• Review Article •

Application prospect of large language model represented by ChatGPT in ophthalmology

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Abstract

● ChatGPT technology based on large language models (LLM) shows great potential in improving the quality of medical care, assisting clinical decision making and optimizing patient communication. The role of ChatGPT in ophthalmology is still in its infancy. This review aims to explore the application prospect of ChatGPT in ophthalmology. Relevant literature was reviewed and analyzed, and the application prospects of LLM represented by ChatGPT in ophthalmology were summarized, including clinical assisted diagnosis, patient education and communication, history collection and text writing, clinical research, and medical education, *etc*. At the same time, the challenges and solutions faced by ChatGPT in ophthalmology were pointed out. Its safety, efficacy and ethics remain controversial in practical applications. Therefore, it is necessary to strengthen the supervision and research on its application to ensure safety and effectiveness. In the future, with the development of technology, ChatGPT is expected to play a greater role in ophthalmology and enhance the medical experience.

● **KEYWORDS:** ChatGPT; large language models; ophthalmology; application prospect

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INTRODUCTION

Large language models (LLMs) are language recognition models built using deep learning methods, with a large number of parameters. These models consist of neural networks that can learn the structure and patterns of human language from a large amount of language data, achieving high-quality language-to-text conversion[1-2]. With the aging population, the number of patients with eye diseases is increasing, and doctors are facing greater pressure. Therefore, the application prospects of LLMs in the medical field are becoming larger. In particular, ChatGPT technology based on LLMs provides better services for ophthalmologists and patients by imitating human language understanding and generation abilities[3]. The purpose of this article is to deepen the understanding of ChatGPT and its potential applications and challenges in the field of ophthalmology.

EVOLUTION OF CHATGPT

ChatGPT is a neural network-based language model that can simulate natural language communication[4]. It started with the GPT-1 model in 2018, which was able to generate articles similar to human writing through large-scale unsupervised training. GPT-1 proved the wide application prospects of artificial intelligence (AI) in the field of natural language processing (NLP)[3].

Subsequently, OpenAI released more advanced models, GPT-2 and GPT-3. Among them, GPT-3 is one of the most advanced dialogue models, with a large parameter size, able to produce more natural and accurate language output[5]. Subsequently, through fine-tuning, GPT-3.5 was developed. It has optimized model parameters, data volume, and training algorithms, providing a more humanized dialogue interaction experience. However, GPT-3.5 requires powerful computational resources and may misunderstand user intentions[6].

In response to the limitations of GPT-3, in 2023, OpenAI developed GPT-4.0[7]. It uses a self-regression approach, learning from large amounts of text data through supervised learning. It captures contextual information through multi-layer attention mechanisms and learns underlying patterns and regularities. It also introduces zero-shot learning capabilities, allowing users to obtain more flexible and personalized answers and solutions through minimal examples or prompts[7].

In recent years, the core breakthrough in LLMs lies in the paradigm shift from unimodal text processing to multimodal synergy. Representative next-generation models such as

GPT-4V and Gemini Pro have demonstrated the capability to integrate images, structured data, and textual information, achieving cross-modal semantic understanding and reasoning[8]. In the field of ophthalmology, this advancement has significantly enhanced the clinical utility of AI. For example, Choi *et al*'s[9] system integrates corneal topography, biomechanics, and medical history to automatically assess laser surgery safety and predict contraindications, outperforming conventional machine learning (ML) models. Furthermore, multimodal LLMs exhibit autonomous tool-use capabilities, such as directly parsing images to generate structured reports or invoking external code to execute disease risk prediction algorithms, substantially reducing manual intervention[10]. These capabilities not only optimize clinical workflows but also provide more comprehensive data support for personalized medical decision-making, marking the evolution of LLMs from "conversational assistants" to "multimodal medical agents".

RETRIEVE LITERATURE

We conducted a literature search in MEDLINE (PubMed) and Scopus, prioritizing studies published between 2018 (the year of GPT-1's release) and 2025 to ensure relevance to the latest developments in LLMs. Studies were included if they were clinical trials, case studies, systematic reviews, meta-analyses, or original research explicitly discussing the application of ChatGPT or LLMs in ophthalmology. Exclusion criteria encompassed studies with low-quality evidence (*e.g.*, small sample sizes, non-peer-reviewed publications, or methodologically weak designs) as well as research on AI technologies unrelated to LLMs or ophthalmology. The search strategy combined terms such as "ChatGPT AND ophthalmology", "large language models AND eye diseases", "artificial intelligence in ophthalmic diagnosis", "ChatGPT AND doctor-patient communication in ophthalmology", and "multimodal LLMs ophthalmology". The screening process involved an initial title/abstract review to exclude non-relevant studies, followed by full-text assessment of eligible articles. Two independent reviewers performed the screening, with discrepancies resolved through discussion or consultation with a third reviewer to ensure consistency.

