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ENSURING A SPECIFIED RELIABILITY LEVEL OF COMPLEX SPECTRAL-BINARY DIAGNOSTICS BY THE «QUANTON» METHOD

Об'єктом дослідження є рівень достовірності неінвазивної комплексної спектрально-бінарної діагностики згідно методу «Quanton». Одним з найбільш проблемних питань цього методу є забезпечення заданого рівня достовірності результатів діагностики при максимальній продуктивності процесу. В ході дослідження використовувалися логіко-математичні моделі типової задачі структурно-параметричної оптимізації та методи підвищення достовірності, які передбачають повторення вимірів та введення додаткового каналу отримання інформації. Модель загального критерію достовірності отриманої інформації в процесі діагностики представлена з врахуванням ймовірностей похибок отримання інформації з двох незалежних каналів (спектрального та бінарного) і можливості її повторення. Для розрахунку продуктивності запропонована адитивна залежність, яка враховує послідовність виконання операцій та структурованість загальної протяжності часу на основну, підготовчу і заключну частини. На основі отриманих залежностей поставлена та вирішена задача оптимізації процесу діагностики по максимальним значенням критерію продуктивності при обмеженнях на рівень достовірності її результатів і кількості вимірів з однієї біологічно активної зони.

Встановлено, що процес діагностики згідно методу «Quanton», який складається з двох операцій і оптимізується по критерію продуктивності, має досить широкі можливості впливу на рівень достовірності його результатів. Цей рівень забезпечується вихідною точністю вимірів та наявністю повторних вимірів. При реальних досить широких значеннях вихідних похибок процесів спектральної та бінарної діагностики за рахунок повторення вимірів можна зменшити загальну похибку методу у 10 і більше разів.

По запропонованих залежностях можна виконувати аналіз придатності різних технічних засобів, що використовуються при спектральній та бінарній діагностиці, по рівню достовірності і по рівню продуктивності процесу. Можливо також визначати доцільність введення додаткового каналу отримання інформації.

Завдяки отриманню високої достовірності діагностичної інформації забезпечується можливість, на основі методу «Quanton», визначити найбільш оптимальний вплив на фізіологічні процеси в живому організмі з метою їх корекції. При цьому забезпечується повна неінвазивність, безпечність та висока ефективність за короткий період часу.

Ключові слова: *біологічний об'єкт, комплексна діагностика, метод «Quanton», неінвазивна діагностика, спектральний метод, бінарний метод, рівень достовірності.*

1. Introduction

Because of the increase in the number of people who, in conditions of an unfavorable ecological environment and nervous stress, suffer from an imbalance in the internal energy balance, the methods of fast non-invasive diagnostics of the population and the restoration of their functional and physiological state become important. To implement such methods, fundamental patterns of human body reactions to certain electro-wave bioresonance effects are revealed. These patterns are manifested in the form of changes in the values of individual physical parameters of the body, which can be objectively measured and used to create new medical and health complexes. One of such reduction complexes is the complex that implements the «Quanton» bioresonance method. At the same time, to date, an unknown method of providing a given reliability level of non-invasive complex diagnostics, in particular, for the «Quanton» method, is unknown in published works and practical activities. This general method combines special spectral and binary methods for obtaining information about the state of the body and the characteristics of the desired normalizing effect on it. This combination affects the reliability level of the results and the performance of the diagnostic process. Therefore, it is important to develop a methodology to ensure a given reliability level of non-invasive complex diagnostics using the «Quanton» method while ensuring a high level of its performance.

2. The object of research and its technological audit

The object of research is the reliability level of non-invasive complex spectral-binary diagnostics using the «Quanton» method. To provide the necessary information in diagnostics, this method uses data from two independent channels for obtaining diagnostic information (Fig. 1).

In Fig. 1, the first channel (1) measures the relative stochastic characteristics of the frequency spectrum of the human body (7), which has functional and physiological deviations, based on the stochastic spectra of diagnostic standards (4). The second channel (2) – binary reactions of the body in the form of a change in the impedance of the body when exposed to information markers (5) by the method of biological feedback (6). It also provides for the availability of additional channels for obtaining diagnostic information (3). Both spectral and binary diagnostic methods have their errors depend on the precision of the instruments, their level of technicalization and the state of the environment. At the same time, being executed consistently, the indicated methods cause their influence on the level of process productivity. In this regard, let's have the problem of ensuring a given reliability level of non-invasive complex diagnostics according to the «Quanton» method with the maximum process performance. For this purpose, the formulation and solution of the problem of structural-parametric optimization (8) is performed.

