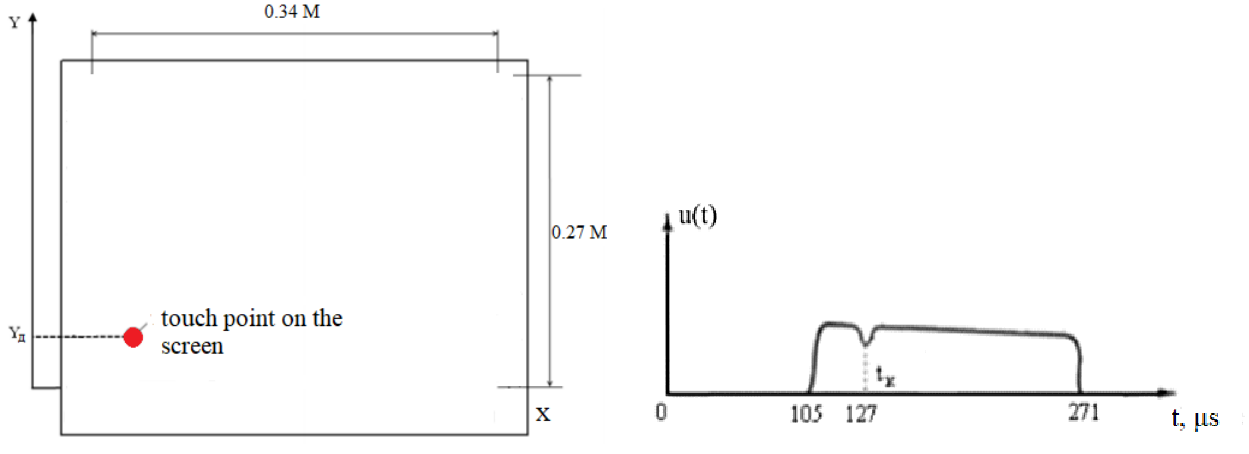
With respect to resistive technology, the panel consists of two plates that are opposite each other. A layer of resistive material is applied vertically on one of the plates and horizontally on the other, 2 electrodes are drawn from each of them. Detecting the point of contact in resistive panels is to determine the presence of contact between two conductive plates. The measurement of the coordinate of the point of click is performed along the x and y axes, respectively. The resolution of the resistive type touch panels is limited by the ADC converter bit and the voltage difference applied to the panel electrodes. Using a 10-bit ADC, you can measure up to 1024 voltage levels (ie points on the touch panel). This technology uses the simplest mathematical processing to determine the coordinates of the touch, which is an advantage over capacitive. The disadvantage of the touch screen resistive type is the wear of the panels and the need for gradual calibration [7, 8].

Here is an algorithm for finding the coordinates of the point of contact of a touch screen with a desktop with a diagonal of 17 inches (0.34m × 0.27m) (fig. 1). The registration of the electrical signal after pressing begins from the moment of receiving the wave that has traveled the shortest distance (0.34 m) on the surface of the touch panel and ends at the moment when it has traveled the longest distance (0.88 m). As can be seen in fig. 1 b the amplitude of the response signal after pressing sharply decreases, indicating that there is a touch at a certain point of the touch screen (fig. 1 a).

The accuracy of determining the coordinates of the touch point depends on the sampling rate of the received signal. Due to the higher sampling rate of the received signal, it is possible to more accurately determine the level of amplitude drop after the touch panel is pressed.

Having tested various types of touch screens for dynamic testing, the optimal specifications listed in table 1 were determined.

ISSN 2522-9818 (print)
Сучасний стан наукових досліджень та технологій в промисловості. 2020. № 1 (11) ISSN 2524-2296 (online)



a) *b)*

Fig. 1. Example of touch point calculation (a) and received feedback response form after pressing (b)

Table 1. *Optimal specifications of sensor devices for dynamic testing*

Options	Specifications
The number of pixels in the matrix	20584 (124x166)
Pixel dimensions	81.6 x 81.6 µm
The dimensions of the sensor matrix	10,1x13,5 mm
Image digitization time	2 ms
Image identification time	100 ms

Experimental psychoneurological studies on multitouch screens

The purpose of the experiment was to investigate the physical parameters during testing on Multitouch screens, which indicate the presence of wrist tunnel syndrome or hand dysfunction. The cause of these disorders is nerve entrapment in the carpal tunnel, accompanied by pain during arm movements. Continuous static loading of the same muscles in a large number of monotonous movements during prolonged work with a computer mouse, joystick, ballpoint manipulator or keyboard, due to which the wrist is in constant tension.

