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Application of Large Language Models in the Field of Neurosurgery: Current Status and Prospects

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Abstract: *In recent years, the potential applications of Large Language Models (LLMs) in the medical field have become increasingly evident, particularly in the complex and precise domain of neurosurgery. This review provides an overview of the current use of LLMs in neurosurgery, emphasizing their roles in clinical decision-making, education and training, and scientific research. Firstly, LLMs contribute to the automatic generation and interpretation of neuroimaging reports, assist in developing surgical plans, facilitate risk assessments, and support patient follow-up management. These applications enhance clinical efficiency and improve the quality of decision-making. Secondly, LLMs play a pivotal role in neurosurgical education and training, including the construction of knowledge bases, case simulations, ongoing education, and the development of surgical skills. In conclusion, the diverse applications of LLMs in neurosurgery not only improve the efficiency of clinical practice but also offer new opportunities for research innovation within the field.*

Keywords: *Large Language Models; Neurosurgery; Clinical Decision Support; Education and Training; Research Innovation*

1. Introduction

In recent years, with the rapid development of AI technology, Large Language Models (LLMs) are driving innovation and change in various industries at an astonishing rate with their powerful natural language processing capabilities. The healthcare industry shoulders a major mission as a key field concerned with human life and health and dedicated to improving patients' health and well-being [1]. In this context, the introduction of LLMs has become a key force in enhancing healthcare efficiency, optimizing patient experience, and driving research innovation [2].

Specifically, LLMs with speech recognition, medical text analysis, medical record management, accurate diagnosis and other applications, help healthcare workers to reduce workload and improve the quality of diagnosis and treatment, and at the same time provide more powerful data support and reasoning ability for medical research [3-6].This paper focuses on the application of in the field of neurosurgery, and analyzes how it can assist doctors by means of intelligent technology LLMs in clinical decision-making, optimize patients' personalized treatment plans, accelerate research results the translation of , and thus help neurosurgery the field of enter a new era of efficient and precise medical services.

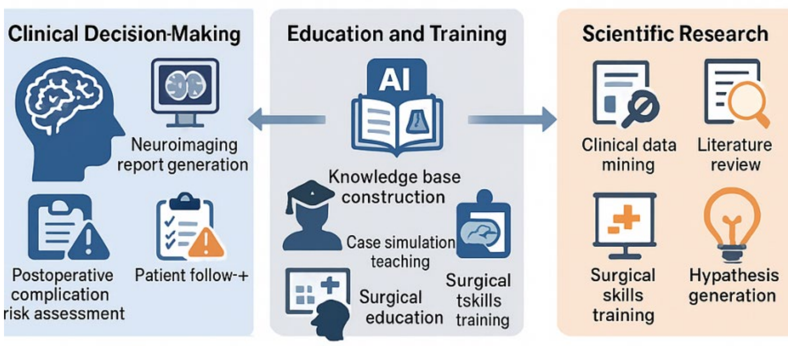

Figure 1: Application of LLMs in Neurosurgery

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2. LLMs to aid clinical decision making in neurosurgery

2.1 Automated generation and interpretation of neuroimaging reports based on LLMs

Automatic generation and interpretation of neuroimaging reports based on LLMs is an emerging research direction in recent years, aiming to utilize the powerful natural language processing capabilities of LLMs to automatically generate neuroimaging reports and assist physicians in their interpretation, thereby improving diagnostic efficiency and accuracy [7]. Traditional image reports rely on the expertise and experience of radiologists, which is time-consuming and susceptible to subjective factors. And the introduction of LLMs is expected to solve these problems. For example, Zhong et al. proposed the ChatRadio-Valuer model, which is based on LLMs, trained with supervised fine-tuning on radiological reports from a single institution, and is able to adapt to clinical-grade events from six different institutions for disease diagnosis tasks covering multiple systems such as the chest, abdomen, musculoskeletal, head, and maxillofacial neck. The model consistently outperforms state-of-the-art models, including ChatGPT (GPT-3.5-Turbo) and GPT-4, among others, in radiological reporting diagnosis [8]. In addition, Li et al. proposed a cue-guided method based on pre-trained LLMs for generating structured chest X-ray reports. The method first identifies anatomical regions in chest radiographs and generates sentences centered on key visual elements to build the basis of a structured report. The detected anatomical structures are then converted into textual cues that guide LLMs to generate reports tailored to specific anatomical regions and clinical contexts [9]. These studies show that LLMs have great potential for automated neuroimaging report generation, generating more accurate and structured reports and providing valuable supporting information to clinicians.

