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The Role of Artificial Intelligence in Medical Imaging: From Diagnosis to Ethical Frontiers

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Abstract

Artificial intelligence (AI) has made a significant difference in radiology, particularly in machine learning and deep learning approaches, for improving tasks such as image processing and X-ray detection. It relies on optimizing the operations and predictions in analytics, computer diagnostics, and image segmentation. Clinical procedures rely on personalized medication and diagnostic techniques. The challenges AI encounters in radiography include the 'black box' issue, accuracy of data, technological and infrastructural complexity, ethical issues such as patient privacy and data security, overreliance on AI, and bias. This article determines the various aspects involved in the use of AI in medical diagnosis (radiological), summarizes the performance of AI in detecting and diagnosing diseases from different radiology procedures, and highlights the potential challenges and ethical issues. AI has a significant impact on radiology and highlights its huge influence on the specialty; it can be used to detect certain pathological conditions, such as cancer, Mets, liver fibrosis, and thyroid disorder. Furthermore, AI aids in assessing the progression of diseases, evaluating therapy responses, and predicting patient outcomes. In cancer treatment, AI can determine tumor size and growth over time, offering essential data for treatment planning. Artificial intelligence in radiology provides significant potential for enhancing diagnostic precision, efficiency, and workflow. However, its incorporation into clinical practice faces several challenges.(**International Journal of Biomedicine. 2024;15(1):37-44.**)

Keywords: artificial intelligence • radiology • healthcare • challenges • identification

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Artificial intelligence (AI) is becoming increasingly popular in the healthcare industry. When AI collates and archives considerable amounts of health-related data from sources such as medical records, social media, and health statistics, it facilitates opportunities for in-depth research.[1-3] Artificial intelligence is the most helpful resource in diagnostics. It supports doctors by giving them an upper hand in procuring, analyzing, and interpreting data to arrive at accurate diagnoses, which are imperative in creating clinical treatments and decisions against various disorders.[4] Artificial intelligence is poised to revolutionize diagnostics through sophisticated algorithms, big data, and cloud computing. This is true for image-based approaches as well as comprehensive evaluations that pool a host of test results. With this rapidly changing focus, AI offers the opportunity for a new era of clinical care by providing accurate diagnosis, decision-making, and remedies for a broad spectrum of clinical diseases. With the increased complexity of illness presentations, image-based diagnostic techniques have remained a staple. Consequently, they have increased the demand for accurate interpretation and diagnosis and facilitated an opportunity for AI to satisfy this.[5] Although AI was initially focused primarily on picture pattern recognition, further advancements in image collection and design can continue to increase AI's diagnostic capabilities to the point where machine interpretation of images far surpasses that of humans.[6,7] Artificial intelligence is important in healthcare because it acquires and processes data to predict and improve patient outcomes. Therefore, AI can tremendously impact diagnosis by reducing medical misdiagnoses and errors and enabling the early detection of infectious diseases that might be unnoticed. For instance, Medopad designed a mobile app that uses touchscreen movements to detect early signs of frontal lobe dementia over a one-year trial.[8,9] The AI Atomwise uses supercomputers to screen existing drugs for potential treatments. This technology could change the health industry by facilitating faster discovery of new treatments. Another breakthrough was collaborating with a Canadian research institution to invent a system for preparing personalized medicine prescriptions based on patient genetic information. Indeed, this collaboration will revolutionize medical diagnosis because physicians can prescribe treatments that suit their patients by analyzing their genetics.[10]