The experimental studies were conducted on the basis of the Laboratory of Biomedical 3D Technologies of the Department of Biomedical Engineering of Kharkiv National University of Radio Electronics. The MEDION MD 20165 monitor was used as a graphical display, which has the ability to touch control and connect Multitouch mode. It was there that the participants of the experiment were tested in the form of repeating the trajectories of motion of dynamic figures. A layout of two HP HD-5210 digital webcams was also used to provide video recording of upper extremity movements as an additional method for detecting hand dysfunction [18].

One of the basic conditions for touch screen video recording is to place bright color markers on each phalanx and hand separately, which can be easily detected by computer vision algorithms. As markers, adhesive material of various colors of circular shape was used, which can be easily attached to a person's hand. The choice of this shape is justified by the properties of the circle or sphere for projecting, since this type of figure has the most optimal shading during color segmentation. Color is used to separate the marker from the background, as well as to identify a specific marker from others. For background marker segmentation, it was decided to use HSV segmentation, which has significant advantages over segmentation in RGB color space. Dynamic test code on a multisensor screen is shown in fig. 2, taking into account the most common multitouch gestures:

- finger shift - the image becomes smaller;
- fingers spread - the image becomes larger;
- multi-finger movement at the same time - scroll;
- two-finger rotation - rotate the subject.

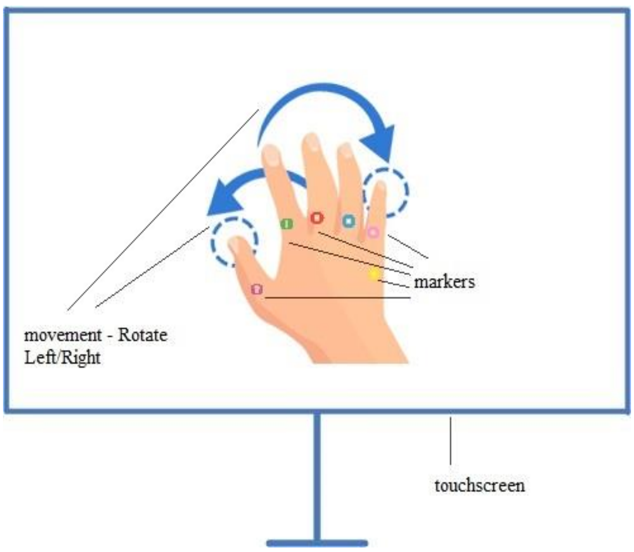


Fig. 2. Symbol for test execution on the Multitouch screen

Dynamic test development is a projection of the complex trajectory of the object's motion. Python high-level programming language was used for this purpose. The chaotic trajectory of the movement of the figure is quite difficult during the testing of the participants, because it requires the maximum concentration of attention and flexibility of the fingers and wrist, the speed of the sensorimotor response, which, as a result, allows to determine different levels of dysfunction of the hand or tunnel syndrome. The testing process itself is organized as a single system of interactive interaction between the participant and the specialist. Task templates have been designed so that the trajectories of the movement of the figure correspond to the entire workspace of the GUI at different ends of the multi-touch screen.

The dynamic test was designed as a game form that allows it to be used for different age groups of experiment participants. The object for the test is a spherical, 800x800 pixel shaped ball that corresponds to the average diameter of the fingertip. In our case, this is a pink ball that moves along a given trajectory with certain conditions. That is, when the ball touches any finger of the ball, it sharply changes its direction of movement to the opposite along the x or y axis. The "working area" of the developed GUI was set, namely 400 pixels. The motion graphic is updated every 0.09 seconds. The xd (85 pixels) and yd (45 pixels) parameters are responsible for the direction in which the figure will move from the starting point. If the object touches the boundaries of the work area, it changes its direction to the opposite according to the main condition:

$$\begin{cases} xd = -xd \\ yd = -yd \end{cases}. \tag{3}$$

Fig. 3 clearly illustrates an example of moving a dynamic object according to the given conditions. In fig. 4 shows the trajectory of the ball and the graphical interface of the software to perform testing on the Multitouch screen to determine dysfunction of the hand or tunnel syndrome of the wrist.

