УДК 004.8:61

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ПРОГРАММНЫЕ СИСТЕМЫ ПОДДЕРЖКИ ПРИНЯТИЯ КЛИНИЧЕСКИХ РЕШЕНИЙ И ПРИМЕНЕНИЕ 3D-ТЕХНОЛОГИЙ В МЕДИЦИНЕ

Аннотация. *Развитие цифровых технологий преобразует современную систему здравоохранения, совершенствуя диагностические процедуры, поддерживая принятие клинических решений и расширяя возможности персонализированного лечения. Программные системы поддержки принятия клинических решений (Clinical Decision Support Systems, CDSS) помогают медицинским специалистам анализировать информацию о пациентах, выявлять потенциальные риски, интерпретировать клинические данные и выбирать соответствующие диагностические и лечебные стратегии. Одновременно трехмерные технологии, включая медицинскую визуализацию, компьютерное моделирование, 3D-печать и виртуальное моделирование. Они открывают новые возможности для планирования хирургических операций, медицинского образования, протезирования и индивидуализированного лечения.*

Ключевые слова: *системы поддержки принятия клинических решений, цифровое здравоохранение, искусственный интеллект, 3D-технологии, 3D-печать, медицинская визуализация, персонализированная медицина*

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SOFTWARE-BASED CLINICAL DECISION SUPPORT SYSTEMS AND THE APPLICATION OF 3D TECHNOLOGIES IN MEDICINE

Abstract. *The development of digital technologies is transforming modern healthcare by improving diagnostic procedures, supporting clinical decision-making, and expanding opportunities for personalized treatment. Software-based Clinical Decision Support Systems (CDSS) help healthcare professionals analyze patient information, identify potential risks, interpret clinical data, and select appropriate diagnostic and therapeutic strategies. At the same time, three-dimensional (3D) technologies, including medical visualization, computer-based modeling, 3D printing, and virtual simulation. They are creating new opportunities for surgical planning, medical education, prosthetics, and patient-specific treatment.*

Keywords: *Clinical Decision Support Systems, digital healthcare, artificial intelligence, 3D technologies, 3D printing, medical imaging, personalized medicine*

Introduction

Digital transformation has become an important direction in the development of modern healthcare. Medical institutions increasingly use software systems, electronic health records, artificial intelligence, medical imaging, and computer-based modeling to improve the organization and quality of healthcare services [1]. These technologies provide opportunities to process large volumes of clinical information, support medical professionals, and improve the accuracy of diagnostic and treatment planning. One of the important developments in digital medicine is the implementation of Clinical Decision Support Systems (CDSS) [2]. These systems use patient-specific information, medical knowledge, clinical guidelines, and analytical algorithms to provide recommendations that assist healthcare professionals in making clinical decisions. Depending on their design, CDSS may generate alerts about medication interactions, identify possible disease risks, recommend diagnostic tests, and support the interpretation of laboratory and imaging results. Another significant technological direction is the application of three-dimensional technologies in medicine. Unlike conventional two-dimensional images, 3D models can represent anatomical structures in a spatial format.

Materials and Methods

This article is based on a narrative analysis of scientific publications and international guidance concerning digital healthcare, clinical decision support systems, medical 3D printing, and related technologies [3]. The analysis draws on literature addressing the practical applications of clinical software, the use of medical imaging and anatomical modeling, and the benefits and limitations of technology-assisted clinical practice. The selected sources were considered in

relation to three main aspects: the functionality of CDSS, the clinical and educational applications of 3D technologies, and the opportunities for integrating digital tools into healthcare workflows. Particular attention was paid to patient safety, clinical validation, data protection, and the need for professional oversight.

Results and Discussion

Applications of 3D Technologies in Medicine

Three-dimensional technologies enable the creation, visualization, and production of digital or physical representations of anatomical structures. They include 3D reconstruction from medical images, computer-aided design, virtual and augmented reality, additive manufacturing, and simulation-based training.

Three-dimensional medical visualization. Computed tomography (CT) and magnetic resonance imaging (MRI) provide detailed medical images that can be processed to construct 3D representations of organs, bones, blood vessels, and other anatomical structures. These models allow specialists to examine spatial relationships that may be difficult to understand from individual two-dimensional image slices. Three-dimensional visualization can be useful in orthopedics, neurosurgery, cardiovascular medicine, oncology, and reconstructive surgery.

3D printing and personalized medical devices. Three-dimensional printing, also known as additive manufacturing, produces physical objects from digital models by building material in successive layers. In medicine, this technology is used to manufacture anatomical models, surgical guides, prosthetic components, and selected patient-specific implants [4]. Patient-specific models can help surgeons plan complex procedures before entering the operating room [5]. Physical models may also be used to explain a diagnosis or planned operation to patients and their families. In medical education, they provide students with tangible representations of anatomical structures.

Virtual reality and augmented reality. Virtual reality (VR) creates computer-generated environments in which users can interact with simulated

anatomical structures and clinical scenarios. Augmented reality (AR) adds digital information to a view of the real environment. These technologies may support medical education, procedural rehearsal, rehabilitation, and selected forms of surgical planning. Students can practice in simulated environments, while clinicians may use 3D representations to improve their understanding of patient anatomy.

Integration of CDSS and 3D Technologies

The integration of clinical decision support systems with 3D technologies represents a promising direction in digital medicine. The two approaches address different but complementary needs: CDSS helps interpret clinical information, while 3D technologies provide detailed spatial representations of anatomical structures.

Discussion

The reviewed literature indicates that CDSS and 3D technologies have distinct yet complementary roles in the modernization of healthcare. CDSS can help transform patient information into clinically relevant alerts and recommendations, whereas 3D technologies support spatial understanding, physical modeling, and simulation-based learning. Their integration may provide a more comprehensive basis for selected diagnostic, educational, and treatment-planning tasks. Nevertheless, technological sophistication alone does not guarantee improved clinical outcomes. Decision-support recommendations may be affected by biased data, outdated guidelines, or insufficient validation.

Conclusion

Software-based Clinical Decision Support Systems and 3D technologies are important components of the digital transformation of modern medicine. CDSS can assist healthcare professionals in analyzing clinical information, identifying potential risks, checking medication safety, and applying evidence-based guidelines. Three-dimensional visualization, 3D printing, and immersive

simulation can support anatomical understanding, surgical planning, personalized medical devices, and practical medical education. Their integration offers opportunities to connect clinical data analysis with detailed anatomical representation, potentially supporting more informed and individualized healthcare. However, the safe and effective application of these technologies requires reliable data, interoperability, clinical validation, information security, qualified personnel, and compliance with ethical and regulatory requirements.

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