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Analysis of Motor-Tractor Simulators

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Abstract

Introduction**:** High-quality training of tractor drivers is possible only with the correct development of professional skills. The skills necessary for a tractor driver to reliably operate tractor equipment can be trained with simulators at the initial stage of training. The use of simulators makes it possible to automate the actions the tractor driver takes when driving the vehicle, and avoid the trainee's exposure to risks. Material and Methods: The article presents the classification of simulators used for training tractor drivers, by their models and information the tractor driver acquires in the process of driving tractor equipment. The existing information models of simulators in a generalized form can be divided into two groups: the first, which involves only reproduction of visual information, without imitation of vestibular information, and the second, which combines both visual and vestibular information. The analysis of information models of existing simulators is carried out, their advantages and disadvantages are reflected. Results: For the presented classification of the information model of simulators, two systematizing features are proposed, namely, the viewing angle of the presented visual information and the presence of imitation of vestibular information. Results and Discussions: The research carried out can be useful for the further development of science in this area, as well as for the choice of simulators for the educational process.

Keywords

Training of Tractor Drivers, Skill, Simulator, Visual Information, Vestibular Information, Viewing Angle.

Introduction

Currently, training machines and simulators are being introduced into the educational process that simulate the operation of automotive vehicles. This makes it possible to significantly expand the skills and abilities of the trainees, the tractor driver needs to work on modern equipment.

The use of real automotive vehicles is extremely limited for a variety of reasons [1, 2]:

- Economic reasons (the cost of real equipment is not comparable with the financial capabilities of an educational institution);
- Educational reasons (not all the processes in automotive vehicles can be clearly demonstrated to students. Therefore, modern trends in the development of innovative technologies force the teacher to introduce multimedia teaching methods).

Trainees do exercises with the use of motor-tractor simulators to develop professional skills in cases where the conditions of the training process do not allow effectively organizing such exercises in a real industrial environment. In addition, the equipment available in educational institutions often implies restrictions on the use of mounted and trailed units for various reasons: no possibility to use, limited range, etc.

The use of simulators for the agro-industrial complex has the following advantages [3, 4]:

- Promotes better adaptation of students in the transition from theory in special subjects to mastering practical actions, activates the learning process;
- Creates an opportunity to bring students closer to the production environment, excluding the risk of accidents, equipment breakdowns;
- Sets, repeats and varies the necessary operating modes of the equipment and simulates various situations up to emergency at any time, which is often impossible in production conditions;
- Repeatedly simulates and predicts interference and malfunctions until they are completely eliminated.

In recent years, a number of simulators have been designed, which not only help form the initial skills to control motor-tractor equipment, but also improve skills by modeling in conditions close to reality, to instill behavior skills in various dangerous (extreme) situations.

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Russia and foreign countries, for example, use simulators for group training, consisting of an automated central console and several models of cabins with all the mechanisms and control devices. The agricultural simulators include projection systems that make it possible to simulate the movement of a car along city streets and highways, as well as special devices to create a sensation of movement depending on the road conditions simulated on the screen. Special devices record the driver's actions and immediately inform him of the mistakes made.
The effectiveness of the simulator depends on its controls and their compliance with similar controls of a real vehicle. Modern visualization technologies create the effect of "immersion in reality".
The work of the agricultural simulator is based on modeling a real process, and the process itself is a multifunctional system based on personal computers.
A full-fledged simulator will help the student to master the basic or improve the already-acquired physical skills of controlling both a single machine and using units right in the educational premises.

Materials and Methods

The design of modern computer simulators is quite diverse: from simple simulators to dynamic specialized training machine [6, 7, 8, 9, 10, 11, 12].
The entire range of simulators can be divided into two groups (Figure 1):
1) Simulators, reproducing only visual information without imitation of vestibular information;
2) Simulators reproducing both visual and vestibular information [5, 9, 10].

