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A Review of the Application of Artificial Intelligence in the Field of Traditional Chinese Medicine Diagnosis and Treatment

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Abstract. Artificial intelligence (AI) technology has been broadly applied in the area of Traditional Chinese Medicine (TCM) diagnosis and treatment. However, the inherent complexity and multidimensionality of traditional TCM lead to poor data stability and insufficient reproducibility. Additionally, generative AI has issues such as bias, and the verifiability of TCM disease diagnosis and treatment remains low. To address these problems, AI-related technologies have demonstrated their advantages. This paper introduces the development history and current status of these technologies, analyzes their application value and impact in scenarios such as TCM's Four Diagnostic Methods, syndrome differentiation and treatment, TCM R&D, and acupuncture, and discusses future development trends.

Keywords: Artificial Intelligence, large language model, Machine Learning, Deep Learning, Traditional Chinese Medicine Diagnosis and Treatment

1. Introduction

With the rapid development of AI technologies, the modernization and scientific advancement of TCM diagnosis and treatment methods have been promoted to a certain extent. Since traditional TCM diagnosis and treatment methods rely more on the experience and subjective judgment of physicians, it is difficult to achieve standardized application and large-scale promotion. Endowed with powerful and efficient automatic data processing and pattern recognition capabilities, artificial intelligence (AI) can objectively extract and analyze TCM diagnostic information, and has shown great application potential in aspects such as auxiliary syndrome differentiation, optimization of TCM prescriptions, and efficacy prediction.

China's "14th Five-Year Plan" explicitly stipulates that it is important to fully leverage the advantages of AI to promote the modernization of TCM, and use AI large models and precise algorithms to assist in analyzing the complex systematic theories of TCM. According to data from CNKI (China National Knowledge Infrastructure), the number of published articles related to AI and TCM increased from 95 to 169 between 2018 and 2023 [1]. At present, there are a series of related projects including TCMLLM, "Shennong" Large Model, "Zhongjing" Large Model, Huatuo GTP, TCM Pangu Large Model, and "Dayi Jinkui" Large Model [2].

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At the same time, it must be noted that the defects in data stability and reproducibility caused by the complexity and multidimensionality of TCM itself restrict the development of AI in the area of TCM. Meanwhile, generative AI still has problems in TCM scientific research. Firstly, due to its inherent bias towards things, it ignores the essential attributes of things; secondly, the complexity and diversity of TCM disease diagnosis and treatment lead to its low verifiability, resulting in poor data stability and difficulty in reproducibility.

Against this background, researching the application of AI technology in TCM diagnosis and treatment is of great significance. Starting from the perspectives of machine learning, deep learning, and large language models, this paper combines the current practical application status of AI technology in various aspects of TCM diagnosis, TCM treatment, and auxiliary equipment, summarizes the advantages and disadvantages of AI technology at the current stage, makes certain predictions about future development trends, and thus puts forward some feasible suggestions that are helpful to improve the integrated progress of AI and TCM diagnosis and treatment and facilitate the modernization of TCM.

2. Research objects and methods

2.1. Fundamental principles of artificial intelligence technology

2.1.1. Convolutional Neural Network (CNN)

Convolutional Neural Network, commonly referred to as CNN, belong to the family of deep learning models, mainly used for image and speech recognition. As shown in Figure1, it extracts features of input data layer by layer primarily through convolutional layers, pooling layers, and fully connected layers, gradually extracting important features while compressing the amount of information, eliminating redundancy, and enhancing generalization ability.

CNN works in a way that is relatively similar to the working principle of neurons in the human brain. Due to its characteristics such as parameter sharing and local connection, CNN is highly suitable for solving problems related to grid-like data such as images and speech. Compared with ordinary fully connected networks, it has the advantages of fewer parameters and stronger representation ability when processing high-dimensional data. Moreover, it can be applied in both supervised learning and unsupervised learning scenarios.

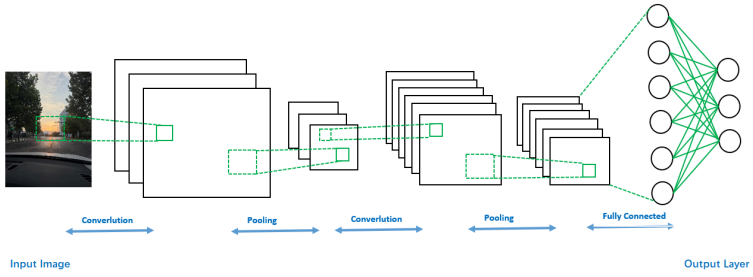

Figure 1. CNN structure

2.1.2. The convolution kernel

The convolution kernel is a key component of a CNN. It is used to retrieve features from images or other types of data. It functions as a sliding small matrix. It can capture local information in a mapping space and form a feature map after isolating the part of the data to be extracted. During the

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training process its parameters are adjusted continuously. Finally, it achieves the optimal solution that meets the requirements of the current task.

