Review

The application of artificial intelligence technology in the field of Chinese herbal medicine

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Abstract

Chinese herbal medicine is a precious legacy of traditional Chinese medicine with a long history. With the progress of science and technology, artificial intelligence has emerged as a transformative force. It can replace the role of traditional production line workers, and provide us with more economical solutions, more accurate data, more environmentally friendly products and easier operation. This paper aims to systematically summarize the application of artificial intelligence technology in the research, production and clinical application of traditional Chinese herbal medicine.

Keywords: Chinese herbal medicine; artifical intelligence; application

1 Introduction

Chinese herbal medicine, a precious legacy of Chinese civilization with a history spanning thousands of years, has been developed and refined through the accumulated wisdom of generations. The medicinal components and physical and chemical properties of Chinese herbal medicine have been continuously studied, and people have become more and more aware of the importance of Chinese herbal medicine. In the context of population explosion driven by the development of science and technology, health and longevity have become topics of increasing concern. As public appreciation for traditional culture grows, Chinese herbal medicine is playing an increasingly important role in the field of national health. Therefore, the development of the field of Chinese herbal medicine has gained ever greater attention in China.

Artificial intelligence (AI) refers to the technology and science that simulates, extends or enhances human intelligence by computer systems, aiming to enable machines to imitate human cognitive functions, such as understanding language, recognizing images and solving problems. When machines possess the ability of perception, reasoning, learning, planning, decision-making and even creation, they can do tasks that usually require human intelligence. In recent years, with the progress of science and technology, AI is applied

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in the development of Chinese herbal medicine resources, mining of traditional Chinese medicinal materials, quality control, authenticity identification, origin differentiation, manufacturing, clinical quality control, content determination, mold detection, the discovery of potential mechanisms and the optimization of the industrial chain.

This study aims to systematically review the application of AI in the research, production and clinical practice of traditional Chinese herbal medicine. It seeks to bridge a gap in the literature by elucidating how AI can solve bottleneck issues in this field. Furthermore, the study is designed to promote interdisciplinary research and deepen the integration of AI technology with traditional Chinese herbal medicine. By exploring the connection between AI and traditional Chinese medicine, the research will provide researchers with insights to advance the scientific utilization of medicinal resources. Ultimately, it aims to offer a reference for enterprises and institution, promoting the modernization, standardization, and the globalization of traditional Chinese herbal medicine.

2 Application

2.1 The application of AI in the differentiation of producing areas

Because of soil, climate, moisture and other factors, the contents of internal chemical substances in Chinese medicinal materials produced in different areas are different. In ancient times, people could not identify the geographic origins of medicinal materials, which resulted in the inaccuracy of medicinal effects. At present, AI picture and image recognition models have been widely used. Based on such techniques, exploratory studies on Chinese herbal medicine have been conducted [1]. For example, Zhao suggests that using the ability of AI in image recognition and processing, a fast, simple and low-cost on-site detection method for authentic wolfberry can be developed based on the correlation between its appearance and the geographic origin [2]. Zhao et al. combined deep learning with goji berry recognition. They used a classic convolutional neural network model set for fine-tuning training and then employed an ensemble learning algorithm to enhance recognition accuracy for assisting in goji berry recognition. They collected goji berry samples from places such as Zhongning, Guazhou, and Jingyuan, and trained the model using CNN. After the initial training, the model not only achieved perfect discrimination on the training set, but also attained a 98% discrimination accuracy rate on the external validation set, providing probability values for its predictions. The method of identifying the authenticity of wolfberry through the extraction of fruit appearance features by AI has a much higher accuracy rate than the identification based on component features. For the same variety of wolfberry, the shape of the fruit after drying varies across regions due to climate conditions. Researchers and traders can roughly identify the origin of the product by sight, indicating that geographic traits are reflected in physical appearance. Based on Zhao's research, AI has shown capability of identifying authtentic *Lycium barbarum* based on appearance analysis. In addition, face recognition punch system, fingerprint recognition system and automatic driving system of many units are based on deep learning algorithm. Deep learning is not only applicable to large-scale image data processing, but also demonstrates high accuracy and speed in target identification. Unlike methods that require time-consuming analysis of sample composition or spectral data, it can identify targets using only their visual image.

2.2 The application of AI in drug planting and quality identification

Under the traditional model, the development

and utilization of TCM resources are highly dependent on manual labor and empirical decision-making, which not only leads to low efficiency and high cost, but also causes serious problems such as unstable drug quality and imbalance of market supply and demand. In addition, the promotion and recognition of TCM in the world are also affected [3]. As a product of high technology, high intelligence and high automation, AI can replace manual work and carry out scientific, stable and accurate screening and regulation of Chinese herbal medicine.

