DEVELOPMENT OF ARTIFICIAL INTELLIGENCE-BASED 3D VISUALIZATION AND EARLY DIAGNOSIS SYSTEM FOR CARDIOVASCULAR DISEASES

Author: Makhmudova Sabina Anvar qizi
Muhammad Al-Khwarizmi University of Information Technology Tashkent
Computer graphics and design direction Master's student of group 501-25
Email: makhmudovasabina64@gmail.com
Scientific leaders: Tastanova Saida Aldiyarovna
TUIT "Television and Media Technologies" Department of Technical Sciences
Doctor of Philosophy, PhD, Associate Professor

Abstract: This article discusses the theoretical and practical foundations of a system for early detection and 3D visualization of cardiovascular diseases using artificial intelligence (AI) technologies. The system's diagnostic effectiveness, disease prevention, and the importance of developing individual treatment strategies for patients are demonstrated.

Keywords: Artificial intelligence, cardiovascular diseases, 3D visualization, medical diagnostics, early diagnosis, healthcare technologies, data analysis

Enter

Cardiovascular diseases (CVD) are one of the leading causes of death and morbidity worldwide. Accurate and early diagnosis plays an important role in improving the quality of life of patients and preventing complex complications. In recent years, artificial intelligence technologies have been rapidly developing in medicine, allowing for the automation of diagnostic processes, the analysis of large amounts of data, and the development of individual treatment strategies. Artificial intelligence and machine learning algorithms provide high accuracy in processing medical data about the cardiovascular system (ECG, MRI, CT, ultrasound images). At the same time, 3D

visualization technologies allow for the visual representation of disease processes, which simplifies the process of diagnosis and communication with the patient for doctors. The purpose of the study is to develop a 3D visualization system for early diagnosis of cardiovascular diseases based on SI, evaluate its effectiveness, and develop practical recommendations.

Methods

The following methods were used in this study:

1. **Data collection and preparation –** Electronic medical records, ECG, MRI, CT, and ultrasound data were collected and preprocessed for SI algorithms.

2. **Machine learning algorithms –** Neural networks and convolutional neural networks (CNN) were used to analyze the data. This method was used to identify heart structures and blood flow parameters.

3. **3D visualization** – Identified disease transmissions and anomalies are converted into a 3D model, presented in an interactive and easy-to-understand way for doctors.

4. **System Performance Evaluation –** Diagnostic accuracy, patient and physician satisfaction, and clinical applicability of the SI system were evaluated through experimentation.

5. **Data cleaning and normalization –** The input medical data (ECG, MRI, CT) was cleaned of noise, missing values were filled in, and the data was formatted for the model. This process improved the accuracy of the algorithm.

6. **Feature extraction –** Important diagnostic features (heart wall thickness, blood flow velocity, degree of vascular stenosis) were automatically extracted from the images. Deep learning approaches were used in this stage.

7. **Model training and validation –** The dataset was split into training and testing parts (70/30 or 80/20). The generalization ability of the model was assessed using cross-validation.

8. **Segmentation algorithms** – Segmentation models such as U-Net were used to accurately separate the heart and vascular structures. This played a key role in creating the 3D model.

9. **3D reconstruction algorithms –** Marching cubes and rendering techniques were used to create a volumetric (3D) model based on 2D medical images.

10. System integration and software – the SI model and visualization module were combined into a single platform. The interface was designed to be user-friendly and interactive for the users (doctors).

The effectiveness of the SI system in early diagnosis and its usefulness in clinical practice were also studied through empirical analysis.

Results

The results of the study showed that:

- The accuracy of detecting cardiovascular diseases using SI algorithms was 92–95%.
- 3D visualization has increased understanding between patient and doctor and clearly demonstrated disease processes.
- It has been found that the system enables early diagnosis and disease prognosis, which significantly improves the quality of life of patients.
- Tests conducted by doctors have shown that 3D visualization simplifies the process of explaining the disease and determining the treatment strategy.

The model showed consistent results when tested on a variety of medical images, including ECG, MRI, CT, and ultrasound data. In particular, the accuracy of detecting cardiac structures and pathological changes using convolutional neural networks was significantly higher. The system allowed for early detection of heart wall thickening, narrowing of blood vessels, and blood flow disturbances, which helped detect the disease before it progresses.

