Specification of Information Technology for Non Invasive Prediction and Correction of Functional State of Human in Complex Conditions

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Abstract

This article is devoted to the development of information technology (IT) in the field of information aspects of low-intensity light stimulation (haptic stimulation). This is important for the control and correction of the functional state of the human body, which operates in extreme environmental conditions. Theoretical and experimental relationships between stimulation energy (diode light radiation) and energy transmitted through layered bioenvironments, responses of body systems are specified as data for design, synthesis of IT for prediction and correction of changes in the human condition. A generalize representation of the light stimulation process is described. With the aid of experiments and electroencephalograms, as response signals on to the stimulus, the principles of the decision to control and correction the functional state of human can be prognosis. The specifications of methods of prediction, statistical modeling (for the prediction and testing), and the approaches to the formation of the IT are stated.

Keywords 1

Information technology, haptic stimulation, organism functional state prediction

1. Introduction

The article presents a method of analysis of information processes in medical and biological systems of a human working in extreme environmental conditions. The theory of medical information systems (MIS) and the specification, based on the theory of MIS, information aspects of haptic stimulation of the body with light to control and correct the functional state of the organism, allowed to develop and study relevant information technology [1]. According to the results of the specification, the information technology of stabilization of the temporarily disturbed functional state of the human is created. It is proposed to use ultra-low levels of stimulation intensity with non-invasive devices to monitor the state of the human organism's and support decisions about the need to recover - for a limited time to recognize and correct the functional state of emotional and cognitive health.

2. Problem Statement

Control-correction technology contains a set of operations:

1. Control - stimulation-response-analysis-decision (if the health in norm, then continue to control);

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2. Selection of correction mode;
3. Corrective direct, or auxiliary stimulation;
4. Control - if the norm, then go to (1), otherwise go to (2).

This set of operations is used in the diagnosis and therapy of existing light stimulation systems [2], But not in an autonomous, automatic, working mode of information technology. In autonomous special working conditions, a significant factor is the need for prognostic control, which will significantly reduce the time complexity of the correction and increase the duration of the working condition of the person. The obtained response potential to stimulation (electrical phenomenon with variable "parameters": amplitude, frequency, duration of the latent period, etc.) and its systematic interpretation appear as a tool for neurophysiological analysis of subcortical interactions, which allows to assess the upward excitation of subcortical formations.

Discovery of the contradictions between

- data of the interception and concept of psychophysics (that sensory function is associated with the sensation when stimulating receptor [2, 3]),
- detection, that interceptive irritation does not cause a sensation [4],
- electrophysiological method,

and all these together, reliably assesses: the interceptive function of the interceptive system is considered as afferent association of vegetative nervous system.

The interceptor is similar to the skin receptor. Afferent pathways derived from these receptors are quite complex. Most pulses of visceral receptors are directed to the central nervous system. Afferent impulses of the interceptor often come to the nucleus of the thalamus of the ventral element (important switching station). The cortical representation of the internal retention is found in the sensorimotor cortex, as well as in the limbic region, located on the medial hidden surface of the cerebral hemispheres. The presence of this central representation explains why intercepting stimuli do not evoke feelings, although they often affect human behavior.

The interceptors of all types fulfil two main functions: they form an affine connection of the special vegetative reflexes, which play an important role in maintaining the homeostasis in the body, and, by sending information about the state of the internal organs, affect the state of the central nervous system. Specificity of interceptors regarding types of physical energy is questionable. EEG is used to study the afferents. Tracked the changes due to desynchronization of EEG (alpha rhythm of rest). Selected the potentials from the cortex areas. These, painless irritations make no sense. This shows that intra-receptor impulses really reach the brain and alter the electrical activity of some cortical neurons. There are two types of afferent nerve mechanisms, namely, conscious and unconscious activity, in people; interceptive impulses remain in the sphere of the unconscious. Since sensory receptors are found throughout the body, including the skin, the experiment is performed to study the sensation (touch), proprioception, and haptic perception (associated with the concept of extended physiological prorioception) of light as an instrument [5, 6].

Research objective: the specification the information technology of implementation of the concept of extended physiological proprioception by light stimulation as a tool for recognition of a working human, which temporarily came to such a state that after this can be lose the ability to continue working.

A result of this goal: an alternative information channel suitable for the extraction of information and method of its use (the noninvasive, rapid detection of signals, prediction and correction of the state at little complexity of wearable system).

