Operator’s workplace virtualization and approaches assessment of its graphic implementation

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Abstract. The authors discuss objectives of creation of a virtual operator’s workplace. These objectives are connected with implementation of 3D virtual interface within the framework of hardware/software currently available on the market, and with general workplace ergonomics. A brief description for different approaches to the design and organization of a virtual workspace is given. The task to develop a test virtual “control panel” to study parameters of the virtual cockpit elements is described.

1. Introduction

This project aims to propose a novel method of increasing informative capacity of interfaces at equipment control centers and stations in industry. The method is based on three-dimensional graphics and display facilities. In fact, the article deals with a control interface which is a three-dimensional virtual space (reality) rather than on the flat or on axonometric projection. Elements in the virtual space are arranged using additionally the dimension of depth, which allows an operator to handle voxel control items or read off information panels located at different distances from the viewpoint.

Hardware components of virtual reality are highly promising tools of automated monitoring and control. They enable immersion into virtual reality, training, modelling of various off-optimum situations and involvement of real-world algorithms of control software, without interaction with machinery and free from heaving influence on real processes.

Regarding development of digital technologies, facilities of immersion into virtual reality are relatively fresh on the market and are insufficiently researched and tested in real conditions in the direction of application in industry for solving dispatching tasks. In particular, there are no science-based approaches to design of a virtual workplace, parameters of three-dimensional media, arrangement, sizes, colors of objects, etc., i.e. all parameters that minimize cognitive load on a user and maximize mental ergonomics and efficiency of operation with large bulk of data. Meanwhile in actual practice, virtual products, mostly used in the gaming industry, are aimed at enhancement of perceptual efficiency, are dynamic, neglect requirements of mental ergonomics of a user and are unadapted to preservation of the user’s cognitive status when in work.

Foreign scientists operating with large bodies of information open to public their research findings on the comparison of human productivity in huge data bank handling in virtual reality and in common 2D space [1, 2]. It is shown that human productivity in data handing in virtual reality is the same or even higher than in operation in front of a customary screen monitor. Some foreign researchers believe gamification (application of game-design elements and game principles in non-game context) of many routine tasks can be beneficial to productivity due to better involvement in the process [3].
Furthermore, immersive reality makes data handling more convenient [4], especially as against processing of graphic data in front of a customary screen monitor. All these listed advantages, together with feasible modification of the data manipulation manner in virtual reality spurred the team of this project to develop a full-fledged virtual environment for an operator to effectively deal with assigned task of control over process flows or production operations.

2. Research objective
The task of a virtual reality designer is to create a virtual scene to be maximum realistic to an operator’s perception [5] as this affects the operator’s mental ergonomics. Creation of such scene requires solving some complex problems which can be divided into two large classes. The first class problems are connected with software implementation of 3D virtual interface using advanced hardware/software available on the market. The second class problems are connected with general ergonomics of an operator’s workplace. This paper discusses some key problems from both classes as well as their solution.

3. Implementation and discussion
By now there are three manufacturers dominating the standards for the virtual reality display fittings: Microsoft, Oculus-Facebook and HTC. Other vendors adhere to the standards of one of these leaders in the industry. This segmentation creates difficulties as it requires adapting a software support to a certain facility.

Aside from the general division by standards of the hardware engineers, there is also a division into virtual reality development environments. In the total array of programs, the major development environments for a virtual content are two competing packages of Unity and Unreal engine. Similar in many ways, they possess singular advantages and shortages. When selecting a development environment, this paper authors prioritized the simplicity of integration of components required for adapting a program code to a selected fitting.

The choice of a manufacturer of fittings for the virtual operator’s workplace display was made after consideration of some indicators, namely:
- Availability of the fitting on the world market;
- Serviceability of the fitting with minimum external accessories;
- Options announced by the manufacturer to be available as new versions of drivers and software support of the fitting appear;
- Dedication of the manufacturer to the market of the virtual reality fittings.

Accordingly, on this basis, the Oculus Quest was selected as the most fitting for the future MVP implementation of a Virtual Cockpit prototype, as the best flexible and less particular about resources of a network host. The fitting and program generation system selected for the prototype design will finally govern the information display capabilities. At this moment, the authors’ team have reviewed the main VR fitting models on the Russian market, aligned their properties with the development environment and improved understanding of their advantages and disadvantages.