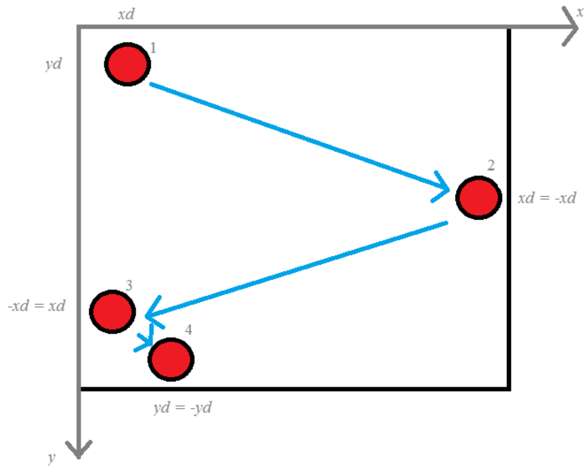
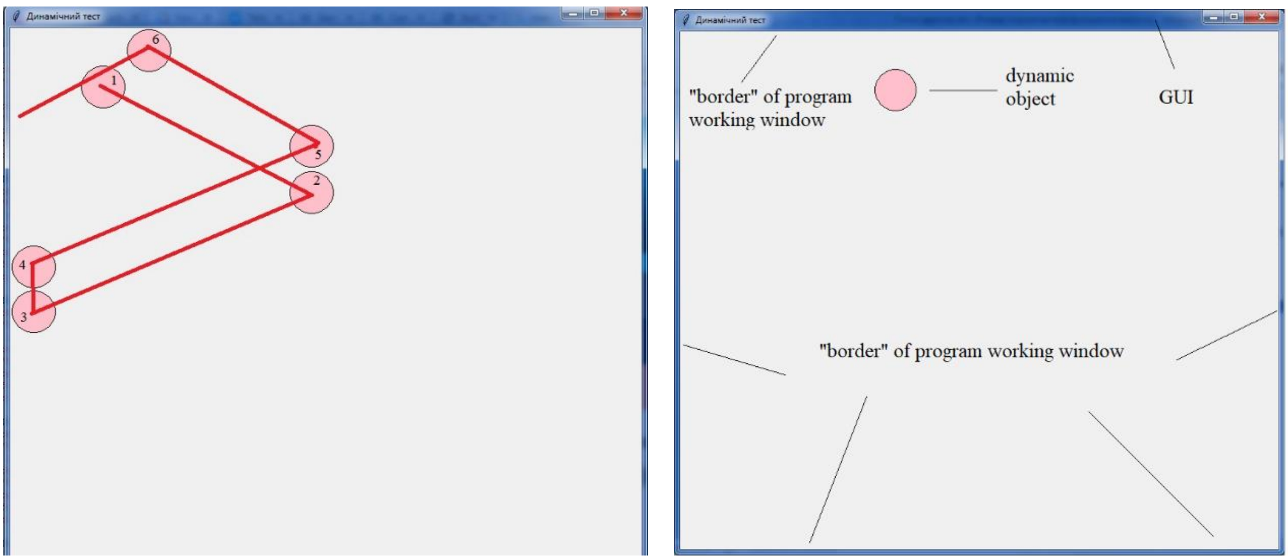


Fig. 3. Symbol for the example of programmed object movement during testing



a *b*

Fig. 4. The trajectory of the object (*a*) and the appearance of the graphical interface of the developed software for testing (*b*)

For the purpose of additional studies, about 100 variations of dynamic tests with "obstacles" were developed to analyze the concentration of attention and the degree of freedom of movement of the brush (fig. 5). The movement vector of a figure in the Cartesian coordinate system starts from the initial (0;0), with a step h=5 pixels and a random velocity of motion v(X) and v(B), for example, on a segment [-5; 5] is given by the following expression:

$$\begin{cases} x = x + v(X) \\ y = y + v(Y) \end{cases}. \tag{4}$$

The adaptation of the background and the color scheme of the main and auxiliary objects can be adjusted

Сучасний стан наукових досліджень та технологій в промисловості. 2020. № 1 (11) ISSN 2522-9818 (print) ISSN 2524-2296 (online)

individually for each participant, depending on his color perception and psycho-emotional state.