3. Informational Technology of Bioobject State Estimation

Information technology (IT) what based on mobile devices was created for obtaining alternative information about necessaries control, or correction of the human state. They implements replacing pure the medical technologies of the control or correction of the state by parts or completely technical means. One of this direction is based on the extraction and stimulation of information by the appropriate IT, which influent and obtain information through biologically active points (BAP), or alternative information channels of human. In case stimulation, a BAP use to be information sources — of response of organism that are carries information from the organism, or stimulus, which

carries information in to the organism. Thus, there are two sorts of stimulus the control and correction of organism state. The statistics evaluation of the response of the bioobject, the automation of the assessment, feedback on the determined of the organism the state of as a norm are the main operations of IT, **Figure (1, 2).**

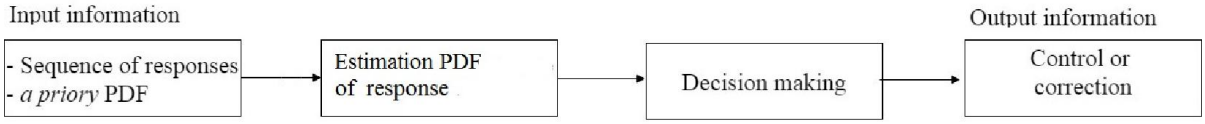

Figure 1: Method of determining of necessary the correction. PDF — probability density function of human the response on haptic stimulation of human which is working at special circumstances; ROC - receiver operating characteristic (for decision making estimation). The probability density function of the human response on haptic stimulation at usual circumstances estimated *a priori*.

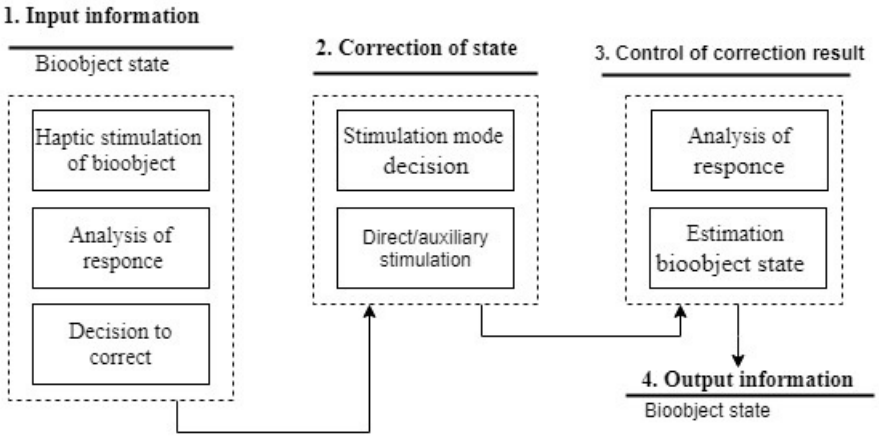

Figure 2. Diagram of the information technology of controlling and correction of functional state of human which are working at special circumstances.

4. Specification of Information Technology for Influent and Obtain Information Through BAP

On fig. 3 is the result of the EEG experiment (a man, 33 years old, without neurological and other diseases, in a position sitting with his eyes closed in a dark room, at rest, the big fingers of both hands are superimposed on the LEDs). The electroencephalograms (is recorded 15000 values - initially without stimulation (7500 values of 20 the lead's potentials), and with stimulation by pulses S_{st} of 1.9×10^{-6} W / m^2, at a frequency of 2 Hz, of the red color (the remaining values, up to 15000). Second order digital filtering (frequency of discretization $f_d = 500\,Hz$) with bandwidth $\Delta f = f_2 - f_1$ = (13-8) Hz and the quality $Q = f_o / \Delta f$ =2.5, was used for selection α - waves. For recording, the EEG used an electroencephalograph system NEUROCOM [7, 8].

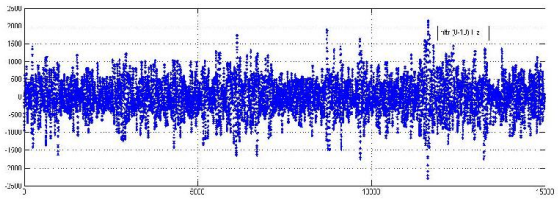

Figure 3. View of the variability of the potential along time on the 10-nd lead: without stimulus (0-7500 samplings), and with stimulus (7501-15000 samplings). Coordinate scales in conditionals units.