Importance of AI in Healthcare Systems and Radiology

Artificial intelligence transforms healthcare by refining diagnostic accuracy, customizing therapies, and streamlining administrative processes.[11] Artificial intelligence applications include medical imaging analysis, predictive analytics, virtual health assistants, and robotic surgery systems.[12] Machine learning (ML) algorithms process huge volumes of patient data to aid clinical decision-making and tailor treatment strategies.[13] Natural language processing systems extract key information from electronic medical records, giving healthcare practitioners better access to patient data.[14] AI-powered solutions are critical for identifying illness, assessing prognosis, and optimizing workflow.[13,14] Because of its potential to alter healthcare delivery and improve patient outcomes, issues such as data privacy, ethical considerations, and legal frameworks must be addressed.[12,13,15,16] Artificial intelligence is transforming radiology by improving diagnostic accuracy, increasing workflow competence, and enabling early disease diagnosis.[17] AI systems, principally deep learning, have proven their exceptional ability to analyze radiographic images, resulting in substantial advances in patient care.[18] Incorporating AI in radiology can help with various functions, including image interpretation, reporting, diagnosis, and communication.[19] While AI has the potential to supplement radiologists' jobs, it is not expected to replace them; rather, it can be used to automate monotonous processes, allowing radiologists to focus on more complicated clinical decision-making, and to give standardized and uniform interpretations to minimize variability; however, the deployment of AI in radiology presents obstacles and ethical concerns that must be addressed.[19,20]

Artificial Intelligence in Disease Diagnosis

Artificial intelligence is revolutionizing disease diagnosis, offering noteworthy potential for refining healthcare outcomes. AI algorithms can scrutinize medical images, patient data, and symptoms to provide quicker and more precise diagnoses.[21] Various AI methods, including machine learning and deep learning, are used to diagnose diseases such as carcinomas and neurological disorders.[4,22] AI's competencies include recognizing biomarkers, distinguishing tumor severity, and diagnosing genetic syndromes using facial features.[22] The integration of AI in healthcare enables immediate access to evidence-based guidelines and tools for producing differential diagnoses.[23] While AI illustrates promise in hurrying diagnostic processes and improving accuracy, it is vital to note that it should accompany rather than replace healthcare professionals.[21,24] Future research must address ethical considerations, data protection, and ongoing model validation to ensure responsible AI implementation in disease diagnosis.[21,23]

AI-Enabled Diagnostic Imaging in Radiology

Artificial intelligence applications in radiology have expanded rapidly, covering many subspecialties and imaging modalities. AI approaches, particularly deep learning, excel in detecting complicated patterns in medical images and providing quantitative feedback.[25,26] These applications include picture segmentation, computer-aided diagnostics, predictive analytics, and process optimization.[27] Artificial intelligence in radiology has prospects for increased accuracy, decreased radiologist burden, and better patient care. However, obstacles remain, including data quality issues, the "black box" dilemma, and ethical considerations.[26,27] A SWOT analysis identifies internal and external barriers to using AI entirely in clinical practice; despite these hindrances, the future of AI in radiology is hopeful, with the potential for continuous revolution and improvements.[28] Artificial intelligence can help radiologists with image interpretation, reporting, and clinical decision-making.[19] According to Bejarano et al.,[29] AI has emerged as a disruptive technology in radiology, providing various benefits, such as improved diagnostic accuracy, early illness identification, and workflow efficiency.

The role of artificial intelligence in radiology extends beyond identifying anomalies. It also enables assessing disease progression, evaluating therapy response, and predicting patient outcomes. In cancer treatment, AI can assess tumor size and growth over time, offering essential data for treatment planning.[30-34]

Artificial intelligence in radiology has been extensively studied for its potential to enhance disease detection, with important findings across several studies. Moreover, AI techniques, especially deep learning ones, are progressively employed to analyze radiography images. These AI models are trained on extensive datasets of X-rays, MRIs, CT scans, and other imaging modalities, allowing them to accurately identify abnormalities such as tumors, fractures, and indications of diseases like pneumonia or cerebral hemorrhages.

Artificial intelligence frequently identifies nuanced facts that may elude human observation, hence functioning as an indispensable resource for radiologists.[35-39] Several studies have demonstrated the potential role of AI in detecting lesions and diagnosing various cancers.[40-50] Table 1 summarizes the performance of several AI models in detecting diseases from radiological images.

Limitations of AI in Disease Diagnosis

While AI shows promise in healthcare, particularly in radiology, continued research and larger-scale studies are needed to address limitations and ensure ethical integration.[51] A systematic review of AI in radiology revealed that most studies are retrospective cohort studies with limited external validation, potentially introducing bias.[52] The review found that performance often decreased during external validation, highlighting the need for more robust validation methods.[42] Furthermore, there are limited FDA-approved algorithms, worries about data privacy and security, algorithm transparency, and probable biases. The need for high-quality training datasets and ethical considerations are also significant hurdles.[43,44]

Figure 1 summarizes the limitations and challenges of artificial intelligence.

