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Practical implementation of a computer simulator complex for training mining excavator

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Abstract. The work considers the basic principles of building simulators and training systems. The authors develop the architecture of a computer simulator - modeling complex for training mining excavator drivers. The paper describes the main tasks of the simulator complex. The complex tasks include the excavator operator's preparation for the adequate information perception and timely response to the management process of a complex technical system (excavator), as well as development of the relationships set defining the system of necessary criteria to judge the quality of training.

1 Introduction

The word «simulator» is a neologism, a product of the 20th century, although the very concept that it contains is a technical device for teaching a person and creating certain skills for him. Any computer simulator is basically a virtual reality system (VR). The technical basis of virtual reality is computer modeling and computer simulation technology, which, combined with accelerated three-dimensional visualization, allows realistic display of movement on the screen.

The main feature of the VR model is the illusion created for the user of his presence in a computer-simulated environment, which is called remote presence. VR is based on computer modeling, in computer models, objects are endowed with their defining properties, which determine their reactions to various types of manipulations. A person navigates by controlling a virtual model of a transport or any other technological means [1].

Simulators are usually used to replace a real machine with a cheaper virtual analogue and are often necessary when simulating a difficult or dangerous situation. The largest manufacturers of simulator software, such as Paradigm Simulation, Inc., Coryphaeus Software, Thomson training & Simulation, Ivex Corporation, Virtual prototypes, MultiGen and others, have covered a large number of training systems in a wide range of areas where transport and technological means management training is used [1-3].

In any simulator there is a mechanical part that simulates the cab, which transmits acceleration and vibration, and a computer, which actually provides the illusion of movement by coordinating the actions of the driver with visual, sound and other effects. The computer part, in turn, is divided into a visualization system, the so-called Out of the window scene, and the Host computing system.

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It is well known that the purpose of most devices of training equipment is to facilitate the task of training, but other goals are also pursued at the same time, including the use of modeling tools at the stages of designing and researching systems, as well as evaluating the work of drivers [1-6].

2 Methodology

The works [5-14], synthesizing many ideas and views on training systems, provide a detailed interpretation of the training complex functions.

Firstly, it is the task of presenting information similar to that provided by some real system that they simulate. The simulator stores, processes and displays information characterizing the functions of the system, as well as the influence of external conditions and input control actions entered by the operator into the system.

Secondly, the simulators are equipped with special tools that improve and expand their capabilities to provide training and operator training, which has a direct impact on their activities when working on a real machine.

The effectiveness of physical modeling as a complex and time-consuming method for studying MEE (Man-excavator environment) largely depends on the organization quality of the whole complex of works. Therefore, all stages of modeling research should be planned and implemented in the form of a single focused system of measures. The general organization of work on the preparation and conduct of physical modeling is presented in Fig. 1.

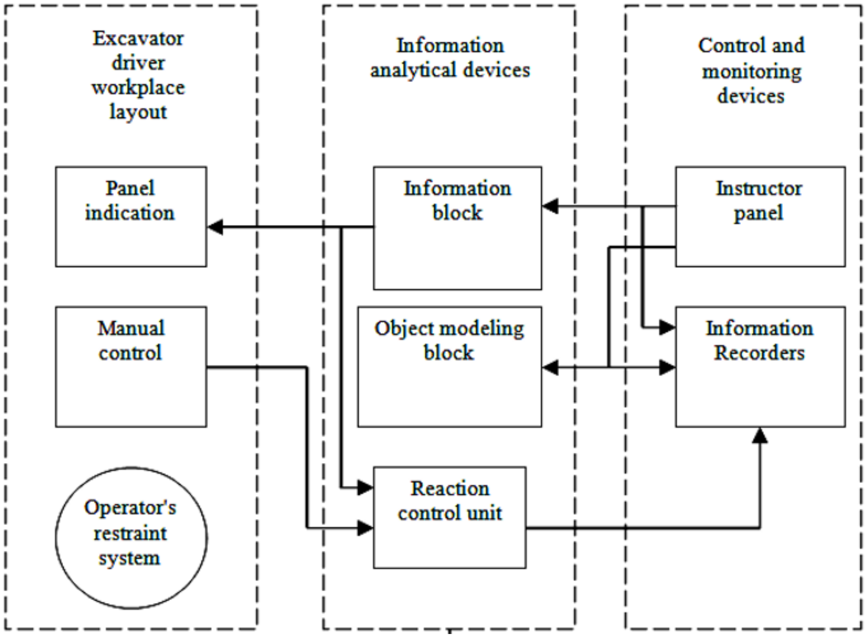

Fig. 1. Block diagram of the MEE functional layout

The training complex corresponds to the following main characteristics that distinguish it from other training facilities and equipment:

Artificiality. Simulators are artificial objects in the sense that they are intended solely to generate the information necessary for the formation of skills for performing a specific task, and not for the implementation of tasks facing a real system.

Storage and data processing. In training systems, data is stored that describes the dynamics of the simulated object, as well as information about external factors that affect the task.

System dynamics. The response of the system to the input control action, or some external disturbance.

