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## **SIMULATION OF THE PROCESS OF THE REMOTELY CONTROLLED DEVICES OPERATORS SELECTION, USING FUZZY LOGIC**

*The paper considers the characteristic features of the construction of the remotely controlled devices and systems of their control. Much attention is paid to the spheres of such devices application and specific requirements to the operators, performing the control of these devices.*

*Main reason of the unsatisfactory realization of the tasks, carried out by the remotely controlled devices is human factor. In greater part of cases it occurs due to the discrepancy of the qualities of the person to the functions, performed by the remotely controlled devices operator. For this reason in the process of the selection of the staff for such activity it is necessary to take into consideration psychophysiological aptitude of the candidate. Among the set of the personal qualities professionally important qualities (PIQ) are determining for the successful professional activity. The paper defines main professionally important qualities of the operator of remotely controlled devices. For the assessment of the basic PIQ of the operator the authors suggest to use psychologic testing, applying Cattell's sixteen personality factor questionnaire. For the evaluation of the candidate aptitude for the work with the remotely controlled devices fuzzy model, based on Mamdani-type inference is developed. Each factor of the model is presented by the linguistic variable, for which the set of values is determined. Output linguistic variable for which the term-set of values is determined, Gaussian function is selected as the membership function. The base of fuzzy rules is constructed. The developed fuzzy model is planned to be used in the automated system for the assessment of the candidates in the operators of the remotely controlled devices.*

**Key words:** *remotely controlled devices, Cattell test, competence, professionally important qualities, assessment model, linguistic variable, membership function.*

### **Introduction**

Wide range of the application of the remotely controlled devices leads to the growth of their number and stimulates their development, aimed at improvement of the reliability and efficiency of such systems. In the systems, containing the devices with the remote control human control element is available (excluding separate cases of the complete automation of the operation).

Nowadays there exists wide variety of devices with the remote control of different classes and designation. They include: antimine robots, robots for the work on the depth, unmanned aerial vehicles and other devices. From the point of view of the construction they may be simple and require constant control of the operator, but they also can be operated in the completely automatic mode. Work places of the operators of such remotely operated devices are equipped with various systems for displaying the information and control, taking into account the duration and content of the possible missions [1].

World experience shows that greater part of problems, connected with the usage of the remotely controlled devices (RCD) are due to the human factor, that is why, leading countries of the world do not spare neither efforts nor material resources for the research of the corresponding direction. All this occurs in the conditions of rapid improvement of the technical component of the remotely controlled devices (RCD) and situational formation of the operation practices according to the current vision of their expediency in the wide range of the tasks, related to the application of RCD.

Dominant aspect of understanding the ways of the human factor optimization in the efficiency of RCD usage is the psychological one in two interconnected spheres, engineering-psychological (information interaction of human and machine components) and organizational (organization of RCD crew functioning as specific small groups and interaction among the members of the crew at the stages of the orientation in the circumstances of the mission, decision making and their common realization).

### **Aim of the research**

In view of the above-mentioned, the aim of the research is to determine the promising directions of the psychological studies for the selection of the operators of RCD for the efficient operation of RCD of new generation, according to world achievements and trends.

### **Main materials**

In the specialized companies in the process of the selection of the candidates for the position of the operator of the remotely controlled devices the following competences are assessed: professional and personal [2]. Professional competences of the candidate are confirmed, as a rule, by the educational certificate and employment history.

Assessment of the personal characteristics of the specialist nowadays is not sufficiently objective. In general, for the assessment of the personal characteristics subjective methods are used: interview questioning, method of pair-wise comparison, etc.

Thus, nowadays, the assessment of the personal qualities of the candidate for the position of the operator of RCD, actually is the subjective evaluation of the person, responsible for staff selection.

It is obvious, that the psychologic testing can determine the level of professionally important qualities. However, the results of the psychological testing are not determinant and accurate, because, as a rule, they represent the interpretation of the points scored by the expert-psychologist, although such interpretation could be subjective.

Thus, the development of the formalized methods, based on the psychological testing, which enable to assess objectively personal qualities is the actual problem. Development and implementation of the similar methods will allow to improve accident incidence rate and increase the safety of RCD.

For the solution of this task the following measures should be realized:

1. Compose the list of the professionally important qualities of RCD operator.
2. Select one or several psychologic tests, by means of which certain professionally important qualities could be tested.
3. Construct the mathematical model, based on the selected mathematical method.
4. Realize this model in the form of the corresponding software [3].

### **Determination of the professionally important qualities of the operators of the remotely controlled devices**

In [4] it is noted that the persons who have not gift to the certain kind of activity, not only longer than others master this kind of activity and do this with greater difficulties but also work worse than others: they more frequently make mistakes and miscounts, they are often responsible for the car accidents and in general, demonstrate less quality work, that is why, it is expedient to spend efforts, time and financial resources for the section of the candidates for study but not on the training of people, the benefit from whom will be minimal. Also the [4] contains the reference to SNALP (State Normative Acts on Labour Protection) 0.03-8.06-94, which contains the list of works, the execution of which requires the professional selection. For instance, for the operators of the unmanned aerial vehicles the following psychophysical characteristics are required for professional selection:

- 1) Spatial orientation;
- 2) Reaction to the moving object;
- 3) Persistent attention;
- 4) Attention switching speed;
- 5) Visual and aural memory;
- 6) Emotional stability and anxiety;
- 7) Calmness under pressure;
- 8) Sensomotor reactions;
- 9) Fatigue;

10) Decision-making ability and ability to act in the extreme conditions;

11) Stability to monogony.