Table 1.
A brief description of the use of AI in radiology for diagnosing some pathologies and the main conclusions.

Author (Year)	AI Techniques	Pathology	Findings
Medhi et al. 2020 [40]	DL (CNN)	COVID-19	DEEP-CNN detects the presence of COVID-19 from the chest X-ray with 93% accuracy, with very few false positive and false negative rates.
Alqudah et al. 2020 [41]	CNN&ML	COVID-19	Deep learning (CNN using Softmax classifier) and machine learning (KNN, RF) detect the presence of COVID-19 from the chest X-ray with 99.46% accuracy and 99.46% sensitivity. According to the results, the performance of all classifiers is good, and most record accuracy, sensitivity, septicity, and precision of more than 98%.
Nayak et al. 2020 [42]	DL	COVID-19	Deep learning models using chest X-rays can effectively detect COVID-19 infection, with ResNet-34 achieving 98.33% accuracy.
Zouch et al. 2020 [43]	DL	COVID-19	The study shows that the proposed models achieved the best accuracy of 99.35 and 96.77%, respectively, for VGG19 and ResNet50 with all the chest X-ray images.
Li et al. 2018 [44]	DL (CNN)	Thyroid papillary cancer	The result showed that 93.5% of papillary thyroid carcinoma could be detected automatically. In comparison, 81.5% of benign and normal tissue could be excluded without additional immunohistochemical markers or human intervention.
Vasilie et al. 2021 [45]	DL	Autoimmune disorders	The two deep learning models obtained excellent results, as follows: the pre-trained VGG-19 model obtained 98.60% for the overall test accuracy with an overall specificity of 98.94% and overall sensitivity of 97.97%, while the Inception v3 model obtained 96.4% for the overall test accuracy with an overall specificity of 95.58% and overall sensitivity of 95.58%.
Liao et al. 2023 [46]	CNN (faster)	Bone Mets	The optimal dice similarity coefficient (DSC) was 0.6640, which differed by 0.04 relative to the optimal DSC of different physicians (0.7040). Object detection can help physicians to efficiently notice bone metastases, decrease physician workload, and improve patient care.
Zhao et al. 2020 [47]	DNN	Bone Mets	The AI model demonstrated significant diagnostic performance; AUC ROC was 0.988 for breast cancer, 0.955 for prostate cancer, 0.957 for lung cancer, and 0.971 for other cancers. Applying this AI model to a new dataset of 400 BS cases represented comparable performance to human physicians individually classifying bone metastasis.
Zheng et al. 2023 [48]	AI	Liver fibrosis	Non-invasive methods, including conventional CT/MRI techniques and AI-based approaches, have been proposed for staging liver fibrosis.
Raimondo et al. 2023 [49]	DL	Uterine adenomyosis	The accuracy of DL and intermediate ultrasound-skilled trainees in diagnosing adenomyosis was 0.51 (95% CI, 0.48-0.54) and 0.70 (95% CI, 0.60-0.79), respectively. Intermediate ultrasound-skilled trainees had sensitivity of 0.72 (95% CI, 0.52-0.86), specificity of 0.69 (95% CI, 0.58-0.79), and F1-score of 0.55 (95% CI, 0.43-0.66), while DL had sensitivity of 0.43 (95% CI, 0.38-0.48), specificity of 0.82 (95% CI, 0.79-0.85), and F1-score of 0.46 (0.42-0.50). Compared to intermediate-skilled trainees, the DL model demonstrated lower accuracy but greater specificity in identifying adenomyosis on ultrasonographic images.
Lamrani et al. 2023 [50]	AI (u-NET)	Brain tumors	ML and DL algorithms provide relevant information and features about tumors. The proposed architecture is pre-trained on MRI images, achieving high precision and classification accuracy rates of 96%.

