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Artificial Intelligence in Tongue Image Recognition

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ABSTRACT

Tongue image recognition is a traditional Chinese medicine diagnosis method, which uses the shape, color, and texture of the tongue to judge the health of the human body. With the rapid development of artificial intelligence technology, the application of artificial intelligence in the field of tongue recognition has been widely considered. Based on the intelligent analysis of tongue diagnosis in traditional Chinese medicine, this paper reviews the application progress of artificial intelligence in tongue image recognition in recent years and analyzes its potential and challenges in this field. Firstly, this paper introduces three steps of tongue image recognition, including tongue image acquisition, tongue image preprocessing, and tongue image feature analysis. The application of traditional methods and artificial intelligence methods in the whole process of tongue image recognition is reviewed, especially the tongue body segmentation, and the advantages and disadvantages of convolutional neural networks are analyzed and compared. Artificial intelligence can use technologies such as deep learning and computer vision to automatically analyze and extract features from tongue images. By constructing a tongue image recognition model, tongue shape, color, texture, and other features can be accurately recognized and quantitatively analyzed. Finally, this paper summarizes the problems existing in artificial intelligence in tongue image recognition and looks forward to the future developmental direction of this field. It can promote the modernization of TCM diagnostic methods, achieve early disease screening and prevention, personalized medicine and treatment optimization, and support medical research and knowledge accumulation. However, there is still a need for further validation and practice, with a focus on patient privacy and data security.

KEYWORDS

AI, Deep Learning, Image Segmentation, Machine Learning, Tongue Diagnosis

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1. INTRODUCTION

In the thousands of years of Chinese history, traditional Chinese medicine has formed its systematic branch of culture. Traditional Chinese medicine believes that the changes in tongue color, coating, and quality can reflect the rise and fall of Qi and blood, the deficiency and reality of viscera, the nature of the disease, and the depth of disease. Tongue diagnosis, as an important dialectical diagnosis and treatment method of traditional Chinese medicine, has been well inherited in China. It is convenient, fast, and low cost, and does not require expensive medical equipment to assist in diagnosis. It is not affected by personal emotions. In the past, the doctor macroscopic observation and the analysis of individual experiences considered patients with illness, but its shortcomings are obvious. Every doctor among individuals vary in medical level and clinical experience. The lack of quantification of tongue diagnosis standard is subject to the influence of environmental factors, such as different light conditions, different viewing angle, etc. To the naked eye, disease recognition accuracy is not high. It also increases the fatigue of individual doctors' vision and other problems, which very easily causes the wrong diagnosis of patients. The consequences of the wrong diagnosis will undoubtedly lead to loss of life and property.

Artificial intelligence (AI) (Xu, 2013) is a discipline that records, accumulates, reproduces, and uses knowledge by simulating human beings. The application of artificial intelligence in tongue diagnosis can overcome the limitation of doctors' observation of tongue images with the naked eye, and realize the precision and digitalization of traditional Chinese medicine (TCM) diagnosis. AI has continuously improved the accuracy of tongue image analysis instruments, and the changes in tongue image are related to diseases. Some tongue images are difficult to distinguish by the naked eye. The comprehensive use of an artificial intelligence system combined with TCM tongue diagnosis can also analyze complex and hidden diseases, reducing the rate of misdiagnosis and miss diagnosis. Therefore, it will be an important modernization development of TCM diagnosis and treatment to make good use of artificial intelligence and establish an intelligent diagnosis and decision support system with TCM characteristics, and to provide a powerful objective basis for the diagnosis, treatment, and prognosis of diseases (Bhatnagar & Bansod, 2022; Wan & Chin, 2021).

Tongue diagnosis based on a machine learning algorithm has been applied to many diseases, such as diabetes (Fan et al., 2021), stomach trouble (Yuan et al., 2023), appendicitis (Pang et al., 2005), etc. (Chung et al., 2022; Lee et al., 2016a; Lo et al., 2015; Park et al., 2022; Wu et al., 2018). Jiang et al. (2012) demonstrated that visual signatures of the microbiome in tongue coatings reflect health status, specifically GI disorders. Han et al. (2016) suggested that tongue diagnosis based on images analyzing tongue features, tongue color, and tongue coating could provide a potential screening and early diagnosis method for cancer. Lo et al. (2013) reported significant differences between breast cancer patients and healthy subjects in tongue characteristics such as the amount of tongue hair in the spleen and stomach region, the largest area covered by tongue coating, thin tongue coating, number of tooth marks, red points, and red points in the spleen and stomach region. In addition, associations of tongue color, tongue coating, and sublingual vessels with risk factors and clinical characteristics in patients with ischemic stroke have been reported (He et al., 2016).

Tongue image processing is a key step in digital tongue diagnosis. It includes image correction, image noise reduction, tongue body segmentation, and tongue coating segmentation (Li et al., 2022). The intellectualized process analysis diagram of tongue diagnosis is shown in Figure 1. Firstly, to determine the acquisition standard in the standard acquisition environment, the use of a digital camera and other shooting equipment to collect tongue images will be transferred to the computer. Secondly, the tongue is labeled. Then the tongue is segmented from the image and the segmented tongue is separated from the moss. Finally, the separated tongue body and tongue coating are classified respectively and an intelligent tongue diagnosis system is formed. To meet the high computational and low latency requirements of edge computing for remote smart tongue diagnostic modeling, Zhang et al. (2021) introduced a similar data transfer strategy to effectively transfer the necessary knowledge

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