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Application of Artificial Intelligence in Medicine

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Abstract: In recent years, generative artificial intelligence has made significant breakthroughs in the medical field. The rapid development of deep learning technology has brought new opportunities to many application fields such as medical image analysis, disease prediction, clinical decision support systems, and surgical robots. This article reviews the current status of artificial intelligence applications in medicine, explores the accurate recognition capabilities of technologies such as convolutional neural networks in medical image analysis, and the potential of machine learning in disease risk assessment and personalized health management. At the same time, it analyzes the ability of artificial intelligence to generate optimization solutions in clinical decision support systems and the advantages of surgical robots in complex operations. Although artificial intelligence has broad application prospects, it still faces challenges such as lack of explainability, data privacy, and security. Future development requires strengthening the improvement of relevant laws and regulations to protect the rights and interests of patients and promote the healthy progress of artificial intelligence.

Keywords: artificial intelligence, medical imaging, disease prediction, clinical decision support system, surgical robot.

1. Introduction

In recent years, generative artificial intelligence with deep learning technology as its core has made continuous breakthroughs. In 2014, the Generative Adversarial Network (GAN) was first proposed, which promoted the development of unsupervised learning on complex data distributions [1]; in 2017, the introduction of the Transformer architecture made it quickly become the mainstream architecture of generative artificial intelligence models [2]; in 2022, OpenAI publicly released the Transformer - based large language generation model ChatGPT; in 2023, OpenAI released GPT-4, and generative artificial intelligence has further developed. The development of artificial intelligence (AI) has been highly valued by governments, enterprises, and academia in various countries. In terms of research dynamics, deep convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have been widely used in fields such as image recognition and natural language processing, such as Aloha Go defeating the Go champion and GPT- 3.5 generating natural language text and other typical cases. In addition, technologies such as Bidirectional Encoder Representation based on Transformer model (BERT) and Generative Pre-trained Transformer (GPT) have made important breakthroughs, making the quality of machine-generated text increasingly close to the human level.

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With the rapid development of artificial intelligence, artificial intelligence is gradually penetrating all walks of life, among which the medical field is an important battlefield for its application. The introduction of AI technology has not only injected new vitality into medical research but also brought new changes to clinical diagnosis and treatment. This article aims to review the current application status of artificial intelligence in medicine, deeply analyze its application results in medical image analysis, disease prediction, clinical decision support, surgical robots, and other fields, and at the same time explore its limitations and look forward to future development.

This article discusses the current status of artificial intelligence applications in medicine and deeply explores their technical characteristics, application advantages, and limitations to provide useful references and lessons for future research and applications. This review can further promote the development of artificial intelligence in the medical field and contribute more wisdom and strength to human health.

2. Application of artificial intelligence in medicine

2.1. Medical Imaging

Medical image analysis is one of the most widely used branches of artificial intelligence in medicine. It covers a full range of processes, from image acquisition, processing, and in-depth research to diagnostic assistance. The basic tasks of medical image analysis are image recognition, classification, and segmentation. Through convolutional neural networks (CNN), key abnormal features such as tumors, lesions, and diseased areas can be mined and identified in large amounts of image data.

With the rapid development of artificial intelligence, machine learning, and deep learning technologies, the field of medical imaging has made significant progress. CNN occupies an important position in medical imaging due to its excellent image feature extraction ability. This technology can automatically learn and analyze subtle features in the original image, to accurately identify subtle abnormalities of the disease. Real-time medical image analysis technology based on deep learning not only greatly accelerates the diagnosis process, but also provides strong support for the formulation of treatment plans. At the same time, image-assisted diagnosis intelligent models built based on advanced algorithms, such as the automatic segmentation technology of brain tumors achieved by optimizing the U-Net++ network, have demonstrated the ability of artificial intelligence to identify abnormal areas in medical images that deviate from normal physiological patterns.

Artificial intelligence is transforming the way things are done in the medical imaging field. These technologies enable doctors to quickly identify diseases and abnormalities, facilitating earlier intervention and more scientific medical decision-making. As research deepens and technology continues to advance, AI will be more widely used in the medical field, providing more accurate and effective diagnosis and treatment services to a wide range of patients.