However, LLMs still face some challenges in automating the generation and interpretation of neuroimaging reports. For example, how to ensure the accuracy and reliability of reports generated by LLMs, prevent the occurrence ofat "phantom" phenomenon, and how to cope with the complexity and diversity of medical imaging data are urgent issues [10]. In addition, how to integrate LLMs with existing medical imaging systems and how to protect patients' privacy are also issues to be considered. However, in view of the continuous advancement of LLMs technology and the in-depth advancement of related research, the automatic generation and interpretation of neuroimaging reports based on LLMs will most likely become a key aspect of in clinical practicethe field of neurosurgery in the future.

2.2 LLMs in neurosurgical surgical programming

The application of LLMs in neurosurgical surgical protocol development is gradually showing its potential. LLMs are able to process huge amounts of medical literature, clinical guidelines, and patient data, which help doctors develop more personalized and precise surgical protocols for their patients [11]. For example, LLMs can analyze a patient's imaging data, medical history, and clinical presentation to predict the risk of surgery and provide doctors with recommendations for multiple surgical options. Miragall et al. point out that Artificial Intelligence (AI) is able to analyze complex medical imaging data to support surgeons to conduct preoperative evaluations and perform "virtual" surgeries. "virtual" surgery and develop personalized treatment strategies [12]. In addition, LLMs can assist surgeons in intraoperative decision making, e.g., by providing real-time feedback and guidance to the surgeon to improve the accuracy of the surgery and reduce the incidence of complications. Sun et al. have shown that the application of Virtual Reality (VR) and Augmented Reality (AR) technologies in hip surgery has great potential, particularly in surgical simulation, training, and can assist orthopedic surgeons to perform surgery more accurately and safely [13]. The combination of these technologies with LLMs is expected to further enhance the intelligence of surgical programming.

However, the use of LLMs in surgical programming is still in its early stages and faces a number of challenges. For example, how to ensure the accuracy, reliability, and ethical compliance of LLMs and how to effectively integrate the output of LLMs into clinical workflow are challenges that need to be explored in depth and resolved . In addition, the training of LLMs requires a large amount of labeled data, while medical data is often private and sensitive, how to protect patient privacy is also an important consideration. Nevertheless, with the technology continued breakthroughs and research progressively deepened, the future of is promising. LLMs in neurosurgery program, which is expected to bring better treatment results for patients.

2.3 Risk assessment of complications after neurosurgery assisted by LLMs

LLMs have also shown great potential in the risk assessment of postoperative complications in

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neurosurgery. While traditional postoperative risk assessment methods often rely on clinicians' experience and limited patient data, LLMs can more accurately predict a patient's risk of postoperative complications by analyzing a large number of patient charts, surgical records, and imaging data. For example, Pfitzner et al. used a machine learning model to analyze perioperative data of pancreatic surgery patients to predict the occurrence of patient death and specific serious complications, and their model's Area Under the Precision-Recall Curve (AUPRC) in predicting these two aspects reached respectively 0.51 and 0.53 [14]. Although the study was not directly targeted at neurosurgery, the methodology and results suggest the feasibility of risk prediction models based on machine learning and large amounts of data for postoperative complication assessment. In addition, the study by Fritz et al. also emphasized the role of machine learning in the prediction of postoperative complications and suggested that machine learning-assisted risk assessment in a telemedicine setting could improve the accuracy of clinicians in predicting postoperative complications [15].

LLMs not only allow for risk prediction, but also help physicians identify high-risk patients so that they can take more proactive preventive measures. By analyzing a patient's past medical history, surgical details and intraoperative monitoring data, LLMs can provide physicians with a personalized risk assessment report with appropriate intervention recommendations. For example, Taha et al. noted that applications of AI in healthcare include predicting perioperative risks, detecting intraoperative events, and identifying postoperative complications, leading to early intervention [16]. Although this study focuses on anesthesia practice, the emphasis behind it on the role of AI technology in risk assessment and early intervention is equally applicable to the field of neurosurgery. In the future, with the continuous development and improvement of LLMs technology, its application in risk assessment of postoperative complications in neurosurgery will be more extensive and in-depth, and it is expected to significantly improve the prognosis and survival of patients.

