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Рассмотрены актуальные вопросы в области математики, информатики и управления: математического моделирования сложных систем и бизнес-процессов, исследования и разработки защищенных и интеллектуальных информационных и телекоммуникационных технологий, математической теории управления, технологий искусственного интеллекта.

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СЕКЦИЯ 1

Қолданбалы математика, информатика және басқару теориясының қазіргі заманғы мәселелері Бизнес процесстер мен күрделі жүйелерді оңтайландыру мен модельдеу. Есептеу математикасы, сандық талдау және программалау, математикалық логика. Статистика теориясы. Статистикалық әдістер

Современные проблемы прикладной математики, информатики и теории управления. Моделирование и оптимизация сложных систем и бизнес-процессов. Вычислительная математика, численный анализ и программирование, математическая логика. Теория статистики. Статистические методы

Current issues of applied mathematics, computer science and control theory Modeling and optimization of complex systems and business processes. Computational mathematics, numerical analysis and programming, mathematical logic. Theory of statistics. Statistical methods

BIOTECHNICAL SYSTEM OF PSYCHOPHYSIOLOGICAL TESTING

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Annotation. A biotechnical system (BTS) has been developed for psychophysiological testing with recording the physiological parameters of the test person in real time. Photoplethysmogram (PP) data of galvanic skin response (GSR) were identified as sources of physiological data. The BTS of psychophysiological diagnosis allows, when answering each question of the test, to record and evaluate the psychophysiological state of the test person, which provides additional information for the psychologist.

As experimental tests, the Bass-Darkey methods were chosen, which allow diagnosing the aggressiveness of a person, assessing neuropsychic stability and diagnosing conflict in a person. These tests are recommended for use in psychological selection for employment in public and private organizations, as well as for service in law enforcement agencies [1-2].

Introduction

In the era of scientific and technological progress, with its intense rhythms, new specific conditions for human activity, the requirements for its intellectual, emotional and volitional resources are significantly increasing. In this regard, there is a particularly acute need on the part of the personnel departments of organizations in an objective psychophysiological portrait of a person. The main apparatus of psychologists are psychological tests. However, as practice shows, due to the general accessibility to tests, the effect of subjectivity will increase in recent years.

The active introduction of technological achievements into the theory and practice of studying the functions of living organisms and biological systems is a distinctive feature of modern medicine, veterinary medicine, agronomy, ecology and biology. In this regard, knowledge of the basics of biophysics, biochemistry and systems analysis acquires a special role in the training of an engineer working in these areas. This knowledge serves as the foundation for the subsequent study of methods for designing biomedical equipment [1].

A single complex in which interactions of a technical device with a biological object are purposefully implemented is called a biotechnical system (BTS). BTS refers to a special class of complex systems consisting of biological and technical components (subsystems) combined and functioning in a single control complex (Fig. 1), where B is a biological object, T is a technical device (TD), T_i are the main subsystems of TD, T_{ij} – components of the main subsystems of TD, B_i – main subsystems of the biological object, B_{ij} – components of the main subsystems of TD. Between a technical device and a biological object, there can be substance (substance flows), energy (energy flows), information (information flows) connections [2-3].

The rapid development of computer technology contributed to the automation of the conduct and processing of psychological testing and the use of new methods of mathematical processing of biomedical data. Modern possibilities for the development of various sensors

and the reduction in the cost of microprocessors also opened up a wide opportunity for the introduction of hardware and software tools for assessing the psychophysiological portrait of a person.

One of the representatives of biotechnical systems is software and hardware systems for psychophysiological testing of a person, the relevance of which is caused by the ever-increasing need on the part of personnel departments of organizations in an objective psychophysiological portrait of a person. At the same time, one of the few possible ways to improve personality recognition is the development of new criteria for assessing the psychophysiological parameters of a person. If previous scientific studies were mainly focused on psychological tests of building a portrait of a personality, then in this work it is supposed to use hardware and software.