Some of these indices are physiological: they can be measured by medical instruments.

We will underline and generalize basic professionally important qualities of RCD operation, to be assessed during psychological testing. We will consider the following qualities:

- 1) Persistent attention;
- 2) Calmness under pressure;
- 3) Communicative qualities;
- 4) Ready for training;
- 5) Persistency and accuracy during the work;
- 6) Responsibility;
- 7) Readiness.

### Selection of the psychological test

For the revealing of the degree of the correspondence of the personal qualities to the professionally important qualities 16-factors Cattell Questionnaire is the best [5, 6]. It enables to reveal the motivations of the personality, features of character and abilities. Cattell Questionnaire is one of the most known multifactorial techniques, that enables to carry out the study of the personality according to 16 factors [3].

Professionally important qualities of RCD operator and corresponding factors determined by means of Cattell Questionnaire are presented in the Table.

Table 1

### Correspondence of the professionally important qualities of the RCD operator and factors of Cattell questionnaire

Professionally important qualities of RCD operator	Factors of Cattell test
Readiness	Self assurance
Calmness under pressure	Emotional resilience
Communication qualities	Sociability, tact
Ready for training	Intellectual development
Persistency and accuracy	Self control
Persistent attention	Self control
Responsibility	Normativity of the behaviour

Factor from Cattell questionnaire allow to assess the professionally important qualities of RCD operators.

### Construction of the fuzzy model

During the processing of the results of the RCD operators personal qualities assessment there appears certain degree of fuzziness, that is why, for the construction of model for the assessment of the professionally important qualities, the mathematical tools of fuzzy logic is used [7].

Fuzzy logic is often used in the studies of various socioeconomic system [8], including the studies, dealing with the staff assessment. One of the most widely used fuzzy models is fuzzy productive model [9], that is why, the model for the assessment of the professionally important qualities can be presented as:

$$M = \langle L, R, P_f, F, P_d \rangle,$$

where L – is the set of the linguistic variables (input and output); R – is the base of fuzzy productive rules;  $P_f$  – is fuzzification procedure; F-block of fuzzy logic inference;  $P_d$ —is defuzzification procedure .Block (algorithm) of fuzzy logic inference uses the base of fuzzy productive rules and consists of three procedures:

1.  $P_1$  – procedure of the aggregation of the truth degree of the fuzzy rules,

2.  $P_2$  – procedure of the activation of the fuzzy rules conclusions,
3.  $P_3$  – procedure of accumulation of the activated fuzzy rules conclusions.

The construction of the model should be started from the definition of the linguistic variables, their term-sets and membership functions.

### Set of linguistic variables

After performing Cattell test we obtain 16 personal factors, which will be our linguistic variables. For each variable term-self of three terms will be allocated: low value of the factor, average value of the factor, high value of the factor.

According to the analysis of the correspondence of professionally important qualities, carried out before, and factors of Cattell questionnaire, the following linguistic variables are obtained:

1.  $L_1$  – unsociability/sociability.
2.  $L_2$  – intelligence.
3.  $L_3$  – mood swing/stability.
4.  $L_4$  – normativity of the behaviour.
5.  $L_{11}$  – outspokenness/tact.
6.  $L_{15}$  – self control.

### Fuzzification

For performing the fuzzification procedure it is necessary to determine the membership function. Zone of determination of the membership functions are primary points (in the range from 1 to 10), that determine the degree of possession of the personal qualities. Rather often Gaussian-type functions are used as the membership functions, as they allow to obtain sloping, continuously differentiated response hypersurfaces of the fuzzy model.

### Output block

For our problem, there are 7 linguistic variables at the input, and at the output – there is a value of a single linguistic variable, that is why, in this research it is convenient to use the rules of MISO type.

The base contains  $N=7^3 = 343$  rules, as 7 input variables are sent to the input; each of them contains the same number of terms – 3.

### Algorithm of fuzzy conclusion

In the process of the determination of the staff selection tasks, connected with the incompleteness, fuzziness of the components, subjective, quality nature of the management decisions, it was noted that the conventional methods of decision-making of such tasks do not always allow to take into account the rate of changes, taking place.

In such situation, the method that meets the put forward conditions, was selected the method of fuzzy logic conclusion – fuzzy Mamdani algorithm.

### Defuzzification

For obtaining the value of the output linguistic variable, the procedure of defuzzification is performed by the centroid method:

$$z = \frac{\int_{\min}^{\max} y \cdot MF(y) dy}{\int_{\min}^{\max} MF(y) dy},$$

where  $z$  – is defuzzificated value;  $y$  – is the output value;  $MF(y)$  – is the membership function for the output variable; max and min – is left and right points of the interval of the fuzzy set of the output linguistic variable B.

## Conclusions

The suggested approach can be used for the selection of the remotely controlled devices operators. The application of the fuzzy logic tools (fuzzy Mamdani algorithm) allows to obtain the following advantages as compared with the conventional methods of selection:

- introduce qualitative changes into the analysis;
- work with fuzzy input data;
- use linguistic criteria.

This fuzzy model can be applied in the automated systems for the assessment of the candidates for the position of RCD operators. If necessary it can be supplemented with psychophysiological indices of the candidate, important for the work with certain types of the devices.

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