In terms of the medicinal material quality identification, Yan et al. divided the students into eight groups through comparative experiments, and each group of students used three plant identification apps to identify at least one hundred medicinal plants [5]. By comparing the recognition rates of the three apps, it was found that the "Xingse" APP had the highest recognition rate. Yan et al. also found that the functions of the three apps and the focus of the identification results were also different, thus proving the feasibility of using apps to replace manual identification of Chinese medicinal materials and quality identification. However, in the process of quality identification of traditional medicinal materials, it mainly relies on the experience of workers to identify the medicinal materials, which requires a lot of practice. This method results in prolonged quality identification, unstable outcomes and even huge differences, which leads to divergence in subsequent production. Such differences are largely irreversible, thereby requiring substantial human and material resources to compensate for the loss [6].

2.3 The application of AI in Chinese herbal medicine manufacturing

In the process of Chinese herbal medicine manufacturing, the manufacturing time and methods play a vital role in the quality of drugs. For example, Guangdong manufacturing method takes 200 g of pure leonuri herbal slices, adds 20 g of 20% brine, 20 g of rice vinegar, 20 g of yellow rice wine, 20 g of ginger juice (20 g of ginger juice diluted with water to 20 g) mixed solution, mixes well after absorption, while Guangxi manufacturing method takes 200 g of net motherwort decoction pieces, adds 20 g of 10% brine, 20 g of rice vinegar, 20 g of rice wine, 20 g of ginger juice (20 g of ginger juice diluted with water to 20 g) mixed solution, mixes well after suction, steam to round steam. The former has less water content and more water-soluble extract in the four-system motherwort obtained by low-temperature drying at 50 ℃ [7]. The introduction of AI technology can select the most suitable manufacturing method for each Chinese herbal medicine, and monitor and adjust the whole process in the manufacturing process, to make the manufacturing process of Chinese herbal medicine more convenient [8]. Different from the traditional manufacturing process where workers often judge the completion of manufacturing and the quality of drugs by looking, tasting and smelling, AI sensory technology uses electronic eyes, electronic tongue and electronic nose to replace workers, making the manufacturing more efficient and accurate [9].

2.4 The application of AI in pharmacokinetics

Pharmacokinetics of Chinese herbal medicine (TCM) is a key branch of TCM pharmacology. It involves a series of processes of Chinese herbal medicine ingredients in the organism, including absorption, distribution, metabolism and excretion [10]. IWATA found that information and communication technologies such as AI and molecular simulation can be used for drug discovery [11]. He developed a computer simulation method that used a probabilistic framework to eliminate the problems of traditional experimental methods. And this method provides a key to understanding

pathways and mechanisms from compounds to phenotypes. In the field of pharmacokinetic analysis, the method is used to predict pharmacokinetic parameters in humans using non-clinical data, which is important for predicting drug efficacy and toxicity in clinical trials. The study of pharmacokinetics of Chinese herbal medicine is helpful to understand the behavior of Chinese herbal medicine components *in vivo*, to better elucidate the material basis of Chinese herbal medicine efficacy, reveal the scientific connotation of the effectiveness and safety of Chinese herbal medicine, develop new Chinese herbal medicine, and improve dosage form and prescription compatibility mechanism. Due to the complex chemical composition of Chinese herbal medicine and its potential interaction with synthetic drugs, traditional experimental methods have the problems of low success rate, long development cycle and high cost. Chinese herbal medicine continues to face complex challenges in pharmacokinetic research [12]. The application of AI has changed drug design and discovery by enhancing target identification, lead drug optimization and toxicity prediction in the pharmaceutical industry.

2.5 The application of AI in the research and development of new drugs

Santos et al. used partial least squares (pls) and artificial neural network (ANN) to conduct computer simulation research in the development of therapeutic drugs for depression, to design new arylpiperazine compounds that can interact with serotonin and predict their biological activity values using PLS and ANN models [13]. Compounds G5 and G7 predicted by PLS model and G3 and G15 predicted by ANN model were found to have the same PLC values as the three highest values of the original set of aromatic piperazine. Therefore, these two models are promising in predicting the biological activities of novel arylpiperazine compounds and may contribute significantly to the design of new drugs for depression treatment. It provides new options for the development of new drugs. AI is expected to be more widely used in the field of Chinese herbal medicine research and development, covering all aspects of Chinese herbal medicine design and discovery. AI can reduce the cycle and cost of drug research and development to a greater extent, and better assist the innovative research and development of Chinese herbal medicine in China [14]. The complexity, diversity and long research and development cycle of Chinese herbal medicine (TCM) lead to uncertainty and instability in the development of new drugs. Therefore, in view of the problems existing in the innovative research and development of Chinese herbal medicine, research on the mode, theory and key technology is an important way to achieve high level and high efficiency of new drug research and development of Chinese herbal medicine [15]. The emergence of AI has opened new avenues for the research and development of Chinese herbal medicine. At present, many AI algorithms have been applied to drug development, such as support vector machine (SVM), artificial neural network and Bayesian algorithm.

