Construction features of procedural simulator for objective control expert systems management devices of rocket and space technology ground infrastructure objects

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Abstract. Paper refers to the construction of procedural simulators for expert systems management devices of rocket and space technology ground infrastructure objects. A classification of courses, which allows to realize the development of skills with both hardware and software components of a diagnostic expert systems. A method of calculating the integrated assessment of the student mastery of the material.

Acknowledgements

Introduction

One of the main problems encountered during testing and operation of the devices that control the ground infrastructure objects of rocket and space technology (RST) is to provide tracking of process of their performance [1]. Therefore, the complex includes means of objective control (MOC), providing analysis of complex hardware and operator's actions.

Using of technology of expert systems (ES) allows extending the functionality of the MOC information, documented by management system [2]. However, the ES itself is a complex technological system, and it is required to have certain skills to work with it. Therefore, along with the development of diagnostic ES, there is a research aiming to build their procedural simulators [3].

The aim of the article is to study ways of building of procedural simulators for diagnostic expert systems of devices controlling ground infrastructure RST objects.

1. Classification of training courses

As it is known, there are several classifications of training methods, one of which is the division taking into account the degree of awareness of the perception of educational material: passive, active and interactive. There is also a division into the methods for monitoring the effectiveness, promotion and organization of training process. However, despite the presence of multiple approaches to training, it is difficult to identify a methodology that would become a basis for designing of a simulator with assessment tools for hardware and software complex MOC for military and civilian applications. The procedural trainer (PT) should ensure the acquisition of the trainees the necessary competencies in the form of practical skills of working with ES during the objective monitoring of the results of application of devices which control ground infrastructure of RST using information registered by registration device, as well as a maintenance of technical servicing of ES hardware and software [4].

Taking into account structural features of the hardware-software complex ES performing objective monitoring of devices managing objects of RST ground infrastructure, it is not possible to implement training in all modes using only interactive courses. The mastering of such competencies as setting of ES hardware and software installation requires the using of modern multimedia tools that can be used in videos and tests [5].

In accordance with the classification of training methods [6], we divide them into active and interactive training courses, presented in Figure 1.

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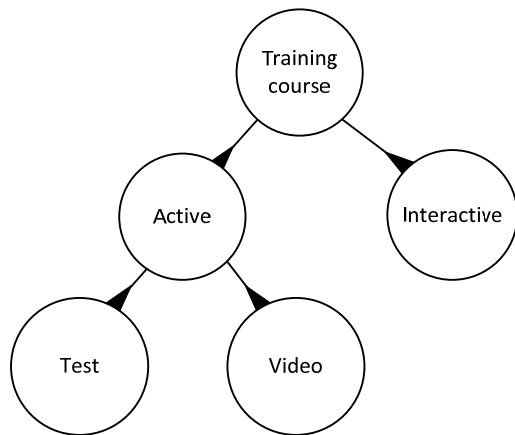
Figure 1. Diagram of training courses classification

Using this classification, it is possible to go to the construction of standard models of training courses.

2. Stages of training

The compositional scheme of the organization of training courses for the PT diagnostic ES for analysis of results of using devices controlling objects of ground infrastructure of RST in terms of ontology language IDEF5 is presented in Figure 2.
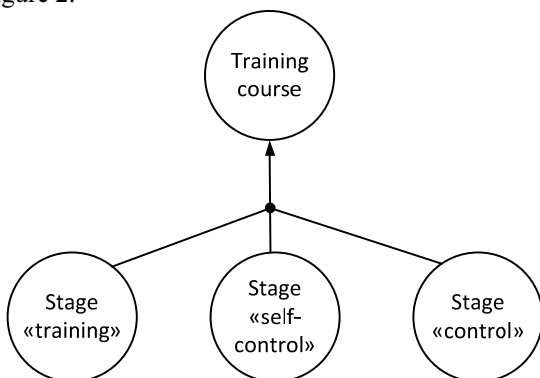

Figure 2. Composite scheme of training course

According to the composite scheme, the mastering of competencies includes the following stages:
- training (direct learning in interactive mode);
- self-control;
- control of the knowledge gained.