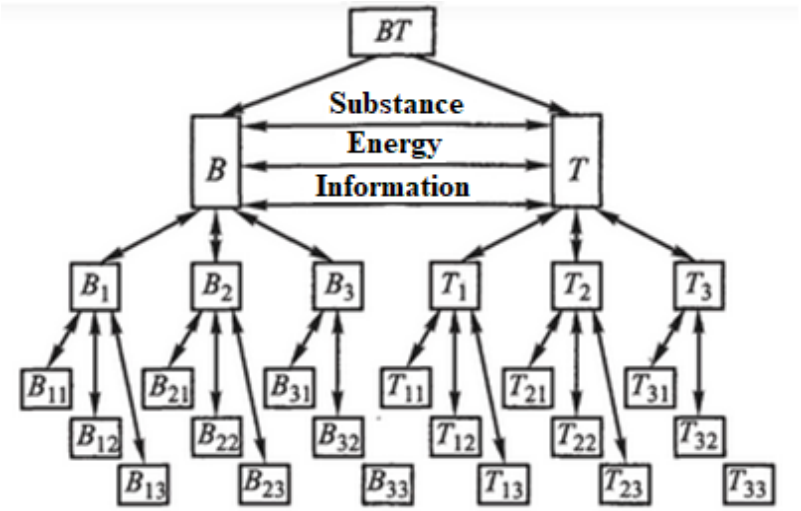

Figure 1. Block diagram of the BTS

The formulation of the scientific and technical problem of the analysis and synthesis of biotechnical systems was due to the need to develop a general theory of integration of technical and biological elements in a single control loop. For the first time, this problem arose in connection with the need to solve applied interdisciplinary problems related to the development of automated systems for artificial circulation and respiration, systems for replacing lost hemodialysis functions, and the creation of biocontrolled limb prostheses. The beginning of these works date back to the late fifties and sixties.

Somewhat later, in the early seventies, new tasks were set for the application of bionic methodology to the development of adaptive biotechnical systems of the ergatic type, as well as biotechnical systems that control the purposeful behavior of living organisms.

The subject, tasks and methods of the BTS theory can be formulated as follows:

– determination of requirements for the characteristics of medical equipment and biotechnology from the standpoint of a systematic approach;

– establishment of links for the intended purpose and technical characteristics of BTS, taking into account the specificity of biological objects;

– development of methods for the quantitative description of biological objects;

– formulation of problems of analysis and synthesis of various classes of BTS.

In the BTS theory, invasive and non-invasive methods of interaction between technical devices and biological objects are distinguished.

Methods and problem statement

Methods for determining the state of a biological object using influences that destroy or damage the biological object and its subsystems to one degree or another are called invasive. Thus, invasive methods (various bioassays, blood tests, bone tissue punctures, biopsies) are associated with dismemberment or destruction of biological objects.

Methods for studying a biological object that use the difference in the physical and chemical properties of subsystems without destroying the integral biosystem are called non-invasive. The current trend in the development of BTS is to improve non-invasive methods, which include fluoroscopy and rheography.

Discussion and results

According to the functions performed by a biological object in the system, BTS can be divided into medical, ergatic, BTS for managing the whole organism. In turn, each group has its own varieties, which differ in the type of objective function or the scope.

There are four main classes of medical BTS:

– diagnostic – radiographs, rheocardiographs, tomographs, ultrasound machines, electrocardiographs, electroencephalographs;

– therapeutic – devices for aeroionotherapy, phototherapy, EHF-therapy;

– surgical – devices for ultrasonic and laser surgery;

– artificial organs (prostheses, artificial heart) and artificial life support devices (artificial liver, kidney, ALV).

Ergatic BTS combine tools that solve the problems of managing complex technical objects with the help of a human operator. These are aerospace and other transport systems, control systems for power plants with a high risk of decision-making, telecommunications, and computer systems.

The study of ergatic BTS is necessary for the formation of requirements for a human operator, the requirements for coordinating the flows of information coming from technical means to a living organism, as well as the control actions of a human operator on technical means.

