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Medical Artificial Intelligence and the Need for Comprehensive Policymaking

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Abstract:
Since the concept of artificial intelligence was proposed in 1956, it has led to numerous technological innovations in medicine and has completely changed the traditional medical practice. The present study mainly describes the application of artificial intelligence in various medical fields from four aspects: machine learning, intelligent robots, image processing, and expert systems. It also discusses the current challenges and future trends in these fields.
In line with the development of globalization, various research institutions around the world have conducted research in the field of application of artificial intelligence in medicine. As a result, medical artificial intelligence has achieved significant progress and its future prospects have revealed its increasing development and the need for comprehensive policymaking in this field.

Key words: Medical Artificial Intelligence, Policymaking, Machine Learning, Intelligent Robots, Image Processing, Expert Systems

1 Introduction

Artificial intelligence was coined by John McCarthy at the Dartmouth Conference in 1956, and the field of application of AI originated there. (Pope, 1997). Kaplan and Hanlin defined AI as the ability to systematically process external data and learn from it to achieve specific goals and tasks. (Kaplan and Hanlin, 2019). Artificial intelligence involves the use of machines to simulate human thought processes and intelligent behaviors such as thinking, learning, and reasoning, and aims to solve complex problems that can only be solved by experts. (Shen and Fu, 2018)

As a branch of computer science, the field of artificial intelligence mainly includes the following topics: machine learning, intelligent robots, natural language understanding, neural networks, language recognition, image processing, and expert systems (Arita et al, 2020). The concept of medical artificial intelligence was formed in the early 1970s (Patel et al. 2019). Its goal was to increase the efficiency of medical diagnosis and treatment with the help of artificial intelligence systems. After that, the development of medical AI can be roughly divided into four stages:

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1) Childhood (1980s): Decision tree algorithm was proposed and artificial neural networks continued to develop.

2) Adolescence (1990s): Expert systems continued to mature due to the emergence of support vector machines.[1]

3) Youth (2000s): The concept of deep learning was proposed and machine learning became a prominent topic of medical AI.

4) And now, we are in the maturity period (2010s to present): because the technologies are relatively advanced.

However, the ability to interact with society still needs to be improved and we are still in the weak stage of AI. (Plegg and Combi,[2] 2013).

2 Applications of Medical Artificial Intelligence

2.1 Machine Learning

In 1959, Arthur Samuel[3] used the term machine learning to describe a class of algorithms and classifiers. (Samuel,[4] 1959). This algorithm automatically learns from input data and builds a model based on the input data to accurately predict new data. (Kumar and Kalra,[5] 2016) and After that, machine learning algorithms experienced many developments: the back-propagation algorithm[6] was proposed in the early 1960s.(Schmidtuber,[7] 2015).

In 1982, Paul[8] applied the automatic differentiation method[9] to neural networks. (Verbosoff,[10] 1982). In 1986, Ross Quinlan[11] proposed a famous machine learning algorithm called the decision tree[12], which involves classifying data according to specified rules. Tin Kam Hu[13] developed an important algorithm called Random Forest[14] (dual spatial feature extraction algorithm), based on the random subspace method[15] which was constructed using decision trees (Hu,[16] 1998). Vladimir[17] invented the support vector machine model in 1995. In 2006, Geoffrey Hinton [18], a pioneer in the field of deep learning[19] , proposed the deep learning algorithm.

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[1] Support Vector Machines (SVM)
[2] Peleg & Combi
[3] Arthur Samuel
[4] Arthur Samuel
[5] Kumar & Kalra
[6] Backpropagation Algorithm
[7] Schmidhuber
[8] Paul
[9] Automatic Differentiation
[10] Werbos
[11] Ross Quinlan
[12] Decision Tree
[13] Tin Kam Ho
[14] Random Forest
[15] Random Subspace Method
[16]Ho
[17] Vladimir
[18] Geoffrey Hinton
[19] Deep Learning

Deep learning is actually based on machine learning, and convolutional neural network[1] is one of its algorithms. In 2008, according to the standards of the Society for the Advancement of Medical Devices[2] and the British and Irish Hypertension Society[3] , a new blood pressure measurement model based on convolutional neural network, named blood pressure convolutional neural network[4] , was developed to solve the problem of low accuracy of pulse wave propagation pattern extraction[5] in the traditional method, which increased the accuracy of this measurement. (Zhang, Zhou, Zhang, Wang, & Wangoff,[6] 2018).

With the continuous development of computer-aided diagnosis technology, a huge data repository is generated during the screening, diagnosis, and treatment of diseases. (Abertney et al.[7] 2010). Organizing and analyzing this data in a short period of time can be a challenge for doctors. Therefore, machine learning is increasingly used in medicine to help doctors predict diseases and treatment outcomes. Random forest is one of the most efficient algorithms in machine learning. In recent years, random forests have played an important role in medicine, especially in disease prediction. Patients with a history of idiopathic gastric ulcer[8] may have a high probability of ulcer recurrence. In the event of a serious complication such as ulcer rupture, patient safety is compromised.

