British Journal of Global Ecology and Sustainable Development
Volume- 52, May 2026
ISSN (E): 2754-9291

METHODS FOR MODELING AND ANALYSIS OF COMPLEX PHYSICAL SYSTEMS

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Abstract
This article examines the specific properties of complex physical systems (CPS), the stages of their systematic analysis, and methods for modeling medical oath biological processes. The study analyzes the effectiveness of modern mathematical tools such as stochastic differential equations, artificial neural networks, and Fourier-Haar series

Keywords: Systematic analysis, uncertainty environment, medical-biological signals, Fourier and Haar substitutions, informativeness assessment, Integral rheography, Impedance plethysmography.

Introduction

Complex physicist systems (MFT) own many edge , uncertainty and structural parts diversity with separated It is based on MFT. physical , chemical , biological and information processes and they between complicated relationship lies . This systems main properties as to oneself uniqueness , openness , variability and uncertainty environment is displayed . The research purpose — in MFT analysis uncertainty factors in consideration received without decision acceptance to do supportive mathematician and methodological tools systematization and medical-biological signals again of work effective algorithms from justification consists of .

A complex physical system (CPS) is based on a heterogeneous system of subsystems consisting of physical, chemical, biological, and information processes and the relationships between them. The following are the main properties of CPS:

1. Uniqueness. MFTs are usually unique and unrepeatable. In this case, the part systems that make them up are considered typical, and the number and types of their interactions are also unique.
2. The uniqueness and lack of strict formulation of the global goals of existence. This necessitates the use of linguistic formulas, which in turn require the use of a certain mathematical apparatus. For example, fuzzy sets, logical inference, etc.
3. Openness and variability .
4. Uncertainty . Since uncertain environments are inhomogeneous and anisotropic, they are associated with factors such as their stochastic nature, incomplete knowledge of the nature of physical and chemical processes , imperfection of measurement and control technical means, subjective factors, and imperfection of mathematical descriptions of the process.

At the initial stage, the MFT is analyzed and studied as an object of systematic analysis in order to obtain theoretical knowledge about the object. This requires conducting

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experiments to study the relevant processes that determine the nature of the MFT. The main attention should be paid to the most effective approaches to the processes of collecting and processing semantic and quantitative information, including the main directions of forming a system of knowledge about a given object. The necessary organizational measures are taken to change the management effects on the MFT and the processes of collecting and processing information.

In the second stage, the focus is on solving quantitative and semantic analysis problems. At the third stage, the basis of software and hardware tools for the decision-maker (DDM) is developed. The apparatus for solving this type of problem must provide access to knowledge and information. In this case, various information is combined and special recommendations are developed for the organizational units of the MFT. Based on the universally presented information, databases and knowledge bases are created and used at the next stage, that is, to build expert systems to support decision-making.

The data obtained from the measurement processing process are processed using multivariate statistical analysis [2,3]. In this case, the initial information is not systematized and may be somewhat redundant. Therefore, the algorithmic support of the research must consist of means for forming initial symbols and compressing the given information. Such problems can be solved by such methods as factor analysis models and methods, multivariate scaling, and the principal components method. Another important class of data processing methods are algorithms that allow predicting the behavior of the parameters of the studied physical processes, as well as methods for classifying multivariate observations, which are aimed at forming groups of observations that are identical in their properties and differ in their external characteristics. Another important class of analysis methods is algorithms that allow predicting the nature of the parameters of the studied physical processes and areas

II. METHODS

Systematic analysis process four in stages done increased: Theoretical Analysis : Object about semantic and quantitative information collection Quantitative and semantic Analysis : Data statistic again work Hardware and software Tools : Knowledge base and expert systems create Decision acceptance To do : Monitoring and expert system results based on final conclusion release In the study following mathematician from methods used : Stochastic differential equations : System development in the laws uncertainties there is when is applied . Artificial neuron Networks : Input-output signals between complicated linear not been dependencies expression for . Orthogonal functions (Fourier and Haar): Periodic signals spectral analysis to do and synthesis for .

