Application Artificial Intelligence for Real-Time Monitoring, Diagnostics, and Correction Human State

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Abstract. The authors present the Artificial Intelligence system of monitoring, diagnostic and according to the correction of the emotional state of patients during treatment. Monitoring of the current emotional state of the human, diagnostics of the deformations of emotional experience and determination of the operator's functional stability will allow timely prevent the development of the situation towards worsening. Developed Intellectual automated control system (IACS) to monitor the human condition, Expert System "Estimation of comfortable ergonomics for patients"

Keywords: Artificial Intelligence, Expert system, Diagnostics Module, Deformation of Emotional State, Hodograph, Stability

Key Terms: Development, Modelling, Process, Methods of correction, Expert estimation

1 Introduction

The life of modern people filled with different events, one-way or another involves changes to the mental and emotional state. The manifestations of mental and emotional states can be both positive and negative. The negative consequence considered "burnout syndrome". The nature of the emotional state significantly affects the healing process of patients. It is very important to continuously monitor the emotional state, timely diagnosis, and deformation of the emotional state of patients during treatment. With a long process of recovery, patients experience fatigue and overwork, which can be classified as burnout syndrome. This emotional state is the most dangerous because it can lead to economic losses and irreversible consequences in their professional activities. So, at the European Conference of the World Health Organization, held in 2005, it noted that the cost of solving the problems of the mental and emotional state of the working people of the European Union amounts to 3-4% of gross national income [1]. Burnout syndrome faced by people whose work takes place under conditions of constant stress and responsibility for life other people, namely, military personnel, pilots, astronauts, medical professionals, teachers, social workers [2].

The main reason for burnout considered a psychological, mental super fatigue. This occurs when the requirements (internal and external) for a long time dominated over

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resources (internal and external) a human equilibrium is disturbed, which inevitably leads to a syndrome of mental and emotional burnout. The connection of the identified changes to the nature of the professional activities involving responsibility for the fate, health, and lives of people is set. These changes interpreted as the result of exposure to prolonged occupational stress.

The psycho-emotional state is the human reaction to the relationship with the environment, expressed in terms of the appearance of his feeling comfortable or uncomfortable state. Independently recognize the state of burnout syndrome is impossible because of the conservatism of retardation and personality assessments. Therefore, scientists of different countries have developed a methodology for assessing the mental and emotional state, and developed tools for the independent qualification of this state [3; 4].

Now allocate about 100 symptoms, one way or another associated with the syndrome of emotional burnout. First of all, it should be noted that the conditions of professional activity can sometimes appear and cause chronic fatigue syndrome, which, incidentally, is often accompanied by a syndrome of emotional burnout. In chronic fatigue syndrome are typical complaints of patients: progressive fatigue, decreased performance; poor tolerance of the previously usual loads; muscle weakness; muscle pain; sleep disorders; headache; forgetfulness; irritability; decrease in mental activity and ability to concentrate [3].

This publication is first offered to consider human (H) as a control object (CO), human state monitoring and diagnostics are based on the definition of the patient's current state according to the analysis of phase portraits.

The authors' proposal introduces in medicine the methodology for assessing the mental and emotional state that was used in aviation [5; 6]. Authors have experience in aviation of operational determination of pilot's emotional state deviations and decision making in risk applied the concept of human mental activity, which is based on a property of consciousness delay or accelerates the flow of subjective time relative to real-time [7]. The most common means of assessment of the pilot are piloting parameters (deviation of ailerons, rudder direction, etc.) and negotiations on the flight deck, i.e. radio communications between the pilot and the controller. More available for investigation are piloting parameters, recorded with modern means. The pace and range of motion of the pilot during controlling the air vehicle that changes with increasing emotional stress is an indicator of emotional state [9].

The first attempts to organize the monitoring of the crew of civilian liners relate to the 70 years of the last century. Then in the USA on the recommendations of the Ames Research Center (ARC) on the body of the pilot intended to place sensors of objective medical and biological control of the body. Their purpose was to provide various electrograms, the information of which in real-time on the communication channels had to be transmitted to the earth, and the earth had to determine what is really happening to the person, and in critical cases to take appropriate measures. The attempt failed: the pilots did not want to have sensors and conducting a signaling system on their body, firmly stating that the sensors would interfere with the work, so for researchers, the first place came the problem of developing contactless systems for assessing the state of the pilot in flight. Automatic recognition of human emotions is

very important in many applications. Emotions can display facial expression, voice, stroke, pulse, blood pressure, etc. At the moment, it is developing models of machine learning that can "feel" individual emotions [10].

