

EXPERT ADVISORY SYSTEM DETERMINING THE FUNCTIONAL RELIABILITY OF THE HUMAN OPERATOR BASED ON PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL INDICATORS

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The article is dedicated to the formation of a "generalized portrait" of the condition of the human operator, which is the main component of the ergatic system, based on psychophysiological indicators, and on this basis, providing corrective advice through an expert-advisory system. A formal-constructive model "generalized portrait" is created according to the stratified description of psychological and psychophysiological indicators. Each indicator included in the strats is realized by means of the corresponding software. Each component of the "generalized portrait" is assigned to different scale types (ratio, interval, ordinal, nominative). The theory of fuzzy sets and relations is used to unify different types of scales. The decision and advice functional block of the expert-advisory system makes a decision about the functional reliability based on the fuzzy knowledge based on the current state of the human-operator.

Keywords: human-operator, psychophysiological state, generalized portrait, expert system.

INTRODUCTION

The component of the human-machine system reliability problem is directly related to the human factor [1,2]. It is in this direction that the vast majority of research is focused on the identification of the current state of the human-operator during the activity. The reliability of the activity can be realized by adequately assessing the human-operator condition based on psychological and psychophysiological indicators [3,5,8]. On the other hand, expert-consultation systems [6,7,9] used in the direction of optimizing the human-operator situation require constructing a constructive

formal model of the current situation. The article proposed a "generalized portrait" as a constructive hierarchical model of the human-operator, the main component of the ergatic system, based on psychological and psychophysiological indicators. Based on the current situation, which is identified as a "generalized portrait" of the human-operator, the decision on functional reliability is realized by means of a special function block of the expert system.

The hierarchical model "generalized portrait" is based on N.I. Plotnikov's concept of functional resources [4]. According to this concept, the functional reliability of the human-

operator has a hierarchical structure. The use of fuzzy mathematical apparatus allows the unifying of different types of both quantitative and nominal indicators of the "generalized portrait".

It should be noted that for each activity if we are to apply this to different types of human-operator activity, we must consider self-sufficiency.

METHODOLOGY

The functional diagram of the expert advisory system, which forms a "generalized portrait" of the human-operator and provides the proposed expert decision on its functional reliability, is depicted in Fig. 1.

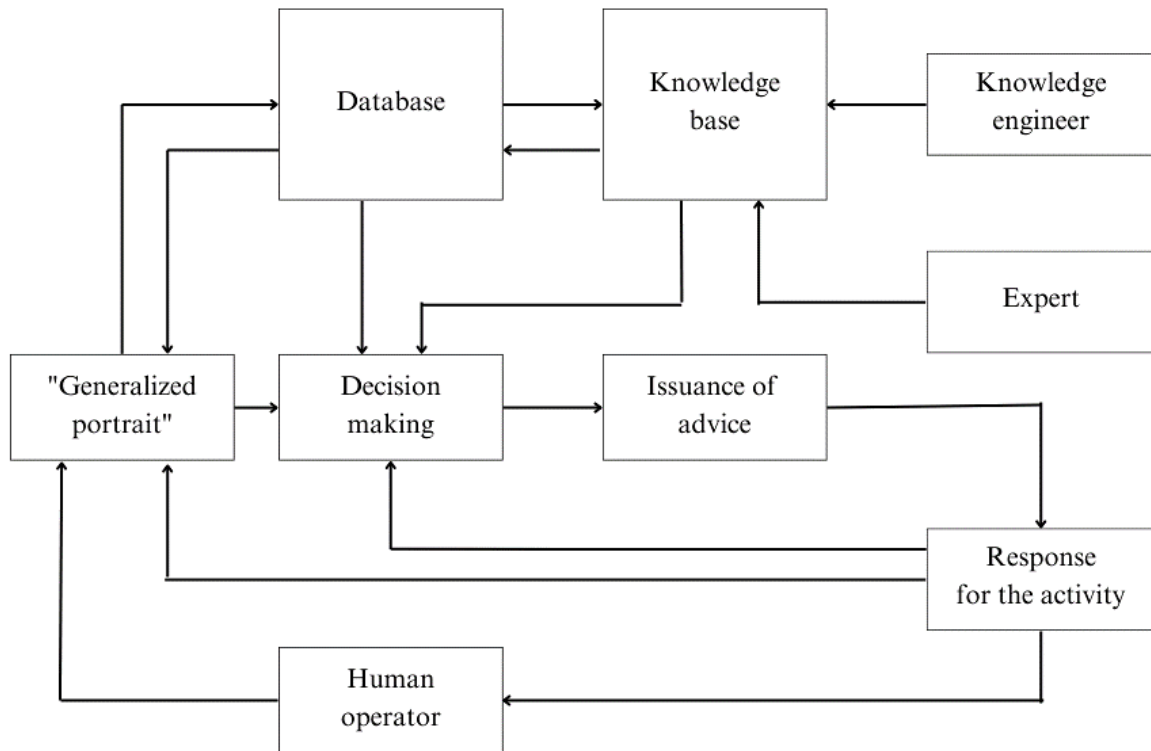


Figure 1. Functional diagram of the expert advisory system.

