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A Review of Advances in AI Algorithm-Based Medical Imaging Technologies

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Abstract. With the rapid advancement of artificial intelligence, its application in medical imaging has become increasingly widespread, particularly in enhancing the clarity and precision of medical images. This paper reviews recent progress in AI-based medical imaging technologies, exploring how advanced techniques such as deep learning and computer vision can effectively analyze and process large volumes of imaging data, thereby improving image quality and assisting physicians in achieving more accurate disease diagnoses. At the same time, the introduction of AI has optimized medical image acquisition and processing workflows, reducing potential human errors. With the rise of multimodal biomedical imaging, the prospects for AI in medical imaging have grown even broader. Through an analysis of relevant domestic and international literature, this review reveals the current state, technical trends, and challenges of AI applications in medical imaging. The application of AI algorithms not only improves diagnostic efficiency but also offers new pathways toward personalized and precision medicine, pointing to a more intelligent and efficient future for medical imaging.

Keywords: Biomedical engineering, Medical imaging, Artificial intelligence

1. Introduction

In recent years, artificial intelligence has developed rapidly, with particularly notable effects in the field of medical imaging. Through deep learning and image processing methods, AI can effectively improve the efficiency and accuracy of medical image analysis. Many studies have shown that AI can surpass traditional techniques in image recognition, feature extraction, and pattern analysis, greatly enhancing the diagnostic value of medical imaging.

Currently, AI is widely used in image enhancement and computer-aided diagnosis. Relevant studies indicate that AI has significantly improved accuracy in pathological diagnosis, anomaly detection, and tumor identification. Intelligent medical robots are also being increasingly used in minimally invasive surgery, making procedures more precise and efficient. Integrating AI into healthcare systems not only reduces misdiagnosis rates but also improves patients' quality of life.

However, medical imaging technologies also face challenges: imaging data are highly heterogeneous and voluminous, making it difficult for traditional processing techniques to meet the demands of efficient diagnosis; insufficient data annotation and difficulties in cross-institutional data sharing limit the effectiveness of model training; and healthcare professionals vary widely in their

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acceptance and proficiency in using AI. These challenges also present opportunities for AI algorithms—by efficiently processing massive amounts of data through deep learning, AI can not only improve diagnostic accuracy but also promote multimodal integration, enabling real-time processing and intelligent decision-making.

This paper aims to explore the latest advances in AI-based medical imaging technologies and analyze their current applications and future directions in medical imaging. With the rapid development of modern technology, particularly the application of AI, medical imaging is undergoing a profound transformation. This review focuses on how AI can improve the efficiency and accuracy of medical imaging, thereby enhancing clinical diagnosis and treatment outcomes.

2. Core concepts and theoretical foundations

2.1. Core concepts

2.1.1. Artificial intelligence and its definition in medical imaging

In the field of medical imaging, the introduction of AI has significantly improved the speed and accuracy of image analysis, making early disease diagnosis and treatment more feasible. AI is primarily used for image recognition, feature extraction, and pattern analysis. AI systems can automatically identify lesion areas in medical images, reducing human error and improving diagnostic efficiency. For example, deep learning is widely used in medical image processing, employing complex neural network models to extract features from large-scale imaging data for classification and prediction. This application of AI not only helps physicians make more accurate diagnoses but also enhances overall healthcare quality.

2.1.2. Medical imaging technologies and the concept of multimodal fusion

Medical imaging technologies refer to methods that use various imaging devices and techniques to visualize the internal structures and functions of the human body, thereby aiding clinical diagnosis and treatment. Common modalities include X-ray computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and positron emission tomography (PET). Each technique has different imaging principles and advantages, providing information on anatomy, tissue metabolism, and physiological function.

Multimodal medical image fusion involves integrating and analyzing data from different imaging modalities to form a more complete and accurate diagnostic basis. Fused imaging data can compensate for the limitations of any single modality in terms of resolution, contrast, or functional information, thereby improving lesion detection rates and diagnostic accuracy.

2.2. Theoretical foundations

2.2.1. Principles of deep learning and computer vision in medical image analysis

Deep learning is a subset of machine learning that analyzes and processes data by simulating the structure of neural networks in the human brain. In medical image analysis, deep learning relies heavily on convolutional neural networks (CNNs), which can automatically extract image features, significantly improving classification and recognition accuracy. Computer vision, which simulates human visual capabilities on machines, can be combined with deep learning to perform in-depth

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analysis of medical images. This technology effectively processes complex image data, enabling automated segmentation, detection, and recognition.

The combination of deep learning and computer vision has provided new perspectives and methods for medical image analysis. The rapid development and application of these technologies have not only improved the efficiency of medical image processing but also provided strong support for early disease detection and precision treatment.

2.2.2. Role of generative AI in medical imaging data processing

Generative AI has garnered significant attention in medical imaging in recent years. By simulating and generating specific medical image data, this technology can provide healthcare professionals with more intuitive and accurate visual information. In medical image data processing, generative AI not only improves image quality but also excels at reducing noise, enhancing features, and filling in missing data. These capabilities support early disease detection in clinical applications. For instance, generating high-resolution MRI or CT images allows physicians to observe lesion areas more clearly, improving diagnostic accuracy.