2.4 LLMs in neurosurgical patient follow-up management

The application of LLMs in neurosurgical patient follow-up management has also gradually demonstrated the potential of. LLMs are able to analyze a patient's electronic medical record, surgical record and follow-up data, automatically generate a personalized follow-up plan, and dynamically adjust it according to changes in the patient's condition. For example, LLMs can automatically identify a patient's potential risk of complications based on his or her postoperative imaging findings and clinical symptoms, and alert the physician to intervene in a timely manner. In addition, LLMs can assist patients in self-health management, e.g., through the technology of natural language interaction, it can provide patients with post-operative rehabilitation guidance, medication reminder, and follow-up appointments, thus improving the patients' satisfaction with their visits to [17].

In addition, LLMs can assist physicians in remote monitoring during follow-up visits. By analyzing the physiological data, symptom descriptions and lifestyle information uploaded by the patient, LLMs can detect changes in the patient's condition in a timely manner and send early warnings to the doctor. This type of remote monitoring not only improves the efficiency of follow-up visits, but also reduces the number of patient trips to and from the hospital and lowers healthcare costs. For example, in diabetes management, a system based on LLMs can analyze a patient's blood glucose data and lifestyle habits to predict the trend of blood glucose fluctuations and provide personalized dietary and exercise advice to the patient, thus helping him or her to better control his or her blood glucose level [18].

3. The use of the LLMs in neurosurgical education and training

3.1 LLMs to aid in neurosurgical knowledge base construction and maintenance

LLMs also have great application value in the construction and maintenance of knowledge bases in the field of neurosurgery. Traditional knowledge base construction often relies on manual organization and updating, which is not only time-consuming and labor-intensive but also prone to errors. On the other hand, LLMs can automatically extract key information from a large amount of medical literature, clinical guidelines and case reports through natural language processing technology, and store them in a structured way in the knowledge base. For example, LLMs can recognize medical entities (e.g., diseases, drugs, surgical methods) and establish relationships among them to build a comprehensive neurosurgical knowledge graph. In addition, LLMs are capable of automatically updating the content of the knowledge base based on the latest research advances and clinical practice outcomes, ensuring its currency and accuracy. For example, in the field of software engineering, LLMs have been used to optimize processes

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and outcomes by analyzing a large body of literature to build a knowledge base [19]. In the field of food science, researchers have also utilized the pre-trained BioBERT language model, to build a knowledge base of food ingredients [20]. These studies show that LLMs have a wide range of applications in knowledge base construction.

However, there are some challenges in the application of LLMs in knowledge base construction and maintenance. For example, LLMs may create "illusions", i.e., generate information that seems reasonable but is actually inaccurate [21]. Therefore, there is a need to manually review and validate the content generated by LLMs to ensure the quality of the knowledge base. Moreover, if there are deviations in the training data of LLMs, it will lead to less comprehensive or accurate knowledge in certain domains in the knowledge base. To solve these problems, the accuracy and reliability of the information generated by LLMs can be improved by through combining them with external knowledge bases techniques such as Retrieval-Augmented Generation (RAG) [21]. It is also necessary to continuously optimize the training methods of LLMs, to ensure their professionalism and authority.

3.2 Neurosurgical case simulation and teaching based on LLMs

Neurosurgical case simulation and teaching based on LLMs is becoming an emerging direction for education and training in the field of neurosurgery. LLMs are capable of generating realistic case descriptions, including patient histories, examination findings, and imaging data, which provide trainees with rich learning resources. For example, LLMs can generate a wide variety of cases based on different disease types and severity, exposing trainees to a wider range of clinical scenarios. In addition, LLMs can simulate a patient's response to a treatment regimen, helping trainees understand the natural course of a disease and the effects of treatment. Such simulations are not limited to textual descriptions, but can also be combined with VR and AR technologies to create immersive simulation environments where trainees are trained to operate in a virtual operating room. The effectiveness of this type of simulation training was demonstrated by Eagleson et al. who showed that there was a correlation between AR and VR based neurosurgical simulation training and trainee's ability to spatially reason with 3D images [22]. In addition, LLMs can provide personalized feedback and guidance based on trainees' performance to help them acquire knowledge and skills in the field of neurosurgery more quickly. For example, LLMs can analyze a trainee's operations in a simulated surgery, point out their deficiencies, and provide suggestions for improvement. This type of personalized instruction can significantly improve learning efficiency and effectiveness.

