

Innovative Technologies in the Training of Surgeons Using Virtual Interactive Training Complexes

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Currently, among the current directions in the development of surgery, the use of immersive technologies, such as virtual reality and augmented reality, is singled out. Virtual reality technology consists in the simulation of a computer-generated image with which the user can interact. Augmented reality, in turn, combines virtual and real objects together, thus creating a semi-immersive environment, which allows the user to more effectively perform their tasks in the field of diagnostics, surgical intervention, and evaluation of the effectiveness of manipulations [1, 2,3]. Immersive technologies are aimed at creating three-dimensional models of anatomical structures, which can then be superimposed on images of the patient's real anatomy, which is especially important in neurosurgery, due to the closedness of the skull and spine and complex microanatomy inside them, which imposes natural restrictions on visualization in diagnostics and surgical interventions, especially those that can be performed by non-invasive methods of exposure.

The purpose of the study is to evaluate modern approaches to the training of surgical personnel, to develop modern digital technologies to improve the educational process.

Material and methods. The analysis of the data of domestic and foreign literature is carried out. The search was carried out using the Google Academy search engine and electronic databases PubMed, Medline, Embase, Scopus, Web of Science, eLIBRARY for the period from 2017 to 2022. Using the Unreal Engine, mixed reality interfaces for surgical interventions were created.

Research results.

The main goals of simulation training in neurosurgery are to work out the algorithm of actions by repeating them many times, to create a risk-free learning environment for the patient. In this case, such models can be:

- 1) Material (physical): living (animals), cadaveric (human and animals), tissue (placenta);
- 2) Artificial: dummies, phantoms, synthetic prostheses;
- 3) Virtual (virtual simulators): both augmented reality models and fully virtual models;
- 4) Hybrid.

- To solve the existing problems of theoretical training - mastering normal anatomy with access to modern information resources, mastering the main surgical approaches to various anatomical structures;

- to solve the problem of admission of orderlies-surgeons to the patient, it is proposed to introduce into clinical practice the concept of "trainee doctor-surgeon" with a mandatory number of independent operations under the supervision of a mentor;

- to solve the problem of clinical work - the organization of residency in surgery on the basis of surgical departments of large hospitals or federal centers with a large number of hospitalizations and operations, in order to instill clinical thinking in the intern, the opportunity to form the desired professional competencies in him;

- there are also problems with the material and technical equipment of clinics, on the basis of which residency training is carried out, as well as the relevance of involving residents in research work.

We have combined proven approaches, new methodological developments and modern digital tools for the professional growth of neurosurgical personnel.

We specialize in custom solutions for a wide range of leading VR headsets and platforms, including HTC Vive, Oculusquest, Oculusgo, Pimax, ValveIndex and more.

Using the Unreal Engine, we have created mixed reality interfaces for training doctors in surgical specialties. An interactive educational VR complex has been developed, in which:

- Functionality was developed for user navigation in the space of the virtual stage;
- Detailed 3D content was created, including 3D models of human organs and skeletal system;

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- The functionality of interactive interaction of the user with the objects of the virtual scene, including operational tools, has been developed.

The package includes:

- Software on external media;
- Virtual reality helmet and controllers;
- Gloves with tactile feedback.

The main scientific, technical, technological, conceptual advantage of the developed product is the possibility of continuous and unlimited training of surgical skills by students at various stages of education without risk to patients.

Thus, we have developed an interactive VR module, which is a virtual three-dimensional simulator for teaching students (students of the postgraduate education system) of medical schools. The product created as a result of the project implementation makes it possible to reproduce an interactive operating environment in virtual reality for trainees to practice the necessary surgical skills in practice without risk to the patient's health (4-10).

The creation of a virtual three-dimensional simulator for training surgeons made it possible to solve a number of conceptual problems. The advantages of the proposed scientific and technical solutions are:

- The possibility of developing practical skills;
- No risk for real patients;
- A high degree of realism of the recreated operating environment and the anatomical structures of the body for the maximum approximation of the training process to real conditions;
- Unlimited training time;
- The use of game mechanics to facilitate the perception of information and speed up the memorization of techniques;
- Availability of the program.

In addition, as part of an extended version of the simulator, planned for further long-term development, a graphical editor will be developed, with the help of which it will be possible to manually or automatically create a virtual representation of a specific person and simulate his vital and medical indicators. Such an approach will allow one to hone surgical skills on an infinitely large set of different patients without risking real people.

Based on the foregoing, it can be concluded that the main scientific, technical, technological, conceptual advantages of the developed product are the following:

- Manufacturability, efficiency and availability of the solution;
- The possibility of continuous and unlimited development of surgical skills at the training stage without risk to patients;
- Game mechanics in teaching methodology as a way to improve the efficiency of knowledge perception;
- Reduction of the training period for independent operations;
- Scalability - the ability to include new operations, techniques, specialized laboratories.

As a result of the work carried out, a virtual simulator of surgical skills was created with the following characteristics and features:

- achieving the effect of maximum immersion in the surroundings of the operating room with the "presence effect" of the trainee in each episode of preparation and performance of the work task;
- Realistic simulation of episodes in virtual reality;
- compliance of equipment elements, instruments, clamps, forceps, scissors, scalpel, needle with thread, needle holder, cotton swab, tweezers, hemostat, operating table, light lamp with real products, so that the trainee can recognize them by their design features, size, color;
- ensuring a realistic response of the simulated reality to the virtual impact and management by users;
- the ability of the module to work in the Windows 10 operating system.

The technological process is divided into episodes, built in accordance with the requirements of regulatory documents on the technology of work and labor protection. Each episode reflects a separate stage in the organization of work.

As a result of the project implementation and its implementation in medical educational institutions in the long term, it will be possible to achieve:

- improving the quality of training and the availability of education in the system of continuous professional development of medical workers, thanks to the mobility of the developed training solution;
- reduction of lethality of patients after surgical interventions;
- reduction of postoperative complications;
- improving the quality of medical services provided to the population;
- Implementation of products, services and platform solutions created on the basis of end-to-end digital technologies.

Thus, at present, in the field of technology development in surgery, it is necessary to note significant achievements regarding the possibilities of diagnosing, monitoring, predicting physiological and pathological processes occurring in various areas and

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departments of the body, as well as the trend towards achieving minimally invasive surgical interventions while increasing their accuracy and efficiency. Technical and technological advances in the field of surgery, improved training will lead to improved outcomes and prognosis for patients.

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