In 2018, machine learning was used to build a highly accurate model to predict rebleeding of idiopathic gastric ulcer (Wong et al.[9] 2019). In another example, severe hand, foot, and mouth disease (HFMD)[10] caused by enterovirus[11] can lead to serious complications such as pulmonary edema[12] and myocarditis[13] in a small number of children (Liu, Wang, Yang, & Ou,[14] 2014). In 2019, a Ctboost model[15] was developed to predict severe hand, foot, and mouth disease, which showed higher specificity and sensitivity than other models such as decision trees and support vector machines (Hamdi, Amr, & Khalid,[16] 2012). (In addition, machine learning can predict the effect of radiation therapy.

For example, patients usually undergo radiation therapy when they suffer from lung cancer, especially small cell lung cancer.[17] However, long-term radiotherapy can lead to serious complications such as radiation pneumonitis[18] , which can lead to respiratory failure and death. (Kang et al.[19] 2016). Using artificial neural networks, researchers have inferred a method for predicting radiation pneumonitis. They also developed a network with extensive memory and data learning that can show higher accuracy in predicting complications. (Su, Mifton, Weedon, Sun, Elliott, & Mars,[20] 2015).

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[1] Convolutional Neural Network (CNN)
[2] Association for the Advancement of Medical Instrumentation (AAMI)
[3] British and Irish Hypertension Society
[4] Convolutional Recurrent Neural Network-Blood Pressure (CRNN-BP)
[5] Pulse Waveform Feature Points
[6] Zhang, Zhou, Zhang, Wang, & Wang
[7] Abernethy et al
[8] Idiopathic Peptic Ulcer
[9] Wong et al.
[10] Hand-Foot-Mouth Disease
[11] Enterovirus
[12] Pulmonary Edema
[13] Myocarditis
[14] Liu, Wang, Yang, & Ou
[15] CatBoost
[16] Hamdi, Amr & Khaled
[17] Small Cell Lung Cancer (SCLC)
[18] Radiation Pneumonitis
[19] Kong et al.
[20] Su, Miften, Whiddon, Sun, Light, & Marks

The black box problem in machine learning needs to be addressed. A black box is a neural network that includes a convolutional neural network for feature extraction and a convolutional neural network for blood pressure with a large short-term memory.[1] (In general, a neural network consists of neural layers consisting of input, processing, and output. The intermediate processing in a neural network is called the black box. This internal structure is hidden from the user's view (Guidotti et al.[2] 2018).

By solving the black box problem, the accuracy and computational power of machine learning can be improved and its scope of application can be expanded, which can lead to greater physician participation.

22. Intelligent Robots

In 1979, the American Robotics Institute[3] defined a robot as: A programmable, multi-purpose actuator programmed to move materials, parts, tools, or other specialized devices through a variety of defined motions to perform various tasks. (Beasley,[4] 2015).

Intelligent robots were used for surgery in the 1980s. For example, Puma560[5]was used in neurosurgical biopsy[6] in 1985 and prostate surgery in 1988. (Gu and Guo,[7] 2018). RoboDoc[8], developed in 1992, was the first intelligent robot approved by the US Food and Drug Administration.[9] It was primarily used for hip replacement in orthopedic surgery. (Barger, Bauer, & Berneroff,[10] 1998).

Currently, three types of robotic surgical systems have been approved by the US Food and Drug Administration, including Zues[11], Vinci da[12], and the automated endoscopic robot for optimal positioning (Wu, Zhao, Bai, & Li,[13] 2019). Intelligent robots are widely used in orthopedics, urology, dentistry, and other fields due to their characteristics of minimally invasiveness, precision, and intelligence (Zhang et al.[14] 2021).

According to the type of orthopedic surgery, robots can be classified into three categories, including joint surgical robots, spinal orthopedic robots, and reconstructive orthopedic robots (Zhang and Ye,[15] 2019) Femoral neck fractures may occur in elderly patients with symptoms of hip deformity, pain, and dysfunction. These fractures can lead to complications such as nonunion and vascular occlusion of the femoral head, and the best treatment for these fractures is surgery. In 2018, a study investigated methods to reduce bleeding during surgery for femoral neck fractures. They compared two surgical methods, orthopedic robotic surgery and manual plating, and concluded that with the help of surgical robots, the