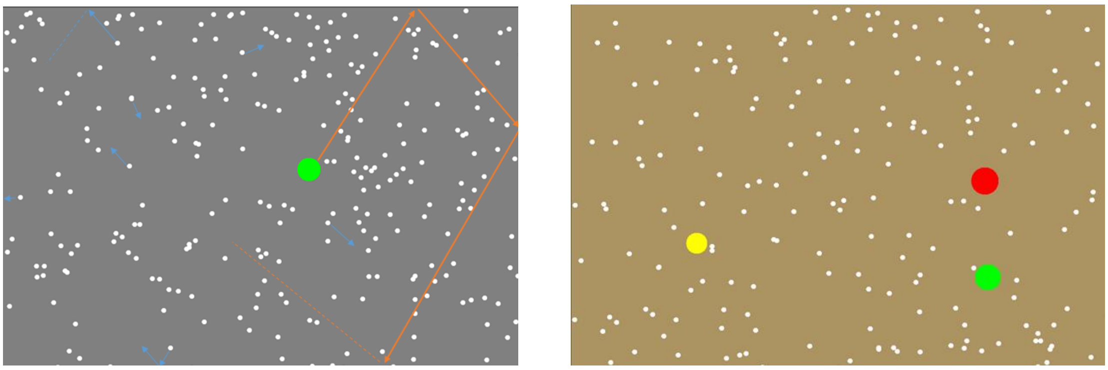


Fig. 5. The appearance of several variants of dynamic test with "obstacles" and conventions of trajectories of objects

The test is considered to have been performed if no deviations from the specified conditions were detected during its repetition of trajectories or touching of the object. If one of the markers of the hand or fingers shows an abnormal deviation from the standard, it may indicate the presence of functional disorders of the hands. The nature of the anomalous movements and the specific marker make it possible to set the type of upper limb movement disorder during video recording in rapid mode and color segmentation. Fig. 6 shows an example of a multisensor screen test performed by a participant in an experiment in the laboratory of biomedical 3D technologies with adhesive colored markers on the hand. At the study, 32 participants (19 males and 13 females), aged 20–26, voluntarily participated in the first stage of preclinical trials, of which 28 were right-handed and 28 left-handed. In this case, 2 people had signs of carpal tunnel syndrome, as participants reported experiencing wrist pain during prolonged work on various computer manipulators. The results of the survey of participants before the tests were experimentally confirmed.

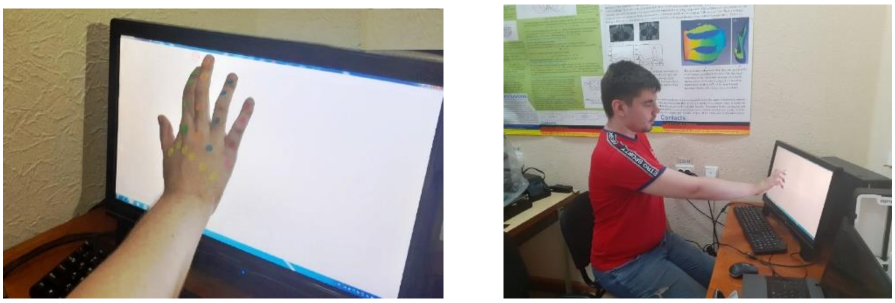


Fig. 6. An example of the implementation of the test developed by a participant (co-author of a scientific article) on a multisensory screen in the laboratory of biomedical 3D technologies of the of BME Department

In fig. 7–8 shows the automated analysis of the results of testing the participants in a graphical form on the example of performing one task in the norm and revealed dysfunction of the hand. The first and second graphs show the deviation of the x coordinates and the given trajectory of motion of the dynamic object from the experimental one, calculating the error as:

$$E = \sum_{t=1}^{n} \sqrt{(\hat{y}_t - y_t)^2 + (\hat{x}_t - x_t)^2}, \qquad (5)$$

where E – integral (cumulative) error; the mean square error (MSE) is calculated as $MSE = \frac{1}{t}E$;

$\hat{y}_t$ і $\hat{x}_t$ – registered coordinates of the participant's finger while repeating the shape's trajectory at a given time t; y_t і x_t – given coordinates of the trajectory of motion at a certain point in time t.

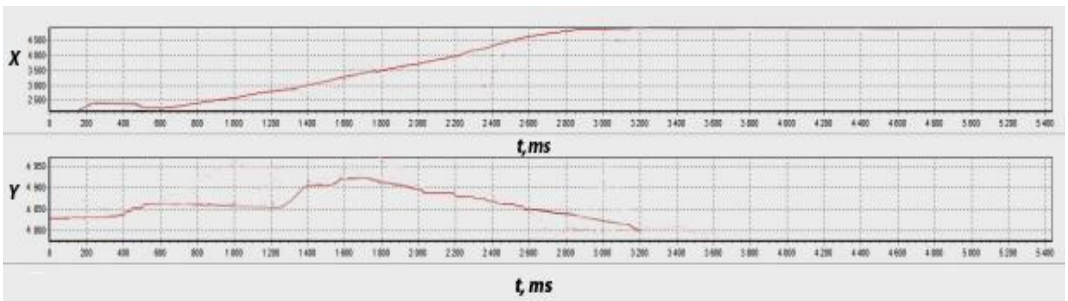


Fig. 7. Automated analysis of test results in a graphical form of the test is normal