As you can see from the picture, the system consists of the following main sub-systems:

- creation of "generalized portrait";
- making a decision;
- providing advice;
- data and knowledge base management.

The above-mentioned expert consultation system was developed by F.H., one of the authors of this article. The system was developed in the Delphi 10.4 environment in the Object-oriented Pascal language.

Forming a "generalized portrait" of a human-operator

"Generalized portrait" is a hierarchical formal representation of the current state of the human-operator.

A copy of the database is the composition of the "generalized portrait" defined as follows: $X := \langle P, PP, PVK, PX, CP, PV \rangle P$ – Passport data, PP – psychological portrait, PVK – important professional qualities, PX – psychological properties, CP – current psychological indicators, PV – psychological state.

Each component of the tuples listed above is assigned to different scale types (ratio, interval, ordinal, nominative). The theory of

fuzzy sets and relations is used to unify different types of scales. A generalized portrait uses descriptive stratified language as a hierarchical structure. Each strat has its own language, model, and features. There are several methods of creating a "generalized portrait":

- initial selection (by default);
- according to the operator's choice;
- according to the repeated choice (according to the training result).

Decision-making based on the "generalized portrait" of the human-operator

The decision-making procedure is carried out by applying the composition rule to the initial data X^* and knowledge of the form $Y \rightarrow Z$, as a result of which the information Z^* is obtained, where \circ - (modus ponens) is realized by means of fuzzy composition rules [7].

CONCLUSION AND DISCUSSION

The interactive systems described above have been used to determine the functional reliability of aviation dispatchers, pilots, and human-operators operating in the oil industry and in various fields to provide corrective advice.

According to the comprehensive assessment of psychological portraits as a result of the listed applications, they can be divided into three categories:

- 1) normal psychological portraits;
- 2) portraits changed due to symptoms;
- 3) syndromologically altered portraits.

Such typification is the basis for identification, prediction, and decision-making procedures.

Normal psychological portraits - on the basis of a large number of data, the statistical gradual variable boundaries of normative indicators are determined on the basis of membership functions of fuzzy sets [2,7].

Symptom-adjusted portraits are created based on the assessment of the deviation of individual indicators from the normative indicators of different strata.

Syndromologically changed portraits - the syndromological features of the portrait are formed on the basis of correlative relationships of individual indicators.

The listed components are a complex of indicators, each of which has a different type of scale.

The portrait of a human operator proposed and realized on a personal computer has many distinctive and superior features:

- In the stratified hierarchical structure, there are effective and informative relationships between each chain, where the special role of the psychological component is evident;
- The flexibility of the hierarchical system allows it to include new indicators;
- Alignment of indicators with different scales creates visual comfort in the graphic image, which allows comparing the images of different individuals or the same individual at different times;
- Interacting with the system allows you to determine the quantitative dimensions of the graphic component in the image of interest.

The formally established structure simultaneously allows for a more adequate construction of the database structure of the expert advisory system.

The process of creating a "generalized portrait" of a human-operator consists of interrelated processes of synthesis and analysis. However, ensuring the adequacy of the portrait formalization process can increase its reliability after passing through the stages of adaptation and improvement. This is possible in the following directions:

- universality;
- breadth of the subject area;
- flexibility – determination of the necessary program configuration according to the required current issue;
- self-regulation and self-organization;
- high ergonomic qualities.