The randomness of the changes in the system under study allows us to take into account stochastic differential equations, namely:

$$dy / dt = f(y,t) + g(y,t)n(t) \qquad (1.1)$$

this on the ground $f(y,t)$ and $g(y,t)$ - Functions satisfying the Lipschis condition, $n(t)$ - white noise [4].

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If the amount of a priori information about the structure of the system is significant and there are uncertainties about the laws of its development, then it is advisable to use models based on stochastic differential equations. However, in this case, an additional amount of statistical information is required.

In modeling MFT, random processes are usually used when there is a priori uncertainty in the information about the structure of the system and the dynamics of its change. Random process in the theory of random processes t random with free variables $x(t)$ expressed as a function [4]. Each test is a specific $X(t)$ gives a function, which is called the process implementation or selection function.

A random process $X(t)$ is a set of process implementations or t can also be viewed as a set of random variables that depend on a parameter. In this case t_1, t_2 A system of random variables is required to have a defined probability distribution $\mathbf{x}(t) = [x(t), y(t), \ldots]$ for an arbitrary finite set of values (selected moments) . In general, a random process $x_1 = x(t_1),\ x_2 = x(t_2), \ldots$ can be described as a multidimensional random variable. In many applications, a free variable t time, $x(t)$ or $\mathbf{x}(t)$ magnitude represents the state of a physical system . In describing a random process $x(t_1)$ size distribution and t_1, t_2 every finite set of values $[x(t_1),\ x(t_2)], [x(t_1),\ x(t_2), x(t_3), \ldots]$ system of sizes It is also necessary to give the distribution. These distributions are usually called appropriate order distribution functions.

In the study of medical and biological systems, researchers often encounter the problems of temporal variability of the system and its elements, as well as the lack of constant input variables and insufficient information about the laws of their interrelation. In this case, the initial data system is described on the basis of general information and assumptions about its structure. This leads to uncertainty in the definition of the goals of the system's activities, some restrictions on management. Therefore, it is necessary to use expert knowledge and apply the principles of system imitation in decision-making. Systems imitation is understood as "...the organization of a computational experiment that provides a logical relationship between the time models of individual system properties and the reality of the process under study in order to obtain information to evaluate the integral indicators characterizing the system " [5].

The general theory of systems serves as the basis for studying complex systems under conditions of maximum uncertainty, and with its help, using a set of statistical decision rules, it is possible to justify the conditions for the dynamic representation of system reactions for a certain class [6]. In this case, the problem of mathematical modeling in the a priori uncertainty of the system structure is solved by representing the development process in the form of a sequential change of macro states corresponding to a discrete moment in time. In addition, at each discrete moment in time, statistical models are formed between the input and output variables.

One of the most effective schemes that allow for the uniform representation of all

elements of a complex system is aggregative systems [7]. This scheme is dynamic in nature and well describes the exchange with the external environment and is able to take into account random factors.

Unlike nonparametric statistical methods, which allow building models of systems with large experimental data samples and relatively uniform distributions in the feature space, neural networks are able to build the necessary models using relatively small amounts of data. This is especially important in the study of medical and biological systems, where experimental data are very expensive, very noisy, inconsistent and incomplete. Neural networks are relatively sensitive in the areas where data are collected and allow smooth interpolation in other areas.

Nowadays, the user does not need to have special knowledge of neural network theory and statistics. Because many algorithms have already been developed that allow creating such neural network models. In this case, the user only selects representative samples and the data structure is automatically determined. However, this requires the user to know how to select and prepare the data, choose a suitable network architecture, and interpret the results.

Methods for modeling and processing medical-biological processes

Modeling medical-biological signals consists of three stages: selecting a model class (algebraic functions, differential equations, probability functions, etc.), defining (identifying) the model structure and parameters.