The proposed system of construction of training courses using the standard of ontological research IDEF5 [7,8], allows to construct a diagram of trainee's state during mastering of the competencies, that is shown in Figure 3.

Stage of training should be carried out by including the PT into the mode "TRAINING". Thus the trainee has one or several available courses for practical courses, including a variety of scripts and tasks different in structure and content of codes [9]. Courses given by the instructor should be formed on the principle "From simple to complex." PT must provide interactive training

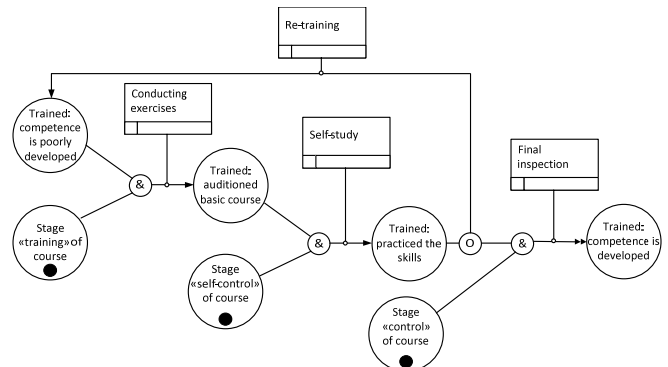mode with the issuance of the necessary clues to the trainee [10].

Figure 3. The diagram of the trainees' state during the mastering of competencies

After passing the course, trainee using the "SELF-CONTROL" mode should be offered to solve the test (without giving tips in the normal mode) task on the basis of the passed course. During the self-control mode, practical skills of trainee should be evaluated. Marks obtained by the trainees during the self-control mode aren't taken into account.

Stage of practical skills monitoring should be implemented by turning on "CONTROL" mode in PT. At the same time instructor gives trainee testing courses. Testing courses in their structure and tasks to perform should be similar to courses offered for training. In content, they can differ. In the "CONTROL" mode acquired practical skills of a trainee should be evaluated [11]. Student's mark, formed in the "CONTROL" mode can be corrected by the instructor. This mark comes as a credit for this course.

3. The methodology for calculating the integrated rating of material mastering degree

As a result of a full course of training a certificate with the integrated rating of the material mastering degree is given.

Method of calculation of integral rating is following: for each employee having training courses' marks are selected, they evaluate the quality of his training. For each course, its weight is taken into account, relative to the others, as well as normalization of rating scales occurs, if marks do not match (e.g., 5-point rating system and 100-point system). The formula for calculating the average mark for each trainee is following:

$$Q_{av} = \frac{\sum_{i=1}^{N}(P_i \times f_{norm}(q_i, scale_i, Scale))}{N}, \qquad (1)$$

where P_i is the proportion of the course;

N is a total number of courses;

f_{norm} is a function converting of value q_i of rating scale $scale_i$ to the value of the total scale $Scale$.

In order to determine the proportion of the competence the method by V. A. Blumberg can be used [12. 146]. For doing this, a group of experts is created

(management interested in training), which compares the pairs of courses but does not give any quantitative assessment to these courses. Comparing each time only two of the courses, the expert determines the relationship between them as "more than" (>), "less than" (<) or equal to (=). On the basis of the system of equations represented by experts, the averaged system of comparisons is constructed. Then a square matrix is made using the accepted system.

$$A = \|a_{ij}\|, \qquad (2)$$

where

$$a_{ij} \equiv \begin{cases} 1{,}5 & \text{when } x_i > x_j \\ 1 & \text{when } x_i = x_j \\ 0{,}5 & \text{when } x_i < x_j \end{cases} .$$

Here a_{ij} is a numerical measure that determines the degree of superiority of the course i over the course j.

Determining of the significance of each course (the value of its priority) is made in such a way:

1. the sum of the elements a_{ij} of rows of the matrix for each course is founded and the total sum of the column is calculated (sum of partial sums obtained in the rows of the matrix);

2. calculation of relative assessments P_i of courses, as the ratio of the sum of the row to the total sum, is made.