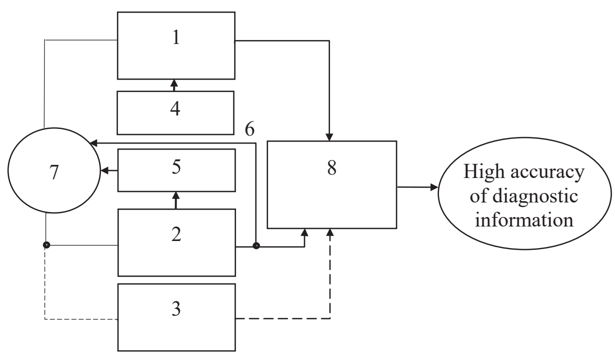

Fig. 1. Two independent channels for obtaining diagnostic information

3. The aim and objectives of research

The aim of research is development of a methodology for ensuring a given reliability level of non-invasive complex diagnostics using the «Quanton» method.

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

1. To make a formalized formulation of the problem of ensuring a given reliability level of non-invasive complex diagnostics according to the «Quanton» method with the maximum process performance and find its solution.
2. To analyze the solution to this problem.

4. Research of existing solutions of the problem

The initial requirements for the functioning of a biological system are determined by the Gelfand-Zetlin principle, which postulates the need for maximum autonomy of the subsystems, in which the biological system functions normally and its individual parts interact with each other minimally. This principle emphasizes the need for feedback, ensures the stability of the system [1].

The human body is an open informational, thermodynamically non-equilibrium system that is in a quasistable state and easily passes into another quasistable state under the influence of external information-wave factors that increase or decrease the entropy of the biosystem [2]. In this regard, any stimuli or special markers (object, word, image, symbol, music, text) can cause a change in internal energy information processes, transferring the biosystem to a new quasistable state. Such a change can occur both with the participation of cognitive functions with the involvement of the senses, and without them. The human body is able to respond to the introduction into its information space of field or material structures that affect its entropy. This ability gives the possibility of obtaining binary information (yes/no or useful/harmful) from the human body in the form of a reaction to the touch of various kinds of objects, such as food, herbs, medicines, chemicals and the like. In addition, it makes it possible to assess the quality of environmental influences on the body and makes it possible to determine the loads of the organism as a whole and its individual systems by chemical, radiation and stress factors.

Any signal transmitted from a biological source can be called a biosignal. The signal source can be at the molecular level, at the cell level, or at the system or organ level.

Examples of the use of biosignals for diagnostic purposes are:

– electrocardiogram (ECG) or electrical activity of the heart;
– electroencephalogram (EEG) or electrical activity of the brain;
– auditory, visual, somatosensory and other potentials, that is, the electrical responses of the brain to a specific peripheral stimulation;
– electroneurogram or field potentials from local areas of the brain, the potential action of signals from individual neurons or heart cells;
– electromyograms (EMG) or electrical muscle activity;
– electroretinogram from the eye and so on.

Modern technologies allow receiving multiple channels of these signals [3]. But the above methods can't show the cause of the identified functional disorders and destructive changes in the human body. In addition, they are not available for offline use in everyday life.

Among the available methods is the I. Nakatani's method, R. Voll's electropuncture method (EIV) and the method of vegetative resonance test (VRT) of H. Schimmel.

I. Nakatani's method allows to identify on the human body lines with increased electrical conductivity, the so-called «riodoraku», the conductivity of which depends on the state of organs and systems. This makes it possible in principle to check the functioning of the body without the need for surgical or other invasive tests. The method is available, simple, but not informative enough; moreover, depending on the experience of the operator, it significantly limits its use [4].

R. Voll's method consists in measuring the electrical resistance of the skin in biologically active points, which depends on the state of the organ. Depending on the inflammation, chronic processes or norms, there will be different resistance of the skin at a particular point when measured with a special device. This was the first step towards rapid and non-invasive methods of technical diagnostics with the registration of parameters for comparison and monitoring during the treatment process. The main disadvantages are the need to measure many points on the arms and legs and a lot of experience in measuring and interpreting the information received. In addition, the patient should be adequately prepared, calm, with intact skin on the fingers and toes [5, 6].