Model class choice usually modeling goals based on is carried out . The most wide distributed type i algebraic functions The class is Model . structure choice being modeled alarm properties in expression demand to be done accuracy level is determined using the Model . parameters of determination the most wide widespread from the methods one the most small squares method According to this method , the best model parameters (coefficients) are those for which the difference between the sum of the squared deviations calculated by the model and the experimental values is minimal.

If $t_i\,(i=1,2,...,N)$ we denote $a_1,a_2,...,a_m$ the experimental values obtained at time instants as , and x_i the theoretical values calculated at the same time using the coefficient model as y_i, the sum of the squared deviations of the theoretical and experimental values is calculated by the following formula, namely:

$$s=\sum_{i=1}^{N}(x_i-y_i)^2\,. \qquad (1.1)$$

The acceptable $a_1,a_2,...,a_m$ coefficients are the coefficients at which the value of σ takes on a minimum value, and they are determined by solving a system of normal equations. If, when choosing a model structure, it is possible to take into account the physical processes occurring in the medical-biological system and to determine the mathematical laws describing these processes, then such modeling is called informal.

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$$\begin{cases} ds / da_1 = 0; \\ ds / da_2 = 0; \\ \dots \\ ds / da_m = 0. \end{cases} \quad (1.2)$$

Informal in modeling medical- biological the process descriptive functional dependency empirical formula Empirical the formula to choose impact doer criteria They are not formal . the most small inconsistency The criterion can be cited as an example .

Let's assume that the subject under study $x_i = x(t)$ magnitude t_i at a moment in time , N values experimental Take your $(i = 1, 2, \dots, N)$ time . known experimental at moments from data minimum difference to do values calculation opportunity giver empirical the formula be required to produce . Informal in modeling process model relatively narrow algebraic functions in class is built . In this , the most small inconsistency criterion following will look like this :

$$D = |x_s - x_d| \quad (1.3)$$

here x_s last x_1, x_N experimental indicated based on values empirical dependencies for taken formulas according to calculating exit name .

Modeling accuracy assessment theoretical and experimental values mean square deviation is , it is an approximation error league that is called and is calculated using the following formula :

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2}. \quad (1.4)$$

Separation of informative characters and assessment of informativeness of medical-biological signal. Unknown object him/her signs analysis to do based on classified as such . characters usually informative as signs There are two approaches to assessing informativeness, namely energetic and informational. The energetic approach is based on assessing informativeness by the magnitude of the sign. The informational approach is based on assessing informativeness as a weighted average of the information related to different levels of the sign. In this case, information is understood as a value without entropy [13]. According to the Shannon method, the informativeness of a sign is defined as:

$$I(x) = 1 + \sum_{i=1}^{G}(P_i \sum_{k=1}^{K} P_{i,k} \log_k P_{i,k}), \quad (1.5)$$

where G - the number of character gradations; K - the number of classes; P_i - the probability of the i -th character gradation; $P_{i,k}$ - the probability of *the* i -th gradation appearing in *the K- th class*.

Kulbak to the method according to , informativeness price as two class difference

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between measure is taken , this divergence that The divergence is calculated using the following formula:

$$I(x)=\sum_{i=1}^{G}(P_{i1}-P_{i2})\log_2\frac{P_{i1}}{P_{i2}}, \qquad (1.6)$$

where P_{i1}, - the occurrence of P_{i2} *the ith* gradation in the 1st and 2nd grade, respectively .

Shannon method informativeness from 0 to 1 changeable normalized value as don't judge me . That's why for Shannon method with determined character informativeness about absolute in indicators to speak possible , that is, to 1 closer if - high ; to 0 if closer - low.