[1] Long short-term memory
[2] Guidotti et al.
[3] The Robot Institute of America
[4] Beasley
[5] UMA 560
[6] Neurosurgical Biopsy
[7] Guo & Guo
[8] ROBODOC
[9] Food and Drug Administration (FDA)
[10] Bargar, Bauer, & Börner
[11] ZUES
[12] Da Vinci
[13] Wu, Zhao, Bai, & Li
[14] Zhang et al.
[15] Zhang & Ye

surgeon can accurately locate the surgical site and reduce the number of holes required, thus reducing bleeding during the operation. (Chunjiang et al.[1] 2018)

Smart robots are also widely used in gynecological surgery. For example, in the early stages of ovarian cancer, patients may suffer from abdominal mass, ovarian torsion, and tumor rupture. Therefore, it is important to perform surgical treatments in the early stages of this cancer. A meta-analysis showed that the da Vinci robot has many advantages during surgery, as it allows for the removal of multiple lymph nodes and a low rate of blood transfusion in patients. Therefore, this type of surgical procedure was even safer than laparoscopic surgery[2] (Huang, Zhang, Zhongmin, & Wang,[3] 2016).

The robots that assist surgeons in clinical practice are mainly discrete robots with limited movement. However, in recent years, integrated robots with flexible structures have been emerging, gradually replacing discrete robots with the characteristics of flexible bending and good environmental adaptation. Integrated robots are expected to become the mainstay of surgical arm in the future. (Sun et al.[4] 2010).

Although intelligent robots are widely used in the field of orthopedics, they still have disadvantages such as high cost, large size, and limited application scope (Gu and Gu, 2018). With the continuous advancement of medical technology and artificial intelligence, intelligent robots are being developed to gradually adapt to the development of future surgeries (Wu, Zhao, Bai, & Li, 2019).

2.3 Image Processing

Image processing is a technology for recognizing and analyzing images through computers. It is an important technology in the field of digital artificial intelligence and object recognition. (Zhang et al., 2021). The recognition process includes five steps of input processing, image preprocessing, image extraction, classification, and output generation. This technology can process image data quickly and efficiently. (Masood, Sheng, Li, Hu, Wei, Chin, & Feng,[5] 2018).

For example, a study showed that image mapping technology[6] can more efficiently and accurately identify the femur and trochanter, which are more prone to fracture, than traditional thermal mapping technology.[7] (Fu, Liu, Liu, & Lu,[8] 2019). They found that the distribution area of the fracture line is related to the age and gender of the patients. (Fu et al., 2019).

Image recognition technology has been very important in the diagnosis and treatment of intermass fractures. In addition, it is also used for disease prediction and diagnosis and bone lesion detection. (Liu, Zhang, & Yang,[9] 2018) Currently, image processing technology is applied in many clinical fields. Cervical cancer is one of the four leading causes of death in women. (McGuire,[10] 2016). And it is mostly caused by infection with human papillomavirus.[11] Patients do not experience any obvious symptoms in the early stages.

[1] Chunxiang et al.
[2] Laparoscopic Surgery
[3] Huang, Zhang, Zhongmin & Wang
[4] Sun et al
[5] Masood, Sheng, Li, Hou, Wei, Qin, & Feng
[6] Map Projection Technology
[7] Heat Map Technology
[8] Fu, Liu, Liu, & Lu
[9] Liu, Zhang, & Yang
[10] McGuire
[11] Papillomavirus

Although many treatments are available for patients with cervical cancer, such as surgery, radiotherapy, and chemotherapy, the prognosis of patients depends greatly on the early detection of cancer.

Based on deep learning, intelligent cervical image recognition can help doctors diagnose cervical cancer early with an accuracy rate of approximately 90%. (Hoskins, Kruger, & Yan,[1] 2020). In 2017, a study was conducted to see whether the accuracy of fungal keratitis diagnosis[2] could be improved by using image processing technology. (Wu, Tao, Qiu, Wu,[3] 2018).

The researchers used a method called slit lamp examination[4] , analyzed the experimental data, and finally concluded that the image processing-based diagnosis method had higher specificity and sensitivity in diagnosing fungal keratitis than corneal biopsy. In addition, the image processing method can help doctors with insufficient knowledge to accurately diagnose the disease. Deep learning plays an important role in the application of image processing technology to cancer detection. (Liu et al.2018).

In 2017, a study used convolutional neural networks to detect malignant breast cancer. (Kooi et al.[5] 2017) This method outperformed other advanced computer-aided diagnosis systems because the convolutional neural network had higher detection accuracy. Although image processing technology can help doctors in the clinical diagnosis of diseases, it cannot completely replace the role of doctors. Due to the different equipment used in hospitals, the resolution of the obtained images is also different and can affect the final diagnosis to some extent. (Liu et al. 2018).

We encounter several problems while using image processing technology. For example, in the multilayer neural network, the training model requires a large amount of initial data. In addition, supercomputers with high processing power have not yet become widespread. Therefore, further research is necessary in the future to solve the problems related to hardware devices, optimal algorithms, and technology integration.

