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APPLICATION OF ARTIFICIAL INTELLIGENCE IN EARLY DISEASE DIAGNOSIS

ВИКОРИСТАННЯ ШТУЧНОГО ІНТЕЛЕКТУ ДЛЯ РАННЬОЇ ДІАГНОСТИКИ ЗАХВОРЮВАНЬ

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Анотація. У статті розглядається застосування штучного інтелекту (ШІ) для ранньої діагностики захворювань, з акцентом на використанні методів машинного навчання, глибоких нейронних мереж і мульти модальної обробки медичних даних у превентивній медицині. Показано, як моделі ШІ аналізують клінічну, генетичну та візуальну інформацію для виявлення ранніх ознак раку, серцево-судинних хвороб і діабету. Окреслено переваги діагностичних систем на основі ШІ - підвищення точності виявлення, скорочення часу діагностики та підтримка персоналізованого лікування. Особливу увагу приділено питанням якості даних, інтерпретованості результатів і етичним аспектам використання ШІ в медицині. Результати свідчать, що системи на основі ШІ мають значний потенціал для трансформації процесів ранньої діагностики та підвищення ефективності системи охорони здоров'я.

Ключові слова: штучний інтелект, рання діагностика захворювань, машинне навчання, медична візуалізація, предиктивна аналітика, автоматизація в медицині, етичний ШІ.

Abstract. The paper explores the application of artificial intelligence (AI) in early disease diagnosis, emphasizing the growing role of machine learning, deep neural networks, and multimodal data fusion in preventive medicine. It discusses how AI models analyze clinical, genetic, and imaging data to identify early indicators of diseases such as cancer, cardiovascular disorders, and diabetes. The study highlights the advantages of AI-based diagnostic tools in improving detection accuracy, reducing time to diagnosis, and supporting personalized treatment planning. Special attention is given to the challenges of data quality, interpretability, and ethical considerations in medical AI deployment. The results demonstrate that AI-driven systems hold strong potential to transform early diagnostics and enhance the overall efficiency of healthcare delivery.

Keywords: artificial intelligence, early disease diagnosis, machine learning, medical imaging, predictive analytics, healthcare automation, ethical AI.

Introduction.

Early disease diagnosis plays a crucial role in modern healthcare, as timely detection significantly improves treatment outcomes, reduces costs, and increases patient survival rates. Traditional diagnostic approaches - based on manual

interpretation of medical images, laboratory tests, and clinical notes - are often limited by human error, resource constraints, and subjective judgment. The rapid advancement of artificial intelligence (AI), particularly in machine learning and deep neural networks, has introduced new opportunities for improving the accuracy and speed of medical diagnostics.

AI systems are now capable of analyzing multimodal data, including radiological images, genetic information, and electronic health records, to identify subtle patterns that may be invisible to the human eye. Convolutional neural networks (CNNs), transformer-based architectures, and hybrid models have demonstrated remarkable success in detecting early indicators of cancer, cardiovascular disease, diabetes, and neurological disorders. For example, Google DeepMind's algorithms achieved near-expert accuracy in breast cancer screening, while BioGPT and Med-PaLM models support automatic interpretation of medical texts and diagnostic reasoning.

At the same time, integrating AI into medical practice raises new challenges related to data privacy, model explainability, and ethical responsibility. Ensuring transparency and accountability in AI-assisted diagnosis is essential to maintain trust among patients and healthcare professionals. This study aims to analyze the potential of artificial intelligence in early disease detection, explore practical implementations, and outline existing limitations and directions for future research.

Main text

Concept and Importance of AI in Early Diagnosis

Artificial intelligence (AI) has become one of the most influential technologies in modern medicine, enabling faster, more accurate, and data-driven disease detection. By analyzing vast medical datasets - ranging from imaging and genetic profiles to patient histories - AI can identify subtle pathological changes that traditional diagnostic methods may overlook. According to Roxanne [1], the introduction of AI-based tools in healthcare has significantly reduced diagnostic errors and improved the early detection of chronic and rare diseases.

AI's importance lies in its predictive capabilities. Through advanced learning algorithms, it can recognize patterns in symptoms or biomarkers long before clinical

manifestations appear. Mugisha [2] emphasizes that such predictive diagnostics transform medicine from reactive to preventive care, allowing doctors to intervene at the earliest possible stage.