Information display tools and controls. The main purpose of the simulator is to display information characterizing the response of the system to the control action, as well as the system response to the action of the controls.

Comprehensive training. Training devices serve to achieve specific learning goals. These include psychomotor, interactive, evaluative, and other learning goals.

Learning management. In training systems, it is possible to control the flow of information and acquire the necessary professional skills, which helps to deepen and simplify the learning process.

3 Results

We have created a computer simulator - modeling complex (CSMC) that provides training for excavator drivers. CSMC is a multi-purpose universal system designed to perform the following functions:

Optimization of the operating modes of the excavator driver and the development of engineering recommendations for improving and modernizing existing control systems, as well as quantitative comparative assessments of the excavator drivers' effectiveness on the control panels.

Conducting experimental studies to obtain information in order to justify the model of an ideal driver can be applied to a system of this type.

Professional selection, training and excavator drivers training, as well as the solution of practical tasks associated with the preparation of their method of stage training.

Providing training for drivers during the development of new excavation equipment is possible long before their implementation in existing structures.

The following principles are implemented in a computer simulator - modeling complex:

- functioning based on the analysis of the elements interaction of the “man – excavator – face” system;
- algorithmic support of the interaction process of the “man – excavator – face” system;
- structural software of the basic computing complex, including the information exchange system;
- instrumentation and design of the training complex, including the jobs of a trained excavator driver and instructor.

A crawler mounted mining shovel belongs to the category of complex technical systems, which suggests the presence of a multi-module software structure. The principle of imitation is based on mathematical modeling of characteristics in a basic computing complex using a block - modular software structure.

The performance of these functions in CSMC is provided by the presence of systems:

1. Modeling of the external environment (environment and objects of influence).
2. Modeling the dynamics of the control object - excavator.
3. Modeling the driver's workplace taking into account anthropometric characteristics and analysis of operator activity.
4. Assessment of the driver's psychophysiological state as applied to a specific type of excavator.

Depending on the operating mode of the CSMC, information on the external environment (the state of the medium and the object of influence), the state of the control object, as well as information on self-monitoring in training conditions (Table 1, Fig. 2) is supplied to the excavator operator's workplace.

Table 1. Information about the external environment

The objects	Observation zone
Face	The interaction of the bucket with the face; collapse of the upper edge of the face and the presence of oversize
Transport	The correct access of transport, the completeness of its load; for the prevention of vehicle impacts on the tail
Gantry	The head blocks and the ladle approaching the gantry
Tracklayers	The prevention of ladle hits on the tracklayers, moving around the site
Excavator side and rear zones	The location of the transport and the appearance of foreign objects; the top edge of the face and the side window
Control panel	The main means of displaying information on the control panel
Ladle	The correct closing and opening of the bottom of the ladle; harness integrity; for the prevention of ladle hits on the transport vessel
Cable	Cable safety
Ropes	The integrity of the ropes
Assistant driver	The visual perception of actions and commands

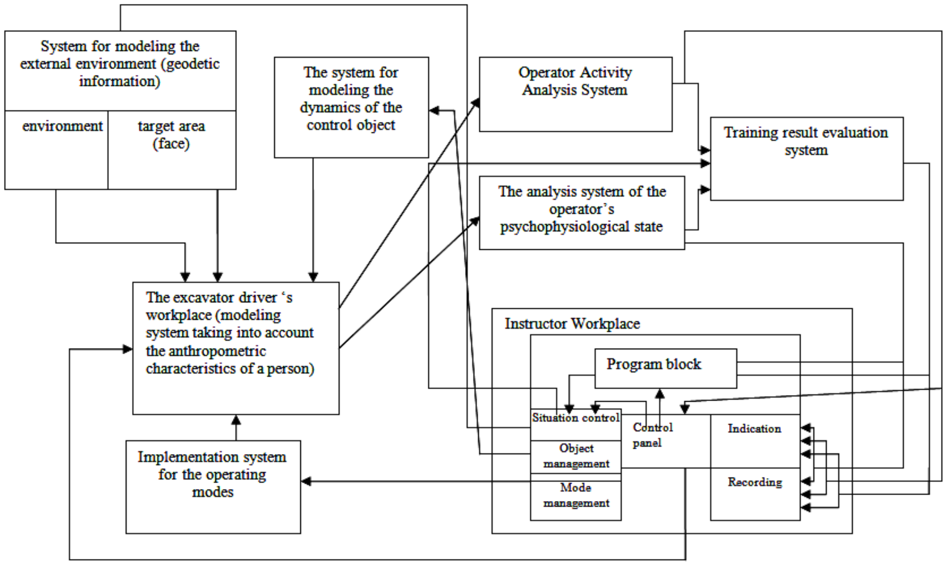

Fig. 2. CSMC Block scheme

4 Conclusion

CSMC can be used to develop a set of relationships that define a system of criteria by which it is possible to judge the quality of training and the readiness of the excavator driver to perform complex tasks in real conditions of mining enterprises. It is also possible to shorten the development period for new excavation equipment by 1.5–2 times due to thorough advanced training of personnel.

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