The choice of hardware will govern characteristics of an operator’s workplace, its design, equipment and performance. In addition, there are different approaches to design information objects of virtual environment, two of which are given below in the form of different graphic examples. However, both neglected a significant distinguishing feature of an operator’s workplace as compared to a computer game—immobility of the operator on the scene. Such project is related to a Seated VR type [6].

The operator observes the VR environment from the same point and only can move his head to change the angle of aspect. This approach to the virtual space implementation obviously levels down the 3D VR advantages over a computer display in terms of the scene depth workability. Nonetheless, the workability remains though on a much lower scale. Renunciation of an operator’s motion in the virtual space ensues from the necessity of a long stay in it, which consequently requires providing not
only physical ergonomics of the workplace—seated or semi-reclined position of an operator, alongside with mental ergonomics. On the assumption of physical position of an operator in the virtual space, the operator’s motion is implementable only as approach (teleportation) of the operator to a spatial point or approach of a certain object to the operator. In view of the static physical position of the operator, such ‘approach’ will always cause disagreement between the brain information and visual information on the body position in space. As a consequence, the operator may become disoriented in a varying degree, while quick motions may even have high consequences [2, 3].

For the same reason, a critical aspect of mental ergonomics is creation of a customary environment for the human brain, with certain references to ensure unambiguousness of body position in space on a correct scale. A person is used to see screens on a wall or on a leg, i.e. there is a physical connection between the screen and the wall, or the floor, or the ceiling. A floating information display may cause discomfort as it is difficult for the human brain to harmonize it with the body position, or to determine its size. Aimed to fix this problem, a room with implements is created in the virtual environment for the operator to tie his body in the physical reality with his body in the virtual reality. The palette of the virtual room walls is chosen in favor of only soft pastel shades, which is, again, due to the need for the operator to stay in the virtual space for a long time, because of mental ergonomics.

The first graphic example of a virtual operator’s room is equipped with a few virtual information panels and shown in figure 1.

**Figure 1.** Graphic example with “floating” information displays.

In the first graphic example of the virtual room, information displays represented flat sub transparent screens floating on air. To simulate activities, the screens displayed scales and digital readouts (figure 1). Here it was wrong to refuse a well-defined pattern of the indoor scene behind the operator. Because in case an operator turned his head in any direction at 70 deg, he looked through ‘nothing’.

For the second example (figure 2) it was upgraded and supplemented the scene of a virtual operator’s room. The primary changes embraced the size of the virtual room. The studies show that, given static position of the operator, the virtual room 20×10×10 m to conform with a reality room is excessive, especially in terms of the height. For another thing, it turns out that modern fittings of the virtual reality mapping fail to depict well-defined interior patterns with sufficient quality. Thus, the camera was placed inside the operator’s room and the back wall of the virtual control room was well drawn. The second important change related the appearance of the information boards. In the second VR graphic example, the information panels are definitely connected with the ‘floor’ and simulate large size TVs set on a leg, with visible screen thickness, and in a frame showing no information. The information panels have a diagonal size reduced to a real size, 2×1 m, and are arranged at a height of 1.5 m from the ‘floor’. For the operator to feel more comfortable, the virtual control room was
equipped with a limitative screen composed of virtual planes. The authors’ team thinks such virtual design confines operator’s head rotations and concentrates the look inside the working zone.

![Figure 2. Graphic example with connected information panels with the floor.](image)

At the moment, the approach to the construction of the second graphical example is taken as a basis for the development and design of a test virtual space for the operator's work. The task is to develop a virtual "control panel" consisting of a keyboard, messenger panel, mail, telephone module, auxiliary information in the foreground and main information boards with imitation of the SCADA system parameters output in the back of the room.

By this time, it is already becoming clear that a simple rectangular shape of the virtual room is nonoptimal in the context of information to be displayed and operator to feel comfortable. The scope of the further perfection will encompass the texture quality, scale, detailed elaboration of items capable to ‘catch’ a human eye (floor, walls, furniture, etc.) as well as the number and arrangement of light sources.

3. Conclusion
The project focuses on the theory and application of three-dimensional virtualization of a control station, with justification of mental ergonomics of an operator and with regard to his interaction with virtual objects. In prospect, this can help improve the process flow control in the coal mining industry and will ensure transition to the advanced digital intelligence production.

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