2.4 Expert System

An expert system is a computer system that simulates the decision-making ability of experts (Myers,[6] 1986) and, as one of the most successful artificial intelligence software, uses the existing knowledge management system[7] to reason and solve complex problems. (Russell and Norvig,[8] 2003). The development of expert systems can be divided into three periods: the inception period (1965-1971), the maturity period (1972-1977) and the development period (1978). (Kandaswamy and Kumar,[9] 1997)(. In the early 1960s, the first expert system, Dendrall[10], was designed.

[1] Haskins, Kruger, & Yan
[2] Fungal Keratitis
[3] Wu, Tao, Qiu, & Wu
[4] Slit Lamp Microscopy
[5] Kooi et al.
[6] Myers
[7] Knowledge Management System
[8] Russell & Norvig
[9] Kandaswamy & Kumar
[10] Dendral

In 1972, the University of Leeds[1] developed the UpHelp[2] system to aid in the diagnosis of sudden abdominal pain. (Sim et al.[3] 2011) In 1974, the University of Pittsburgh[4] developed the Internist system[5], which was mainly used for the diagnosis of complex diseases in internal medicine.

In 1976, Stanford University[6] developed the Mysin Intelligent Diagnosis System[7] which could be effective in the diagnosis of infectious diseases. However, for reasons such as ethical considerations, it was not used in clinical practice. (Shurtliff and Buchanan,[8] 1975)

A study suggested that the use of personal digital assistants[9] to provide expert knowledge to less experienced trained rescuers could significantly improve the quality of first aid. An evaluation of the findings of this study led to the conclusion that the use of expert systems could improve the quality of first aid to individuals and strengthen the weakest link in the chain of survival. (Ertel and Christ,[10] 2001).

In another study, an expert system was used to diagnose different types of headaches, such as tension headaches, migraine headaches, and medication-induced headaches (Maysles and Wolf,[11] 2008). The computer-aided tool for this assessment, called Chat[12], accurately diagnosed 94.4% of migraine headaches and 93% of common headaches. The average accuracy rate was 98%, Therefore, the introduction of a Chat expert system can help physicians diagnose the type of headache, which is of considerable value in medical care (Maysles and Wolf, 2008).

The expert system has a high ability in clinical decision-making and shows advantages in the field of disease identification and diagnosis. However, it is necessary to increase the accuracy of the system, use the system's data related to the patient's medical history, and integrate it with the physician's clinical experience. In addition, medical knowledge and findings must be constantly updated so that physicians can provide more accurate diagnosis and treatment. (Sheikh Taheri, Sadoughi and Hashemi,[13] 2014)

Conclusion

Artificial intelligence is expected to face greater challenges in the future. In data mining and machine learning, researchers are required to provide a structure to solve the black box problem. Also, the widespread use of fifth-generation mobile communication technology[14], the increase in Internet penetration, and the development of robots connected to the Internet of Things, on the one hand, provide the basis for the growth and development of medical artificial intelligence, and on the other hand, remind us of the need for policymaking in this field. In image processing technology, there is a need to provide a more optimal training model for the participation of doctors in strengthening the rules related to diagnosis.

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[1] University of Leeds
[2] AAPHelp
[3] Sim et al.
[4] University of Pittsburgh
[5] INTERNIST-I
[6] Stanford University
[7] MYCIN
[8] Shortliffe & Buchanan
[9] Personal Digital Assistants (PDA)
[10] Ertl & Christ
[11] Maizels & Wolfe
[12] CHAT
[13] Sheikhtaheri, Sadoughi, & Hashemi
[14] 5G

Also, the expert system must continuously update the knowledge base to provide more complete information to the medical system. In the past decade, significant advances have been made in the field of artificial intelligence. Research institutions in many countries around the world have collaborated extensively to realize these advances.

The volume of research related to artificial intelligence has developed rapidly during this period, as researchers in Asia, Europe, and the United States have achieved significant achievements in this field. Meanwhile, China has attached special importance to this issue and has gradually overtaken others. (Tran et al.[1] 2019) The rapid deployment of the fifth generation mobile communication technology network has made remote collaborative surgery possible, and has increased the stability, reliability, and safety of surgery.

This enables specialists to understand the operation process and patient status in real time and in real time, and thus effectively reduce the risk of surgery. Artificial intelligence has completely changed medical practices, significantly improved the level of medical services, and ensured human health in various aspects.

Given the increasing progress of artificial intelligence technology, a broader development prospect is expected for medical artificial intelligence in the future. This point reveals the need for sound policy-making to guide future research, the targeting and convergence of technology and medical budgets, and the planning of interdisciplinary cooperation.

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[1] Tran et al.

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