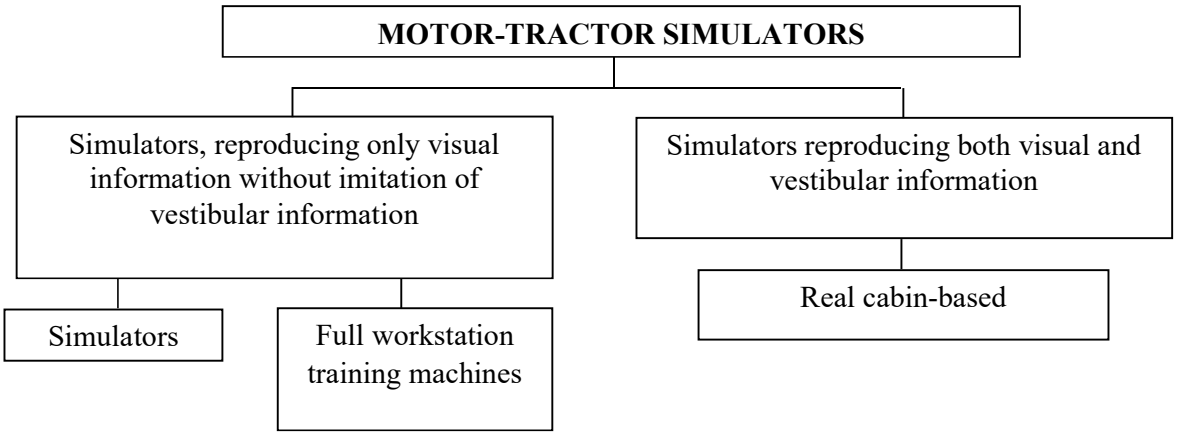

Fig. 1: Simulator Classification

Simulators that reproduce only visual information can be divided into two subgroups: simulators and full workplace training machines (see Figure 1).
Simulators are computer simulators of the control of a process, apparatus, or vehicle [12, 13].
The design of the full workplace training machine includes a set of devices with all controls, information display facilities and auxiliary equipment, similar to those installed on real automotive vehicles.
Simulators of this group form the initial skills for driving motor-tractor equipment and provide the consolidation of theoretical knowledge by modeling various field situations [9, 10, 11].
Such simulators usually consist of three modules (Figure 2) [9, 10]:
1) A full workplace module;
2) A hardware and software module – a personal computer with software and a matching device that ensures the joint operation of the sensors of the simulator and computer controls;
3) a visual-acoustic module, consisting of a monitor(s) displaying visual information from acoustic speakers, which reproduce the main noises arising from the movement of automotive vehicles, as well as the acoustic characteristics of the operation of various units and systems (engine start sound).
The simplest option is when the trainee is fed a picture on one monitor, which is an artificially formed visually observed virtual space (Figure 2, a) with a viewing horizontal angle from 30 to 40°.
3D models are used to simulate visual information.
During the simulation, the entire environment of the car is projected, which allows to achieve a high degree of reliability in quality comparable to images obtained with video cameras.
The main disadvantage of these simulators is that it projects the volumetric image onto a flat monitor, and not onto a spherical surface concentric with the retina. Therefore, a distortion of the boundaries of the field of view appears, and the information perceived by the peripheral vision of a person is not simulated at all, while when performing various maneuvers in real conditions, the driver (tractor driver) controls the position of the machine using a viewing angle of at least 180°.

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A: Simulation of Visual Information on One Monitor, Viewing Angle 30–40°

B: Simulation of Visual Information on Three Monitor, Viewing Angle 150–180°

C: Simulation of Visual Information on a Panoramic Monitor, Viewing Angle 150-180°

D: Simulation of Visual Information Using Disparate Glasses

Figure 2: Simulators with a Tractor Driver's Workplace

This disadvantage is eliminated by installing, instead of a conventional monitor, three widescreen monitors or a panoramic monitor providing a horizontal viewing angle from 150° to 180° (Figure 2, b, c).

However, this visual information model also has its drawbacks.

The presence of a "dead zone" between the student's eye and the first model of a three-dimensional object closest to it does not allow the formation of skills related to determining the distance to moving objects or between moving objects in time, which is important for the perception of information and the response of a driver (tractor driver).