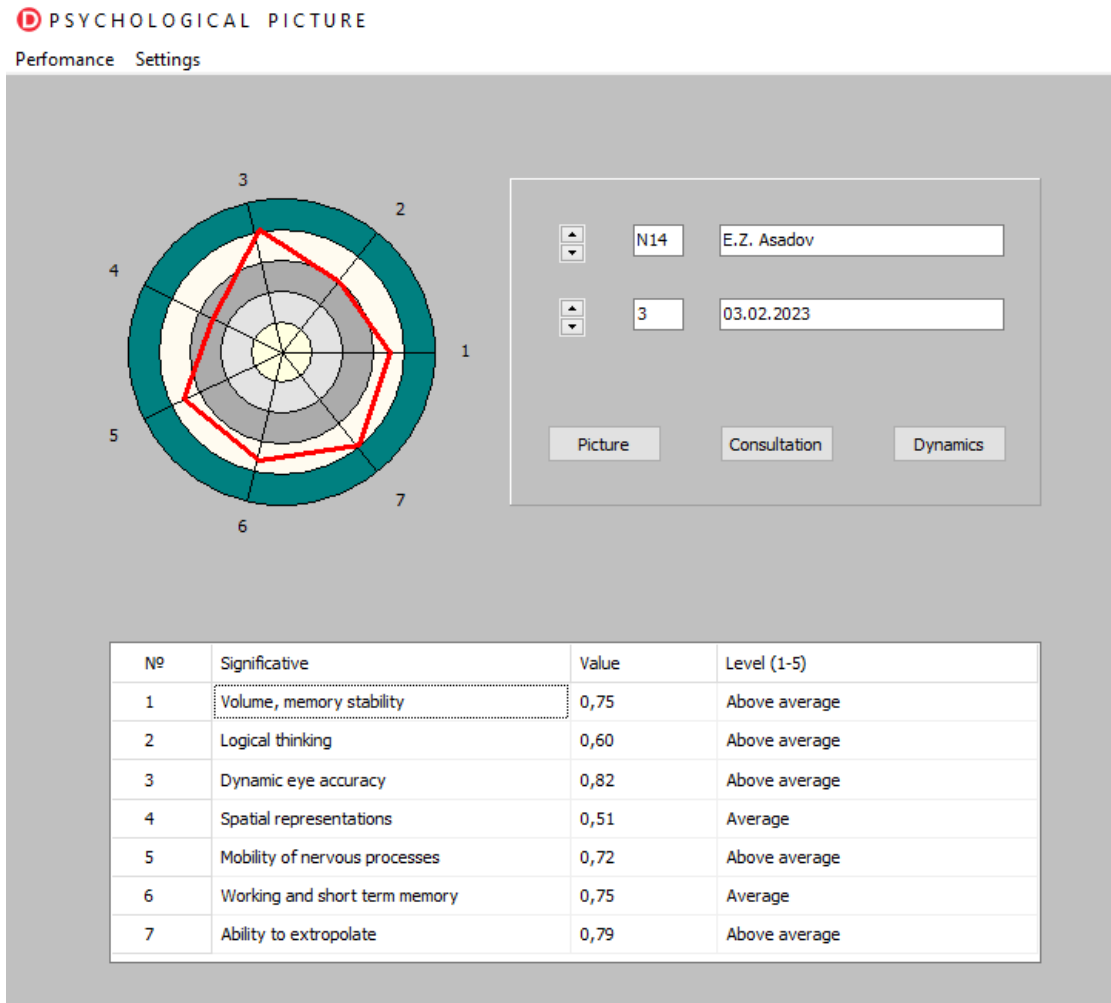


Figure 2. Dialog "window" of the expert system user. Identification of the stratum reflecting the professional quality of the "generalized portrait" of the human-operator. Interface of the system supports 3 languages - Azerbaijani, Russian and English, depending on the user's preference.

Each component of the vector $X = \langle x_1, x_2, x_3, x_4, x_5, x_6, x_7 \rangle$, which reflects the professionally important qualities, is detected by means of a psychological test bank included in the system. Here

- x1 – an indicator of the stability of attention;
- x2 – an indicator of the logical thinking;
- x3 – dynamic eye accuracy;
- x4 – an indicator of spatial images;
- x5 – an indicator of the mobility of nervous processes;
- x6 – practical memory indicator;
- x7 – extrapolation indicator.

All vectors are normalized to facilitate integration and visual comparison of

psychological states with both "benchmark" and previous states.

Each X_i^* parameter $X_i^* = (X - X_{\min}) / (X_{\max} - X_{\min})$, $i=1,7$, is normalized by means of conversion.

The value of each parameter X_i^* belongs to the interval $[0,1]$, which allows entering a fuzzy set of "desired states" for each parameter defined by the relation function $\mu_i(x): \{X_i\} \rightarrow [0,1]$.

According to the normative data, each psychological parameter is evaluated with different levels such as "low", "below average", "medium", "above average" and "high".

The universality of the system is evaluated by the breadth of the subject area. The selection

of current issue is selected from the issues entered into the system in dialog mode. The openness of the system allows to extend that class. This is done with the direct participation of the knowledge engineer of the system.

The multi-functionality of the system is realized through the selection of visual elements in the "dialog" window. Fig. 2 shows the diagram and evaluation of the indicators selected by the user of the psychological stratum of the human-operator "Generalized portrait" as an example. In a special window, the dynamics of certain indicators of the individual and, if necessary, appropriate expert advice are provided.