APPLICATION PROSPECT OF LLMS REPRESENTED BY CHATGPT IN OPHTHALMOLOGY

Clinical Auxiliary Diagnosis Ophthalmic diagnosis requires doctors to comprehensively consider the patient's condition and personal judgment, but cognitive biases may lead to misdiagnosis. AI-based diagnostic assistance systems provide doctors with strong clinical decision-making support to help them make more accurate clinical decisions[11]. ChatGPT can assist clinical diagnosis based on evidence-based medicine's patient/problem, intervention, comparison, and outcome (PICO)[12]. ChatGPT has the permission to access patients' medical records and case data, and can analyze these data to provide possible diagnoses and further examination recommendations[13-14]. Madadi *et al*[15] conducted a study in which they used ChatGPT v3.5 and ChatGPT Plus v4.0 to diagnose 22 cases of neurological eye diseases, comparing the results with the diagnosis of two neuro-ophthalmologists. The results showed that the accuracy of ChatGPT Plus v4.0 and the two neuro-ophthalmologists was close to 80%, indicating a high level of accuracy and potential as a clinical auxiliary diagnostic tool. In addition, Rojas-Carabali *et al*[16] also showed that ChatGPT has good diagnostic capabilities in uveitis cases, and most experts express great confidence in its potential as a clinical auxiliary diagnostic tool.

At present, most ophthalmic diagnoses rely on imaging examinations, mainly because imaging examinations can provide more intuitive and accurate information on the structure and function of the eye, which is of great significance for the diagnosis and treatment of eye diseases. Ma *et al*[8] developed and evaluated ChatGPT-powered Intelligent Ophthalmic Multimodal Interactive Diagnostic System (IOMIDS), integrating text-based interactions with ocular images (slit-lamp/smartphone-captured) for disease diagnosis and triage. They constructed a text model and three multimodal models, validated through a two-stage study involving 15 640 clinical data entries. Results demonstrated that the text+smartphone model achieved the highest diagnostic accuracy (internal: 79.6%; external: 81.1%), significantly outperforming the unimodal text model, particularly for anterior segment diseases like cataracts. The study concludes that IOMIDS serves as an effective auxiliary tool to enhance primary care efficiency.

ChatGPT can understand and analyze complex ophthalmic disease symptoms through deep learning of a large amount of ophthalmic case data, providing valuable diagnostic reference for doctors. Its powerful NLP ability enables it to understand and parse patients' subjective descriptions. Crucially, the multimodal approach enables AI systems to combine visual evidence with textual medical knowledge and patient history, significantly improving the accuracy of diagnosis of eye disease. However, despite ChatGPT's significant advantages in diagnosis, it cannot replace the professional judgment of doctors[17]. Therefore, in practical applications, ChatGPT should be regarded as an auxiliary tool, which can improve the accuracy and efficiency of diagnosis by combining with doctors' experience and expertise.

Patient Education and Communication In ophthalmic treatment, patient education and communication are crucial. Traditional education methods have limitations and cannot meet individual patient needs. ChatGPT can understand

patients' specific questions and needs through NLP technology, providing targeted answers and suggestions[18]. This approach can help patients increase their awareness of their own diseases, enhance their self-management ability and preventative awareness, relieve communication barriers between doctors and patients, and improve patient satisfaction and trust. It is expected to provide more convenient, efficient, and personalized education services for patients[19].

The most important aspect of using ChatGPT for patient education and communication is to verify whether ChatGPT can accurately provide disease-related information. Potapenko *et al*[20] conducted a study to evaluate the accuracy of ChatGPT in providing information on retinal diseases. A total of 100 responses were obtained to a series of questions about five common retinal diseases. Of the 100 responses evaluated, most were accurate, but a few were marked as containing misleading or potentially harmful errors. The results indicate that ChatGPT provides highly accurate general information, disease prevention information, prognostic information, and treatment options. In addition, the study by Grünebaum *et al*[21] found that ChatGPT was valuable for users seeking initial information, as the answers are usually convincing and informative, and do not contain a significant amount of errors or misinformation. However, a major drawback is that the training model's data is not easily updated.