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2020. No. 1 (11)

While observing the tasks of one participant, there were no health factors that could be prerequisites for wrist tunnel syndrome. As can be seen in fig. 8, the test run time is 54 ms, the force of the pressure is gradually changing, the deviation of the coordinates of the given and experimental trajectories looks like a positive and negative curvilinear dependence. The obtained test data are within the normal range, the inaccuracy of the task is explained by the non-concentration of the participant.

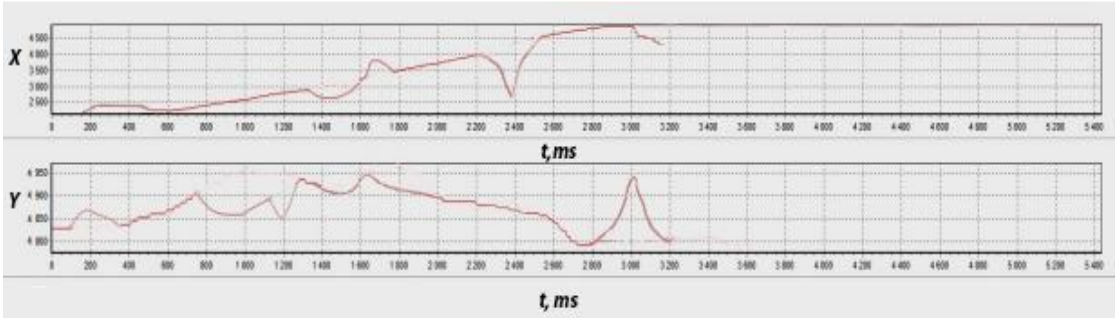


Fig. 8. Automated analysis of test results in graphical test form during functional brush disorder

Fig. 8 shows the nature of the deviation of the coordinates of the trajectories has uncharacteristic "peaks" on the graphs, which indicates the presence of functional disorder during the task.

Using the analysis of the physical parameters of the test participants, the conditional ranges for the norm and functional disorders of the upper extremities corresponding to the data from scientific sources were calculated [1–13]. Table. 2 lists the basic physical parameters of psychoneurological research.

According to the obtained data, the average experimental dependence of the force of pressure on the touch screen during touching a dynamic object and repeating its trajectory of motion from the time of tasks was constructed (fig. 9)

Table 2. *The main physical parameters of the experimental studies*

Parameter	Norm	Functional disorders of the hand
Task completion time, In seconds	< 50	> 100
The number of tasks completed correctly (20 is the maximum number of tasks)	> 15	< 7
Deviation of the experimental trajectory length from the specified one, in pixels	< 60	> 100
Force of onslaught of the dominant hand on the touch screen, in N/mm2	> 370 < 800	< 200 > 1000

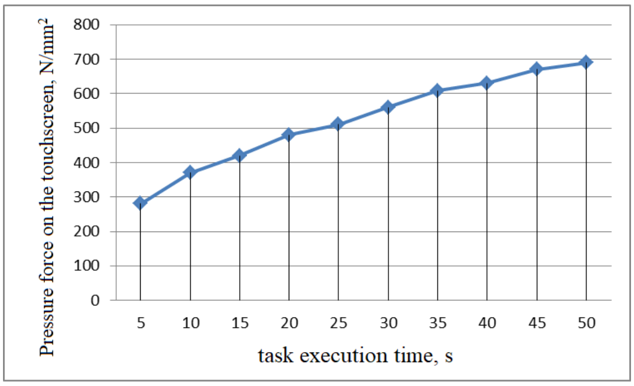


Fig. 9. The average experimental dependence of the pressure of the touch screen on the time of tasks

According to the graph, you can see a direct correlation of the curve, i.e. the increase in the force of the pressure leads to an increase in the time of the test, indicating a gradual fatigue during the perception of the task and decrease the speed of the sensorimotor response or difficulties associated with functional disorders of the hands.

Analysis of the test results showed that in 23 persons (71.88%) of the total number of participants of the experiment, the values of calculated and registered parameters correspond to the established range of norm, and in 9 (21.13%) the values of indicators have deviations from the norms, of which 2 people (6.25%) had significant abnormalities, which indicated the presence of functional disorders of the hand.

