Application of VR and AR Technologies in Educational Process

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Abstract—**Education system is constantly developing and now people can use new AR and VR technologies to improve their learning process. Augmented reality, abbreviated AR, is a combination of the real world and additional data "entered" in the area that the user sees. VR is generally defined as an interactive computer simulation.They have many advantages and can be used both for training in simulators through special VR devices and for designing something new. There are many platforms for developing augmented reality: 8th Wall, ARToolKit X, VUFORIA, ARCore, Unreal Engine. The list of all possible platforms is still incomplete, because the list is growing every year. T-FLEX is a Russian computer-aided design system. It includes CAD/CAM/CAE/CAPP/PDM /CRM/PM/MDM systems. T-FLEX CAD has all the necessary modules that are not available in other systems. For example, the T-FLEX VR module can contribute to product development at all stages of creation. This technology allows studenys to take a different look at the details and entire design process.**

Keywords—*Augmented reality, Virtual reality, 3D model, aircraft design*

I. Introduction

There is a special place for information, computing systems and technologies in modern lifestyle.

Augmented reality, abbreviated AR, is a combination of the real world and additional data "entered" in the area that the user sees. Environmental effects are amplified through visual, auditory, tactile, somatosensory, and olfactory receptors [1]. For example, if you take a city and a Central street located in the historical center, mobile construction cameras focus on the sights, and the screen shows how the building looked 100 years ago. This is how we plunge into augmented reality [2]. VR is generally defined as an interactive computer simulation. Technology that uses the user's position and actions to replace or increase the user's feedback through one or more senses, thereby giving the user a cognitive immersive experience (virtual world experience) [3].

- A combination of the real and virtual world.

- Real-time interaction.

- Location objects and users in 3D space.

AR is based on the user's location or marker. A marker is an object in enviroment, in other words, a label that is read by special software to draw a virtual object in its place. A simple shape in 2D is often used as a marker, but its structure must be unique and identifiable.

II. FEATURES OF USING VIRTUAL REALITY

VR may be very popular now, however it's not always positive. Many people suffer from nausea and other side effects. In the twentieth century already, scienists made a study about this problem. A 20-minute study with 150 subjects gave the following results: 61% reported some symptoms during or after the testing period, and even 5% had to abandon the study because of their symptoms [4]. The question is whether using VR outweighs the symptoms. The answer is different for each user, but it leads to new research on this topic. It is important to understand what forms of "simulation disease" may occur. Numerous studies have found that it can be divided into three groups of symptoms: oculomotor disorders (such as eye strain, difficulty focusing, headaches), mental disorders and disorientation (such as difficulty concentrating, dizziness), and physiological disorders or nausea (such as: discomfort, headache, sweating, vomit).

There are several causes of symptoms and effects caused by virtual reality (VRISE). The main reason is the sensory discrepancy between emotions from virtual reality and feelings in a real environment. Various aspects affect this discrepancy. First, the image quality and naturalness of the simulation are the most important [5]. When the user moves and the image slows down, a simulation disease may appear, because our brain will be disoriented. The third important reason why the symptoms occur or not occur is the influence of user control. If the user can control their own views and movements, they will experience fewer symptoms because the brain knows what movements to expect. From the various aspects that facilitate VRISE, it can be concluded that the occurrence of cyber disease varies for different VR devices. The sense of immersion, different experiences, and differences in user control will have a big impact. With HMD (head mounted display), the user will determine their own movements. In the cave, you can see your own body and other users. This will lead to a more realistic experience. Only the person who controls will have the same control experience as with HMD. Other people will have more difficulty focusing and orienting, which will lead to more symptoms. Measuring cyber-illness during research is not easy [6].

The most common method is a questionnaire containing several questions in the three categories mentioned above, but the answers vary from person to person [7]. Another option is the pre - and post-survey questionnaires, but they are still personal. The last option is an psychophysiological measurement in which researchers try to detect VRISE based on heart rate, electroencephalography of blinking and

indigestion. If the user, before working in VR, spends more time configuring the system for their individual characteristics (focal length, helmet fixation, image clarity), the probability of side effects is reduced.

Sometimes it makes almost impossible to use VR on a daily basis in their projects and developments for small firms. Due to the rapid pace of technology development, prices are lower today than a couple of years ago. Using VR becomes possible and more accessible for use in all areas of design. If you look at the hardware, HMD is now an available tool for displaying a project in virtual reality. More advanced technologies are still expensive due to the large number of projectors and computers that are needed. A more serious problem is the need for software. The price of licenses can be very low or very high, depending on the selected software. Some programs require people with specific knowledge to program the virtual environment, but in other cases, standard design programs are good enough to display the project in VR [8].