ChatGPT can provide patients with accurate disease-related knowledge, including prevention, prognosis, and treatment options. In the field of ophthalmology, it has a wide range of application prospects. It can understand and respond to patient questions, provide personalized educational content, help patients better understand their condition and treatment options, and also reduce doctor stress[22]. It can also improve communication efficiency and satisfaction. However, it cannot replace real communication and requires continuous updating and improvement of knowledge bases and algorithms.

Medical History Collection and Text Writing With the increasing number of ophthalmic patients, clinical history collection and text writing account for a significant proportion of ophthalmologists' daily work. Doctors may spend up to 35% of their working time writing and reviewing patients' medical records[23]. Clinical history collection and text writing not only increase doctors' work burden, but also may lead to excessive fatigue, increased cognitive load, anxiety and other adverse states[24-25]. Therefore, automating clinical history collection and text writing is of great significance for reducing doctors' work burden. Combined with speech recognition technology, ChatGPT can not only engage in dialogue with patients to collect relevant medical history, but also has the potential to automate the writing of all clinical texts required for the entire diagnosis and treatment process, thereby greatly reducing doctors' work burden.

Singh *et al*[26] studied the ability of ChatGPT in constructing discharge summaries and surgical records in ophthalmology. They found that ChatGPT performed well, but needed adjustment and verification. ChatGPT can quickly generate content and acknowledge and correct errors. After targeted training and manual verification, it is expected to have a positive impact on healthcare. In addition, Chintagunta *et al*[27] utilized the output variability of ChatGPT-3 to make it an effective method for generating discharge summaries. The research showed that ChatGPT-3 can automatically write discharge summaries in a few seconds and has strong ability of automatic discharge summary writing.

ChatGPT has great application potential in the collection of medical history and writing. Its core technology is contextual learning ability[28]. By constructing task description and examples, the model can learn new tasks and give satisfactory answers, thus improving small sample learning ability. ChatGPT helps doctors quickly obtain patients' medical history, improve diagnosis and treatment efficiency, and generate high-quality ophthalmic diagnosis records and medical records, reducing doctors' workload and improving medical quality. However, ChatGPT has limitations in dealing with complex cases and rare diseases, and needs doctors to verify and adjust.

Clinical Research Clinical research is crucial for the progress of ophthalmic medicine and improvement of patient treatment. With the rapid development of AI technology, models like ChatGPT are changing every aspect of our lives, especially in clinical research. ChatGPT can respond to human instructions, simplify reports, assist in the automated reading and knowledge extraction of medical literature, as well as aid researchers in experimental design and data analysis[29-30].

Medical authors can use ChatGPT to quickly generate drafts, improve writing efficiency, and provide powerful support for medical research[31]. Abuyaman[32] found that GPT-4 had advantages in scientific writing, such as editing language and writing abstracts, but it needs to be used cautiously. ChatGPT is also used to simplify radiology reports. In the study by Jeblick *et al*[33], most doctors believed that the simplified reports were accurate and complete, harmless to patients, and helped researchers quickly understand the main points of the literature. Additionally, ChatGPT provides reference suggestions for experimental design and data analysis[34]. In the experimental design stage, ChatGPT helps to determine the purpose, select methods, consider sample sizes, and formulate scientific plans. In the data analysis phase, ChatGPT provides statistical method suggestions, helps to correctly interpret data, and discovers patterns and significance. At the same time,

ChatGPT helps to better understand and interpret experimental results, pointing out the reliability, significance, and practical application value of the data.

ChatGPT has a broad application prospect in ophthalmology clinical research, providing doctors with powerful auxiliary tools, improving research efficiency, saving time and energy, and providing strong support for scientific research. Although ChatGPT has many potential benefits, it cannot currently fully replace doctors' professional judgment and experience. With technological advancements and applications, ChatGPT is expected to play a greater role and promote rapid scientific research development.

Medical Education As a leader in the field of AI, ChatGPT has brought new opportunities for the development of medical education in the field of ophthalmology with its powerful NLP capabilities. In ophthalmology education, it can not only simulate conversations or generate learning resources, but also provide personalized learning experiences based on each student's learning needs and abilities[35].