2.1.3. Multi-scale Convolutional Neural Network

The multi-scale CNN mainly learns image features of various scales. It enhances the model's accuracy in image recognition and processing under the condition of unchanged scale. In this network, different scales of convolution kernels are set in the convolutional layers. These kernels learn different features in the different scales of image.

2.1.4. Residual Network (ResNet)

As the number of layers in the model increases, vanishing or exploding gradients may occur. To solve this problem, ResNet was proposed. It is common to apply numerous convolutional layers and pooling layers in conventional neural networks, especially in the application of image processing. Since each layer derives features from the one before it, degradation and other issues occur as the number of layers increases. To resolve this, ResNet utilizes a skip connection approach, which helps prevent the set of issues brought about by deep neural networks.

2.1.5. Approximate entropy

The approximate entropy algorithm is a method used to measure the complexity of a sequence. It calculates the approximate entropy based on the approximate probability distribution of a sample dataset. The definition of approximate entropy is as follows: Let X be a random variable where $x \in [0,1]$, and its sample set is $\{x_1, x_2, \ldots, x_n\}$, and m is the number of sub-sequences in this sample set; then the definition of the approximate entropy ApEn(X) is:

$$ApEn(x) = -\sum_{i=1}^{m} p(i|m)\log_2 p(i|m)$$

$p(i|m)$ denotes the probability as the i-th sequence appears in a subsequence of length m.

While the sample dataset is small the approximate entropy algorithm is suitable. By using the number of subsequences in the sample set and the approximate probability distribution of each subsequence, it can calculate the approximate entropy. To make the resulting outcome more accurate., the length of subsequences (m) and the size of the sample set (n) can also be appropriately adjusted according to actual conditions.

2.1.6. Bayesian network model

Bayesian Network is a strong probabilistic graphical model utilized to describe the probabilistic dependency relationships in random variables.

2.1.7. Large language models

Large language models gain knowledge of natural language's patterns and structures through massive unsupervised learning, and they reproduce the cognition and formation of human language.

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These models, which are trained on enormous quantities of text data, can carry out a broad array of tasks, such as text summarization, translation, sentiment analysis, and beyond.

2.2. Sources of literature and analysis methods

2.2.1. Sources of literature

In the topic selection phase, articles in both Chinese and foreign languages were searched on CNKI (China National Knowledge Infrastructure) and Google Scholar to review the development trends of the artificial intelligence (AI) field at home and abroad. Emphasis was placed on searching for core journal papers, doctoral/master's theses, industry conference papers, and national standard documents in the interdisciplinary field of TCM diagnosis and treatment and AI. The "subject term + free term" search method was adopted, with search terms of: Artificial Intelligence; Machine Learning; Deep Learning; Large Language Model; Convolutional Neural Network; Bayesian Network; Traditional Chinese Medicine Diagnosis and Treatment; TCM's Four Diagnostic Methods; Tongue Diagnosis; Pulse Diagnosis; TCM Syndrome Differentiation; Traditional Chinese Medicine R&D; Acupuncture and Moxibustion.

2.2.2. Analysis methods

The "content analysis method" was adopted to analyze how artificial intelligence (AI) integrates into and adapts to the rules and characteristics of TCM diagnosis and treatment. Literature was coded based on the "AI technology type – TCM diagnosis and treatment link" framework. The technology types include Convolutional Neural Network (CNN), Residual Network (ResNet), Bayesian Network, Large Language Model (LLM), Artificial Neural Network (ANN), etc.; the diagnosis and treatment links cover 7 categories: inspection, auscultation-olfaction, inquiry, palpation (the Four Diagnostic Methods of TCM), syndrome differentiation and treatment, TCM R&D, and Acupuncture and Moxibustion. Technical parameters, application cases (e.g., ResNet for coated tongue recognition), advantages, and shortcomings extracted from each dimension were organized into a structured analysis table, which systematically sorted out the applicability of various technologies in TCM diagnosis and treatment. Specifically, the efficiency of multi-scale CNN and ResNet in feature extraction for Tongue Diagnosis, and the compatibility of LLM with TCM thinking in the inquiry link were included in the comparison, serving as sub-field arguments for "the application of AI in TCM diagnosis".