Synthesis of signals based on an orthogonal system of trigonometric functions. A periodic function T with a period $S(t)$ can be expressed in terms of a system of trigonometric functions with multiple arguments using a Fourier series as follows [14-15]:

$$S(t)=\frac{a_0}{2}+\sum_{n=1}^{\infty}(a_n\cos n\Omega_1 t+b_n\sin n\Omega_1 t), \qquad (1.7)$$

or

$$S(t)=\frac{a_0}{2}+\sum_{n=1}^{\infty}A_n\cos(n\Omega_1 t+\varphi_n), \qquad (1.8)$$

where $\Omega_1=\frac{2\pi}{T}=2\pi F_1$, T is $S(t)$ the signal period.

$$\frac{a_0}{2}=\frac{1}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}}S(t)dt, \qquad (1.9)$$

$$a_n=\frac{2}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}}S(t)\cos n\Omega_1 t dt, \qquad (1.10)$$

$$b_n=\frac{2}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}}S(t)\sin n\Omega_1 t dt, \qquad (1.11)$$

$$A_n=\sqrt{a_n^2+b_n^2}, \qquad (1.12)$$

$$\varphi_n=arctg\frac{b_n}{a_n}. \qquad (1.13)$$

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A Fourier series represents $S(t)$ a periodic signal as a sum of $a_0/2$ a constant component and A_n harmonic components with amplitude and initial phase. φ_n Harmonic organizers amplitudes , phases and frequencies package suitable accordingly amplitude , phase and frequency spectrum that Amplitude - frequency and phase-frequency spectra graphic in appearance can also be shown .

E amplitude l i, τ continuous and Ω rectangular with crossover frequency video impulses periodic sequence for harmonic amplitudes of the organizers the following expression through is:

$$A_n = \frac{2E}{n\pi}\sin\frac{n\Omega_1\tau}{2}. \qquad (1.14)$$

In the synthesis of complex signals, T a system of trigonometric functions of multiple arguments that are orthogonal in cross section is usually used as an orthogonal system of functions.

Signal synthesis based on an orthogonal system of Xaar functions. $\{\chi(x)\}$

The system of Xaar orthogonal functions is a basis for expanding an arbitrary continuous function on the interval [0,1] $f(x)$ into a non-uniformly converging Fourier-Xaar series [14-15] .

$$f(x) = \sum_{n=1}^{\infty} c_n \chi_n(x) \qquad (1.15)$$

here

$$c_n = \int_0^1 f(x)\chi_n(x)dx. \qquad (1.16)$$

is used as a basis for approximating signals in a cross-section $S(t)$ by Fourier polynomials , the Xaar function is replaced by a $[0,T]$ dimensionless x argument at, where $a = 1/T$ the coefficient defines the required time scale of the functions and the time dimension is minus one degree . The definition of the Xaar function uses the concept of binary cross-sections. Cross-sections that can be obtained by dividing $[0,1]$ the cross-section 2^m into equal parts are called binary. If their right end differs from 1, then these cross-sections are closed on the left and open on the right.

If the right end of the intersection is 1, then the intersection is also closed on the right side. Thus, [0, 1], [0, 1/2), [1/2, 1], [0, 1/4), [1/4, 1/2), [1/2, 3/4), [3/4, 1], [0, 1/8) are binary intersections, while the intersections [1/4, 3/4) or [5/8, 7/8) are not binary.

The following notation is introduced for binary cuts:

$$l_{mj} = \left[\frac{j-1}{2^{m-1}}, \frac{j}{2^{m-1}}\right], \qquad (1.17)$$

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where j varies from 1 to 2 m -1, m = 1 , 2 , ... ($j = 2^{m-1}$ at l_{mj} closed from the right).

Every m is performed for $l_{m1} + l_{m2} + l_{m3} + ... + l_{m,2^{m-1}} = [0,1]$. $\{\chi(x)\}$ It is convenient to construct a system of Xaar functions using groups : m digital group 2 $^{m-1}$ has a function $\{\chi(x)\}, j = 1,2,...,2^{m-1}; m = 1,2,...,$ first of all $\chi_1(x) = 1$ function remains outside the group. The mathematical representation of the Xaar function is as follows.

$$\chi_{mj}(x) = \begin{cases} 2^{\frac{m-1}{2}}, x \in l_{mj}^{-} \\ -2^{\frac{m-1}{2}}, x \in l_{mj}^{+} \\ 0, x \notin l_{mj} \end{cases} \qquad (1.18)$$

A unique feature of Xaar functions is their relative simplicity in deriving them.