The accuracy of ChatGPT-generated educational content and users' confidence in the model's output are key to its widespread application. Raimondi *et al*[36] evaluated the performance of LLMs-powered chatbots in Fellowship of Royal College of Ophthalmologists (FRCOphth) exams, showing that they can consistently provide accurate answers, with an accuracy rate as high as 82.9%, regardless of the topic or difficulty of the questions. In addition, Cai *et al*[37] evaluated the ability of ChatGPT-4.0 and Bing Chat to answer ophthalmology-themed questions, finding that their accuracy rates were 71.6% and 71.2%, respectively, compared to an average accuracy rate of 72.2% for human respondents. Similarly, Taloni *et al*[38] compared the performance of GPT-4.0, GPT-3.5, and humans in answering questions in the American Academy of Ophthalmology's (AAO) Basic and Clinical Science Course (BCSC) self-assessment program, finding that GPT-4.0 had the highest accuracy rate of 82.4%, followed by humans (75.7%) and GPT-3.5 (65.9%). These studies demonstrated that ChatGPT's accuracy in answering ophthalmology-related questions was comparable to or exceeds that of humans, providing evidence for its application in ophthalmic medical education and confirming the accuracy of its educational content generation.

ChatGPT has personalized learning capabilities, able to tailor the learning experience to the needs and abilities of each student, enhancing efficiency and self-learning ability. ChatGPT is well-suited as an auxiliary tool in medical schools and has the potential to impact ophthalmic medical education. For non-professionals in ophthalmic teaching, such as general practitioners, ChatGPT has also shown exceptional talent[6]. ChatGPT will transform the knowledge boundaries and methods of ophthalmic medical education, reshaping the entire industry.

Risk Assessment of Ophthalmic Surgery and Diseases Under Multimodal LLMs Multimodal LLMs integrate text, images, and clinical data, significantly enhancing the precision and efficiency of ophthalmic diagnosis and treatment. In the risk assessment of ophthalmic surgery and diseases, their capabilities for automated computation, cross-modal analysis, and personalized prediction provide efficient support for clinical decision-making, while also optimizing surgical safety and early intervention strategies[8-10].

Regarding the application of multimodal LLMs in ophthalmic surgery, Choi *et al*[9] used ChatGPT-4 to analyze multimodal information such as corneal topography and refractive data in laser vision correction surgery. They automatically calculated key safety indicators (such as residual stromal bed thickness and percentage of tissue ablation) and generated a no-code calculator. The diagnostic performance of this tool [area under the curve (AUC)=0.977] was significantly better than that of traditional ML models and manual calculations. In terms of disease risk assessment, multimodal LLMs can build predictive models by integrating demographic and laboratory data. Choi and Yoo[10] developed a glaucoma risk scoring system using ChatGPT-4. They generated a no-code calculation tool through logistic regression analysis, with a predictive performance (AUC=0.639) comparable to ML algorithms. Based on key factors such as age, hypertension, and liver function, this system provides a convenient tool for primary healthcare screening, especially in resource-limited settings.

Despite the excellent performance of multimodal LLMs in ophthalmic applications, their limitations must be noted. For example, the models may generate "hallucinations" due to insufficient training data or ambiguous instructions, and they may also have relatively long computation times. In the future, it is necessary to further optimize the professionalism and real-time performance of the models and verify their clinical value through prospective studies. Overall, multimodal LLMs provide efficient and personalized auxiliary tools for ophthalmic surgery planning and disease risk assessment. However, their application still needs to be combined with the judgment of professional doctors to ensure safety and effectiveness.

CHALLENGES AND SOLUTIONS FOR USING CHATGPT

Although ChatGPT may bring extensive benefits to the ophthalmology field in many aspects, its widespread application and promotion still face many challenges[39].

Interpretability and Transparency The decision-making process of ChatGPT is obtained by training the deep learning neural network based on a large amount of data. Due to its "black box" nature, the decision-making process is not

intuitive, making it difficult for people to understand the reasons for its specific decisions[40]. This poses a significant challenge for the medical field, which requires explicit explanations and transparency. Specifically, if ChatGPT gives a certain result in the diagnosis of ophthalmic diseases, doctors and patients may have difficulty understanding why it made such a decision. The lack of interpretability and transparency may reduce people's trust in ChatGPT. Additionally, if ChatGPT's decisions are inconsistent with a doctor's judgment, it can be difficult to determine who is more accurate, which may mislead doctors and cause significant controversy in the ophthalmic medical process.

To increase the interpretability and transparency of ChatGPT in the medical field, we need to gain a deeper understanding of its internal workings. Visualization tools, decision trees, and other tools can be used to help people understand ChatGPT's decision-making process. At the same time, it is necessary to introduce third-party regulatory agencies or experts to evaluate and validate ChatGPT's decision-making process. In addition, experts suggest using a step-by-step thinking approach known as the Chain-of-Thought (CoT) to guide chatbots to demonstrate their reasoning process while providing answers. Experts have evaluated the CoT explanations generated by models for medical question-answering tasks and found that most answers exhibit good reasoning and in-depth understanding[41].