H. Schimmel's method is more refined. It is based on the reaction of the human or animal body to the vibratory or energetic effect of a material substance, which touches the body. When testing, only one representative point on the arm is used, in which the change in skin impedance on the drug connected to the body is recorded according

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to the principle: «yes/no». If the body reacts to the drug by changing the impedance, then this means that this drug has an effect on the body, does not react – neutral. That is, a binary identification of the state of the body occurs [7, 8]. For this method, special preparations were created – nosodes, which were then copied in the form of space charges to integrated electronic circuits – read-only memory (ROM).

For the storage of information, reprogramming is performed on a permanent storage device on n-MOS structures (metal oxide-semiconductor). Such storage devices are built on the basis of the physical phenomenon of charge storage at the boundary between two different dielectric media or a conductor and a dielectric [9].

Dielectrics possessing low electrical conductivity are capable of maintaining the non-equilibrium spatial distribution of electric charge created in them for a long time. The formation of such a distribution can be carried out in various ways. In a ferroelectric dielectric, charge relief can be created by forming a domain structure with a given location of charged domain walls in a crystal [10].

Vibration copies of all biological structures, namely: organs, cells, microelements, all known microorganisms, toxins and many other substances necessary for testing, can be copied and stored in electronic devices. These information units received the general name «marker» and constitute the so-called electronic medical selector, which contains more than 30 thousand markers. By testing various markers selected for testing using special algorithms, the operator finds diseased organs according to the principle: the body's response to a specific organ marker – there is a problem in this organ; reaction to the virus – the virus in the body.

The big advantage of the Schimmel's method is that by combining various markers in a certain configuration, it is possible to determine the cause of the identified dysfunction in a particular organ and find the best way to eliminate it, while predicting the effectiveness of the chosen therapeutic effect [11].

A significant drawback of all the considered methods is subjectivity in testing and the need for extensive work experience on which the reliability of the information obtained depends. All this prevents the standardization of methods for use in a wide range of medical professionals.

More independent of the operator and automated is the method of spectral analysis, based on a set of methods for qualitative and quantitative determination of the composition of the object. And it is based on the study of the spectra of interaction of matter with radiation, including the spectra of electromagnetic radiation, acoustic waves, mass and energy distribution of elementary particles, etc.

In the past few years, the interest of developers of diagnostic methods has been given to time-frequency analysis, especially as regards the processing of a biological signal. In fact, analysis in the frequency domain is a well-standardized tool for quantifying many clinical and physiological phenomena [12, 13].

In the «Quanton» method, spectral analysis is based on performing Fourier transforms and consists of decomposing a signal received from an organism into its frequency or spectral components, as well as evaluating their spectral characteristics – amplitude, phase, power spectral density, etc. This allows to quickly assessing the state of an organism based on a comparison of its stochastic characteristics with the stochastic characteristics of the corresponding markers in the database. But spectral analysis does not use biofeedback for verification and correction of the data obtained, therefore the probability of error in obtaining diagnostic information is quite high.

The method of non-invasive complex diagnostics «Quanton» combines spectral and binary methods for obtaining information about the state and characteristics of the desired normalizing effect on a biological object [14, 15]. It can be realized with the help of multichannel and efficient diagnostic equipment, minimizing the dependence of the diagnosis process on the operator's experience.

Thus, the results of literature review allow to conclude that it is necessary to automate the binary method of obtaining fixed body responses to the action of the marker by creating a multi-contact sensor. This sensor is superimposed on certain parts of the body and sends a signal to the automated device that the body impedance changes. Such refinement will allow to increase productivity, and the parametric synthesis of diagnostic information obtained by various ways will optimize the process and increase the reliability of diagnosticum.

5. Methods of research

The following scientific methods are used:

– method of analytical modeling of reliability indicators of diagnostic results based on general approaches of probability theory;

– method for solving the problem of parametric optimization using the search of variants;

– method of quantitative analysis – when studying the degree of influence of process indicators on its results and when evaluating the optimality criterion.

6. Research results

According to the «Quanton» method, spectral and binary methods for obtaining information about the state of a biological object (human) are organized through two independent channels. In this regard, the probability of errors in the diagnosis can be considered related. Moreover, both spectral and binary methods allow repetitions. In this regard, it is possible to pose and solve the problem of optimizing the diagnostic process, taking into account the value of the performance criterion with restrictions on the general criterion of the reliability of its results.