At the same time, LLMs can be used in neurosurgical case simulation and teaching not only to provide cases and feedback, but also to assist in building more intelligent teaching systems. In addition, LLMs can be used to create interactive learning platforms that allow trainees to deepen their understanding through questions and discussions. For example, trainees can ask LLMs questions about a case, and LLMs can provide detailed answers based on their knowledge base and reasoning skills. This interactive learning approach can stimulate trainees' interest in learning and improve their learning outcomes.Chan et al. showed that users began to view LLMs as personal assistants or partners rather than just sources of information, which suggests that LLMs have a great potential in the educational domain [23]. Overall, neurosurgical case simulation and teaching based on LLMs has great potential to provide a richer, more personalized, and more effective learning experience.

3.3 LLMs assisted neurosurgery skills training

The application of LLMs in surgical skills training in the field of neurosurgery also has very promising prospects. LLMs can assist in building smarter and more personalized training systems. For example, LLMs can provide trainees with real-time feedback and guidance by analyzing surgical videos and operation data, thus improving the efficiency and quality of training. Varas et al. point out that LLMs have the potential to transcribe, translate, and summarize feedback, which can help trainees better understand their own operations and make improvements [24]. In addition, LLMs can dynamically adjust the content and difficulty of training according to the trainee's learning progress and skill level, enabling personalized instruction.

In addition to providing feedback and personalized instruction, LLMs can assist in creating more realistic surgical simulation environments. For example, LLMs can generate a variety of complex surgical scenarios and cases for trainees to practice over and over again in a virtual environment, thus improving their surgical skills and resilience. Chen et al. developed a realistic Willis ring simulator for training neurosurgeons to perform aneurysm clamping, and LLMs can further enhance the interactivity and feedback mechanisms of such simulators, for example that provide more detailed feedback and guidance by analyzing the trainee's actions [25]. In addition, LLMs can assist in generating linguistic descriptions of surgical operations, providing trainees with more comprehensive learning resources. Wang et al. showed that LLMs can provide linguistic descriptions for video editing, which can also be applied to the analysis and learning of surgical videos [26]. In conclusion, LLMs also have a promising application in neurosurgical surgical skills training, which can help trainees master surgical skills more efficiently and safely.

4. The application of LLMs in neurosurgical research

4.1 LLMs assisted clinical data mining and analysis in neurosurgery

Traditional clinical data analysis often relies on manual extraction and statistical analysis. The emergence of LLMs provides new ways to process and analyze large amounts of clinical data in an automated and efficient manner. For example, LLMs can assist in extracting key clinical information from electronic medical records, such as patient history, surgical records, and imaging reports, and structuring them for subsequent analysis. A study has shown that LLMs can achieve an accuracy of 94%-97% in extracting key information from pathology reports, which greatly improves efficiency and accuracy compared to manual extraction [27].The use of LLMs in clinical data analysis is not limited to the processing of structured data. They can also process unstructured data such as text reports and imaging descriptions, which is particularly important in the field of neurosurgery. For example, LLMs can be used to automate the generation and interpretation of neuroimaging reports, thereby reducing the workload of radiologists and improving the efficiency and accuracy of diagnosis.

In addition, LLMs can be used to analyze patient follow-up records and identify patients who may require further intervention, enabling more effective patient management. For example, LLMs can assist physicians in analyzing a patient's follow-up records and predicting the patient's disease control, which can help physicians make timely adjustments to treatment plans. However, the application of LLMs in clinical data analysis still faces some challenges, such as data privacy protection, interpretability of models, and adaptability to clinical practice, which need to be further addressed in future studies.

4.2 LLMs in neurosurgical research literature review

The application of LLMs in neurosurgical research literature review is gradually showing its advantages. Unlike traditional literature review methods that require a lot of time and effort, LLMs can efficiently analyze a huge amount of research literature through natural language processing technology, quickly distill core information, and generate well-organized review content. For example, Ye et al. proposed a semi-automated LLMs-assisted workflow, which significantly reduces the manual workload in systematic reviews by extracting identifiers, validators, and data fields from the literature , and identified 1.53% of articles missed in manual reviews in a case study [28]. These studies show that LLMs can assist researchers in conducting literature reviews more efficiently, but also emphasize the importance of manual validation to ensure the accuracy and reliability of the review.

