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USING VIRTUAL REALITY TECHNOLOGIES IN MEDICAL REHABILITATION AND DIAGNOSTICS

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Annotation. The article is devoted to the application of virtual reality (VR) technologies in medical electronics, with an emphasis on rehabilitation, diagnostics, and training. The key areas of VR use are considered: the creation of virtual simulators for the restoration of motor functions, improving the accuracy of diagnostics using 3D models, and the use of VR to reduce pain and anxiety in patients. It is shown that the integration of VR with medical devices allows for a personalized and safe approach to treatment, increasing the effectiveness of medical procedures and the quality of life of patients.

Keywords: virtual reality, VR, medical electronics, rehabilitation, diagnostics, medical training, 3D models.

Introduction. Modern technologies continue to be actively implemented in various areas of medicine, transforming approaches to diagnostics, treatment, and rehabilitation. One of the most promising and innovative areas is the use of virtual reality (VR) in medical electronics [1].

This technology opens up new horizons for patients and doctors, allowing not only to improve the accuracy of diagnostics but also to create effective, individually adapted rehabilitation programs.

Main part. One of the most significant applications of VR in medical electronics is in rehabilitation. Patients recovering from strokes, injuries, or surgeries often face significant challenges in regaining motor functions. Traditional rehabilitation can be time-consuming and physically demanding, sometimes leading to a lack of motivation. VR-based rehabilitation programs provide an engaging, interactive, and highly effective method for restoring motor skills. Virtual rehabilitation environments create a safe space where patients can perform movements similar to those in real life without the fear of falling or injury. The integration of motion capture technology enables doctors to track every movement with high precision, allowing for real-time adjustments to treatment plans. Special programs are designed to cater to individual patient needs, ensuring a customized approach that maximizes the effectiveness of therapy. Moreover, VR-based rehabilitation can be adapted for a variety of conditions. Patients with spinal cord injuries, for instance, can use VR to simulate walking or other lost motor functions, encouraging muscle memory and neuron reactivation. Individuals with amputations can benefit from VR prosthetic training, which enables them to practice controlling artificial limbs before they even receive them, increasing the effectiveness of prosthetic adaptation. Furthermore, studies have shown that VR rehabilitation helps patients with neurological disorders, such as Parkinson's disease or multiple sclerosis, by enhancing neuroplasticity—the brain's ability to reorganize itself and form new neural connections. This is particularly important for stroke patients, as VR exercises can stimulate affected brain areas, promoting faster and more effective recovery. The repetitive, task-oriented exercises in VR therapy help reinforce brain-to-muscle coordination, making it a powerful tool for long-term rehabilitation strategies [2].

Pain management is another critical area where VR technology has shown immense potential. Virtual environments can distract patients from pain, reducing the need for medication. Studies indicate that when patients immerse themselves in virtual worlds, their perception of pain decreases significantly. This approach is particularly useful for burn victims undergoing painful dressing changes, as VR can shift their focus away from the discomfort and onto a soothing, immersive experience. Additionally, VR-based pain management is being explored for chronic pain sufferers. Patients with conditions like fibromyalgia or arthritis can use VR therapy sessions to engage in guided relaxation techniques, immersive experiences, and interactive physical therapy

exercises that reduce discomfort. By creating an alternative sensory environment, VR helps patients redirect their focus from pain to engaging and pleasant stimuli. In addition to pain relief, VR is effective in reducing anxiety, especially in patients undergoing complex medical procedures. For example, patients with a fear of needles can be immersed in a calming virtual landscape, reducing their stress and making the procedure more tolerable. VR exposure therapy is also used for individuals suffering from post-traumatic stress disorder (PTSD), where controlled virtual environments help them gradually confront and manage their fears. Additionally, pre-surgical VR experiences can prepare patients by familiarizing them with the operating room environment, reducing preoperative stress and improving overall patient cooperation.

Planning Modern VR technologies enable the creation of highly detailed 3D models of organs and tissues, providing doctors with a more comprehensive understanding of a patient's condition. This has transformed the way medical professionals approach diagnostics and preoperative planning. For example, in cardiology, VR allows specialists to examine the structure of the heart in a three-dimensional space, aiding in the detection of congenital defects and planning surgical interventions. Similarly, in oncology, 3D tumor models enable doctors to analyze the precise location and size of malignant growths, improving surgical precision and minimizing damage to healthy tissues. Surgeons also benefit from VR simulations, which allow them to practice complex procedures in a risk-free environment before performing them on actual patients. This not only enhances their skills but also significantly reduces surgical risks. VR-guided surgical planning is especially crucial for operations involving the brain, heart, and spine, where the accuracy of every movement is paramount. Moreover, VR technology has been used in ophthalmology to assist with intricate eye surgeries and in orthopedics for planning joint replacement procedures. The ability to view patient-specific anatomy in VR significantly improves precision and surgical success rates, offering a revolutionary step in preoperative preparation.

Regarding the future prospects of VR in Medicine, the integration of VR into medical electronics is still in its early stages, yet the potential for future developments is vast. As hardware and software technologies continue to evolve, VR applications in medicine will become even more sophisticated and accessible. Some of the most promising future advancements include the following.

1 AI-Driven VR Medical Assistants: Artificial intelligence (AI) integrated with VR can create intelligent virtual assistants that guide doctors through complex procedures, offering real-time suggestions based on patient data.

2 Haptic Feedback Technology: Future VR systems will incorporate advanced haptic feedback, allowing doctors and students to «feel» virtual organs, improving surgical precision and training realism.

3 Remote VR Consultations: VR telemedicine could enable doctors to conduct remote consultations with patients while interacting with detailed 3D scans of their bodies, improving diagnostic accuracy and accessibility.

Conclusion. In conclusion, we can say that virtual reality is rapidly transforming the medical field by providing innovative tools for rehabilitation, diagnostics, and training. Its ability to create personalized and immersive experiences enhances the effectiveness of medical procedures while improving patient outcomes. As VR technology continues to advance, its integration with medical electronics will further revolutionize the healthcare industry, making treatments more effective, surgeries safer, and medical education more comprehensive. By embracing VR, the medical community can push the boundaries of traditional medicine, offering new hope and possibilities for patients worldwide.

References

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