

Correlation of a Face Vibroimage Informative Parameters With Characteristics of a Person's Functional State When Using VR and AR Technical Means. *Victor M. Alyushin* (vmalyushin@mephi.ru)

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ABSTRACT

An analysis of the specifics of modern VR, AR, MR and XR systems use in educational, recreational and recovery processes is presented. The urgency of continuous monitoring of the current functional state (FS) and its psycho-emotional state (PES) using VR, AR, MR and XR technical means has been substantiated. Maintaining the state of health, as well as the required level of performance, are highlighted as the main requirements for the applied VR, AR, MR and XR means. The relevance of the use of infrared (IR) biometric technologies for the registration of the most informative human bioparameters, determining his current PES, has been substantiated. Analysis of IR vibroimage of a face is highlighted as the most promising technology for assessing its current PES. The possibility of determining the current FS on the basis of a set of bioparameters determining its PES is substantiated. For this purpose, the analysis of the correlation of the FS and the most informative bioparameters determined by the analysis of the IR vibroimage of the user's face by VR, AR, MR and XR means is given. To assess the FS in the study, it was proposed to use a value determined by the number of errors committed during periodic execution of specialized tests integrated into the VR, AR, MR, and XR scenario. Experimental data obtained during laboratory testing of the method confirmed the possibility of assessing FS based on a set of bioparameters measured during the processing and analysis of the IR vibroimage of the VR, AR, MR and XR user's face. The research results are of particular importance when training operators to control potentially hazardous facilities using VR, AR, MR or XR technologies, and, first of all, for the nuclear industry.

STATE OF RESEARCH

IN THIS AREA

Currently, biometric measurements are used to solve problems of user identification in VR and AR systems [6, 7]. For this purpose, recognition of gestures, the nature of movements, and gait features is usually used [8]. Another direction in the development of virtual systems based on optical biometric technologies is the use of gaze tracking tools [9] to create a convenient interface for managing such systems. To monitor the human condition in [10], it is proposed to use the image analysis of the eyes and pupils.

Unfortunately, many of the technologies used in practice, primarily based on the analysis of the direction of gaze, as well as the dynamics of changes in the pupil, are characterized by the effect of interference with the scenario implemented by the virtual system. This does not make it possible to carry out accurate biometric measurements during the stay of a person in the virtual space.

INTRODUCTION

The widespread introduction of VR, AR, MR and XR technologies into everyday life has undeniable advantages, but at the same time causes a number of serious problems. Especially actively these technologies are currently being introduced in education, medicine, in vocational training and retraining, in VR simulators, in the field of recreation and entertainment [1, 2]. Indicative, in this regard, is the use of VR, AR, MR and XR technologies as a tool for relieving stress, including for medical purposes [3]. The increased interest in VR, AR, MR and XR technologies in recent years is due, among other things, to the desire to go on an exciting virtual journey during the coronavirus epidemic.

However, frequent and prolonged presence in these realities can cause headaches, vision problems, disturbances in the mental state of a person. Excessive fascination with these realities by children is especially harmful. The negative impact of VR, AR, MR and XR technologies depends to a large extent on factors such as the quality of the synthesized video information, the accuracy and performance of the positioning systems. It is well known, for example, that disturbances between the visual perception of the environment and its perception by the senses lead to headaches, dizziness, and disorientation. As a result - to an increase in blood pressure, deterioration of health, in some cases - to nausea and vomiting.

In connection with the above, it is relevant to constantly monitor the current FS and PES of the VR, AR, MR and XR means user. It should be noted that FS determines the ability of a person to perform certain actions, duties, for example, production. PES shows what physical and mental costs are incurred by a person, taking into account the resources available to him. For this reason, FS and PES depend on each other in a rather complex way. Maintaining the state of health, as well as high performance, necessitate constant monitoring of the VR, AR, MR and XR means user's current PES.

The main requirements for the tools used for monitoring the current PES of a person are safety and ease of use. The safety of use, first of all, assumes the absence of harmful effects on humans, which determines the predominant use of the so-called passive biometric technologies. The requirement for ease of use leads to the need to use small-sized, including built-in biometric devices. Modern optical biometric technologies should be singled out as the most promising for use in conjunction with VR, AR, MR and XR technical means. The latter, first of all, should include the technology for analyzing the vibroimage of a person's face [4, 5].

The aim of the work is to study the correlation of the face vibroimage informative parameters, reflecting the PES, with the characteristics of the human FS when using VR, AR, MR and XR technical means.