LLMs not only speed up the process of literature review, but also help researchers discover new research directions and trends. By analyzing a large amount of literature data, LLMs can identify research hotspots, unsolved problems, and potential innovations in the field of neurosurgery. For example, Roman et al. conducted a systematic review of ChatGPT in neurosurgery, exploring its potential in surgical planning, image recognition, and medical diagnosis, and emphasizing its limitations and the need for manual validation [29]. These studies show that the application of LLMs in literature reviews is not limited to information extraction, but can also help researchers better understand the current state of the field and provide directions for future research.

5. Summary and discussion

LLMs have demonstrated immense potential in the healthcare sector, particularly in the specialized field of neurosurgery. Their applications span various crucial domains, including clinical decision-making, education and training, as well as research and innovation. In the realm of clinical decision-making, LLMs play a pivotal role in the automatic generation and interpretation of neuroimaging reports. This capability holds the promise of significantly enhancing diagnostic efficiency and accuracy, enabling quicker and more precise evaluations of complex imaging data. However, challenges persist, such as the "hallucination" phenomenon, where the model may generate inaccurate or fabricated information, and the inherent complexity of medical data, which still needs to be addressed in order to improve the overall reliability of these models.

Additionally, LLMs are making strides in assisting clinicians in formulating surgical plans. By analyzing vast amounts of medical data, these models offer personalized suggestions tailored to each patient's unique conditions, which could ultimately improve the quality of care. Nevertheless, the accuracy of these suggestions, along with the ethical implications of incorporating AI-driven advice into critical healthcare decisions, remains an area of ongoing research. Ensuring the ethical standards of LLMs in clinical settings is a priority, as their use may have profound implications on patient safety and the overall decision-making process. In postoperative care, LLMs exhibit significant potential in improving patient prognosis and management, particularly in the assessment of postoperative complications and long-term follow-up. By assisting healthcare professionals in identifying potential risks and providing personalized recommendations, these models can enhance the quality of patient care post-surgery and support clinicians in proactive decision-making. When it comes to education and training, LLMs are revolutionizing the way neurosurgeons and medical professionals access and assimilate knowledge. By assisting in the construction and maintenance of an up-to-date neurosurgical knowledge base, these models provide physicians with easy access to relevant information and research, helping them stay informed about the latest advancements. Furthermore, LLM-based case simulations and teaching platforms offer young doctors valuable practice opportunities, enabling them to develop their skills in a controlled, risk-free environment. In the context of continuing medical education, LLMs facilitate ongoing professional development, supporting the advancement of surgical techniques and expertise throughout a physician’s career. In scientific research, LLMs assist in mining and analyzing clinical data, enabling researchers to uncover new patterns and insights that might otherwise be difficult to detect. Their ability to process large volumes of complex data quickly and efficiently presents an opportunity to accelerate the pace of research, leading to innovations and discoveries that could benefit the entire medical community. However, while LLMs show significant promise in research applications, their integration into the field of neurosurgery is still in its early stages, and several challenges remain. Issues such as data privacy, model interpretability, and the establishment of ethical guidelines for their use in clinical and research environments need to be addressed through further study and validation.

Looking toward the future, as LLM technology continues to evolve, its applications within neurosurgery are expected to become even more extensive and integrated. These advancements will not only streamline clinical workflows and enhance patient management, but also foster greater innovation in the field. LLMs have the potential to transform scientific research, leading to breakthroughs that could reshape neurosurgical practices and improve patient outcomes. Future research should focus on resolving the current challenges associated with LLMs, particularly how to ensure the accuracy and reliability of their outputs. Protecting patient privacy remains a top concern, requiring the development of secure protocols for handling sensitive data. Additionally, integrating LLMs effectively into existing clinical and educational systems will be crucial to maximizing their impact and utility. As the field of neurosurgery continues to evolve, the potential applications of LLMs will expand further, with exciting possibilities such as personalized treatment planning and the development of new medical devices. The intersection of LLMs and neurosurgery is not merely a technological revolution—it represents a shift in the very concepts of medicine, bringing about a new era of intelligent, precise, and individualized care. By addressing the existing challenges and continually exploring new applications, LLMs have the potential to revolutionize neurosurgery, improving patient outcomes and propelling the field into a future of greater innovation and excellence.

