EDITORIAL

Opportunities and Challenges of Large Language Models in Medical Imaging

Ali Tarighatnia [1], Masoud Amanzadeh [2*], Mahnaz Hamedan [2], Mahnaz Kiani [3], Nader D. Nader [4]

[1] *Department of Medical Physics, School of Medicine, Ardabil University of Medical Sciences, Ardabil, Iran*

[2] *Department of Health Information Management, School of Medicine, Ardabil University of Medical Sciences, Ardabil, Iran*

[3] *Research Center for Molecular and Cellular Imaging, Tehran University of Medical Sciences, Tehran, Iran*

[4] *Department of Anesthesiology, Jacobs School of Medicine and Biomedical Sciences, University at Buffalo, Buffalo, NY, USA*

*Corresponding Author: Masoud Amanzadeh
Email: M.amanzadeh@arums.ac.ir

Received: 25 December 2024 / Accepted: 15 January 2025

Abstract

Large Language Models (LLMs) have the potential to revolutionize medical imaging by improving diagnostic accuracy, enhancing workflow efficiency, and advancing personalized medicine. However, addressing the challenges related to data privacy, hallucinations, interpretability, bias, and regulatory issues is crucial for the successful and ethical integration of LLMs into clinical practice. Collaboration between radiologists, AI developers, and other stakeholders is essential to ensure this technology benefits patients and healthcare providers.

Keywords: Large Language Models; Medical Imaging; Opportunities; Challenges.

DOI: https://doi.org/10.18502/fbt.v12i2.18267

1. Introduction

Imaging modalities are technology-driven medical specialties that have always been intertwined with computer science, continuously utilizing new technologies to enhance diagnostic accuracy and patient care [1]. Recent advances in Artificial Intelligence (AI), especially deep learning algorithms, are transforming medical imaging modalities [2]. AI has various applications in automating and optimizing radiological workflows, including image processing, image annotation, image segmentation, object detection, and image interpretation [3, 4]. The integration of AI into radiology practices. It transforms medical imaging and improves patient outcomes by optimizing healthcare resource utilization [5].

AI encompasses various branches that emulate human intelligence using computational systems, including machine learning, Natural Language Processing (NLP), computer vision, robotics, and expert systems. These technologies tackle complex challenges in multiple fields, particularly in healthcare, where AI enhances diagnostics, personalizes treatment plans, and streamlines administrative processes [6]. One of the transformative developments in AI is Large Language Models (LLMs), such as OpenAI's ChatGPT-4 and Google's Gemini, which perform exceptionally well in NLP. These models have enabled human-like text comprehension, interpretation, and generation in various fields, including healthcare. Large language models in medical imaging could help tackle major challenges, including the rising workload of radiologists, inconsistencies in diagnostic reports, and the integration of extensive clinical data. The capabilities of these models extend from producing accurate radiology reports to assisting in differential diagnosis and combining clinical histories. In addition, their ability to analyze and summarize scientific articles can help radiologists stay up-to-date with new developments. Although LLMs provide significant advantages in medical imaging, they pose challenges that must be addressed to maximize their potential in radiology. This paper examines the current benefits and challenges of LLMs in this field and future trends. While prior research has explored the broad applications of LLMs in medical science [7], our study specifically focuses on their impact on medical imaging workflows and the challenges of clinical implementation.

2. Applications of LLMs in Medical imaging

Large language models have demonstrated exceptional capabilities in NLP and data analysis, establishing their value in medical imaging. This section explores their primary applications within this domain.

2.1. Report Generation

One of the prominent applications of LLM in medical imaging is the automated generation of diagnostic reports. These models can analyze imaging findings and present them as coherent, detailed, and accurate reports [8]. This feature can reduce the time needed to write reports and prevent human errors. Studies have shown that LLMs can produce reports of similar or even better quality than experienced radiologists [9]. Additionally, the LLMs can suggest structured report templates and transform free-text reports into valid structured reporting. This feature ensures that the report includes all the necessary information [10, 11].

2.2. Clinical Decision Support

Another possible application of LLMs in radiology is their use in clinical decision-making. LLMs can analyze the patient’s data, such as imaging data and medical history, and suggest initial diagnoses, differential diagnoses, and treatment plans. They can also be used as decision-support systems for radiologists, helping them interpret medical images and provide initial assessments [12].

2.3. Integration with Information Systems and Image Analysis Tools

LLMs can be integrated with existing information systems, such as Radiology Information Systems (RIS), helping radiologists retrieve patient data and report more easily and quickly. For instance, they can be connected to Electronic Health Records (EHRs) to extract essential information and integrate it with imaging findings. This integration enables radiologists to comprehensively understand the patient's condition, leading to more accurate diagnosis. In addition, LLMs can be integrated with image analysis tools to assist radiologists in image extraction and interpretation [13].