In addition to monitoring the emotional state of a person, it is proposed to additionally use expert systems that can assist the experts during medical treatment.

The purpose of the publication are

– building an Expert system (ES) as Artificial Intelligence (AI) for estimation of priority of patients “Estimation of comfortable ergonomics for patients” using Expert Judgment Method (EJM);

– the diagnostics of the mental and emotional state of a person; development of the algorithms of human psycho-emotional diagnosing and monitoring.

2 Expert systems for estimation of emotional state of patients

Expert Systems are software systems developed using different techniques of artificial intelligence that can act parallel to the "human" experts. The main role is consultative. Databases of such systems can contain a huge number of data about different diseases, therapy modalities, corrects methods for care, etc. In the development of "Medical Expert Systems", the rules and knowledge of human experts are crucial. The teams of such experts are developing an Expert System considering the changes in medicine and care methods. The Expert System is one of the varieties of Artificial Intelligence (AI) [11]. AI in healthcare is the use of algorithms, mathematics methods, and software to approximate human cognition in the analysis of complex medical data and for helping of forecasting of the future emotional state of patients after healthcare. Specifically, AI is the ability for computer algorithms to approximate conclusions; the ability to gain information, process it and give a well-defined output to the end-user; the ability to support for medics. These algorithms can recognize patterns in behavior and create their own logic decision and rational DM. There are many Expert Systems need for medicine, such as: quantitative estimation of the complexity of the care methods; quantitative estimation of the complex procedures operators during the working process; quantitative estimation of the problem; the significance of the procedures performed by the patients; the importance of individual psychological factors influencing the Decision Making (DM) in care methods; the importance of social and psychological factors influencing the DM in care methods; definition the difficult of procedures for care methods of persons; comfortable color characteristic of the room; quantitative estimation of the significance of the corrected methods for improvement of emotion states, etc.

The main task to develop this system - quantitative estimation of parameter’s system using Expert Judgment Method (EJM) [4]. For example, consider the simple example of building Expert System “Estimation of comfortable ergonomics for patients. Part 1 Comfortable color characteristic of the room” - the significance of color characteristics for patient recovery as characteristic of significance by sight. The famous Luscher Color Test is a psychological test, developed for the use of psychiatrists, psychologists, physicians and those who are professionally involved with the con-

scious and unconscious characteristics and motivations of others. As is known, emotions (from lat. “emoveo”) are subjective reactions of a person to any external and internal stimuli through the senses. A person has five basic feelings (hearing, touch, sight, smell, and taste) that can be used to change a person’s emotional state. Researchers took to calculate and choose the next colors (factors for estimation): pink, blue, yellow, white, and choosing. In this example the “experts” are the “medics”, who may choose a need color for patients according to ways of treatment.

Example of estimation using EJM. Firstly, it was necessary to create a matrix of individual preferences of each expert. We determined the opinion of each expert and their systems of individual preferences are the following (Table 1).

Table 1. The matrix of individual preferences

Color	Pink	Blue	Yellow	White	∑r	R
Pink	*	0	1	1	2	2
Blue	1	*	1	1	3	1
Yellow	0	0	*	0,5	0.5	3.5
White	0	0	0,5	*	0.5	3.5

The system of preferences of expert No 1: $S(R^1) = R_1 \succ R_2 \succ R_3;\ R_4$.

The next step was to gather all expert`s opinions and create the matrix of group preferences. As a result, the matrix of group preferences is the following (Table 2).

Table 2. The matrix of group preferences**.**

Experts, m=5	Pink	Blue	Yellow	White
1	2	1	3.5	3.5
2	1.5	1.5	3.5	3.5
3	1.5	3.5	1.5	3.5
4	1	2	3	4
5	1.5	1.5	3.5	3.5
Rgr	1.3	1.9	3	3.6

To determine the coordination of experts' opinions, it is necessary to calculate dispersion, squared deviation, and coefficient of variation. The results are in Table 3.