Single sided amplitude spectrum of potential (**Figure 3**) is given on to **Figure 4:**

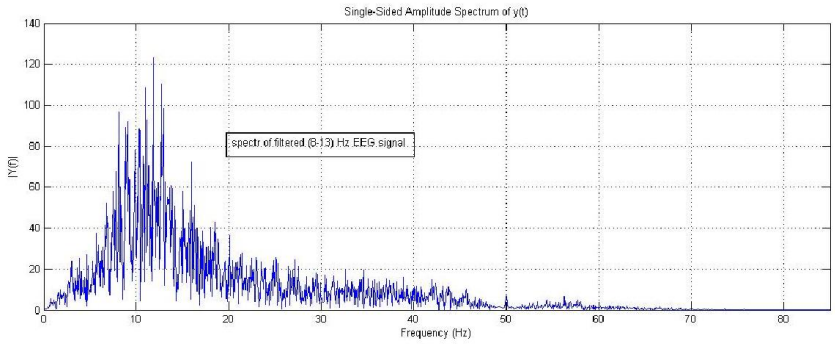

Figure 4. Amplitude spectrum without stimulating.

Diagram of the amplitudes of the spectrum (**Figure 4)** in diapason of α-waves, i.e. (8-13) Hz, is given on to **Figure 5**:

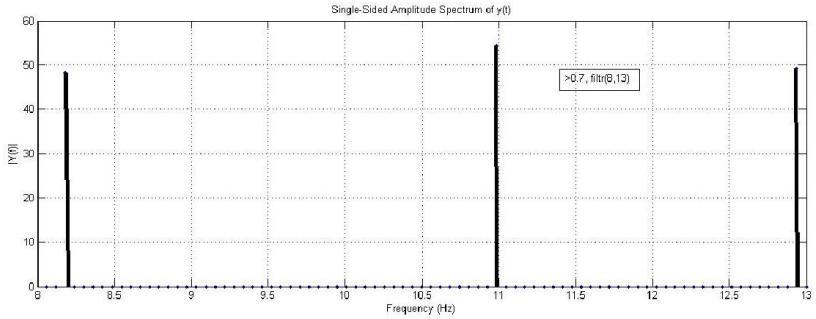

Figure 5. Lines of α- waves spectral frequencies in diapason of spectrum on **Figure 4** which amplitudes of spectral lines are bigger √2/2 of max amplitude**.**

Analogical to **Figures 4-5**, on to **Figures 6-7** are given band's spectrums (8-13) Hz, these received after stimulation.

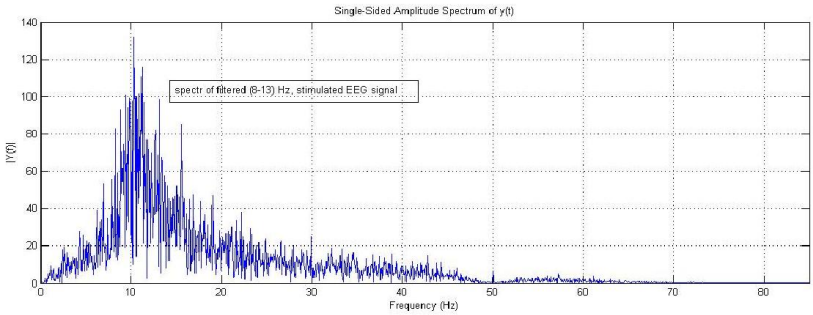

Figure 6. Amplitude spectrum after stimulation.

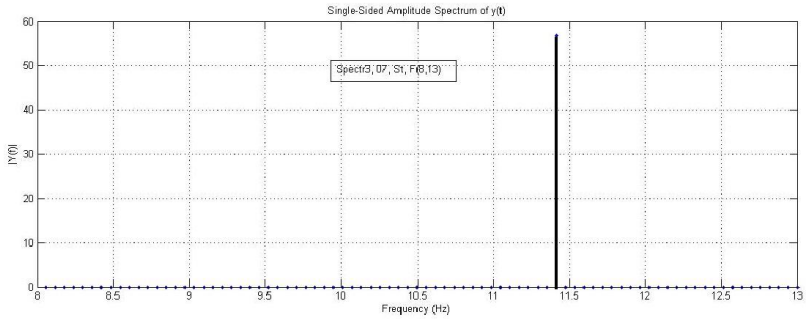

Figure 7. Spectral frequency lines of α- waves with amplitudes larger of √2/2 of max amplitude of spectrum on **Figure 6.**

The all leads spectrum diagram (α-waves human diagram) presented on to **Figure 8**, this relate to 10th lead, before stimulation (**Figure 4-5**).

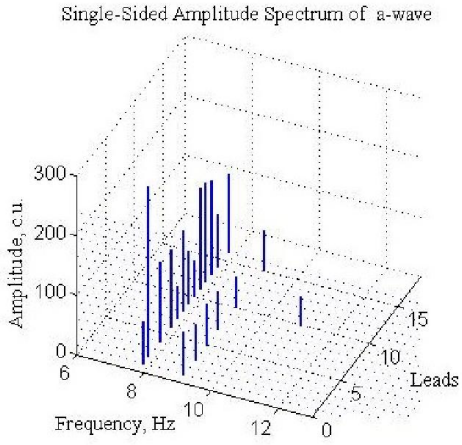

Figure 8. Amplitude spectra of α-waves vs encephalography leads (the human functional state pattern) without stimulus.