2.4. Education and Training in Medical Imaging

Large learning models are powerful educational tools for training radiologists, medical students, and patients [14]. They could interact with these models to obtain answers to radiology-related questions. These models can also explain imaging findings, explore differential diagnoses, provide context-specific information for various clinical scenarios, and offer learning resources [15]. In addition, LLMs can simulate real-world cases, offering an interactive and dynamic learning environment that enhances medical education. The results of the studies have shown that LLMs like ChatGPT and Gemini can successfully pass a radiology board-style examination [16, 17].

2.5. Support for Medical Imaging Research

In medical imaging research, LLMs can analyze data and scientific articles to identify new research trends and provide valuable suggestions for future studies. This can help accelerate knowledge generation and improve diagnostic and therapeutic methods. LLMs can assist in retrieving, translating, and summarizing scientific literature on various medical imaging topics [18, 19].

3. Challenges and Ethical Considerations of LLMs in Medical Imaging

Despite LLMs' transformative potential in medical imaging, their adoption and use are accompanied by significant ethical concerns. Addressing these challenges is essential to ensure these models' effective and ethical integration into clinical practice. The following explores the most important challenges of LLM in medical imaging.

3.1. Data Privacy and Security Issues

Large learning models for training require large datasets that include sensitive patient information. Uploading sensitive patient information to LLMs can compromise data privacy and security. Improper management of patient data can lead to confidentiality issues, legal issues, and reduced access [1]. To ensure the secure use of patient data in the LLM, robust data encryption processes and secure storage solutions must be developed.

3.2. Hallucinations

Hallucinations in LLMs occur when they generate fake or artificial information that appears valid. In medical imaging, this problem can be misinterpretations of images, incorrect diagnoses, or fake references, leading to incorrect clinical decisions. Such errors pose serious risks to patient safety, reduce trust in AI systems, and raise ethical and legal concerns. Therefore, addressing hallucinations is critical for the safe and secure use of LLMs in medical imaging. In addition, validation of LLM outputs, primarily when used in patient care, is essential against clinical guidelines and expert opinions [20].

3.3. Lack of Interpretability

Large language models often act as "black boxes," meaning their decision-making process is not easily explained. This lack of transparency becomes problematic in medical settings, where understanding the rationale behind a recommendation or outcome is critical. Radiologists may hesitate to trust these models if they cannot provide clear and understandable reasons for their conclusions. Increasing the explainability of these models is essential to gain trust and widespread acceptance [21].

3.4. Risk of Overconfidence

Overconfidence in LLMs occurs when these models provide incorrect answers with high confidence, which is dangerous in sensitive areas such as radiology. Patients can use LLMs to interpret or understand radiological reports. Although LLMs can make these reports more straightforward and more understandable, there is a risk of overconfidence, as patients are unaware of the output errors and assume that the answers provided are always correct [22].

3.5. Risk of Bias

Like other deep learning models, LLMs are vulnerable to producing incorrect or biased outputs. Errors can occur due to insufficient or unbalanced training data, leading to incomplete analyses or recommendations. Biases in the data can exacerbate disparities, such as underrepresenting specific demographic groups in diagnostic predictions. Even minor errors can have serious consequences in the healthcare domain, so careful validation and monitoring of these models' performance are essential for accuracy and fairness [23].

3.6. Regulatory and Legal Issues

The legal landscape for AI in healthcare is still developing. Due to their novelty and complexity, LLMs often do not fit into existing legal frameworks. Questions about liability in the event of diagnostic errors, clinical use approval processes, and compliance with medical device regulations remain unanswered. Clear legal guidance is needed to ensure these models' safe and effective use in radiology.

3.7. Resistance to Adoption

Healthcare professionals who are unfamiliar with or distrustful of AI technologies may resist the introduction of LLMs into radiology. Problems such as job replacement, loss of autonomy, and overreliance on AI can make it challenging to adopt this technology. Appropriate training emphasizing the complementary role of these models rather than their replacement is necessary to overcome this challenge.

The LLM in medical imaging is promising and exciting. This technology can potentially revolutionize medical imaging by increasing diagnostic accuracy, improving workflow efficiency, and advancing personalized medicine. However, achieving this potential requires addressing technical, ethical, and legal issues. Overcoming these barriers requires collaboration between radiologists, AI developers, policymakers, and other stakeholders to ensure that this technology improves radiology practice and patient care.

References

1- Tugba Akinci D'Antonoli *et al.*, "Large language models in radiology: fundamentals, applications, ethical considerations, risks, and future directions." *Diagnostic and Interventional Radiology,* Vol. 30 (No. 2), p. 80 , (2024).

2- Dakai Jin *et al.*, "Artificial intelligence in radiology." in *Artificial Intelligence in Medicine*: *Elsevier*, pp. 265-8, (2021).