3. Artificial intelligence application in Traditional Chinese Medicine diagnosis

The following summarizes the application of artificial intelligence (AI) technology in the fields of TCM's Four Diagnostic Methods, syndrome differentiation and treatment, TCM R&D, and Acupuncture and Moxibustion from four aspects respectively.

3.1. The four diagnostic methods

3.1.1. Inspection

Inspection in Traditional Chinese Medicine (TCM) refers to a method by which doctors observe the patient's external signs, such as vitality, complexion, physical form, posture, and tongue appearance, to collect information about the patient's condition and thus understand the illness [3].

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In machine learning, deep learning technology possesses strong information processing capabilities and can perform efficient intelligent image analysis, which has advanced the objective diagnosis of tongue appearance in TCM [4]. Scholars such as Wang Li [5] applied artificial intelligence (AI) technologies including AI computational analysis models, machine learning, and multi-scale Convolutional Neural Networks (CNNs) to conduct quantitative and qualitative calculations on tongue appearance. They developed a TCM health status identification system based on AI-powered tongue diagnosis for mobile devices, which can quickly and accurately analyze tongue images uploaded by users to assist TCM diagnosis. Scholars such as Zhong Liqin [6] used the ResNet (Residual Network) deep learning image recognition model for coated tongue recognition, and established a TCM tongue diagnosis dataset for coated tongues. This addresses the issue of false appearances of coated tongues and provides data support for TCM tongue diagnosis research.

3.1.2. Auscultation-olfaction

Unlike structured data such as images and text, voice signals and odor signals are unstructured, time-series data that contain complex physiological information. Processing such information is a key research direction in the field of intelligent healthcare [7].

In traditional TCM auscultation-olfaction (the "listening-smelling" diagnostic method), doctors' diagnostic results are easily influenced by elements like the surroundings, personal experience, and individual perceptions, leading to a lack of unified and quantitative standards. However, AI technologies like machine learning and deep learning can support the objective research of this diagnostic method [8]. Scholars such as Chen Chunfeng [9] effectively identified voice signals corresponding to normal, yin-deficiency, and qi-deficiency syndromes by combining wavelet transform with approximate entropy for support vector analysis, providing an objective basis for comprehensive TCM syndrome differentiation. Scholars such as Jiang Yiliang [10] proposed a method for auscultation-olfaction based on data augmentation, using Convolutional Neural Networks (DACNN) for implementation.

3.1.3. Inquiry

The Zhongjing Traditional Chinese Medicine Large Language Model (CMLM-ZhongJing) applied in the TCM scenario field in Document [11] is modified based on the open-source LLaMA model. With the input of various special context prompts (Prompt templates), the model has acquired stronger professional capabilities, which are mainly reflected in its ability to recognize more TCM prescription data, better understand knowledge reasoning in Chinese semantics, and possess stronger logical thinking, among other capabilities.

Scholars such as Cong Huiyuan [12] established a database containing a large number of real TCM teaching and clinical cases, which is used to train and validate AI models. They also developed a TCM AISP inquiry model and took in a one-group pretest-posttest design method to compare four types of models.

3.1.4. Palpation

Pulse diagnosis is the core content of palpation (one of TCM's Four Diagnostic Methods). Artificial intelligence (AI) technology enables the objectification and quantification of pulse diagnosis through high-precision sensors and signal processing algorithms. AI systems use Bayesian Networks

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to identify human pulse conditions and establish models for classifying pulse parameters [13]. Scholars such as Zhao Guoqing [3] used signal amplitude data from horizontal and vertical sensing units and interpolation algorithms to convert original graphs into target images. They then performed spatial amplitude fitting on the pulse signals at the human radial artery based on the intensity changes of the signals to obtain target source data of the images. Based on this, they developed a portable pulse collector.

3.2. Differentiation of syndrome and treatment

In the part of model optimization, scholars such as Lu An [14] used mHealth (mobile Health) technology combined with AI algorithms to achieve the objectification of TCM syndrome differentiation. They explored how to apply mHealth technology in the process of insomnia screening, diagnosis, treatment, and evaluation, while also optimizing and improving the syndrome differentiation method. Meanwhile, the research results of scholars such as Wang YQ [15] showed that mHealth technology, when integrated with AI algorithms, helps improve the objectivity of TCM syndrome differentiation.