Table 3. The matrix of coordination of experts’ opinion

Experts	Pink	Blue	Yellow	White
1,2,…*n*	2	1	3.5	3.5
R_{gr}	1.3	1.9	3	3.6
D_j	0.12	0.92	0.75	0.05
σ_j	0.35	0.96	0.86	0.22
υ_j, %	23.57	50.61	28.87	6.21
Results	< 33%	> 33%	< 33%	< 33%

The system of preferences for group of experts:

$$S(R_{gr}) = R_1 \succ R_1 \succ R_3 \succ R_4 . \quad (1)$$

If the variation is less than 33% – the opinion of experts is coordinated. If the variation is more than 33% – the opinion of experts is not coordinated. For "blue", v_2 = 39% > 33% and need to obtain Kendal's coordination coefficient.

As a result, Kendal's coordination coefficient is equal to 0.71. Our result shows that the opinions of the experts are coordinated. The significance of the calculations using χ^2-criteria (6,75 > 0,5):

$$\chi_f^{\,2} = \frac{76.5}{\frac{1}{2}\cdot 5(4+1) - \frac{1}{12\cdot(4-1)}\cdot 42} = 6.75 . \quad (2)$$

$$\chi_\phi^{\,2} > \chi_t^{\,2} \quad (3)$$

The rating correlation coefficient of Spirman and Student's *t*-criterion. The seventh task is to compare the opinion of the group of experts and expert No 2 with the help of the rank correlation coefficient of Spirman (Table 4).

Table 4. The matrix of the correlation coefficient of Spirman

Ranks	Pink	Blue	Yellow	White
Ranks of the group, Rgr	1.3	1.9	3	3.6
Ranks of expert No 2	1.5	1.5	3.5	3.5

Our result is r_{si} = 0.934. So, the coordination of opinions of the group and expert No 2 is high. The significance of the calculations using *t*-criteria:

$$t_{critical} = 0.934\sqrt{\frac{4-2}{1-0.934^2}} = 3.69 . \quad (4)$$

6. Definition of weight coefficients ω_i (Table 5) and graphical presentation of results (see Fig. 1). Weight coefficients w_j of *j*-factors:

$$w_j = \frac{Cj}{\sum_{j=1}^{n} C_j} \quad (5)$$

where *n* – is a number of factors; $\sum_{j=1}^{n} w_j = 1$; $C_j = 1 - \frac{R_i - 1}{n}$ – are the estimates.

Table 5. The matrix of the definition of the significance of color characteristics

Color	*Rgrj*	*Ci*	ω_i
Pink	1	1	0.4
Blue	2	0.75	0.3
Yellow	3.5	0.375	0.15
White	3.5	0.375	0.15

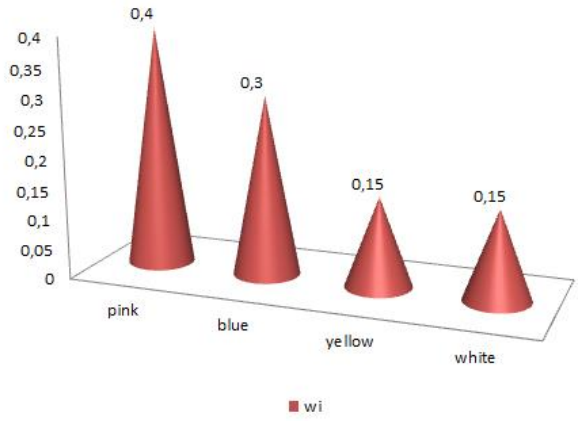

Fig. 1. Graphical presentation of weight coefficients

3 Intellectual Automated Control Systems of Monitoring Human State for Medicine

For operational determination of the pilot's emotional state deviations and bias in decision making (DM) in risk applied the concept of human mental activity, which is based on a property of consciousness delay or accelerates the flow of subjective time relative to real-time. Deformation of the emotional state defined using a priori model of human- operator (H-O), based on actual material posterior studies of investigating aviation accidents received by the International Aviation Committee (IAC) [7]. There are three types of H-O emotional activity:

- spontaneous (optimal) type of activities;
- emotional type of activities;
- reasonable type of activities.

With the development and improvement of technology in modern Intellectual Automated Control Systems (IACS) the problem of effectively monitor the human state can be solved. This research was first offered to consider human as a control object, human state monitoring and diagnostics is based on comparison patient's actual and normal state according to the analysis of phase portraits (see Fig. 2). The analysis and synthesis of the IACS are carried out in a similar way to poliergatic (man-machine) system [4; 7; 8], however, as a "control object"(CO) is a person (patient), "control device"(CD) is an element of control system or a doctor.