The general criterion P_g for the reliability of the information obtained in the diagnostic process can be represented taking into account the probabilities of errors in obtaining information from two independent channels (spectral and binary) with regard to its repetition n and m times, respectively, can be represented by the following model:

$$P_g = 1 - q_s^n \cdot q_b^m, \quad (1)$$

where q_s, q_b – the error probabilities in obtaining information from two independent channels: spectral and binary, respectively.

Since the lower value of P_g is normalized, the condition for providing the required level of diagnostic accuracy is:

$$P_g \geq [P_g]^-, \quad (2)$$

where $[P_g]$ is the minimum allowable value of P_g.

From dependence (1) it follows that with constant values of the error probabilities in obtaining information, it is possible to provide the necessary value of P_g by choosing n and m, respectively. That is, in the general case, a transition from a single measurement to a set of measurements with certain values of their repetitions is necessary. It should be borne in mind that the values of n and m differently affect the performance of the diagnostic process and the P_g value.

Fig. 2 shows this impact on performance, and Fig. 3 – on the P_g value, respectively.

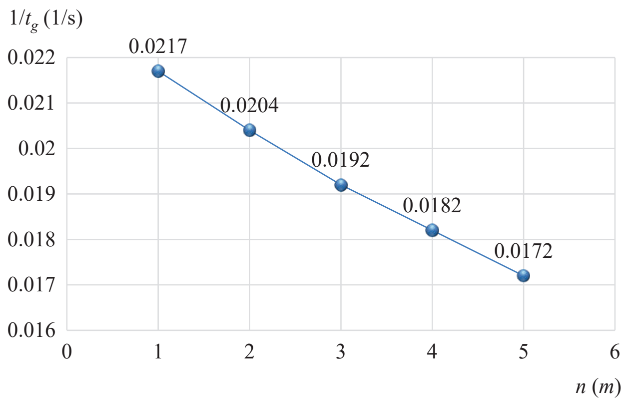

Fig. 2. The effect of the number of repetitions on the performance indicator of the diagnostic process

In Fig. 2 performance is defined as $1/t_g$, where t_g – the total duration of the diagnostic process in seconds (s). In this case, the total preparatory-final time is taken equal to 40 s, and the main – 3 s.

As can be seen from Fig. 2, 3, as $n(m)$ increases, performance drops and the reliability level increases.

A feature of the «Quanton» method is that operations on two independent channels (spectral and binary) are performed sequentially, the results of the first is the condition for the start of the second. In addition, this method may have an extension.

In particular, this can be accomplished by using an additional channel for receive information (for example, temperature dynamics at representative points or thermal imaging), which add a multiplier depending on (1). Also, providing a transition from one measurement point to a set of points, with binary diagnostics, q_b can be reduced.

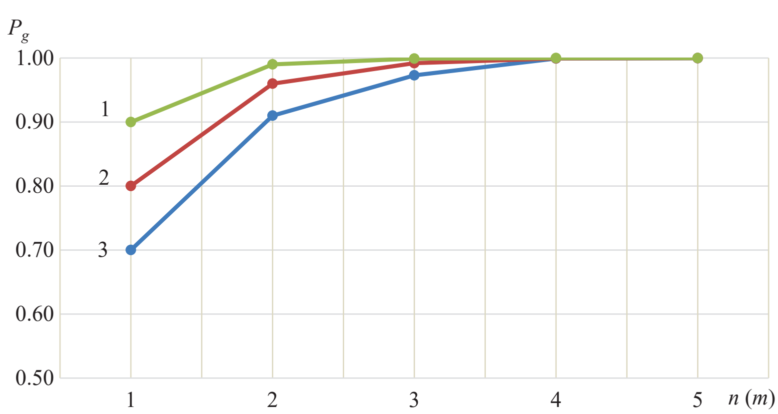

Fig. 3. The effect of the number of repetitions on the reliability level of the diagnostic process: 1 – $q_s=q_b=0.1$; 2 – $q_s=q_b=0.2$; 3 – $q_s=q_b=0.3$

In this regard, the formulation of the parametric optimization problem may be as follows:

– criterion:

$$T_g=t_{pfs}+t_s^n+t_{pfb}+t_b^m\geq \min; \quad (3)$$

– restrictions:

$$(1-q_s^n q_b^m)\geq[P_g];\ n\geq 1;\ 4\geq m\geq 1, \quad (4)$$

where t – time; pf subscripts means preparatory-final time, s and b – the ratio of the parameter to the operations of spectral and binary diagnostics, respectively; t_s, t_b – the main (machine) time on these operations.

The number 4 means that the number of repetitions of measurements on one biologically active zone should not exceed 4. If necessary, further measurement can be carried out in other zones.

