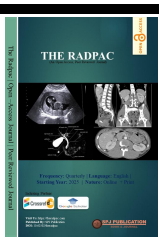
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Short Communication

Artificial Intelligence in Digital Radiography: Current Applications and Future Trends

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ABSTRACT

Digital radiography (DR) remains the most widely performed imaging modality worldwide, forming the backbone of diagnostic workflows in emergency care, outpatient clinics, and screening programs. Despite technological advances, challenges such as image noise at low radiation doses, positioning errors, workflow inefficiencies, and increasing radiologist workload persist. Artificial intelligence (AI) has emerged as a transformative tool capable of addressing these limitations. This paper reviews the current applications of AI in digital radiography, including image enhancement, automated positioning assistance, abnormality detection, workflow optimization, and radiation dose reduction. Additionally, emerging trends such as multimodal AI integration, explainable AI, edge computing, federated learning, and ethical AI frameworks are discussed. The evidence suggests that AI-enhanced DR can improve diagnostic accuracy, reduce repeat examinations, optimize radiation dose, and support radiographers and radiologists in high-volume clinical environments. However, challenges related to validation, cost, bias, and regulatory standardization remain. Continued collaboration between clinicians, engineers, and regulatory bodies is essential to ensure the safe and equitable integration of AI into routine radiographic practice.

Keywords: Artificial intelligence, digital radiography, image enhancement, radiation dose optimization,

INTRODUCTION

Digital radiography (DR), including computed radiography (CR) and direct digital detector systems, continues to serve as the first-line imaging modality across healthcare systems worldwide. Chest radiographs, skeletal imaging, and trauma radiography constitute a substantial proportion of daily diagnostic imaging, particularly in emergency departments and screening programs. [1]. Despite its accessibility and speed, DR faces ongoing technical and operational challenges. These include image degradation at low radiation doses, positioning and collimation errors, high repeat rates, and growing interpretive workload for radiologists and radiographers. [2,3] In recent years, artificial intelligence (AI), particularly deep learning–based algorithms, has demonstrated significant potential to enhance medical imaging workflows. AI systems can analyze large volumes of imaging data rapidly, identify subtle patterns beyond human perception, and provide decision support in real time. [4] While much of the early focus of AI research has been on computed tomography (CT) and magnetic resonance imaging (MRI), digital radiography has increasingly benefited from AI-driven innovations due to its high examination volume and standardized image acquisition. [5] The integration of AI into DR aims not to replace radiographers or radiologists, but to augment their capabilities by improving image quality, reducing unnecessary radiation exposure, minimizing errors, and enhancing diagnostic confidence. [6] This paper provides a comprehensive overview of current AI applications in digital

radiography and explores future trends that may shape the next generation of radiographic practice.

CURRENT APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN DIGITAL RADIOGRAPHY

Image Enhancement and Noise Reduction: One of the most established applications of AI in DR is image enhancement, particularly noise reduction in low-dose examinations. Deep learning–based reconstruction algorithms have been shown to suppress quantum noise while preserving fine anatomical details, enabling dose reductions of up to 30–70% without compromising diagnostic quality. [7,8] This capability is especially valuable in chest radiography, pediatric imaging, and follow-up examinations where cumulative radiation exposure is a concern. AI-based denoising techniques differ from traditional filtering methods by learning complex noise patterns from large datasets, resulting in more natural-looking images and reduced loss of spatial resolution. [9]

Automated Positioning and Quality Control: Positioning errors and improper collimation are major contributors to repeat radiographic examinations. AI-powered positioning systems, such as automated patient alignment and collimation tools, assist radiographers in achieving optimal projections consistently. These systems analyze patient anatomy in real time and provide visual or auditory feedback during positioning, significantly reducing retake rates. [10] Automated quality control algorithms can also detect common technical errors, including rotation, motion blur, and incorrect exposure parameters, allowing immediate correction before image submission [11]

Detection and Triage of Abnormal Findings: AI algorithms have demonstrated strong performance in detecting abnormalities on radiographs, particularly in chest imaging. Applications include identification of pulmonary nodules, consolidation, pleural effusion, pneumothorax, tuberculosis, and COVID-19–related lung changes. [12–14] Some commercially available systems can triage normal examinations autonomously, prioritizing abnormal studies for rapid radiologist review and improving reporting turnaround times. [15] These tools are particularly beneficial in high-volume settings and regions facing shortages of trained radiologists.

Workflow Optimization and Reporting Support: Beyond image interpretation, AI contributes to workflow efficiency by automating routine tasks such as image labeling, projection recognition, laterality assignment, and preliminary report generation [16] Natural language processing (NLP) tools can assist in structured reporting, ensuring consistency and reducing reporting time [17] Such workflow enhancements help mitigate radiologist fatigue and burnout while maintaining reporting accuracy. [18]

Radiation Dose Optimization: Radiation dose optimization remains a fundamental principle of radiographic practice. AI-based exposure control systems can dynamically adjust acquisition parameters based on patient size, anatomy, and clinical indication, ensuring adherence to the ALARA principle. [19] By enabling high-quality imaging at reduced doses, AI supports safer imaging practices, particularly for vulnerable populations such as children and pregnant patients.

FUTURE TRENDS IN AI-DRIVEN DIGITAL RADIOGRAPHY

Multimodal and Predictive AI Systems: Future AI systems are expected to integrate radiographic images with electronic health records, laboratory data, and vital signs to enable predictive diagnostics and risk stratification. Such multimodal AI approaches may facilitate early identification of disease progression and guide clinical decision-making beyond image interpretation alone.[20]

Explainable and Trustworthy AI: A major challenge in AI adoption is the lack of transparency in decision-making processes. Explainable AI techniques, including heatmaps and attention maps, aim to make algorithm outputs more interpretable for clinicians, thereby increasing trust and accountability.

Edge Computing and Real-Time Feedback: Embedding AI algorithms directly into imaging detectors and acquisition consoles through edge computing will allow instant image evaluation and feedback. This development is particularly relevant for mobile radiography units and resource-limited settings, where rapid decision-making is critical.

Federated Learning and Ethical AI: Federated learning enables AI models to be trained across multiple institutions without sharing patient data, addressing privacy concerns and improving algorithm generalizability. Concurrently, ethical AI frameworks are being developed to address bias related to age, gender, ethnicity, and geographic variability, ensuring equitable diagnostic performance.

CHALLENGES AND LIMITATIONS

Despite its promise, AI integration in DR faces several challenges. These include limited external validation of algorithms, high implementation costs for smaller institutions, variability in regulatory approval processes, and the need for continuous training of healthcare professionals. Addressing these challenges is essential for sustainable and responsible AI adoption.

CONCLUSION

Artificial intelligence is rapidly reshaping digital radiography by enhancing image quality, reducing radiation dose, improving workflow efficiency, and supporting diagnostic accuracy. Current applications have already demonstrated tangible clinical benefits, while emerging trends promise even greater integration and intelligence in radiographic practice. Successful implementation, however, requires robust validation, ethical oversight, and active collaboration between radiographers, radiologists, engineers, and policymakers. When thoughtfully integrated, AI has the potential to transform digital radiography into a safer, smarter, and more patient-centered imaging modality.

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