References

[1] Han P, Li X, Liu S L, et al. Research on Knowledge Service Model in Medical and Health Field Based on Large Language Models[J]. Journal of Xihua University (Philosophy and Social Sciences), 2025, 44(1): 24-35. DOI: 10.12189/j.issn.1672-8505.2025.01.003

[2] Zhao C P, Zhu W G, Zhao F, et al. Research on a Few-shot Medical Named Entity Recognition Method Based on Large Language Models[J]. Chinese Journal of Health Information Management, 2024, 21(6): 902-908,914. DOI: 10.3969/j.issn.1672-5166.2024.06.018

[3] You M L, Cao C Y, Fu W L, et al. Application of Artificial Intelligence in Laboratory Medicine Medical Decision-making System[J]. International Journal of Laboratory Medicine, 2025, 46(1): 1-6. DOI: 10.3969/j.issn.1673-4130.2025.01.001

[4] Zhu Z, Zhou W Q, Lin J, et al. Emergency Management Framework Empowered by Large Language Model Technology[J]. Journal of Command and Control, 2024, 10(6): 677-688. DOI: 10.3969/j.issn.

ISSN 2616-5791 Vol. 6, Issue 6: 1-8, DOI: 10.25236/AJMHS.2025.060601

2096-0204.2024.06.0677

[5] Zhang Z Q, Liu Y, Fan B T, et al. Construction of Hypertension Structured Database Based on Yi-9B Large Language Model[J]. Chongqing Medical, 2025, 54(1): 57-62. DOI: 10.3969/j.issn.1671-8348.2025.01.011

[6] Li G H, Chi R, Sun S W, et al. Application of Large Language Model GPT-4 in the Construction of Smart Psychiatric Hospital[J]. Chinese Modern Doctor, 2024, 62(33): 84-88. DOI: 10.3969/j.issn.1673-9701.2024.33.017

[7] Xu F R, Li B H, Xu S. Research Progress on Sequence Recommendation Based on Deep Learning and Large Language Models[J]. Journal of Computer Science and Exploration, 2025, 19(2): 344-366. DOI: 10.3778/j.issn.1673-9418.2407090

[8] Zhong T, Zhao W, Zhang Y, et al. ChatRadio-valuer: A chat large language model for generalizable radiology report generation based on multi-institution and multi-system data[J/OL]. arXiv preprint: arXiv:2310.05242, 2023. http://arxiv.org/abs/2310.05242.

[9] Li H, Wang H, Sun X, et al. Prompt-guided generation of structured chest X-ray report using a pre-trained LLM[C]//2024 IEEE International Conference on Multimedia and Expo (ICME). Niagara Falls, ON, Canada: IEEE, 2024. DOI: 10.1109/ICME57554.2024.10687707

[10] Mao X Y, Bi B Z, Cao C L, et al. Application of Large Language Model Technology in Pharmaceutical Clinical Research and Development[J]. Chinese Journal of Medicinal Guide, 2024, 26(11): 1093-1097. DOI: 10.3969/j.issn.1009-0959.2024.11.007

[11] Ji X M, Zan H Y, Cui T T, et al. A Survey of Chinese Medical Large Models: Progress, Evaluation and Challenges[J]. Journal of Chinese Information Processing, 2024, 38(11): 1-12. DOI: 10.3969/j.issn. 1003-0077.2024.11.001

[12] Miragall M F, Knoedler S, Kauke-Navarro M, et al. Face the future—Artificial intelligence in oral and maxillofacial surgery[J]. Journal of Clinical Medicine, 2023, 12(21): 6843. DOI: 10. 3390/jcm12216843

[13] Sun P, Zhao Y, Men J, et al. Application of virtual and augmented reality technology in hip surgery: Systematic review[J]. Journal of Medical Internet Research, 2023, 25: e37599. DOI: 10.2196/37599

[14] Pfitzner B, Chromik J, Brabender R, et al. Perioperative risk assessment in pancreatic surgery using machine learning[C]//2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). Mexico: IEEE, 2021: 2211-2214. DOI: 10.1109/EMBC46164. 2021. 9630897