BTS of whole organism control combines living organisms and means that serve to form an artificial habitat (space, deep-sea research), the formation of directed behavior in living organisms (behavioral reactions in animals, virtual reality in humans).

Depending on the field of application, the BTS under consideration may contain one biological link – the subject, and three technical links: a data recording and processing device, a device for diagnosing the condition of the subject and a device for influencing the formation of a functional test, or the BTS may include two biological links (the subject and the doctor conducting diagnostics of the condition of the subject) and two technical ones: a device for recording and processing data and an impact device for forming a functional test [4].

BTS design includes the following main stages:

1. Determination of the intended purpose and class of the designed BTS. Based on a detailed analysis of the possible scope, it is established which of the four classes listed above

belongs to the created BTS, formulate the development goal and the objective function of the BTS.

2. Creation of a database on the properties of a biological object based on reference materials and, if necessary, studies of a biological object. Due to the complexity of a biological object, it is often practically impossible to give its qualitative and, even more so, quantitative description as an integral system. To determine the state of a biological object, a description of individual subsystems is used. For example, during a general examination of a patient, the doctor prescribes a blood test. Based on the results of such an analysis, a conclusion is made about the state of the whole organism. Special diagnostic methods are based on the fundamental relationship between the properties and functions of individual organs, tissues and cells of the body with the state of homeostasis of the body.

3. Analysis of the bioobject, choice of the state vector and method of quantitative description of the bioobject. This stage of the study consists in describing the biological link of the BTS based on the study of the physiological processes of the body in the conditions of its interaction with the technical links of the BTS.

As noted earlier, the state of a biological object is characterized by a state vector. To describe in detail such a biological object as a human body, it is necessary to operate with a state vector containing a huge number of components ($n \sim 10^4$). As a rule, to solve specific problems of analysis and synthesis of BTS, such a number of components is not required, therefore, minimization (reduction) of the number of state vector components is carried out.

4. Designing an objective function that determines the degree of compliance of the designed medical equipment with the basic requirements for this class of BTS: bioadequacy, criteria for operating errors (for example, the accuracy of measuring the properties of a biological object), the criterion of optimality, both in terms of technical characteristics and cost (resources).

5. Creation of verbal, physical and mathematical models of a biological object. At this stage, it determines the model of the biological link of the BTS, which connects the input and output variables of the considered physiological system. The study of BTS in order to establish requirements for the construction of equipment and algorithms for its functioning is carried out by the method of sequential modeling of verbal, physical and mathematical models of a biological object.

6. Determining the dose-effect relationship. Accounting for the main factor of BTS bioadequacy – the minimum harmful effect of a technical device on a biological object.

7. Regularization (correctness check) of the BTS model.

8. Description of the structure and design of the BTS includes the development of experimental models of equipment and testing of the created methods and tools. At this stage, medical and technical requirements for prototype equipment for serial production are also established.

Instrumental methods of psychophysiological testing (as opposed to psychological tests-questionnaires) objectively evaluate physiological indicators that characterize the state of the central nervous system. When performing these tests, conscious control by the criterion of "improvement" is impossible, and therefore the results obtained are more reliable and veracible [5-6].

To conduct psychophysiological research in medicine and other fields, various devices for collecting and analyzing human physiological reactions are widely used, which include

polygraphs, voice stress analyzers, strain gauge platforms, etc. These devices register and process human responses to perceived stimuli [7].

Psychophysiological examination helps to determine the level of stress resistance, the ability to concentrate, which will significantly reduce the likelihood of accidents at work [8].

Psychophysiological studies of a person allow us to conclude that:

- the level of concentration of attention;
- resistance to stressful situations;
- the level of anxiety.

Psychophysiological testing examines certain psychophysiological characteristics of a person's condition:

- activity of the brain;
- activity of the cardiovascular system;
- electrical activity of the skin;
- activity of muscle groups;
- activity of the respiratory system;
- eye reaction.