Thus, the main advantages of the developed specialized software for testing on multi-touch screens are:

Сучасний стан наукових досліджень та технологій в промисловості. 2020. № 1 (11) *ISSN 2522-9818 (print)* *ISSN 2524-2296 (online)*

- non-invasiveness of the research method;
- ease of setup and ease of implementation;
- no need for contact sensors that can be uncomfortable and limit movement, creating additional noise or interference;
- the possibility of flexible adaptation of tests for any age group, taking into account the individual characteristics of fine motor skills and psychomotor skills;
- the ability to integrate the "game form" of tests;
- great space for enhancing and expanding functionality, as well as introducing new authoring ideas to meet new research challenges.

Conclusions and prospects for further development

1. As a result of the first stage of theoretical and experimental psychoneurological studies, it was found that the optimal technical parameters of multisensory screens are: resolution in the mode of displaying tests not less than 1280x800; minimum number of finger pressure sensitivity levels is 1024; the minimum sizes of the working window of the software - 1024x768; the best resolution of a digital webcam for recording hand movements - 1280x720, which combines the trade-off between price, accuracy and performance; the pixel brightness of the dynamic test display according to [0… 255] - not less than 28 intensity levels; contrast – not less than 227 levels of intensity; minimum color gamut of tasks - two-color.

2. The data obtained during dynamic testing indicate that in participants with manifestation of fatigue of the muscles of the arm or the presence of painful sensations in the wrist, the speed of the sensorimotor response significantly exceeds the parameters of the established range of norm, and reaches from 120 to 200 ms, which may indicate about the possibility of using this parameter as a diagnostic perspective.

3. A specialized software tool, which has been adapted for multisensor screens, enables the detection of functional disorders of the hand by registering basic physical parameters during testing. Comparison of values of indicators of a conditional norm with values corresponding to different degrees of deviation allows to estimate a psychoneurological condition of the person in dynamics.

The prospect of further research is the conduct of clinical trials on the basis of medical institutions and the introduction of scientific results to improve the diagnostic process in psychoneurology.

References

1. Bogov, A. A. et all (2014), "Carpal tunnel syndrome", *Practical Medicine*, Vol. 4–2, No. 80, P. 35–40.
2. Aksekili, M. A. (2015), "Comparison of the early postoperative period electrophysiological and clinical findings following carpal tunnel syndrome: is EMG necessary?", *Int J Clin Exp Med,* Vol. 8, No. 4. P. 6267–6271.
3. Bland, J. D. P. (2007), "Treatment of carpal tunnel syndrome", *Muscle Nerve*, Vol. 36, No. 2, P. 167–71.
4. Blazar, P. E. (2015), "Prognostic indicators for recurrent symptoms after a single corticosteroid injection for carpal tunnel syndrome", *J Bone Joint Surg Am*, Vol. 97, No. 7, P.1567–1570.
5. Zaytseva, N. et all (2016), "The diagnostic opportunities of sympathetic skin response in patients with carpal tunnel syndrome", *Journal of the Neurological Sciences*, Vol. 381, P. 270.
6. Belova, N. et all (2016), "Autonomic disturbances in CTS", *2nd 108 Congress of the European Academy of Neurology, Copenhagen: Proceedings of theses*, P. 117.
7. Meshchaninov, S. K., Spivak, V. M., Orlov, A. T. (2015), *Electronic methods and means of biomedical measurements* : a tutorial, K. Chair, 211 p.
8. Asmakov, S. (2010), "Multiplicity of touch displays", *Computer Press*, No. 8, P. 60–67.
9. Mukhin, I. A. (2006), "Touch screens – problem solving", *BROADCASTING: Television and Broadcasting*, No. 7, P. 64–66.
10. Bhalla, M. R., Bhalla, A. V. (2010), "Comparative Study of Various Touchscreen Technologies", *International Journal of Computer Applications*, Vol. 6, No. 8, P. 12–18.
11. Quinnell, R. A. (1995), *Touchscreen Technology*, EDN.
12. Korolchuk, M. S. Kraineuk, V. M. (2006), *Socio-psychological support of activity in ordinary and extreme conditions*, Kyiv : Nika-Center, 580 p.
13. By general ed. O. P. Mintzera (2010), *Modern methods and means for definition and diagnosis of emotional stress*: a monograph, Vinnytsia : National Technical University, 228 p.
14. Selivanova, K. G. Tymkovych, M. Y., Avrunin, O. G. (2018), "Introduction of multi-touch technology for the implementation of interactive testing in psychoneurology", *XVII International Scientific and Technical Conference "Physical Processes and Fields of Technical and Biological Objects": Conference Proceedings*, Kremenchuk : KRNU, P. 121–122.
15. Lebedev, V. V. Selivanova, K. G. (2019), "Application of multi-touch technology for express estimation of stress level of flight composition of aircraft", *Proceedings of the reports of the Second All-Ukrainian Scientific and Practical Conference of Young Scientists, Cadets and Students "Aviation, Industry, Society"*, Kremenchuk, P. 265–266.
16. Selivanova, K. G. et all (2017), "Computer-aided system for interactive psychomotor testing", *Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments. Proc. of SPIE: Proceedings,* Vol. 10445: 104453B. DOI: https://doi.org/10.1117/12.2280815
17. Selivanova, K. G. et all (2019), "Virtual training system for tremor prevention", *Information Technology in Medical Diagnostics II.*, P. 9–14.
18. Avrunin, O. G. et all (2015), "The surgical navigation system with optical position determination technology and sources of errors", *Journal of Medical Imaging and Health Informatics*, No. 5 (4), P. 689–696. DOI: https://doi.org/10.1166/jmihi.2015.1444