The presented system has a number of advantages over existing systems:

1. The system is equipped with a functional unit that gives advisory decisions in order to optimize the functional state through corrective procedures based on a database where the results of the dynamics are stored.
2. Another direction that makes it possible to adapt to other types of human operator (pilots, dispatcher, etc.)
3. The flexibility of the system allows it to be applied to operators in various production areas by expanding the bank of tests for the corresponding professionally important qualities of a human operator.

Correspondence between the current psychophysiological profile and the trainer's assessment was investigated. Numerous checks have shown that it was about 85%.

All psychophysiological important activities of high consistency activity by the expert were above average level (>0.80).

According to the expert definition, it was characterized by the average of one or two indicators in the average group (0.4 - 0.6).

In the conditionally unreliable group, the generalized portrait was characterized by its syndromal variability, where the number of

average and below-average psychophysiological indicators was 3 or more.

The expert advice system can be used for the following purposes:

1. Professional choice;
2. Admission to current work;
3. Choice of extreme conditions that require special skills.

The proposed open expert advisory system is capable of deciding on functional validity it can be expanded to realize the psycho-corrective function.

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ЭКСПЕРТНАЯ КОНСУЛЬТАТИВНАЯ СИСТЕМА, ОПРЕДЕЛЯЮЩАЯ ФУНКЦИОНАЛЬНУЮ НАДЕЖНОСТЬ ЧЕЛОВЕКА-ОПЕРАТОРА НА ОСНОВЕ ПСИХОЛОГИЧЕСКИХ И ПСИХОФИЗИОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ

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Статья посвящена формированию «обобщённого портрета» состояния человека-оператора, являющегося основным компонентом эргатической системы, на основе психофизиологических показателей и на этой основе предоставлению коррекционных рекомендаций через экспертно-консультативную систему. Формально-конструктивная модель «обобщенный портрет» создается по стратифицированному описанию психологических и психофизиологических показателей. Каждый индикатор, входящий в страты, реализован с помощью соответствующего программного обеспечения. Каждому компоненту «обобщенного портрета» отнесены разные шкаловые типы (отношение, интервал, порядок, номинатив). Теория нечетких множеств и отношений используется для унификации

различных типов шкал. Функциональный блок решений и советов экспертно-консультативной системы принимает решение о функциональной надежности на основе нечетких знаний, исходя из текущего состояния человека-оператора.

Ключевые слова: человек-оператор, психофизиологическое состояние, обобщенный портрет, экспертная система.

İNSAN-OPERATORUN PSİXOLOJİ VƏ PSİXOFİZİOLOJİ GÖSTƏRİCİLƏR ƏSASINDA FUNKSIONAL ETİBARLILIĞINI TƏYİN EDƏN EKSPERT MƏSLƏHƏT SİSTEMİ

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Məqalə erqatik sistemin əsas komponenti olan insan-operatorun psixofizioloji göstəricilər əsasında vəziyyətinin “ümumiləşdirilmiş portretinin” formalaşdırılmasına, bunun əsasında ekspert-məsləhət sistemi vasitəsi ilə korreksiyaedici məsləhətin verilməsinə həsr edilmişdir. Formal-konstruktiv model olan “ümumiləşdirilmiş portret” psixoloji və psixofizioloji göstərici-lərin stratlaşdırılmış təsvirinə uyğun olaraq yaradılır. Stratlara daxil olan hər bir göstərici uyğun proqram vasitəsi ilə realizə olunur. “Ümumiləşdirilmiş portretin” hər bir komponenti müxtəlif tip şkala tiplərinə (münasibət, interval, sıra, nominativ) aid edilir. Müxtəlif tip şkalaları unifikasiya etmək üçün qeyri-səlis çoxluqlar və münasibətlər nəzəriyyəsiindən istifadə edilir. Ekspert-məsləhət sisteminin qərar və məsləhət funksional bloku, insan-operatorun cari vəziyyəti əsasında, qeyri-səlis biliklərə əsaslanaraq funksional etibarlılığı barədə qərar verir.

Açar sözlər: insan-operator, psixofizioloji vəziyyət, ümumiləşdirilmiş portret, ekspert sistem.

Çapa təqdim etmişdir: Arif Məmməd oğlu Məmmədov, b.e.d., professor, AMEA-nın müxbir üzvü
Redaksiyaya daxil olma tarixi: 05.12.2022.

Təkrar işlənməyə göndərilmə tarixi: 25.12.2022.

Çapa qəbul edilmə tarixi: 14.06.2023.

<https://ajp.az>