The next big problem is technical issues such as low trigger sensitivity to recognition, GPS errors, file size issues, etc. Computing power must be high, resulting in the high cost mentioned above, and even then there may be display issues and hardware limitations. When a VR model is too detailed, it will be difficult to visualize and watch at a high speed, and the technique can run very slowly.

Virtual reality needs high-precision trackers. Even a tiny bug can cause problems in order to have a good VR experience. If the technical part doesn't walk or look around at the same time or in exactly the same direction as the user, then VR doesn't work properly and won't be useful. With slow rendering times or slow trackers, this can lead to VRISE, mainly nausea, as mentioned earlier the lack of necessary space for some virtual reality devices. For example, a CAVE solution needs a large, fixed surface where it can be built. This makes it difficult to implement it in the field of urban design. There is also a mobile CAVE from Barco, but its construction takes half a day, and the cost is very high. For other forms of VR, mobility and outdoor use is a limitation. Most systems require a lot of heavy material to carry, making it difficult to get it to any desired location. Outdoor use is limited and often impossible because the equipment is not weather-resistant. The brightness, contrast, and resolution aspects cause many problems when used outdoors.

Next, there is the time needed to create a VR model. Especially at the design stage, this can take much longer than drawing by hand. This is one of the reasons why designers will stick to traditional design methods. To get a good virtual reality model, all information must be prepared and recorded with maximum accuracy. Most often, designers do not have sufficient technical knowledge to create VR models, because this is not within their competence. For example, CityGML requires knowledge of the GML encoding language [9].

At Korolev Samara University, 3D models and model drawings are created as part of the course "conceptual design". The student designs aircraft Assembly using CAD, CAE systems such as Siemens NX, Nastran NX, ANSYS, Compass, and others. The student acts as a designer, making decisions (choosing a wing diagram based on the problem, etc.). d.) Seven years have passed since the article "Robot designer: fantasy and reality" was published in the journal

"Ontology of designing" in 2012, and in 2015 the article "Robot designer: on the way to reality" was published, where the system of decision-making assistance and the construction of a parameterized model of the aircraft was already specifically described. The purpose of this article is to summarize the results achieved at the Samara state aerospace University in the field of automation of preliminary design of aircraft (See Fig.1). Emphasis was placed on the formalization of knowledge, development of scenarios and operations in the chosen engineering field, semantic and mathematical modeling [10].

Fig. 1. Robot designer CAD aircraft

The aircraft pre-design thesaurus serves as a semantic basis for the future software system, serving as an integration framework for databases and knowledge, design operations, and scenarios. Significant progress has been made in the field of mathematical modeling-a symbiosis of parameterized geometric models, statistical and finite element models for estimating aerodynamic loads, structural stresses, and weight. A specific user interface is created in order to provide the designer with a comprehensive tool that would give the user the necessary information about the project and, if necessary, "explain " the decisions that the system makes or offers independently based on the selected de - sign scenario. The prototype of the "robot-constructor" system, created as a demonstration unit in a complex high-tech field, gives hope for the possibility of full automation in the field of designing structures of traditional forms, reducing the time required for designing artifacts of traditional schemes [11].

New projective technologies such as virtual reality and augmented reality were used for further development.

Now, the "robot designer" has a sufficient set of tools to help the designer with the construction of a parameterized model. It planned to add a visual demonstration with the ability to change and Refine the model in the virtual space.

III. PRACTICAL APPLICATION

A. Using augmented reality

There are many platforms for developing augmented reality: 8th Wall, ARToolKit X, VUFORIA, ARCore, Unreal Engine. The list of all possible platforms is still incomplete, because the list is growing every year. In our Department, we used HP Reveal technology , a powerful web Studio that makes it easy to create, manage, and share augmented reality events. Using this function, the user can point the camera at a drawing of the aircraft and get a parameterized 3D model of

the aircraft on the screen of their smartphone. The drawing serves as a kind of marker, which was mentioned above, by which the program determines the model to be shown to the user. A demonstration of the application is shown in Fig. 2.
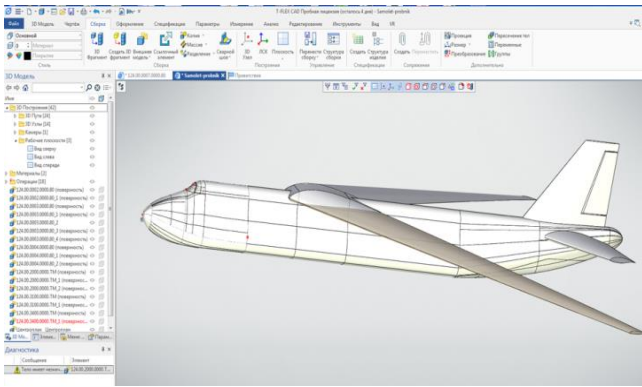

Fig. 2. 3D model of t-FLEX CAD aircraft

In the future, it is planned to improve the application by adding new features, such as hiding the plane's skin and demonstrating its power elements, splitting it into separate blocks, into separate 3D objects [12].