The experiment showed:

- the lack of a feeling of low-intensity stimulation and its effect on the body's condition;
- the appearance of the effect from stimulation of the organism in its functional systems.

This indicates:

- existing potential prognosis of the detection of changes in the functional state of a human who works in special conditions;
- the possibility of statistical studies of the functional state in the "norm" and under special conditions.

Due to physiology properties of bio objects [9, 10, 11, 12], and by experimental researches were stated that energy S of potential on the lead of the electroencephalogram after impulse stimulation of BAP are exponentially decreasing:

$$S = S_0 \exp^{-\alpha S_{st}}, \quad (1)$$

where S_0 — "dark room energy" of alpha-wave, S_{st} — energy of light stimulation. After the LED impulse light stimulation of the big fingers of both hands was coefficient a determining by formula

$$\alpha = (\ln S_0 - \ln S) / S_{st}. \quad (2)$$

The stimulation energy S_{st} =1.9·10^{-6}W/m of LED is determining by photometer, as well as by calculations, which including times parameters of LED and pulse.

On to **Figure 9** is given function $S(S_{st})$, which builds by points from $S=S_0|_{S_{st}=0}$, and $S=S_0|_{S_{st}=1.9\cdot10^{-6}}$, and formula (1).

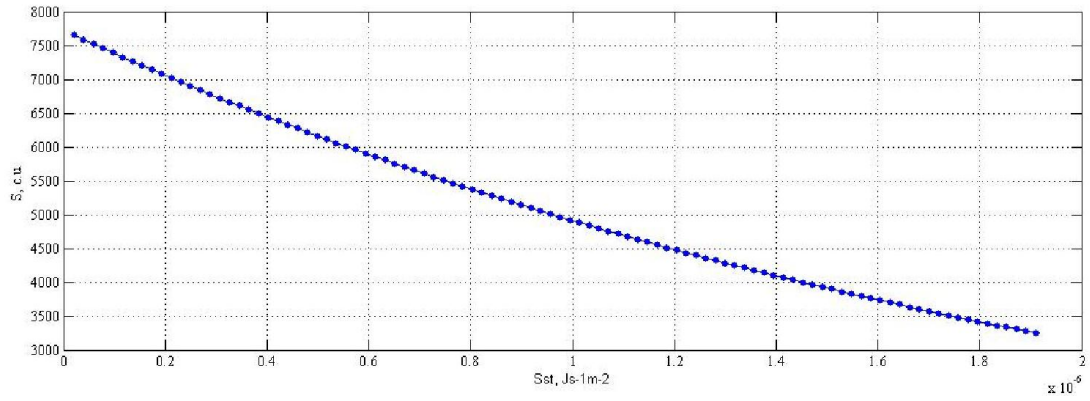

Figure 9. Energy spectrum of α-waves vs light stimulus.

The results of the experiment confirmed:

- the lack of a feeling of low-intensity stimulation and its effect on the body's condition;
- the apparent appearance of the effect of this stimulation on the functional systems of the organism.

This indicates:

- the potential prognosis of the detection of changes in the functional state of a person who works in special conditions;
- the possibility of statistical studies of the functional state in the "norm" and under special conditions.

5. Conclusion

The article presents the solution of the actual problem of alternative support for people in whom the functional state is temporarily begin decreasing. The following scientific specifications are obtained for methods:

1. detect information by a haptic stimulation by light;
2. develop of prediction the functional state decreasing that most often occur after the special environmental condition appeared;
3. develop IT that implements human support with the use its existing properties, which is achieved by control and correction using mobile and auxiliary devices.

Using the proposed information system of alternative communication significantly increases the level of defense of human in special environment conditions, improves the quality of sustaining, develops self-stability and gives the opportunity to feel like a personality.

The specifications of the problem of controlling and correcting the state of the human organism in the extreme conditions of its life give to obtain:

- requirements to the functions and structure of the body's stimulation system with the light;
- calculation formulas for representing the functional blocks of the organism system;
- the method of recursive determination of the intensity of the light flux after each layer of the biological environment;
- decrease computational complexity of testing and automated haptic control and correction of the body's condition;
- conditions to confirm the statistical significance of representative samples of the body's responses to haptic stimulation of it through biologically active points.

6. References

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