Let us consider the following example of calculating the average degree of mastering of the material in the specialization "Engineer" of documenting and displaying console (DDC engineer). For this specialization the courses listed in Table 1 are offered.

Table 1. Training courses in "DDC Engineer"

Number	Name of competence	Rating Scale
1	Installing of general software DDC	5-point
2	Installing of functional software DDC	5-point
3	Technical maintenance of PDO	5-point
4	Comprehensive objective control	5-point
5	Work with the passport of the experiment and the input information, work with menus and basic operations and XML files	passed-not passed (2-point)

5-point rating scale is looking like this:

E[-2] – one does not meet the requirements;
D[-1] – one poorly meets the requirements;
C[0]   – one possesses them on an average level;
B[+1] – one meets the requirements;
A[+2] – one meets the requirements perfectly.

The averaged matrix of assessment has the form:

$$A = \begin{bmatrix} 1 & 1{,}5 & 0{,}5 & 0{,}5 & 1 \\ 0{,}5 & 1 & 1 & 1{,}5 & 1{,}5 \\ 1{,}5 & 1 & 1 & 0{,}5 & 1{,}5 \\ 1{,}5 & 0{,}5 & 1{,}5 & 1 & 1{,}5 \\ 1 & 0{,}5 & 0{,}5 & 0{,}5 & 1 \end{bmatrix}$$

Let us find the sum of elements in each row of the matrix S and the total sum S_{sum}:

$$S = \begin{bmatrix} 4{,}5 \\ 5{,}5 \\ 5{,}5 \\ 6 \\ 3{,}5 \end{bmatrix};$$

$$S_{sum} = \sum S_j = 4{,}5 + 5{,}5 + 5{,}5 + 6 + 3{,}5 = 25;$$

Then, we find the proportion of each course:

$$P = \begin{bmatrix} 0{,}18 \\ 0{,}22 \\ 0{,}22 \\ 0{,}24 \\ 0{,}14 \end{bmatrix}.$$

As it can be seen in Table 1, there are two types of rating scales that are used to evaluate the degree of mastering of the material: 5-point rating system and 2-point rating system (passed-not passed). Therefore, it is necessary to introduce the function of values' convention:

$$f_{norm}(q, 2, 5) = \begin{cases} -2, & \text{when } q = \text{not-passed} \\ +2, & \text{when } q = \text{passed} \end{cases} \qquad (3)$$

Thus, for the trainee who has got the following marks on the results of the courses:

- installing of general software DDC – B[+1];
- installing of functional software DDC – B[+1];
- technical maintenance of DDC – C[0];
- comprehensive objective control – A[+2];
- work with the passport of the experiment and the input information, work with menus and basic operations and XML files – passed

the average mark will be calculated in such a way:

$$Q_{av} = \frac{1*0{,}18 + 1*0{,}22 + 0*0{,}22 + 2*0{,}24 + 2*0{,}14}{5} = 1{,}16$$

In accordance with the rating criteria that were introduced previously, the resulting value can be defined as "satisfactory".

4. The interaction between the trainees' workstation and instructor workstation

The interaction between the trainees' workstation and instructor workstation is carried out by the overhead commands with information about the actions of the trainee, the state of the complex, tips, test results, etc.

During the test the instructor controls the correct sequence of commands for a specific time. Thus, there is the concept of exercises scenario. It consists of a set of instructions, in the form of a mandatory and specific sequence occurs in the trainee and the time in which passes the test.

The scenario file is described in a format xml, file encoding of *UTF*-8. Structure description of the scenario workshops on language *XMLSchema* shown in Figure 4.

Where the description string of a single operator action contains the following mandatory attributes:

- *comand* - action of the operators;
- *passing* - fuzzy sequence may wedging other teams prior to this (true, false);
- *itemnum* – item number of sequence;
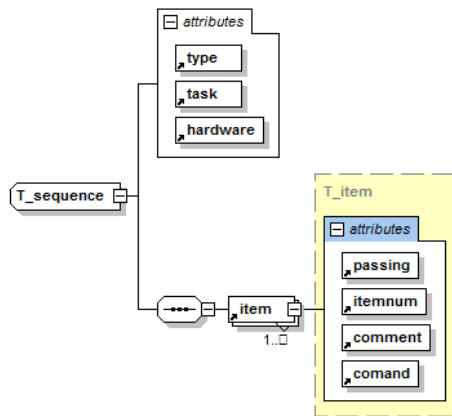
- *comment* – text comment.