III. RESULTS

Research MFT analysis as a result for following to the results achieved : Modeling algorithm : Medical-biological signals in modeling model class selection , identification and the most small squares method using parameters optimization order working was released.Informativeness Price : Signals informativeness level in determining Shannon (entropy) based on) and Kulbak (divergence based on) methods comparative analysis Shannon in the way informativeness from 0 to 1 was normalized in value evaluation determined . Correlational Analysis : Characters between dependency of determination three step (field build , regression the line determination and coefficient calculation) methodology formed .

In some cases, viewing medical-biological signals as time series provides effective results. This results from the observation of any characteristic of the research object over time [13-14, 16].

A signal model is an analytical expression or function that reflects the functional relationship between a dependent and an independent characteristic over time. Often, there is a close relationship between the changes in the characteristics of objects. For example, the taller a person is, the greater his weight. However, this relationship is not strictly functional, since in some cases there may be deviations from the general trend. Such relationships are called Correlation.

The subject of correlation analysis is to determine the correlation between the signs. Correlation analysis consists of determining the presence and type of correlation and calculating its strength. This process is carried out in several stages.

In the first stage, the presence of a correlation relationship is determined based on the construction of a correlation plot or scatter diagram. Each one measurement result characteristic to values suitable coordinated point as is obtained . Determining whether a correlation relationship exists or not requires a complete analysis of the type of

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correlation field.

In the second stage, the type of correlation relationship is determined based on the ranking of the sample. In this case, the values of one of the signs are ranked in ascending order. The resulting dependence on the variable can be graphically represented in a scatter diagram. This regression line that is called . Regression line regression equation that adverb analytical function through The name of the expression and its correlation shows the type .

Third in stages Correlation coefficient Calculate and Correlate the bond density is considered . Correlation coefficient value according to being studied features connection level about conclusion is taken .

Modeling discrete medical-biological signals based on Fourier series. In medical-biological data processing, they can be well modeled using Fourier series in terms of orthogonal functions [13-14]. The model structure represents a Fourier series and is expressed as follows:

$$y(t)=\sum_{i=1}^{\infty}c_i\psi_i(t)=c_0\psi_0(t)+c_1\psi_1(t)+\ldots+c_m\psi_m(t)+\ldots, \qquad (1.30)$$

where c_i – Fourier series coefficients; $\psi_i(t)$ – a system of orthonormalized basis functions on some interval [a,b], known as the orthonormalized interval. A series of the form (1.30) is called a generalized Fourier series.

Examples of widely used and popular special functions for expanding a continuous signal into a Fourier series are Legendre, Chebyshev, Lager, and Hermite polynomials. Legendre polynomials have the following form :

$$p_j(t)=\frac{1}{2^j\cdot j}\cdot\frac{d^j}{dt^j}(t^2-1)^j, \qquad (1.31)$$

here $j=0,1,2,\ldots$ – polynomial order .

built on the basis of the Fourier series by $y(t)$ the Legendre polynomial will look like this:

$$y(t)=\sum_{j=1}^{m}c_j p_j(t), \qquad (1.32)$$

The Fourier - Legend coefficients are calculated according to the following formula.

$$c_j=\frac{2j+1}{2}\int_{-1}^{1}x(t)p_j(t)dt. \qquad (1.33)$$

If alarm experimental done increase known one time between T, at the following points taken discrete $x_i=x_i(t_i)$ values complex if , that is:

$$t_i=ih, \qquad (1.34)$$

here i – the order of counting , $i=0,1,\ldots,N$; h – discretization step .