You can also implement an animated display of an object, for example, a mechanization located on the wing or a landing gear release-cleaning.

B. Using virtual reality

T-FLEX is a Russian computer-aided design system. It includes CAD/CAM/CAE/CAPP/PDM/CRM/PM/MDM systems [13].

VR in training allows you to increase the efficiency of learning - you can put a person in situations that are difficult or expensive to simulate in reality or analyze how a person will act in an unusual situation. For example, banking employees can work out scenarios of communication with customers.

The virtual reality module uses OpenVPN tools. The equipment consists of a helmet , controllers, and signal reception stations. The module itself is integrated into the design system and is enabled with a single click in a special menu by the connected equipment to the system. The model in VR opens on top of the model created in the CAD system, and the user can return to the CAD development window (Fig. 3).
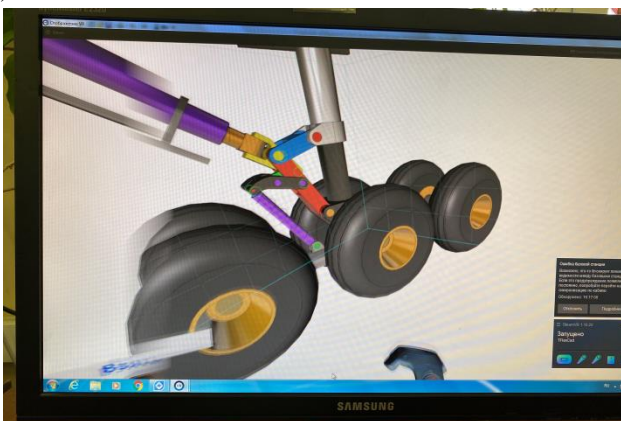

Fig. 3. Disassembly of the product

IV. DESIGNING IN VR TODAY

If a 3D Assembly is built using the interface principle, users of the VR module can "capture" and move selected structural elements in the VR space, as if they were moving parts with their hands in the real world [14]. This simulates the effect on the mechanism, as if the corresponding force was applied to the selected point of the part. Under the influence of this force, part of the mechanism begins to move.

All virtual reality control is performed using controllers that are in the hands of the designer, Fig. 4. As part of our development, we use the HTC VIVA helmet with two controllers and two base stations that determine the user's position in space. On the virtual stage, controllers are represented as two manipulators that allow you to change the geometry of parameterized parts and assemblies through the user menu. During the design process, the part can be updated by other designers working behind other machines and connected to the project.

The T-FLEX CAD system allows you to analyze the designed product using the finite element method and hydrodynamics.using the finite element method and hydrodynamics [15].

Fig. 4. Controllers HTC VIVA

V. DESIGN PROCESS AND HIDDEN FEATURES OF T-FLEX VR

The VR module is able to demonstrate the model created by CAD to the student developer. This feature increases the interest of the student, forcing him to bring the model to perfection, so that the model on the virtual stage seems as realistic and plausible as possible. The VR command set allows you to perform a huge number of actions, such as zooming, locking the axis, and rotating using special devices. The VR user controls the entire process using two controllers, each of which he can customize at will, for example, the right one can build a cross section with a plane, the left one can hide surfaces.

The automated projective T-FLEX system is used at all stages of product preparation: planning, design, purchasing, storage, after-sales service, and support in use. Fast interaction with other CAD systems, such as Siemens NX, makes it easier to integrate the model. T-FLEX VR features allow developers

to make a visual assessment of the product, inspect the design, analyze its ergonomics, but also make a new real design in the virtual space itself, which greatly simplifies all stages of design. Virtual design opens up new horizons, because the easier is creation process – the easier is learning.

VI. GROUP IMMERSION IN VIRTUAL REALITY

Further development of one of the areas of virtual reality is team design. Our colleagues from Delft University of technology were able to create a communication system from several users working on a single task. The system combines virtual and augmented reality, the user can be immersed in VR through a helmet or watch the process through a tablet screen, Fig 5.

Fig. 5. TU Delft VR system

This will be helpful during work on the projects with huge or microscopic objects, where several people should be involved. Group immersion in virtual reality will make learning easier too. Several students and professor may do some designs wearing VR helmet and the rest of the group can take notes, while waiting for their turn.

VII. CONCLUSION

Currently, the introduction of augmented reality is faster than virtual reality. This is due to the fact that for augmented reality, you only need to have a smartphone with a good camera, while for virtual reality, you need expensive equipment and powerful computers. In addition, it is not always possible to quickly transform a rapidly growing body of knowledge about our environment into an interactive form.

Studying new developments allows us to open the door to virtual worlds where there will be no material restrictions. The development of such a system is based on a multi- agent paradigm [15].

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