In Fig. 4, as an example, in the coordinates n–m, a blocking contour formed by constraints (4) is shown under the condition that q_s and q_b are equal. Fig. 4 shows the lines reflecting the value of the optimality criterion for different n and m.

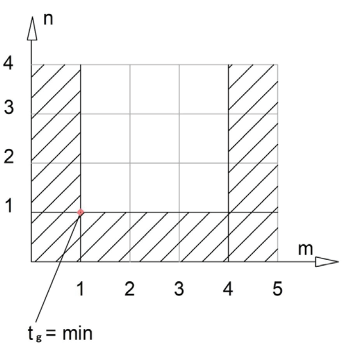

Fig. 4. A blocking circuit formed by constraints (4) under the condition that q_s and q_b are equal

The lines of the graphs in Fig. 4 built with the values: t_{pfs}=30 s; t_s=3 s; t_{pfb}=30 s; t_b=3 s.

Based on the dependencies (3), (4) and graphs in Fig. 4, it is possible to conclude that the diagnostic process, consisting of two operations and optimized by the performance criterion, has sufficiently broad possibilities to influence the reliability level of its diagnostic results. This level is provided, first of all, by the presence of repeated measurements.

For example, for a given standard level $[P_g]=0.99$ and for real sufficiently wide values of $q_s=q_b=0.1$, condition (2) is satisfied for $n=m=1$ ($P_g=1-0.1\cdot 0.1=0.99$). Increasing, for example, m to 2 by repeating measurements at $q_b=0.1$ reduces the total error by a factor of 10.

Considering the total symmetrical influence of the product of parameters in powers of n and m on P_g, it can be established that with the increase of one of them there is an opportunity to reduce the second.

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Obviously, according to dependencies (3), (4), it is possible to perform an analysis of the suitability of various technical means used in spectral and binary diagnostics, both in terms of the accuracy of diagnostics and in the level of process performance. For example, the transition from manual contact of an electrode with a biologically active point to an automated one ensures a reduction in diagnostic time by a factor of 20 or more.

Optimal by the criterion of performance is a solution in which the minimum number of repetitions of measurements has an operation in which the main (machine) time of its execution is longer.

In the case of non-compliance with restrictions (4), an additional channel for receiving information should be entered. When optimizing by the performance criterion when performing diagnostics on this channel, it should coincide with the time of carrying out one of the previously mentioned operations – spectral and binary diagnostics.

7. SWOT analysis of research results

Strengths. The formulation and solution of the problem of parametric optimization of the process of non-invasive complex diagnostics using the «Quanton» method make it possible to provide the required (normative) reliability level of its results. In this case, as a rule, normative accuracy (error not more than 1 %) can be provided by using means of spectral and binary reliability with errors not exceeding 10 %, with single measurements on each channel for receiving information. This creates the conditions for building personal (mobile) smart medical and recreational apparatus complexes with a high level of their functional capabilities with minimal complexity and maximum process performance.

Weaknesses. The weak side of the existing medical and fitness apparatus complexes is the significant dependence of the diagnostic results on their design features.

Opportunities. In the future, it is advisable to develop fully automated (using elements of artificial intelligence) smart medical and health-improving apparatus complexes with a high level of their functional capabilities. This will significantly increase the scope of their application by moving the diagnostic process from specialized centers to personal life, which is important for all countries of the world.

Threats. The complexity of the implementation of the research results lies in the need for initial investment in the preparation of the production of medical and health apparatus complexes. However, in modern specialized flexible industries, capital costs can be minimized.

8. Conclusions

1. A formalized formulation of the problem of ensuring a given reliability level of non-invasive complex diagnostics according to the «Quanton» method with maximum process performance is made. The solution of this problem will allow to obtain the value of the number of repetitions of measurements that are optimal in terms of the performance criterion of the diagnostic process.

2. The analysis of the found solution of the optimization problem shows the possibility of ensuring the normative reliability of diagnosing the state of biological objects using measures to:

– receive of information on multiple channels, in particular spectral, binary and others;

– transition from one measurement point to a set of points when using a binary channel;

– transition from a single measurement to a set of measurements on the available channels.

The standard reliability level (an error of no more than 1 %) of the diagnostics results with the maximum performance of the process can be ensured with single measurements for each of the receiving channels.

These measures can be implemented in a computerized medical and recreational complex, including a portable, acceptable for everyday individual use.

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