2.2. Disease Prediction

The application of artificial intelligence in disease prediction mainly covers two major areas: public health prevention and control and personal disease screening and health management. Traditional disease prevention methods have many shortcomings, and the introduction of artificial intelligence has brought significant breakthroughs and developments in disease prediction.

In recent years, with the continuous development of technology, the types of diseases that can be predicted by artificial intelligence have gradually increased. For example, AI-based telemedicine and home monitoring equipment have been widely used in the screening and monitoring of fundus diseases [3]. For cardiovascular disease, a complex disease caused by the combined effects of genetic, environmental, and behavioral factors, machine learning algorithms can optimize traditional risk assessment models by comprehensively integrating patient risk factors and coronary anatomical

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imaging parameters, thereby more accurately predicting the development of the disease and prognosis assessment [4]. As a chronic metabolic disease, diabetes mellitus requires blood sugar prediction, blood sugar abnormality detection, and prediction of diabetic complications, which are all important aspects of diabetes prediction. These have made new breakthroughs due to the addition of artificial intelligence technology [5].

The application of artificial intelligence has greatly promoted the development of the field of disease prediction. Providing more in-depth analysis and decision-making support, not only improves the treatment effect of patients, but also provides the possibility for the formulation of personalized health management plans, such as personal health consultants, preventive treatment measures, and medical treatment and medication guidance. It is also an important direction for the future application of artificial intelligence in the field of disease prediction.

2.3. Clinical decision making

Clinical Decision Support System (CDSS) is an important application of artificial intelligence in the medical field. Its core principle is to conduct in-depth mining of collected medical data and knowledge. CDSS combines clinical information with the knowledge base to identify and extract potential relationships in massive data, thereby providing optimized diagnosis and treatment plans based on evidence-based medicine. These systems not only improve the accuracy and efficiency of diagnosis and treatment but also promote the quality improvement of medical services.

CDSS based on artificial intelligence is the result of in-depth cross-collaboration between computer technology and medicine, and its application is very extensive. In the clinical diagnosis and treatment of cerebrovascular diseases, CDSS can assist in identifying high-risk groups, support decisions on acute reperfusion therapy, automate etiology classification, and formulate personalized secondary prevention strategies. In addition, AI's powerful capabilities in medical image processing and multimodal data integration have made it play an increasingly important role in the clinical decision-making process. In the medical transformation of Alzheimer's disease, CDSS is regarded as a key link, helping doctors make more reliable decisions in diagnosis and treatment [4].

In addition, the AI-based electronic medical record quality control system was officially launched at the end of 2020, marking the transition of medical record quality control from manual mode to machine mode. With the help of AI technology, the system realizes the quality control of electronic medical records on an integrated information platform, covering multiple levels such as hospitals, doctors, departments, and core medical systems. This transformation not only improves the efficiency of monitoring medical record quality but also provides strong support for promoting the standardization of medical processes and reducing human errors, thereby further improving the quality and safety of overall medical services.

2.4. Surgical Robot

Surgical robots perform specific actions based on specific surgical environments and clinical needs, according to established plans and specific processes. Robot-assisted surgery involves many disciplines and technologies such as medicine, robotics, materials science, computer science, and AI. It is often used in narrow surgical areas and can achieve precise control of surgical instruments beyond the doctor's ability. Compared with traditional surgical operations, robot-assisted surgery is flexible and controllable, with smaller incisions, shorter recovery time, and fewer complications.

In 1994, the Computer Motion Research Institute of the United States developed the first minimally invasive surgical robot, Aesop. Its robotic arm can simulate the doctor's arm to achieve 7 degrees of freedom switching, assisting doctors in controlling endoscopes, and is widely used in cardiac and thoracic surgery [6]. Since the da Vinci surgical robot system was first approved by the

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FDA in 2000, it has been continuously updated and iterated. It has now been widely used in countries around the world and has had a huge impact on the field of surgery [7]. The most advanced ones are the fourth-generation Da Vinci Xi robotic surgical system and the Da Vinci SP robotic surgical system [8]. At present, the capsule robot technology developed in China is at the forefront of the world. The capsule robot is a miniature robot that can detect and treat the disease by swallowing into the gastrointestinal tract. It actively detects the lesion site in the gastrointestinal tract, transmits images for doctors to diagnose, and can also deliver drugs to the lesion site.