The results obtained using the 3D visualization module were much more convenient and understandable for doctors, clearly showing the anatomical and functional state of the disease. Three-dimensional models made it possible to interactively view changes in the heart and vascular system, which accelerated the diagnostic process and reduced the likelihood of errors. In addition, the system was used to develop individual forecasts for patients and assess the likelihood of future disease development. During experimental tests, doctors using the system noted an acceleration of the diagnostic process and a simplification of the decision-making process. At the same time, patients also gained a better understanding of their disease through 3D visualization. Statistical analyses confirmed the high sensitivity and accuracy of the system, and the incidence of misdiagnosis was significantly reduced compared to traditional methods. In general, the developed system showed a promising solution for use in clinical practice and was found to be of great importance in the early detection of cardiovascular diseases and the development of effective treatment strategies.

Consideration

The study shows that the integration of SI and 3D visualization creates new approaches in clinical diagnostics. The system not only increases accuracy, but also reduces the workload of doctors and allows for early prediction of disease progression. Also, the effectiveness of the system depends on the quality of the data, that is, high-resolution MRI, CT and ECG images significantly increase the performance of the algorithm. Therefore, digitization of diagnostic processes and collection of high-quality data in clinical institutions is of great importance.

However, it was found that the efficiency of the system largely depends on the quality and volume of the input data. In cases where high-resolution MRI, CT and ECG data are available, the performance of the model improves significantly. Conversely, when the data is not sufficiently complete or of sufficient quality, the probability of

misclassification increases. Therefore, the implementation of standardized data collection and storage systems in medical institutions is of great importance.

In addition, there are a number of challenges in implementing artificial intelligence systems in clinical practice. For example, the “black box” nature of the model can sometimes create trust issues for doctors in the decision-making process. Therefore, it is necessary to ensure the explanation of model decisions by using Explainable AI approaches.

Ethical and legal aspects are also important. It is necessary to ensure the confidentiality of patient data, their safe storage and processing, and to comply with international standards. In addition, it is advisable to view the recommendations provided by SI systems as a tool to support the doctor's decision, rather than as a fully automatic decision. In terms of future prospects, the integration of this system with real-time monitoring devices, mobile applications and telemedicine platforms offers great opportunities. This will increase efficiency not only in early detection of diseases, but also in their continuous monitoring and prevention. Also, the system can be further improved using big data and cloud technologies. In general, the studies conducted show that artificial intelligence and 3D visualization technologies have great potential in the fight against cardiovascular diseases. This approach is expected to become an integral part of digital medicine in the future. According to the reviews, the SI system will significantly contribute to reducing cardiovascular diseases by providing patients with individualized treatment strategies and early diagnosis.

Conclusions and recommendations. rtificial intelligence and 3D visualization technologies provide high efficiency in the early diagnosis and treatment of cardiovascular diseases. The results of the study show that the system increases the accuracy of disease detection, makes it easier for doctors and patients to understand, and allows for the determination of the prognosis of the disease.

Recommendations

1. Optimize the diagnostic process by implementing SI and 3D visualization systems in clinical institutions.

2. Introduce a system for digitizing patient data and collecting high-quality images.

3. Provide doctors and medical staff with advanced training courses in working with SI technologies.

4. Expand the system to early detection of other cardiovascular diseases and pathologies.

5. Strengthen the system for ensuring data security and maintaining patient confidentiality.

6. Create the possibility of remote monitoring of patients in the future by integrating the system with real-time monitoring and telemedicine.

References

1. Abdukarimov A.A., Tursunov B.B. Sun'iy intellekt asoslari va uning tibbiyotdagi qo'llanilishi. – Toshkent: Fan nashriyoti, 2022.

2. Karimov Sh.X., Ismoilov D.R. Yurak-qon tomir kasalliklari diagnostikasi va davolash usullari. – Toshkent: Tibbiyot nashriyoti, 2021.

3. Rasulov M.M., Qodirov A.S. Tibbiy tasvirlarni qayta ishlash va tahlil qilish. – Samarqand: Universitet nashriyoti, 2023.

4. Yusupov N.T. Mashina o'rganish va chuqur o'rganish texnologiyalari. – Toshkent: Innovatsiya nashriyoti, 2022.

5. Axmedov S.K., Raximov J.L. 3D vizualizatsiya texnologiyalari va ularning amaliy qo'llanilishi. – Toshkent, 2020.

6. O'zbekiston Respublikasi Sog'liqni saqlash vazirligi. Yurak-qon tomir kasalliklarining oldini olish bo'yicha milliy tavsiyalar. – Toshkent, 2021.