Figure 4. Structure description of the scenario workshops

Order of interaction of trainee and the instructor when passing TRAINING exercises presented using UML sequence diagram in Figure 5.
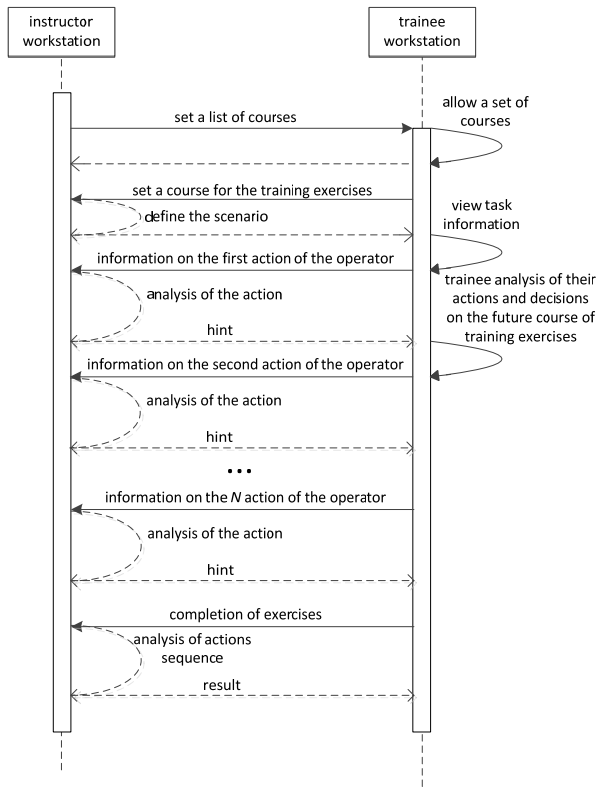

Figure 5. Order of interaction of trainee and the instructor when passing TRAINING exercises

Order of interaction of trainee and the instructor when passing CONTROL exercises presented using UML sequence diagram in Figure 6.
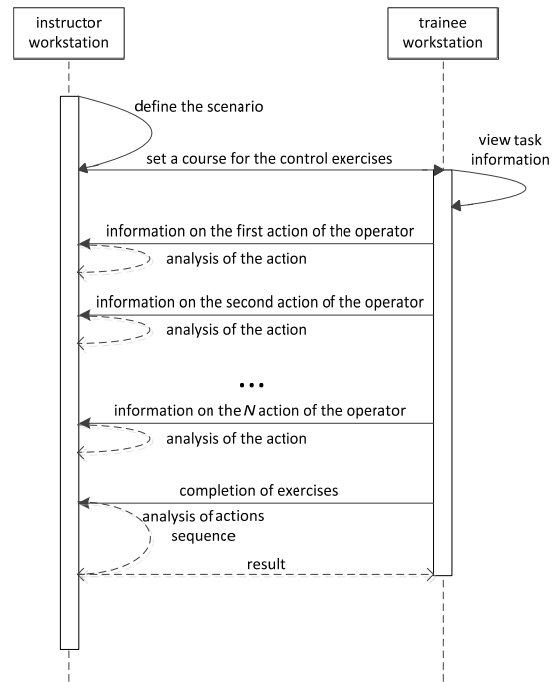

Figure 6. Order of interaction of trainee and the instructor when passing CONTROL exercises

Presented system of training scenarios construction allows the instructor to easily modify existing training courses descriptors, as well as to introduce new courses, thus not requiring a deep knowledge in the field of information technology and programming.

Conclusion

The proposed way of organizing the procedural simulators allows holding multi-user and multi-mode training how to work with the ES devices controlling objects of ground infrastructure of RST and with similar in their functional purpose hardware-software complexes.

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