During testing, the following physiological parameters are recorded and processed [9-10]:

1. Galvanic skin reaction (rheogram)
2. Cardiovascular activity (photoplethysmogram)
3. Breathing (pneumogram)
4. Motor activity (mechanogram)
5. Trajectory of eye movement
6. Change in pupil area
7. Blink

Indicators of the cardiovascular system are usually assessed by the method of electrocardiogram and plethysmography. Plethysmography allows recording the reactions of the vascular system in the body [11-12].

In addition, during the psychophysiological study, the electrical activity of the skin is determined in order to follow the reactions of a person. The fact is that the electrical activity of the skin is directly related to the activity of the sweat glands, which in turn are controlled by the work of the nervous system. By examining the electrical activity of the skin, the expert determines the emotional state of a person under the influence of various external stimuli.

Human muscle activity is analyzed using electromyography. This method allows you to determine the electrical impulses in the muscles, to record the potentials in the fibers.

In psychophysiological testing, respiratory rate is recorded using a pneumograph, a special belt that is wrapped around a person's chest. The sensors of this device register any changes in the volume of the chest. As a result, the expert makes a conclusion about the number of breaths per minute of time and about the change in the amplitude of movements under the influence of various factors.

The GSR sensor is used to measure the magnitude and amplitude of the human galvanic skin response. Measures the electrical resistance of the skin, phasic and tonic component. One of the most sensitive and informative sensors. Clearly fixes the reactions of recognition and activation of mental representations. The amplitude and magnitude of the reaction is fixed in real time and depends on the functional state of the human body. Method of measurement – according to Ferret. Sensor type – electrodes with a special coating to

eliminate the effect of coating polarization. The current in the measurement circuit is 2 μA. Operating range 1 – 2048 kOhm [13-15].

Photoplethysmogram pickup sensor (PPG). Measures indicators of cardiovascular activity of a person. Sensor type – optocoupler. Gain factor – 1500. Automatic and manual gain correction in the range of 1-64. Retrieval of information from the finger of the hand (signal reflection). In a state of strong emotional stress, when a person is presented with verbal stimuli, the amount of blood in the vessels of the extremities changes significantly. With each heartbeat, the size of the gaps and the elasticity of the vessels and a number of other indicators change. This sensor makes it possible to detect a whole range of changes in the body caused by emotional stress and can serve as a reliable indicator of their magnitude during polygraph tests [16].

On the Arduino platform, a system has been developed for receiving and processing data from PP and GSR sensors. To connect the sensors, the AD8232 chip (a product of Analog Devices) was used, which is an integrated signal processing unit for the PP and GSR.

A distinctive feature of this module is its compactness and external connection to computers, which allows you to create mobile systems of diagnostic equipment. The device connects to the computer via a USB connector.

The BTS of psychophysiological testing allows, when answering each question of the test, to record and evaluate the psychophysiological state of the test person, which provides additional information for the psychologist.

When processing physiological data, the following parameters of PP and GSR are calculated, which are necessary for a mathematical model for assessing the state of the subject: minimum and maximum amplitude; the mean value is the standard deviation of the amplitude. For the PP, the minimum and maximum values of the RR-interval and the minimum and maximum values of the amplitude T-peak are additionally calculated; minimum and maximum offset of the T-peak.

Personality aggressiveness test

Aggression is an individual or collective behavior, an action aimed at causing physical or psychological harm, damage, or destruction of another person or group of people. Aggressive behavior in this case is defined as one of the forms of response to various physically and mentally unfavorable life situations that cause stress and frustration. Aggressive actions with aggressive behavior act as a way to achieve some significant goal, a way of psychological relaxation, a way to satisfy the need for self-realization and self-affirmation [17].