To address this problem, simulator manufacturers offer a visual system with stereo glasses (virtual helmet, stereo display) - a system that creates a stereo effect, a sense of the extent of space and terrain relief. This effect is achieved by modeling each human eye of its own image, synthesized considering the location of this eye in space (Figure 2, d).

The main disadvantage of computer simulators without vestibular information is that they do not simulate linear and angular accelerations that a person experiences when driving a real machine, and this, in turn, does not allow the formation of the following skills: stopping at a given place, choosing the optimal acceleration of the tractor, driving a vehicle when cornering with different radii.

Simulators reproducing both visual and vestibular information

The main distinguishing feature of this group of simulators is the presence of a system for imitation of vestibular information.

Simulation of linear and angular accelerations in such simulators is implemented through various types of dynamic platforms or stands used in their design.

The dynamic platform of the simulator is understood as a device designed to move the simulator cabin in space.

The main group of simulators, which use various types of dynamic platforms, are designed on the basis of tractor cabins.

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The information model of such simulators is more adequate to the real movement process than simulators without vestibular information.
Such simulators include the following modules [13, 14, 15]:
1) A cabin that simulates a full-fledged interior of the driver's (tractor driver's) workplace, with an active control panel;
2) Visual acoustic module, consisting of a panoramic monitor and an acoustic system;
3) Hardware and software module;
4) A dynamic platform that simulates the acceleration experienced by the driver (tractor driver) during acceleration, braking and turning, as well as the unevenness of the road surface, engine vibration.
The advantages of this type of simulators are:
- A full-fledged interior of the driver's (tractor driver's) workplace develops the skill of working not only with the main tractor controls (steering wheel, pedal assembly, transmission control), but also with additional ones (control of the tractor hinged system, etc.);
- Panoramic screen, monitors for viewing through rear-view mirrors, as well as the presence of a system that identifies the position of the driver's head (tractor driver) to generate visual information, considering the movement of the observation point, ensure the maximum approximation of the training conditions to the operating conditions of a real vehicle;
- A dynamic platform simulates changes in the speed of movement in a different range, inertia, movement on ascents and descents, braking by the service brake system, as well as by the engine or in a combined way, angular accelerations affecting the driver (tractor driver) in a turn.
Currently, six-degree dynamic platforms are increasingly used as part of simulators; such platforms have increased mobility and can simulate, in addition to angular accelerations, rotational movement around the vertical axis, as well as linear accelerations in the vertical, longitudinal and transverse planes.
The main disadvantages of such simulators are:
- The complexity of the design;
- Lack of mobility;
- Increased requirements for equipment safety;
- The need for periodic maintenance of power units;
- High cost (more than the cost of a training car).
The effective use of simulators in the educational process can significantly reduce the number of errors, increase the speed of manipulation and decision-making, reduce training time, more adequately assess the level of knowledge and acquired skills, individualize training, and form conclusions on the student's actions.

Results and Discussions

The result of the presented article is the classification of simulators that allow the driver (tractor driver) to acquire the appropriate skills and abilities when working on a modern machine, incl. agricultural machinery.
The viewing angle of the presented visual information and the presence of imitation of vestibular information were used as the classification features.
The analysis of the information model of simulators presented in the article can be useful for the further development of science in the studied area. The revealed advantages and disadvantages of modern simulators can help in choosing a simulator model, in organizing the educational process.

Conclusion

The training of machine operators in training centres at the initial stage can be carried out not only with real equipment, but also with the use of modern training complexes. The simulator allows tractor drivers to bring to automatic performance the actions taken by them when driving their machines, while not exposing trainees to risks. Currently existing simulators have various information models, which can be divided into two groups: with visual information display, and in combination with vestibular influence, for which dynamic platforms are integral parts. An important step for the creation of modern simulators is also the possibility of using augmented reality systems and 3D images in visualization systems. In addition, an important factor in training is the presence of a full-fledged workplace in the simulator, which includes all controls, similar to those installed on real automotive vehicles. Thus, it is the symbiosis of modern technologies when completing training complexes for automotive equipment that will allow achieving high results in training machine operators in training centers.

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