THE ESSENCE OF THE PROPOSED APPROACH

In the study, for the implementation of continuous monitoring of the current PES of a person, it is proposed to use the technology of the face vibroimage analyzing in the deep IR range [11]. This range of optical radiation with a wavelength of 8-15 microns is far enough away from visible optical radiation, the wavelength of which for most people is in the range of 0.38-0.78 microns. This makes it possible to almost completely eliminate the interference between the optical biometric channel of the monitoring system and the image projection channel of VR, AR, MR and XR systems.

The IR biometric technologies developed to date [11] allow real-time registration of such informative bioparameters as heart rate (HR), arterial pressure (AP), respiratory rate and depth, motor activity, and reactions, similar to galvanic skin. From a technical point of view, to register IR optical radiation of this type, it is sufficient to use modern small-sized sensors that are embedded in wearable hardware of virtual technologies.

Analysis of the dynamics of changes in the above bioparameters makes it possible to build a behavioral model of a person, which permits to predict a possible change in his state. This allows you to reasonably plan and conduct educational and other types of activities, monitor the effectiveness of medical rehabilitation and ultimately guarantee the preservation of health, especially with frequent and prolonged use of VR, AR, MR and XR systems.

The monitoring system under consideration should also be considered as a tool for an objective comparison of the quality of various virtual reality systems, as well as the individual choice of the system, taking into account the physiological characteristics of the user. This circumstance is of paramount importance for children and adolescents with physical disabilities.

RESULTS OF EXPERIMENTAL TESTING

Experimental approbation of the approach included the assessment of PES and FS of tested people using VR, AR, MR or XR means based on the analysis of their current bioparameters. To estimate the PES, two measurement options were used. The first measurement option was based on IR technology. The second - on the use of biometric bracelets, the application of which, due to the convenience of their use, was very reasonable. Both options made it possible to record HR, AP and motor activity.

To assess the PES of the test subjects, the G value was used [12], which was determined on the basis of the analysis of bioparameter data. The value G ($0 \leq G \leq 3$) is a dimensionless relative value that characterizes the PES of a person in comparison with his normal state in a calm environment ($G=1$). At $G < 1$, the person's state is assessed as relaxed, drowsy. The states of high stress, fatigue and tension are characterized by values of $2 \leq G \leq 3$. At values $1 < G < 2$, the state is characterized by mild to moderate degrees of excitement. The greatest contribution to the identification of the state was made by such bioparameters as HR and AP. To assess FS embedded in the context of the VR, AR, MR or XR story and periodically repeated tests were used. The number of errors committed was used to estimate the current FS. To assess the current FS, the following ratio was used:

$$FS_0 = 1 - N / NMAX, \quad (1)$$

where N is the number of mistakes committed on a given time interval (5 minutes); $NMAX$ is the maximum number of errors committed when $PES > 2.5$. $FS=1$ corresponded to normal operability, and $FS=0$ corresponded to low operability level. In Fig. 1 shows the time dependences of FS_0 , G_{IR} , HR_{IR} , G^* or HR^* averaged for the entire contingent of tested (27 people), where: G_{IR} and G^* - PES estimates based on bioparameters measured using IR technology and biometric bracelets, respectively; HR_{IR} and HR^* - HR measured respectively using IR technology and biometric bracelets.

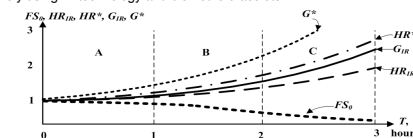


Fig. 1. Typical change in PES and FS of the tested.

The measurements were carried out for three modes of using VR, AR, MR or XR technologies, differing in the degree of the test subjects' involvement: A - light degree; B - medium; C - high degree. Game scenario were used as content. An analysis of the results obtained shows that with a prolonged (two or more hours) use of VR, AR, MR or XR means, the PES of the tested changes from normal to stressed and highly stressed. Accordingly, FS begins to degrade from normal to low. At the same time, PES changes (function G) have a good inverse correlation (0.7-0.8) with changes in FS.

Comparison of those shown in Fig. 1 of the time dependences of G_{IR} and G^* shows that the G^* function has almost 1.5 times higher PES estimates than the G_{IR} function. The main reason for this is the overestimation of HR measurement using biometric bracelets using optical biometric technology. This technology, when placing sensors on the hands, measures the vascular blood filling, which is modulated by both cardiac and, to a large extent, motor activity. Moreover, the influence of the latter component increases with the growth, for example, of the intensity of game movements.

CONCLUSIONS

Thus, the established correlation between FS and PES, determined on the basis of the analysis of informative bioparameters measured using IR technology, makes it possible to assess the current FS state of a person with a sufficiently high degree of reliability. This permits to reasonably solve the problems of planning educational, as well as recreational and recovery processes using VR, AR, MR or XR means. The results of the study are of particular importance in the training of operators to control potentially hazardous facilities using VR, AR, MR or XR technologies, and, first of all, for the nuclear industry.

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