The Algorithm of human's emotional monitoring and diagnostics

1. Definition of the phase portrait of human *Hn* – diagnosis of the normal condition by characteristics of performance, movement, communication, etc.
2. Introduction into circuit IACS of human parameters and real-time monitoring of human condition *Hn*.

3. Analysis of IACS “control device (CD) – human *Hn*” (current condition):
4. Determination of IACS “CD – human *Hn*” stability.
5. Determination of area of IACS “CD – human *Hn*” stability.
6. In case of violation of IACS "CD – human *Hn*" stability, system correction is required.
7. Determination of characteristics of links for human condition correction.
8. Synthesis of new corrected system IACS "CD – human *Hn*+1".
9. Analysis of new system IACS “CD – human *Hn*+1” (current human condition), etc.

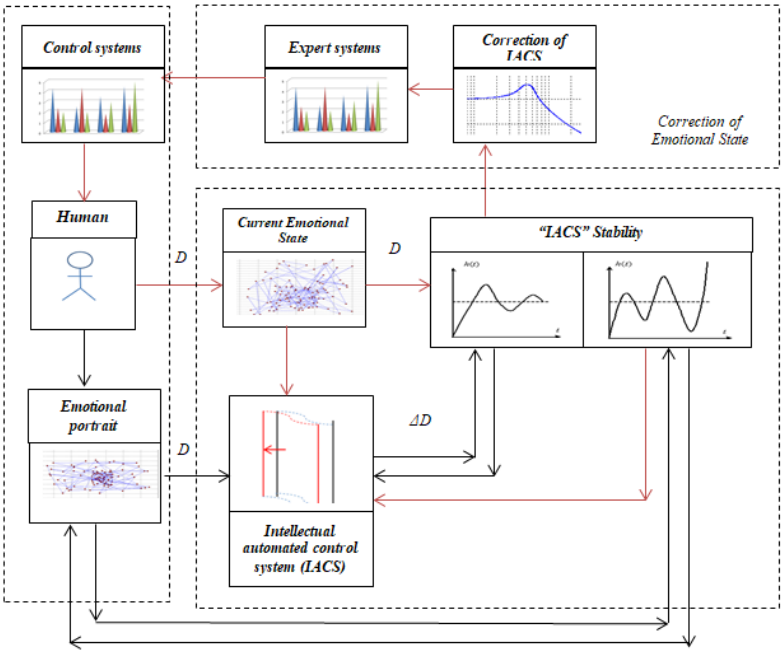

Fig. 2. The conceptual model of medical IACS

For testing single system approach to the researching of polyergatic systems, it is advisable all diversity of management systems reduce to several typical systems, in which main elements are distinguished, and it's functioning should be estimated during the investigation of any system. Using dynamic modeling method for solving the problems of complex technical ergatic systems maintenance can lead to exactly the same models. The approach lies in the construction of the system of equations, which describing CO, H-O equations of the automatic control system (ACS), analysis of control system (CS) for the stability, synthesis of a new reliable system. IACS “CD – *H*” could be displayed by following the functional diagram (Fig. 3), which reflects activity human in case of H state monitoring, i.e. during changes of blood pressure H - Ψ_f, for example.

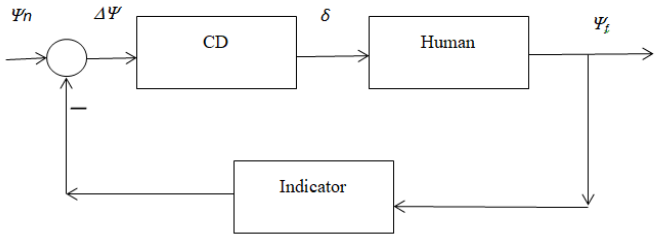

Fig. 3. The conceptual model of medical IACS

During identification with the help of indicators of deviation $\Delta\Psi$ ($\Delta\Psi = \Psi_f - \Psi_n$) actual blood pressure Ψ_f from defined pressure Ψ_n of H, CD (or human (Doctor)) relevant information is analyzing and controlling action is defined δ until deviation $\Delta\Psi$ disappears. Stability of IACS "CD – Human (H_n)" has been obtained with using criteria: Mikhailov, Nyquist, Hurwitz, area of stability for all coefficients and constants. Determination of IACS "CD – *Hn*" stability by the Mikhailov criterion. To find the hodograph by Mikhailov criterion it is necessary to put into a characteristic equation *jw* instead of p, received vector *M(jw)* as the sum of the actual *P(w)* and imaginary part:

$$M(p) = (T_2 p + 1)(T_3 p + 1) + K_1 K_2 K_3 K_{ind} K_{CD}(T_1 p + 1) \quad (6)$$

$$M(jw) = (T_2 jw + 1)(T_3 jw + 1) + K_1 K_2 K_3 K_{ind} K_{CD}(T_1 jw + 1) = P(w) + jQ(w) \quad (7)$$

$$P(w) = 1 + K_1 K_2 K_3 K_{ind} K_{CD} - T_2 T_3 w^2 \quad (8)$$

$$Q(w) = (T_2 + T_3 + K_1 K_2 K_3 K_{ind} K_{CD} T_1) w \quad (9)$$

Where a real part is *P(w)* and the imaginary part is *Q(w)*. According to the characteristics of value *P(w)* and *Q(w)* Mikhailov's hodograph has been built [5]. The type of hodograph determines the stability of the system. The stability of the system has been determined by the Nyquist criterion under appropriate deformation of emotional experience. For example, has been obtained system stability using the Nyquist criterion with consideration of the dispersions by the operative model in the emotional state. The indication of diagnostics results of current emotional state pilot in flight using dynamic panel display of digital data encoding [12; 13].

Synthesis of IACS on the basis of monitoring and diagnostics of human has been made by building a transition process. Indicators of quality of IACS and reliability of human have been defined: over-control, oscillations, time of adjusting, etc. With the help of IACS correction characteristic of the desired system has been obtained. Synthesis and adjustment of the system are planned through a variety of methods to improve human wellbeing and regulation of the human state. The intelligent automated control system of monitoring and diagnosis of the human condition that is being treated has been proposed. System IACS has been built with the help of dynamic modeling principles, the algorithm of human psycho-emotional diagnosing and monitoring

through IACS system has been provided. IACS subsystems have been formalized in the form of transmission functions and algorithm of modeling, analysis, and synthesis by methods of IACS automatic control theory has been developed.

An example of IACS modeling by analysis of the influence of the time constants and coefficients on the stability and reliability of the system, including and humans has been represented. Therefore, as a CO it is proposed to consider the human, for whom applying diagnosis and monitoring of H condition in comparison to its normal state by the analysis of phase portraits, we can develop methods for adjusting and improving the human condition.

In cases of large and complex data, methods can be integrated into traditional and next-generation hybrid systems by processing unsupervised situation data in the deep landscape models, potentially at high data rates and in near real time, producing a structured representation of input data with clusters that correspond to common situation types [14].

4 Conclusion

Controlling mental and emotional state becomes important for various professional groups of people, especially those related to risk (military, pilots, social workers, and others). This is due to the invisible appearance of this state, with heavy loss of individual and community, as well as the difficulty of self-establishing the state of mental and emotional causes of burnout. It is advisable to apply the methods of monitoring the emotional state in medicine. Existing therapeutic approaches based on the patient's part in the process of emerging from this state. In addition to the psychological impact on the patient needed: compliance work and rest, avoiding harmful habits, proper nutrition, clarifying professional and personal goals. Timely detection of the state of discomfort and constant control of the quality of life is possible when using special diagnostic equipment. Insufficient level of industrial development in this direction stimulates the search for new and effective solutions, the basic directions of the creation of technical solutions presented. The proposed method of monitoring and diagnostics the patient's emotional state can have a significant interest in medical institutions (hospitals, motels, hospitals, rehabilitation centers). The new system of monitoring and diagnostics IACS has been built with the help of dynamic modeling principles, the algorithm of human psycho-emotional monitoring and diagnostics has been provided. The IACS subsystems have been formalized in the form of transmission functions; algorithm of modeling, analysis, and synthesis of IACS by automatic control theory methods has been developed. Correction of emotion state proposed do use Expert systems, for example, in the article Expert System “Estimation of comfortable ergonomics for patients. Comfortable color characteristic of the room” presented. An example of IACS modeling by analysis of the influence of the time constants and coefficients on the stability and reliability of the system, including humans, has been represented. It is proposed to consider the human as a control object, to monitor and to diagnose human state on the base of the phase portraits analysis, which will make it possible to develop methods for its adjusting and improving. Monitoring of the current emotional state of H-O and diagnostics deformations of emotional experience in the forms of transitions to dangerous types of human activities (reasonable or emo-

tional) in dangerous situations and determining the functional stability of system "CD - human" will allow timely prevent the development of critical situation towards worsening.

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