As a mature application direction of medical robots, surgical robots are developing rapidly and have broad application prospects. The rapid development of artificial intelligence and the cross-integration of various disciplines have also brought new opportunities for the development of surgical robots.

3. Current limitations and prospects

3.1. Lack of interpretability

Although artificial intelligence has brought new possibilities to the development of medicine and has also shined in the fields of medical imaging, disease prediction, clinical decision-making, and surgical robots, its technology still has great limitations.

Because it is difficult to rationalize and explain the principles and mechanisms of AI, i.e., the “black box theory” [9], the application of AI in the medical field has been questioned. Many clinical prediction models that use machine learning or deep learning algorithms are unable to explain and illustrate the prediction results. Missing data, misclassification, measurement errors, etc. will aggravate the algorithm bias, resulting in wrong predictions, which are fatal to clinical judgment, because, for clinical judgment, a small error will lead to serious consequences. If people want to solve this hidden danger and better apply artificial intelligence in the medical field, the people need to improve the interpretability of AI models, obtain the recognition of doctors and patients, and reduce the possibility of wrong predictions.

3.2. Privacy security and legal supervision

In addition, there is another important issue in the development of artificial intelligence in the medical field, which is data privacy and security [10]. More and more patients' medical data are being used in AI-related research, and smart devices and applications are also continuously collecting patients' personal information. This faces a series of serious problems such as patient information being leaked or even used for illegal transactions. Ensuring patient data security and preventing personal privacy leaks are major challenges faced by AI applications. At the same time, the causes of these problems are not only the limitations of technology but also the limitations of laws and regulations on AI supervision. Setting medical AI diagnosis and treatment rules and defining the attribution of doctor-patient responsibilities all require the formulation of relevant laws and regulations for strict regulation [11].

3.3. Outlook

In the future, the application of artificial intelligence in the medical field will be more extensive. In terms of medical imaging, it can improve the accuracy and efficiency of artificial intelligence analysis and automatic recognition of images, promote the improvement of early diagnosis rate, and reduce the serious consequences caused by untimely diagnosis; at the same time, it can further promote the development of personalized medicine. AI can analyze the patient's genomic data and formulate personalized treatment plans to meet individual needs; in the field of pharmacy, AI can be used to

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simulate and predict the function and side effects of drugs, reducing the cost and time of research and experiments; health management and remote monitoring use AI-driven applications to help patients manage chronic diseases and achieve personalized health monitoring; in addition, for medical robots, AI can further improve surgical accuracy and accelerate patient recovery, while playing an important role in nursing and rehabilitation. AI can also monitor disease transmission and predict epidemics, and further apply it to public health monitoring and epidemic management, enhancing the public's ability to respond to sudden situations of disease transmission. With the continuous development of artificial intelligence, laws and regulations on artificial intelligence should also be continuously strengthened, and at the same time, attention should be paid to and improved. Doctors and medical professionals should be aware of and educated on the ethical issues of artificial intelligence in patient diagnosis and treatment.

4. Conclusion

This article discusses the wide application of artificial intelligence in the medical field and its impact. Through in-depth analysis of four core areas, namely medical imaging, disease prediction, clinical decision support systems, and surgical robots, it reveals how artificial intelligence can promote the development of the medical field with its powerful data processing capabilities and precise analysis technology. In the field of medical imaging, artificial intelligence has achieved accurate identification of key abnormal features such as tumors and lesions through technologies such as convolutional neural networks; in the field of disease prediction, artificial intelligence's deep learning algorithms have made more accurate predictions and risk assessments of various diseases, providing the possibility for the formulation of personalized health management plans; clinical decision support systems provide doctors with optimized diagnosis and treatment plans based on evidence-based medicine by integrating medical data and knowledge bases; surgical robots have demonstrated the outstanding performance of artificial intelligence in complex operations. However, the application of artificial intelligence in the medical field also faces many challenges and limitations. Lack of explainability is a major shortcoming of current AI technology. At the same time, data privacy and security issues also need to be addressed. The improvement of relevant laws and regulations is the key to protecting the rights and interests of patients and promoting the healthy development of AI technology. In the future, the application prospects of artificial intelligence in the medical field are broad. With the continuous advancement of technology and the improvement of laws and regulations, artificial intelligence will further improve the accuracy and efficiency of medical image analysis, promote the development of personalized medicine, and play an important role in pharmacy, health management, and public health monitoring.

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