2.6 The application of AI in clinical quality control and service of Chinese herbal medicine

Zhao et al. used AI quality control technology, constructed a full amount of electronic source data set of clinical trial subjects in the hospital, established an automatic mining algorithm model and constructed an intelligent comparison algorithm to control the clinical quality of Chinese herbal medicine [16]. At the same time, cost were estimated for both AI quality control and traditional manual quality control methods. 100% source document verification (SDV), researcher folders, drug and other experiment-related materials were

checked. AI quality control increased the demand for computer engineers and reduced the demand for manual quality control. The overall working hours were reduced by 96 compared with manual quality control. The quality control cost was reduced by 34.29%. AI quality control was also applied to 20 projects, all of which were clinical trials of registered anti-tumor drugs, totaling 7,723 aes and 10,935 CM. The AI quality control compared 100% source data of the aes and CM in the EDC database. The results show that the error rate of AE in EDC is 5.08%, the missed negative rate is 7.55%, and the error rate and missed negative rate of CM are 4.82% and 7.36%, respectively. The statistical results showed that there were differences in the number of AE entry errors, AE underreporting situations, CM entry errors, and CM underreporting rates among different clinical trial phases, different sponsors, different administration methods, and different trial design types in the EDC database, but there was no statistical significance ($P > 0.05$). Although manual confirmation was still needed, it saved substantial costs. In addition, Kenta et al. also developed a soft and wearable monitoring device that combines sensors, printable material active pressure adaptation devices and machine learning for real-time, wearable and continuous tissue stiffness monitoring, to prevent and diagnose internal body discomfort, skin diseases and other related diseases [17]. The fact that the instrument could not quantify the hardness index proved the feasibility of the application of AI in clinical research. In recent years, with the gradual improvement of laws and regulations in the pharmaceutical industry, the clinical quality control of Chinese herbal medicine attracted increasing attention from the government, and clinical research is becoming more and more important for Chinese herbal medicine enterprises. However, limited by technological constraints, current clinical research still relies mainly on manual operation, which are often time-consuming, costly, inefficient and inconsistent in quality. The application of AI is expected to address these issues and achieve cost reduction with improved efficiency [18].

3 Discussion and prospect

As an emerging technology, AI has attracted increasing attention for its advanced and innovative capabilities. In the fields of Chinese herbal medicine, AI presents revolutionary potential by shifting the paradigm from traditional experience to data-driven scientific verification and intelligent application. Through deep learning algorithms, it can efficiently analyze the complex action mechanisms of multiple components and multiple targets in traditional Chinese medicine compound prescriptions, accelerating the research and development of new drugs and the study of their mechanisms. Despite these advancements, several challenges remain. These include the immaturity of the technology itself, a shortage of skilled professionals proficient in AI applications, insufficient integration with Chinese herbal medicine production, underdeveloped interdisciplinary frameworks, and the inablitiy to achieve full automation. Therefore, the development and research of AI and Chinese herbal medicine resources still need to be further explored, so as to promote the modernization, intelligent and continuous production and development of Chinese herbal medicine resources.

As a priceless treasure cultivated for thousands of years, Chinese herbal medicine resources must be preserved. It is our responsibility to develop and modernize the resources, present this heritage on the global stage, and demonstrate its potential to a wider audience.

4 Summary

In this paper, the development and applications of AI in the field of Chinese herbal medicine are

reviewed. AI has been widely applied across various dimains including the origin identification, quality evaluation, manufacturing, pharmacokinetic study, research and development of new drugs and clinical quality control and other fields. It enables functions such as target prediction, process analysis, and effectiveness research and optimization, thereby supporting the more comprehensive and modernized development of Chinese herbal medicine research. The rational application of AI in traditional Chinese medicine can greatly enhance the efficiency of research and development. By scientifically verifying the mechanism of compound prescriptions through data analysis, it can achieve precise planting and intelligent diagnosis as well as strict quality control. However, it also faces challenges such as strong reliance on data quality, weak integration with the field of traditional Chinese medicine, difficulty in digitizing tacit knowledge, regulatory lag, and the lack of standardization. In the future, AI will integrate more closely with the research of Chinese herbal medicine resources, and will provide new methods for species identification of Chinese herbal medicine, the research and development of new targets and multi-targets, the mining of more effective ingredients, the exploration of mechanism of action, the optimization of preparation process, and the optimization of the difference of process batch.

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