Privacy and Data Protection

The overlap of AI systems with electronic data management has led to serious privacy concerns, particularly in clinical settings wherein personal information is intimate. Health algorithms should ensure the privacy and security of patient information and remove any fear of patients' consent to the use of their information. Handling and usage should be performed to respect this right to privacy so that patients do not suffer from unauthorized access to or vulnerability to personal information.[24,45-50] AI devices are dependent on health-related data. Health-related information is included in the data obtained from the monitoring sensors. Further, malware must not be able to access or steal this information. The system must implement stringent measures to safeguard the security and privacy of collected data. However, these risks toward protection of data must be balanced with the benefits brought about by real-time information availability, which allows the overall management of patients.[55,57] Data security is among the most important issues yet to be addressed. This information must be maintained on a centralized system, shared across various healthcare providers, and accessed through multiple tools, including cloud applications. Therefore, it should be safely encrypted. Authorized internal or external personnel must log and trace every access.[57-61] The need for disclosure should be overtly justified, and frequent audits should be conducted while processing or transmitting protected health information. Users aim to fine-tune the balance between accessibility and protection by basing sharing on the 'need-to-know' principle.[52-54] In this safe mode of transmitting analytical findings, secure channels are set up to share the analysis results with access controlled by authorized levels. The system maintains integrity by providing access to audit reporting and other impartial measures. This could involve periodically transitioning to a new framework while safely retiring from older endpoints. Moreover, the mechanisms related to monitoring, accountability, and the responsibility of workers and vendors must be re-evaluated and enhanced in line with the evolving obligations in data management when engaging in cloud services.[62-64]

Bias and Fairness in AI Algorithms

The aspects of analyzing AI algorithms for bias and fairness and adopting artificial intelligence as a diagnostic tool in health systems must be evaluated.[65,66] Artificial intelligence algorithms in various industries, such as technology, social media, e-commerce, health systems, finance, hiring, social welfare, and digital law enforcement, are under strict scrutiny for many types of bias. Scientific literature and courts have thoroughly documented these biases.[67,68] They have highlighted the absence of robust regulations safeguarding marginalized communities from the negative impacts of these technologies, primarily because of the lack of consensus on the definition of bias in the decisions made by data-driven algorithms. The evidence and notions of bias and fairness form the foundation of many AI algorithms that handle complex data. The primary challenge lies in the sophisticated nature of these algorithms, which various complex social, political, and flexural forces influence.[69,70] Thus, information is a limiting constraint in AI-based systems. None of these is an objective reality because algorithms learning from data embody certain values and incentives. For instance, when training an AI algorithm with pictures, the artificial intelligence may attempt to categorize jobs into indoor and outdoor categories based on the presence or absence of helmets in the images.[71-75] This algorithm will most likely misclassify all construction and blue-collar jobs as outdoors. At the same time, all indoor jobs will be deeply divided along gender lines. Moreover, training AI on biased data and deploying it can reinforce and exacerbate existing bias. Thus, enabling the artificial intelligence to empower underrepresented groups becomes considerably challenging. This is because accurate predictions inevitably conflict with agendas resulting from power imbalances. There is an equity problem in terms of whether the array of services offered and used is comparable for various groups from the latter's perspective.[74,76,77]

Patient Autonomy and Informed Consent

AI and ML diagnostic tools are earning their place in patient care, slowly overcoming the contribution of or need for human input in healthcare decision-making. They fundamentally alter the medical judgment and responsibilities associated with decision-making.[78-80] At this point, the debate on the negative and positive effects of artificial intelligence on healthcare assumes that patients understand what affects their treatment processes. Therefore, proper inclusion of transparency and accountability might go a long way toward really diminishing the positive impact of artificial intelligence. Therefore, the acceptance of AI in healthcare depends on technological performance and patient reception. Even if artificial intelligence can significantly improve the quality, safety, and cost management of medical systems, contentious consequences may arise that need to be carefully considered. This could lead to potential damage claims, affecting certain patient rights and additional physician duties, owing to AI medical systems. Regulations should guarantee the ethical use of clinical AI and appropriately equip professionals to provide care in the current virtual-based system with minimal direct interaction.[81-86] However, the specific physical and moral imperative requirements cannot be dismissed, as there are valid arguments for prioritizing medical certainty. Informed consent is generally regarded as permission given by a patient to undergo any medical procedure, treatment, or research project. Such consent is considered informed when certain key facts are known; it is provided voluntarily under circumstances that permit freedom of choice, make sure that knowledge of possible adverse consequences is provided, as well as knowledge of alternative treatments.[87,88] However, when patient consent becomes automated, there is cause for concern. A patient app can delegate legal consent and access; however, many ambiguities can persist.[89] A patient is unlikely to know what a diagnostic artificial intelligence algorithm may uncover, let alone the consequences of missing a diagnosis. For instance, one study indicated that younger women with advanced breast cancer were found to have been overtreated for up to 30% of benign, non-invasive lesions following sweeping mammography screening. It is probably wise to provide basic, convenient explanations for shared understanding and responsibility of AI decisions, as well as the source of the technology. This is because health information typically necessitates high standards of accuracy for medical decision-making. The integration of artificial intelligence into healthcare systems is currently underway.[90]