Personality traits are more pronounced in a state of emotional stress. Therefore, psychologists carefully study the reactions of the individual in a situation of frustration. Considering the concept of "frustration" within the framework of the psychodiagnostic approach and from the point of view of interpersonal interaction, we mean situations in which the persons surrounding the individual intentionally or inadvertently infringe on his interests, which leads to blocking of significant needs, or hurt his pride, negatively affecting him self-esteem.

In a situation of frustration, the emotional state manifests itself:

1) as a reaction of fear, anxiety, refusal of self-realization, may be accompanied by a sense of guilt, the desire to escape from the conflict;

2) as offensive, blaming others, active or even aggressive behavior, hostile statements or actions;

3) as a desire to suppress both those and other reactions, to take a passive or indifferent attitude to what happened, to try to level the sharpness of the conflict.

Test of neuropsychic stability of personality

Neuropsychic stability is a property that characterizes a person in the process of complex activity, some of his emotional mechanisms, closely interacting with each other, lead to the successful achievement of goals.

The main elements here are: the level of self-esteem, emotional stability, social approval of the surrounding people. The concept of reliability and functionality of reality is included in the understanding of stability. The stability of psychological stability depends on the realization of the individual in society, it affects life satisfaction, the success of professional activity and the worldview in general. A decrease in neuropsychic stability leads to the emergence of stressful situations with negative consequences for health and the fading of personality development in the process of life. Nervous-psychic stability is considered as an integral personality trait and a complex of individual abilities. Its manifestation in a person depends on various factors. Among the variety of factors, there are personality traits and factors associated with the social environment.

Factors of neuropsychic stability are:

- environmental factors maintaining self-esteem;
- support in self-realization;
- promotion of adaptation;
- reliable help from the social world, including from friends, relatives, colleagues.

These factors have a positive effect on neuropsychic stability in a person. Their presence forms favorable behavior in the process of professional activity and personal development of a person. With the negative influence of these factors, neuropsychic stability weakens, symptoms of apathy, despondency, depressive states and anxiety appear.

Psychological stability represents various personality traits and individual aspects of character, which are determined by stamina, poise, and resilience. These qualities help to resist a person in the process of life's difficulties, unfavorable circumstances, while maintaining health and efficiency of labor activity [18].

One of the most important criteria for entering the military service is an assessment of the level of neuropsychic stability. The assessment of neuropsychic stability and the identification of persons with neuropsychic instability is an important direction in the psychological (psychophysiological) support of conscripted and contracted military personnel in military units.

Personal conflict test

The conflict nature of a personality is understood as its integral property, which reflects the frequency of entry into interpersonal conflicts. With high conflict, the individual becomes a constant initiator of tense relationships with others, regardless of whether this is preceded by problem situations. Personal conflict is determined by the complex action of psychological (temperament, level of aggressiveness, psychological stability, level of claims, current emotional state, accentuation of character, etc.), socio-psychological (social attitudes and values, attitude towards the opponent, the focus of interaction "on oneself" , competence in communication, etc.) and social factors (living and working conditions, relaxation opportunities, social environment, general level of

culture, opportunities to meet needs, etc.). Let us consider the most commonly used tests and questionnaires that allow us to identify certain aspects of personality conflict [19].

The most numerous are interpersonal conflicts. 75-80% of interpersonal conflicts are generated by a clash of material interests of individual subjects, although outwardly this manifests itself as a mismatch of characters, personal views or moral values. These are communication conflicts. Conflicts between the individual and the group are similar [20-21].

Conclusions

A BTS has been developed for psychophysiological testing of personality conflicts, which allows recording and evaluating the psychophysiological state of the test person when answering each question of the test. The graphical user interface of the application is implemented in Kazakh and Russian languages. When processing physiological signals, algorithms and programs of interval mathematics were used [22–24].

For the system of professional selection, tests were selected that allow diagnosing aggressiveness, neuropsychic stability and conflict of personality.

It is expected to use a hardware-software complex to obtain a psycho-physiological portrait of a person when applying for a job in public and private organizations, as well as for service in law enforcement agencies.

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Содержание

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