Received 21.02.2020

Відомості про авторів / Сведения об авторах / About the Authors

Селіванова Каріна Григорівна – кандидат технічних наук, Харківський національний університет радіоелектроніки, старший викладач кафедри біомедичної інженерії, Харків, Україна; email: selivanova_kg@ukr.net; ORCID: http://orcid.org/0000-0003-1002-0761.

Селиванова Карина Григорьевна – кандидат технических наук, Харьковский национальный университет радиоэлектроники, старший преподаватель кафедры биомедицинской инженерии, Харьков, Украина.

Selivanova Karina – PhD (Engineering Sciences), Kharkiv National University of Radio Electronics, Senior Lecturer of the Department of Biomedical Engineering, Kharkiv, Ukraine.

Аврунін Олег Григорович – доктор технічних наук, професор, Харківський національний університет радіоелектроніки, завідувач кафедри біомедичної інженерії, Харків, Україна; email: oleh.avrunin@nure.ua; ORCID: http://orcid.org/0000-0002-6312-687X.

Аврунин Олег Григорьевич – доктор технических наук, профессор, Харьковский национальный университет радиоэлектроники, заведующий кафедрой биомедицинской инженерии, Харьков, Украина.

Avrunin Oleg – Doctor of Sciences (Engineering), Professor, Kharkiv National University of Radio Electronics, Head of the Department of Biomedical Engineering, Kharkiv, Ukraine.

Казимиров Микита Андрійович – Харківський національний університет радіоелектроніки, студент-магістр кафедри біомедичної інженерії, Харків, Україна; email: kazimirov539@gmail.com; ORCID: http://orcid.org/0000-0002-6447-4622.

Казимиров Никита Андреевич – Харьковский национальный университет радиоэлектроники, студент-магистр кафедры биомедицинской инженерии, Харьков, Украина.

Kazimirov Nikita – Kharkiv National University of Radio Electronics, Master's Degree Student of the Department of Biomedical Engineering, Kharkiv, Ukraine.

ВИЗНАЧЕННЯ ОСНОВНИХ ПАРАМЕТРІВ СЕНСОРНИХ ПРИСТРОЇВ ДЛЯ РЕАЛІЗАЦІЇ ПСИХОНЕВРОЛОГІЧНИХ ДОСЛІДЖЕНЬ З ВПРОВАДЖЕННЯМ MULTITOUCH-ТЕХНОЛОГІЇ