Produce Inaccurate Results ChatGPT may produce inaccurate results in applications, which is called "hallucination"[42]. When facing specific topics, it may give wrong answers due to insufficient depth and inaccurate details in the database[43]. Although the model performs well in ophthalmology exams, it may still produce incorrect responses when facing the diversity and complexity of diseases[36-37]. Although the model performs well in ophthalmology exams, it may still produce incorrect responses when facing the diversity and complexity of diseases. ChatGPT mainly obtains knowledge from the internet and does not fully understand professional knowledge, but imitates general cognition. Data from different sources may have differences and uncertainties[44]. It is not designed for complex tasks, and its ability to grasp anatomy, physiology, and diseases of the eye is still insufficient. When users input clear or wrong questions, ChatGPT may give inaccurate answers because its training data is limited and its decisions are based on statistics rather than expert logic[45].

To ensure that ChatGPT provides more accurate and professional ophthalmic data, high-quality ophthalmic data needs to be collected for training. It is necessary to clean and deduplicate the data to ensure accuracy and consistency, and reduce the input of incorrect information. Additionally, a user feedback mechanism should be introduced to optimize the training data and model parameters. With the development of the ophthalmic field, it is necessary to regularly update and optimize ChatGPT's training data to ensure it remains in its optimal state. Through these improvement methods, significant reductions in output errors and increases in data accuracy can be achieved.

Data Privacy and Security With the frequent use of ChatGPT, data security issues are increasingly attracting attention. In the field of ophthalmology, when using ChatGPT to train models, it may involve patient privacy data such as ocular conditions and examination records, *etc*. Under multimodal LLMs, the combined use of image and text data may aggravate the problem of privacy disclosure and cause serious consequences for patients. Since the development and application of ChatGPT, OpenAI has temporarily taken it offline due to errors that caused user chat records to be leaked[46]. Samsung employees have also received warnings for using ChatGPT because they may accidentally disclose sensitive company information[47].

To protect patient data privacy and security, the following measures should be taken: encrypting ophthalmic data, storing it in a secure environment, and taking physical and logical security measures; implementing strict access controls and authentication mechanisms; anonymizing and pseudonymizing the data; complying with relevant regulations and policies, such as the European General Data Protection Regulation; and implementing internal auditing and monitoring mechanisms to monitor and review the use of ChatGPT.

Ethical and Social Issues In the field of ophthalmology, while ChatGPT and other large models are powerful, ethical and social issues cannot be ignored. Firstly, patient data may be disclosed or misused, harming the interests of certain groups. Additionally, ChatGPT cannot fully replace doctors, as misdiagnoses can cause serious harm. Furthermore, the legal and regulatory frameworks are inadequate, leading to a lack of legal basis for disputes[48].

To address ethical and social issues, comprehensive measures are necessary, including strengthening data privacy protection, limiting access rights, and ensuring legal collection and use. To reduce the risk of misdiagnosis, establish a multi-level diagnosis system, regularly optimize the ChatGPT model, and conduct professional reviews and validation of outputs. Improve the legal and regulatory framework, formulate clear laws and policies, establish independent ethical review institutions or unified standards to standardize industry guidelines. Increase ethical awareness education, establish multi-party participation mechanisms, and continuously monitor and evaluate. Establish effective feedback mechanisms to collect and address feedback from all parties in a timely manner, and optimize ChatGPT applications. Through these

methods, ethical and social challenges can be effectively addressed to promote healthy and sustainable technological development.

CONCLUSIONS

In ophthalmology, LLMs like ChatGPT have evolved from "text agents" to "multimodal clinical assistants". By integrating text, imaging, and clinical data, these models have significantly improved the accuracy of disease diagnosis, surgical planning, and risk assessment while providing clinical decision support through real-time image analysis. Although AI technology is advancing rapidly, its role as an assistive tool must be emphasized—it cannot replace physicians' professional judgment. Future efforts should focus on strengthening regulation, improving transparency, and ensuring safety through clinical validation. Looking ahead, the integration of multimodal LLMs with robotic surgical systems will advance precision surgery, while their application in real-time imaging analysis for emergency ophthalmology will become a key research area, potentially significantly reducing critical treatment windows for urgent eye conditions.

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