Regarding the syndrome differentiation and diagnosis of vertigo based on a novel interpretable reasoning model for TCM artificial intelligence, scholars such as Jiang Qiyu [16] selected a pre-trained deep learning large language model as the base model. Combined with a large-scale annotated corpus, they constructed a large-scale graph neural network model with strong forward transmission capabilities. Based on this model, they used a scattering backpropagation algorithm to automatically extract abstract representations from large-scale sample data—these representations describe patient characteristics, basic medical knowledge, and doctor explanations—to form a basic case knowledge base that includes symptoms, syndrome classifications, and their conversion rules. On this basis, a new machine learning model was established. Guided by doctors' knowledge reasoning and combined with a variety of auxiliary diagnosis and treatment methods, this model can identify patients' diseases/syndromes and make judgments. Compared with the 5-fold cross-validation of random forests, this model exhibits better predictive performance and possesses strong knowledge reasoning capabilities for TCM syndrome differentiation and diagnosis.

3.3. Traditional Chinese Medicine research and development

Machine learning has led to breakthrough developments in the field of TCM for AI. For example, scholar Wu Wenyu [17] summarized the widespread applications of machine learning in TCM, including quality control, active ingredient screening, drug compatibility, prescription classification, and efficacy prediction. By counting the number of relevant literatures, they concluded that machine learning methods have achieved steady development in the TCM field and have experienced rapid growth in recent years. Scholar Wu Chong [18] proposed a lightweight TCM identification network model based on the attention mechanism (Attention-TCM-Net) and a TCM feature description network model based on the adaptive attention mechanism. Using these two models, he established a new intelligent TCM identification system, which improved the accuracy and effectiveness of TCM identification. Scholars such as Ma Lei [19] used the Artificial Neural Network (ANN) algorithm to build a prediction model for predicting in vitro bacteriostatic rate.

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3.4. Acupuncture and moxibustion

AI technology is used to organically integrate clinical data and biological information to establish an acupuncture efficacy prediction model; deep learning technology can improve the accuracy of acupoint localization [20].

To reliably distinguish the meridian stimulation manipulation movements of TCM acupuncturists, an action recognition method for identifying acupuncture manipulations was established by leveraging the ultra-sensitive characteristics of tactile array finger sleeves, based on existing research on action recognition. The ChongS team [21] proposed the use of tactile array finger sleeves combined with the CatBoost ensemble learning model for basic manipulations such as lifting-thrusting and twirling-rotating. The results showed a maximum validation accuracy of 99.63% and a maximum test accuracy of 92.45%, which can distribute a new research method for the quantitative study of acupuncture manipulations.

As mentioned earlier, most of the existing AI solutions for intelligent acupoint localization are implemented based on the following logic: collection of feature point data from various parts of the human body → manual annotation of training sets → training and output of models → detection and generation of models and feature points → positional correspondence between feature points and acupoints, and finally determination of acupoint localization [22].

Scholars such as Li Zhijun [23] constructed a knowledge graph related to acupuncture treatment by means of the Python programming language and graph database technologies such as Neo4j. This graph presents acupuncture treatment knowledge in a structured and visualized manner, promoting the modernization of acupuncture and its integration with artificial intelligence.

4. Conclusion and outlook

Based on relevant literature in the past few years, it can be observed that artificial intelligence (AI) has penetrated all aspects of the Traditional Chinese Medicine (TCM) diagnosis and treatment field. It has addressed the key challenges of traditional TCM, such as "reliance on experience and subjectivity": the process of the Four Diagnostic Methods has accelerated toward objectification; breakthroughs in intelligent development have been achieved in syndrome differentiation and treatment; a new big data-based system has been established for TCM R&D; and new technological breakthroughs have been made in acupuncture and moxibustion diagnosis and treatment.

Given the current problems of "low-quality and non-sharable data" and "difficulty in clinical implementation," future AI development can achieve further breakthroughs by focusing on areas such as "establishing multi-center standardized datasets and sharing mechanisms" and "promoting clinical translation and application in primary medical institutions." To a certain extent, this will expand the research scope, deepen international cooperation, integrate more fields based on more effective models, and promote technologies such as TCM tongue diagnosis models and acupuncture manipulation quantification to the global stage and the international community. In doing so, the achievements of TCM modernization will be brought to the world, enabling a clearer understanding of TCM globally.

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