Overcome the Challenges to Adopt AI in Health

Artificial intelligence has the potential to revolutionize healthcare, but it faces several challenges. Data security and privacy concerns are significant, as healthcare organizations handle sensitive patient data, making them vulnerable to cyberattacks. To address these, organizations must implement robust encryption techniques, access controls, regular audits, and employee training. Staying up to date with regulatory requirements like HIPAA is crucial for compliance. Insufficient data is another challenge, as artificial intelligence systems rely on high-quality data for accurate predictions. To overcome this, organizations must invest in data collection processes, such as wearables and remote monitoring devices. Interoperability issues are another challenge, as artificial intelligence often requires sharing data across various platforms. To ensure secure data transfer, organizations must invest in standardized formats and protocols. Regulatory compliance is another challenge, as organizations must comply with strict regulations like HIPAA. Ethical and bias concerns arise, and organizations must ensure AI systems are developed and deployed ethically. Resistance to adoption is another challenge, as healthcare professionals may be resistant to adopting artificial intelligence. Figure 1 summarizes the challenges of AI implementation.[91]

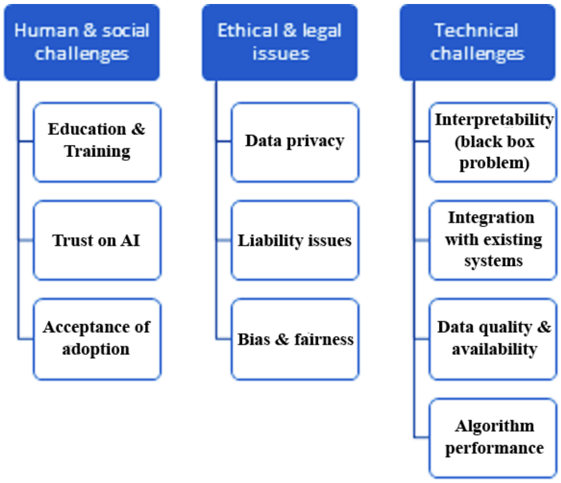

Fig. 1. Challenges of AI implementation in radiology.

Prospects

The future of AI in radiology is focused on increasing precision, efficiency, and affordability in medical imaging. Artificial intelligence is expected to greatly increase diagnosis accuracy, particularly in identifying early illness using sophisticated picture processing. Integrating AI with multimodal data, such as electronic health records and genetics, would enable more customized and predictive healthcare, allowing radiologists to make more educated judgments about patients' conditions. AI-powered automation would simplify radiologists' workflows by performing mundane activities such as image segmentation and preliminary reporting, allowing them to focus on difficult cases. Furthermore, AI would play an important part in radiomics by assisting in identifying patterns and biomarkers in medical pictures that correspond with specific diseases or treatment responses, hence boosting precision medicine. AI has great global potential since AI-powered telemedicine platforms may give radiological services to underdeveloped locations, closing the healthcare access gap.

Conclusion

Artificial intelligence in radiology offers significant potential for enhancing healthcare, particularly in radiology. Artificial intelligence significantly impacts radiology issues; it can be used to detect pathological conditions. Furthermore, AI aids in assessing the progression of diseases, evaluating therapy responses, and predicting patient outcomes. In cancer treatment, AI can assess tumor size and growth over time, offering essential data for treatment planning. However, its adoption into clinical practice faces several challenges, such as data privacy, bias, and fairness in AI algorithms.

Competing Interests

The author declares no competing interests.

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