3- Michael L Richardson *et al.*, "Noninterpretive uses of artificial intelligence in radiology." *Academic Radiology*, Vol. 28 (No. 9), pp. 1225-35, (2021).

4- Ahmed Hosny, Chintan Parmar, John Quackenbush, Lawrence H Schwartz, and Hugo JWL Aerts, "Artificial intelligence in radiology." *Nature Reviews Cancer*, Vol. 18 (No. 8), pp. 500-10 ,(2018).

5- Koichiro Yasaka and Osamu Abe, "Deep learning and artificial intelligence in radiology: Current applications and future directions." *PLoS medicine*, Vol. 15 (No. 11), p. e1002707 ,(2018).

6- Hongjian Zhou *et al.*, "A survey of large language models in medicine: Progress, application, and challenge." *arXiv preprint arXiv:2311.05112* ,(2023).

7- Adib Bin Rashid and Ashfakul Karim Kausik, "AI revolutionizing industries worldwide: A comprehensive overview of its diverse applications." *Hybrid Advances*, p. 100277 ,(2024).

8- Takeshi Nakaura *et al.*, "Preliminary assessment of automated radiology report generation with generative pre-trained transformers: comparing results to radiologist-generated reports." *Japanese Journal of Radiology*, Vol. 42 (No. 2), pp. 190-200, (2024).

9- Zhaoyi Sun *et al.*, "Evaluating GPT-4 on impressions generation in radiology reports." *Radiology*, Vol. 307 (No. 5), p. e231259.(۲۰۲۳) ,

10- Felix Busch *et al.*, "Large language models for structured reporting in radiology: past, present, and future." *European Radiology*, pp. 1-14, (2024).

11- Lisa C Adams *et al.*, "Leveraging GPT-4 for post hoc transformation of free-text radiology reports into structured reporting: a multilingual feasibility study." *Radiology*, Vol. 307 (No. 4), p. e230725 ,(2023).

12- Daiju Ueda *et al.*, "Diagnostic performance of ChatGPT from patient history and imaging findings on the Diagnosis Please quizzes." *Radiology,* Vol. 308 (No. 1), p. e231040 ,(2023).

13- Koichiro Yasaka, Jun Kanzawa, Noriko Kanemaru, Saori Koshino, and Osamu Abe, "Fine-Tuned Large Language Model for Extracting Patients on Pretreatment for Lung Cancer from a Picture Archiving and Communication System Based on Radiological Reports." *Journal of imaging informatics in medicine* ,(2024).

14- A. Mahdavi, M. Amanzadeh, and M. Hamedan, "The Role of Large Language Models in Modern Medical Education: Opportunities and Challenges." *Shiraz E-Med J,* Letter Vol. 25 (No. 5), p. e144847 ,(2024).

15- Augustin Lecler, Loïc Duron, and Philippe Soyer, "Revolutionizing radiology with GPT-based models: current applications, future possibilities and limitations of ChatGPT." *Diagnostic and Interventional Imaging,* Vol. 104 (No. 6), pp. 269-74 ,(2023).

16- Rajesh Bhayana, Satheesh Krishna, and Robert R Bleakney, "Performance of ChatGPT on a radiology board-style examination: insights into current strengths and limitations." *Radiology,* Vol. 307 (No. 5), p. e230582, (2023).

17- Rajesh Bhayana, Robert R Bleakney, and Satheesh Krishna, "GPT-4 in radiology: improvements in advanced reasoning." *Radiology,* Vol. 307 (No. 5), p. e230987 , (2023).

18- Rajesh Bhayana, "Chatbots and Large Language Models in Radiology: A Practical Primer for Clinical and Research Applications." *Radiology,* Vol. 310 1p. e232756 ,(2024).

19- Liyan Tang *et al.*, "Evaluating large language models on medical evidence summarization." *NPJ digital medicine,* Vol. 6 (No. 1), p. 158, (2023).

20- Matthew Hill, "Hallucinating machines: Exploring the ethical implications of generative language models." *Open Access Te Herenga Waka-Victoria University of Wellington* ,(2023).

21- Neetu Soni, Manish Ora, Amit Agarwal, Tianbao Yang, and Girish Bathla, "A Review of The Opportunities and Challenges with Large Language Models in Radiology: The Road Ahead." *American Journal of Neuroradiology* , (2024).

22- Hanzhou Li *et al.*, "Decoding radiology reports: potential application of OpenAI ChatGPT to enhance patient understanding of diagnostic reports." *Clinical Imaging,* Vol. 101pp. 137-41 ,(2023).

23- Hanzhou Li, John T Moon, Saptarshi Purkayastha, Leo Anthony Celi, Hari Trivedi, and Judy W Gichoya, "Ethics of large language models in medicine and medical research." *The Lancet Digital Health,* Vol. 5 (No. 6), pp. e333-e35 ,(2023).