[15] Fritz B, King C, Chen Y, et al. Protocol for the perioperative outcome risk assessment with computer learning enhancement (Periop ORACLE) randomized study[J]. F1000Research, 2022, 11: 653. DOI: 10.12688/f1000research.122286.1

[16] Taha B, Alsharaf Y, Al-Ameer D M. Revolutionizing anesthesia practice with AI-assisted referral management[J]. International Journal of Innovative Research in Medical Science, 2023, 8(11): 508-511. DOI: 10.23958/ijirms/vol08-i11/1781

[17] Li B, Gross O, Crampton N, et al. Beyond the waiting room: Patient's perspectives on the conversational nuances of pre-consultation chatbots[C]//Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems. New York, NY, USA: Association for Computing Machinery, 2024: 1-24. DOI: 10.1145/3613904.3641913

[18] Nicoletta M, Zilich R, Masi D, et al. Overcoming therapeutic inertia in type 2 diabetes: Exploring machine learning-based scenario simulation for improving short-term glycemic control[J]. Machine Learning and Knowledge Extraction, 2024, 6(1): 420-434. DOI: 10.3390/make6010021

[19] Hou X, Zhao Y, Liu Y, et al. Large language models for software engineering: A systematic literature review[J]. ACM Transactions on Software Engineering and Methodology, 2024, 33(8): 220. DOI: 10.1145/3695988

[20] Youn J, Li F, Tagkopoulos I. Semi-automated construction of food composition knowledge base[J/OL]. arXiv preprint: arXiv:2301.11322, 2023. http://arxiv.org/abs/2301.11322.

[21] Eagleson R, Kikinov D, Bilbie L, et al. Clinical trainee performance on task-based AR/VR-guided surgical simulation is correlated with their 3D image spatial reasoning scores[J]. Healthcare Technology Letters, 2024, 11(2-3): 117-125. DOI: 10.1049/htl2.12066

[22] Zhang H, Kotanko P. #1506 Uremic toxicity: Gaining novel insights through AI-driven literature review[J]. Nephrology Dialysis Transplantation, 2024, 39(S1): gfae069-0657-1506. DOI: 10.1093/ndt/gfae069.657

[23] Chan S, Li J, Yao B, et al. "Mango mango, how to let the lettuce dry without a spinner?": Exploring user perceptions of using an LLM-based conversational assistant toward cooking partner[J/OL]. arXiv preprint: arXiv:2310.05853, 2023. http://arxiv.org/abs/2310.05853.

[24] Varas J, Coronel B V, Villagrán I, et al. Innovations in surgical training: Exploring the role of artificial intelligence and large language models (LLM)[J]. Revista do Colégio Brasileiro de Cirurgiões,

ISSN 2616-5791 Vol. 6, Issue 6: 1-8, DOI: 10.25236/AJMHS.2025.060601

2023, 50: e20233605. DOI: 10.1590/0100-6991e-20233605-en

[25] Chen P C, Lin J C, Chiang C H, et al. Engineering additive manufacturing and molding techniques to create lifelike Willis' circle simulators with aneurysms for training neurosurgeons[J]. Polymers, 2020, 12(12): 2901. DOI: 10.3390/polym12122901

[26] Wang B, Li Y, Lv Z, et al. LAVE: LLM-powered agent assistance and language augmentation for video editing[C]//Proceedings of the 29th International Conference on Intelligent User Interfaces. Greenville, SC, USA: ACM, 2024: 699-714. DOI: 10.1145/3640543.3645143

[27] Sun D, Hadjiiski L, Gormley J, et al. Outcome prediction using multi-modal information: Integrating large language model-extracted clinical information and image analysis[J]. Cancers, 2024, 16(13): 2402. DOI: 10.3390/cancers16132402

[28] Ye A, Maiti A, Schmidt M, et al. A hybrid semi-automated workflow for systematic and literature review processes with large language model analysis[J]. Future Internet, 2024, 16(5): 167. DOI: 10.3390/fi16050167

[29] Roman A, Al-Sharif L, Al Gharyani M. The expanding role of ChatGPT (Chat-generative pre-trained transformer) in neurosurgery: A systematic review of literature and conceptual framework[J]. Cureus, 2023, 15(8): e43502. DOI: 10.7759/cureus.43502