3. Current state of research on AI-based medical imaging technologies

3.1. Domestic research status

Domestic researchers have explored the clinical application of AI in medical imaging from multiple perspectives, with notable achievements. Ran Lin et al., through empirical studies, found that multimodal medical image fusion combined with AI-assisted diagnosis significantly increased the detection rate of cervical cancer and precancerous lesions while greatly reducing the missed diagnosis rate, providing an efficient tool for cervical cancer screening [1]. Liao Huangjunqing et al., focusing on malignant tumors in the trunk, pointed out that the integration of AI and medical imaging has been applied to the diagnosis, treatment, and prognosis assessment of colorectal cancer, liver cancer, and other diseases, greatly improving clinical efficiency and accuracy [2]. These studies indicate that AI in medical imaging has moved from theory to practice, providing technical support for the precise diagnosis and treatment of various diseases.

Domestic scholars have also paid close attention to technological innovation and future directions in medical imaging AI. Hu Liwei et al. reviewed the application of generative AI in medical imaging, noting its potential to play a key role in image generation and cross-modal conversion, while emphasizing the urgent need for standardized management of generative image data [3]. Xu Ying and Zhao Xinming systematically reviewed the progress of large language models in medical imaging, including image diagnosis, report generation, and research assistance, while also pointing out their limitations in direct image interpretation [4]. Li Wenjie et al. conducted an in-depth analysis of the technological development trends of AI in medical diagnostics, providing a reference for healthcare institutions in technology adoption and system development [5]. These studies point the way for technological innovation and future development in medical imaging AI, while also raising core issues such as data standardization and ethical governance.

3.2. International research status

International researchers have conducted in-depth studies on both clinical applications and technological frontiers of AI in medical imaging. Obuchowicz et al. systematically reviewed the clinical applications of AI in medical imaging and image processing, emphasizing its important role

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in diagnosing diseases such as cancer, providing a reference for clinical practice [6]. Potočnik et al. explored current and potential future applications of AI in medical imaging practice, including workflow optimization and personalized medicine, and analyzed related challenges and factors that healthcare professionals need to consider, offering insights for clinical implementation [7]. The book Applications of Artificial Intelligence in Medical Imaging comprehensively summarizes various application cases and technological developments of AI in medical imaging, covering multiple levels from foundational technologies to clinical applications, providing a rich reference for research in this field [8].

International researchers have also explored the integration of AI with other technologies and specific applications in medical image data processing. Singh et al. studied the application of AI and blockchain technology in healthcare, combining the strengths of both to provide new technical pathways for the secure storage, sharing, and traceability of medical imaging data [9]. Research from Xinyang Normal University investigated the application of AI-based digital image processing techniques in medical image analysis, focusing on methods for image feature extraction and analysis, providing technical support for automated medical image processing [10].

3.3. Research commentary

Based on the above summary and analysis of domestic and international literature, Chinese researchers have achieved substantial results in research on AI-based medical imaging technologies, including algorithm optimization, image recognition accuracy improvement, and clinical applications. They have studied the role of AI in medical imaging from perspectives such as technological development, application cases, and industry challenges, providing a rich theoretical foundation and practical experience for the development of this field. International researchers have focused more on cutting-edge technologies such as the integration of AI and deep learning, as well as cross-modal data fusion.

Although domestic and international researchers approach the topic from somewhat different angles, overall, research has concentrated on the application and optimization of AI algorithms in medical imaging. Practical studies have largely focused on cases in hospitals and research institutions, involving close collaboration with clinicians and technology developers. The in-depth research by both domestic and international scholars has provided a solid foundation for theoretical development and has also contributed numerous case studies for practice in clinical medicine and healthcare technology, playing an important role in advancing both the theory and practice of medical imaging technologies.

4. Conclusion

This paper reviews recent advances in AI-based medical imaging technologies, emphasizing the widespread application and importance of AI in medical imaging. With the rapid development of deep learning, computer vision, and related technologies, AI has demonstrated significant advantages in image recognition, feature extraction, and pattern analysis in medical imaging, greatly improving diagnostic accuracy and efficiency.

This paper has not yet explored in depth the interpretability of AI models and their ability to generalize across different datasets. Existing studies are mostly based on specific devices or single-center data, and the transferability and robustness of models across different populations and imaging devices still need to be validated—this remains a key bottleneck for moving from the laboratory to clinical practice. Through in-depth analysis of medical imaging data, AI has not only

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enhanced diagnostic capabilities but also promoted the development of intelligent hospital systems. Although AI holds great promise in medical imaging, challenges remain in areas such as data privacy protection, technical standardization, and patient acceptance.

As AI technology continues to develop, medical imaging will see further innovation and transformation. The application of AI in medical image analysis will become more widespread, and advances in deep learning and computer vision will further improve image recognition accuracy and processing speed.

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