AI Models and Diagnostic Techniques

Machine learning (ML) and deep learning (DL) are the core technologies driving AI-assisted diagnosis. ML algorithms such as random forests, support vector machines, and logistic regression have proven effective for classifying diseases based on structured clinical data. More advanced DL architectures, including convolutional neural networks (CNNs) and transformers, have demonstrated remarkable results in image-based diagnostics, such as radiology, histopathology, and ophthalmology [3].

Emma [3] notes that CNNs trained on thousands of medical images achieve diagnostic accuracy comparable to expert radiologists in detecting pneumonia, diabetic retinopathy, and lung cancer. Similarly, transformer-based models analyze sequential data from electrocardiograms (ECG) or genetic sequences, allowing multi-dimensional evaluation of disease progression.

Torshin [4] further illustrates real-world applications where AI-assisted screening identifies early cardiovascular irregularities or precancerous lesions in large-scale patient populations. These examples highlight AI's capacity to generalize across modalities - images, signals, and text - and provide unified diagnostic insights.

Integration into Clinical Workflows

The practical success of AI in healthcare depends not only on its algorithms but also on its seamless integration into existing clinical workflows. Tian et al. [5] describe hybrid systems that combine human expertise with automated decision support, where AI acts as an assistant - analyzing scans, suggesting hypotheses, and flagging anomalies. Such cooperation enhances productivity and allows clinicians to focus on complex reasoning rather than routine verification.

Modern hospital information systems are increasingly incorporating AI modules for triage, diagnostic reporting, and treatment planning. For instance, integrated decision-support systems in oncology can cross-reference imaging results with genetic data to suggest targeted therapies. Dunsin [6] emphasizes that this kind of synergy

between AI and clinical data accelerates response times and ensures continuity of care across departments.

Challenges and Limitations

Despite significant advancements, several challenges still hinder large-scale adoption of AI in early disease detection. The most pressing issue is **data quality and representativeness**. Training models on biased or incomplete datasets can lead to diagnostic inaccuracies and reduced generalizability across populations [5].

Another major concern is **interpretability**. Clinicians must understand how AI arrives at specific conclusions before trusting its recommendations. Mugisha [2] and Torshin [4] both stress that transparency in AI-driven diagnostics is essential for patient safety and professional accountability.

Additionally, **privacy and ethical governance** remain key issues. Medical data often contain sensitive personal information that must be securely stored and processed. As Dunsin [6] points out, implementing federated learning and anonymization protocols is critical to ensuring data confidentiality.

Finally, **cost and accessibility** can limit AI deployment in low-resource settings. Esther and Adelusi [7] underline the need for lightweight, cloud-based systems that can deliver diagnostic support even in developing regions without advanced infrastructure.

Future Perspectives and Practical Implications

The future of AI-assisted diagnostics lies in personalization and multimodality. Roxanne [1] predicts that next-generation systems will integrate genomic, clinical, and lifestyle data to deliver individualized health forecasts. Such predictive analytics will allow continuous monitoring of patient health and early alerts for potential complications.

In addition, advances in explainable AI (XAI) and self-supervised learning are expected to improve transparency and reduce dependence on labeled datasets. Tian et al. [5] foresee that integrating XAI methods - such as heat maps and attention visualization - will make AI decisions more interpretable for physicians and regulatory bodies.

AI will also contribute to global health equity by democratizing diagnostic expertise. Cloud-based tools can provide remote analysis for under-resourced hospitals, enabling early detection even in regions lacking specialists [6][7].

Overall, artificial intelligence is not replacing clinicians but augmenting their diagnostic capabilities. By combining computational precision with medical intuition, AI is reshaping the landscape of preventive healthcare and early disease detection. The next decade will likely see widespread implementation of intelligent, ethical, and adaptive systems capable of saving millions of lives through timely diagnosis and personalized treatment recommendations.

Conclusions.

Artificial intelligence has become a transformative force in early disease diagnosis, offering tools that combine precision, scalability, and continuous learning. By analyzing vast and heterogeneous medical datasets, AI models enable early identification of diseases and personalized prediction of patient risks. The integration of machine learning and deep learning into diagnostic systems not only accelerates clinical workflows but also enhances the accuracy and consistency of medical decisions.

However, to fully realize this potential, healthcare institutions must address key challenges - data standardization, explainability of models, and ethical governance of patient information. Responsible deployment requires collaboration between AI researchers, clinicians, and policymakers to ensure transparency and fairness.

In conclusion, AI should not replace the physician but augment medical expertise. When applied responsibly, artificial intelligence can transform early diagnostics from a reactive process into a proactive, data-driven practice that advances global healthcare outcomes.

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