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The discretization step is calculated as follows.

$$h = \frac{T}{N}. \qquad (1.35)$$

Such discrete alarm for Fourier - Legend row coefficients based on the following formula is determined .

$$c_i = \frac{2j+1}{N}\sum_{I=0}^{m} x_i p_j\left(\frac{2i}{N}-1\right). \qquad (1.36)$$

The array itself is a set of discrete values, each of which can be calculated by the formula, namely:

$$y_i = \sum_{j=0}^{m} c_j p_j\left(\frac{2i}{N}-1\right). \qquad (1.37)$$

Generalized Fourier series can be used not only to model complex non-periodic processes, but also to model the series with a small number of terms to achieve a sufficiently good approximation to the original function. In this case, it is recommended to use lower-order polynomials.

Modeling accuracy is usually estimated by the mean square error of approximation, i.e.:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2}. \qquad (1.38)$$

the model parameters are calculated as series coefficients that have no physiological significance, c_j modeling medical-biological data using generalized Fourier series can be considered formal.

Blood rotation and breath to take functional status assessment . Body integral rheography method . Human body integral rheography is a non-invasive method for studying blood circulation. It is a registration of the electrical resistance of the human body, which changes with changes in blood filling during the cardiac cycle by the forced passage of a probe current in a sequential circuit: arms - body - legs (Fig. 1.1). It is usually performed on devices with a probe frequency of 25–50 kGs and is suitable for integral rheography [13,16].

Electrodes right from the y- direction after are used and they rheograph entrance to the cable connect and not less than 10 minutes is skipped . This time " physiological" " peace " adverb conditions create and interelectrode resistance stabilization is passed for the purpose of . As a registrar to the rheograph one piece hardware to the complex connected You can use a computer . It rheograms register transfer and again processing is carried out . Reographic the alarm file in appearance save or realistic at the time software again It can also work .

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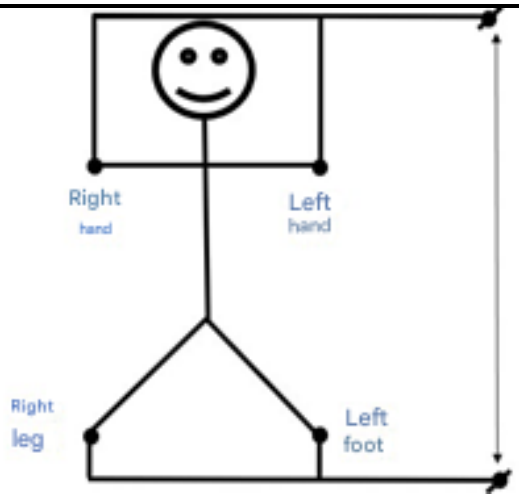

1.1 . Recording an integral rheogram

Rheogram usually clear 3-5 expressive breaths to take cycle for record Its processing is carried out in four stages, namely , calculating appropriate values and coefficients based on available patient information, defining the curve and measuring its elements, calculating integral rheogram indicators, analyzing the indicators, and drawing conclusions.

The integral rheogram has all the main features of a volumetric, arterial sphygmogram - a curve characterizing the oscillations of the vascular walls. The main advantage of integral rheography, which distinguishes it from many methods of measuring cardiac output, is the ability to simultaneously obtain information about other parts of the circulatory system and respiratory functions by comprehensively assessing their state at each moment of the study. In this case, the respiratory coefficient of change in stroke volume for a selected respiratory cycle is calculated. In addition, according to the typical changes in the shape of the curve, it is possible to predict with great confidence that the patient has pulmonary hypertension and increased central venous pressure. Currently, conductometric methods of measuring the aqueous environment of the human body are being effectively used. The method of integral rheography using a current with a frequency of 30 kHz allows you to measure the electrical equivalent of the volume of extracellular fluid.

IV. DISCUSSION

MFTs traditional deterministic methods with expression every always also adequate result does not give, because such in systems subjective factors and measurement of tools imperfection because of uncertainty high will be . Neuron networks advantage is that they nonparametric statistic from methods different less than , less than information amount with also necessary models build opportunity This is especially true for data extreme expensive or " noisy " medical-biological in research important importance has . Fourier-Haar rows and signals time scale according to more precisely approximation opportunity to give proved .