Предметом дослідження статті є процес тестування на мультисенсорних пристроях для реалізації психоневрологічних досліджень. **Метою** роботи є розробка спеціалізованих динамічних тестів з впровадженням Multitouch-технології для виявлення тунельного синдрому зап’ястя та дисфункції кисті на ранніх стадіях захворювання. **Завданнями** роботи є провести теоретичний аналіз із визначення оптимальних параметрів сенсорних пристроїв для реалізації психоневрологічного тестування; на підставі експериментальних досліджень визначити основні фізичні показники результатів тестування, що свідчать про наявність функціональних розладів кисті руки. Постійне користування комп’ютерами, смартфонами, гаджетами передбачає одноманітні багаторазові навантаження на зап’ястя; постійне зорове та нервово-емоційне напруження; сидяче положення тіла; статичне напруження опорно-рухової системи, що викликається необхідністю підтримки робочої пози; зниження загальної рухливої активності. Були використані **методи** комп’ютерного моделювання та візуалізації динамічних тестів із застосуванням мультиплатформенної мови програмування Python. **Результати.** Наукова новизна та практичне значення отриманих результатів полягає у розробці спеціалізованого програмно-алгоритмічного забезпечення для проведення динамічного тестування на сенсорних пристроях з можливістю відеореєстрації рухів верхніх кінцівок в режимі "рапід". Перевагою цього методу є його неінвазивність, простота реалізації, а також відсутність застосування датчиків, котрі можуть обмежувати рухи. За допомогою рапід-методу можна легко відрізнити патологічний стан рухової активності кисті руки від установленої норми **Висновки.** Розроблений спеціалізований програмний засіб, котрий був адаптований для мультисенсорних екранів, дає змогу виявити функціональні розлади кисті руки за допомогою реєстрації основних фізичних параметрів під час тестування. Динамічні тести пристосовані для будь-якої вікової категорії учасників (пацієнтів), мають додаткові режими для індивідуального кольорового сприйняття та різні рівні складності.

Ключові слова: тунельний синдром зап’ястя; дисфункція кисті руки; мультисенсорні пристрої; динамічне тестування; психоневрологія.

ОПРЕДЕЛЕНИЕ ОСНОВНЫХ ПАРАМЕТРОВ СЕНСОРНЫХ УСТРОЙСТВ ДЛЯ РЕАЛИЗАЦИИ ПСИХОНЕВРОЛОГИЧЕСКИХ ИССЛЕДОВАНИЙ С ВНЕДРЕНИЕМ MULTITOUCH-ТЕХНОЛОГИИ

Предметом исследования в статье является процесс тестирования на мультисенсорных устройствах для реализации психоневрологических исследований. **Целью** работы является разработка специализированных динамических тестов с внедрением Multitouch-технологии для выявления туннельного синдрома запястья и дисфункции кисти на ранних стадиях заболевания. **Задачами** работы является провести теоретический анализ по определению оптимальных параметров сенсорных устройств для реализации психоневрологического тестирования; на основании экспериментальных исследований определить основные физические показатели результатов тестирования, свидетельствующие о наличии функциональных расстройств кисти руки. Постоянное использование компьютеров, смартфонов, гаджетов предусматривает одинаковые многократные нагрузки на запястье; постоянное зрительное и нервно-эмоциональное напряжение; сидячее положение тела статическое напряжение опорно-двигательной системы, вызываемое необходимостью поддержания рабочей позы; снижение общей двигательной активности. Были использованы **методы** компьютерного моделирования и визуализации динамических тестов с применением мультиплатформенного языка программирования Python. **Результаты.** Научная новизна и практическое значение полученных результатов заключается в разработке специализированного программно-алгоритмического обеспечения для проведения тестирования на сенсорных устройствах с возможностью видео регистрации

движений верхних конечностей в режиме "рапид". Преимуществом этого метода является его неинвазивность, простота реализации, а также отсутствие применения датчиков, которые могут ограничивать движения. С помощью рапид-метода можно легко отличить патологическое состояние двигательной активности кисти руки от установленной нормы **Выводы**. Было разработано специализированное программное средство, которое адаптировано для мультисенсорных экранов, позволяет выявить функциональные расстройства кисти руки с помощью регистрации основных физических параметров во время тестирования. Динамические тесты приспособлены для любой возрастной категории участников (пациентов), имеют дополнительные режимы для индивидуального цветового восприятия и разные уровни сложности.
Ключевые слова: туннельный синдром запястья; дисфункция кисти руки; мультисенсорные устройства; динамическое тестирование; психоневрология.

Бібліографічні описи / Bibliographic descriptions

Селіванова К. Г., Аврунін О. Г., Казимиров М. А. Визначення основних параметрів сенсорних пристроїв для реалізації психоневрологічних досліджень з впровадженням multitouch-технології. *Сучасний стан наукових досліджень та технологій в промисловості*. 2020. № 1 (11). С. 147–155. DOI: https://doi.org/10.30837/2522-9818.2020.11.147.

Selivanova, K., Avrunin, O., Kazimirov, N. (2020), "Determination of the basic parameters of sensor devices for the implementation of psychoneurological research with the introduction of multitouch technology", *Innovative Technologies and Scientific Solutions for Industries*, No. 1 (11), P. 147–155. DOI: https://doi.org/10.30837/2522-9818.2020.11.147.