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Rheography method initially human heart and blood vein system status assessment for the purpose offer done is , it is clinical in practice wide apply started . Rheogram to the analysis based blood vein system signs determination and calculation according to many methods working was released . Later to rheography was attitude negative color polka dot started . Because there is methods almost all " clear " rheogram information for relatively simple results to take opportunity gave [17-19].

Relatively complicated was in cases clear conclusions formation many problems solutions demand For example , in rheowaves temporary stamps placement through blood vein system signs calculation and conclusions in formation also to the surface It comes . separately highlight okay rheograms analysis to do many tools working to the exit despite current on the day also rheograms analysis to do clear and formal rules there is not . From this except , rheographic measurement results based on human blood vein system status enough at the level assessment opportunity provider characters and them values not determined . Clinical in practice rheographic information based on enough conclusions to take opportunity low at doctors to rheography was their interests to weaken take came and this to rheography relatively negative relationships to the formation cause It happened . This such as problems rheography that's it in the period good quality equipment there is not being with depends on . From this except , rheographic signals analysis in the process of from doctors alarm amplitude and time with related was signs at hand measurement demand However , the current on the day measurement and equipment with related was problems noticeable at the level decreased .

Rheography Greek from the word taken becomes , the flow to write meaning means. Wider in the sense and impedance plethysmography medicine and experimental " obsolete " in physiology and reliable research tool was , initially body optional field mine with to fill probe variable vine using this the field complete electricity in opposition vibrations through to measure to study intended [17-25].

Electrodes using body tissues electricity conductivity measurement method rheography that It is called rheography . tissues electricity conductivity them composition , structure , size and in tissues blood to the flow related said to the idea is based on . Rheography through blood circulation , tissues size such as other physiological indicators changes about information to take possible .

Rheography in the procedure electrodes body known one places on the skin is installed and from them weak electricity till Electricity flow in tissues various to the effects occurs and they body other to the part placed electrodes through record arrived It is going . this in order taken to the information hardware-software tools through processing is given . Then processing given information based on tissues electricity conductivity changes representative graphic is formed .

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CONCLUSION (SUMMARY)

Complex physicist systems research in the process of quantitative and semantic information harmonization necessary . Proposal done systematic analysis stages and mathematician models complex decision acceptance doer for person (QQQ) information scale expands and errors probability reduces . Neuron networks and orthogonal polynomials based on models medical-biological processes high in accuracy prediction opportunity gives .

Medical-biological systems extreme complicated physicist systems is considered and them practical research in the process of entrance information , them structure and work principles mainly uncertainties based on is increased.

Current on the day medical signals again at work neuron network and timely rows modern from the methods effective is being used, but this mainly electroencephalogram, electrocardiogram and electromyogram such as to signals relevant , this methods other directions information in the analysis application about information less and they whole it's not .

Rheograms far periods to the analysis based on the GAB method new options one time in itself vital organs neurogenic and circular status assessment opportunity gives . Initial in research From GAB use methods shown , but clinical diagnostic , experimental physiology in the likes them opportunities complete not studied . Through multicyclic GAB taken the most important result blood veins periodic not only pulse wave , maybe breath to take and Mayer in the rhythms to the veins impact indicator neurogenic vasomotor in the effects also own status change possible . Pulse to the wave ratio in bioimpedance more precisely changes brought releasing smooth muscle in the organs neurogenic vasomotor effects noticeable at the level strong to be logical contrary become This is the output . the fact smooth muscles physiology understanding for importance still also not rated .

Rheogram spectrum peaks between relationship determined mutual from dependence according to more complicated to be also possible . Bioimpedance multicyclic spectral analysis research relatively recently started , but they already cardiology , urology and to andrology relatively systematic and regional level neurovascular relationship important features determined by . Rheograms harmonic from the analysis in the future clinical diagnosis tools as use on the road is placed .

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