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REVIEW

The Applications of Artificial Intelligence in Radiology: Opportunities and Challenges

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ABSTRACT

Purpose: **This article aims to provide insight and a better understanding of how the rapid development of artificial intelligence (AI) affects radiology practice and research. The article reviews existing scientific literature on the applications of AI in radiology and the opportunities and challenges they pose.**

Materials and Methods: **This article uses available scientific literature on AI applications in radiology and its subspecialties from PubMed, Google Scholar and ScienceDirect.**

Results: **The article finds that the applications of AI in radiology have grown significantly in the past decade, spanning across virtually all radiology subspecialties or areas of activity and all modalities of imaging such as the radiographer, computer tomography (CT) scan, magnetic resonance imaging (MRI), ultrasound and others. The AI applications in radiology present challenges related to testing and validation, professional uptake, and education and training. Nevertheless, artificial intelligence provides an opportunity for greater innovation in the field, improved accuracy, reduced burden of radiologists and better patient care among others.**

Conclusions: **Despite the challenges it presents, artificial intelligence provides many worthwhile opportunities for the development of radiology and the next frontier in medicine.**

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1. Background

Artificial intelligence is an important new technology with the potential to transform medicine and in specifically, radiology. Artificial Intelligence (AI) refers to the development of computer systems which can perform tasks usually requiring human intelligence, such as learning, reasoning, problem-solving and interpretation [1]. AI systems do this by using algorithms, data, and computational power. The main benefits of artificial intelligence include the automation of repetitive tasks, complex analysis of large data sets, data-based problem-solving and decision-making, and personalization [1].

Thanks to its ability to automate, analyze data and assist in decision-making, artificial intelligence has a wide range of applications across many industries, including finance, manufacturing, retail and transportation among others. Some of the most transformative applications of AI exist in the field of medicine [2]. For example, artificial intelligence can significantly speed up the process of drug discovery and development. It can assist in the early detection and diagnosis of various diseases via analysis of patterns from large amounts of data. AI can also improve the techniques and outcomes of surgery thanks to AI robots which can assist human professionals. Finally, artificial intelligence can improve patient outcomes by analyzing genetic data to assess health and make personalized treatment recommendations [3].

The development of new technology has been the key driver in the field of radiology. The history of radiology begins with the discovery of the X-rays with the aid of a Crookes cathode ray tube [4]. The radiographer was the first form of medical imaging, but new modalities for radiology propelled radiology forward, including computer tomography (CT) scans, magnetic resonance imaging (MRI), ultrasound, nuclear imaging and hybrid scanners, and most recently, digital images [4]. Radiology not only incentivizes technological innovation but it is quick to adapt to new technologies.

This makes the study of the applications of AI in radiology extremely important. Hence, the purpose of this article

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is to review the existing scientific literature concerning the applications of AI in radiology. The focus of this review is to identify the opportunities and challenges of the use of AI in the field.

2. Materials and Methods

This article presents a literature review of the AI applications in radiology as well as the opportunities and challenges they bring to the discipline. It uses available scientific literature in this area from PubMed, Google Scholar and ScienceDirect.

3. Review Results

The applications of AI in radiology are wide and varied. There are over 200 accessible, commercially available specialized tools which utilize AI applications in radiology [5], [6], excluding tools under development and testing. To better understand the general applications of artificial intelligence in radiology, AI uses in the field can be divided into two categories: interpretative uses of AI and non-interpretative uses [7], [8].

The interpretative uses of AI in radiology include virtually all fields of activity or subspecialties of radiology, including breast radiology, neuroradiology, musculoskeletal radiology and cardiovascular radiology. AI applications extend to all modalities of radiology, including the radiograph, computed tomography (CT) scans, magnetic resonance imaging (MRI), ultrasound and nuclear medicine. The existing applications of artificial intelligence in different subspecialties are summarized below (Table I).

The non-interpretative uses of AI in radiology are no less important. They include tools for improved workflow and assistance with clinical protocols, scheduling scanners and patients, and structured radiological reporting via natural language processing (NLP) [29]. In terms of imaging, AI can significantly improve and assess the image quality of raw images and processed images, decrease scan time in MRI, and reduce the radiation dose in CT [30].

While the applications of artificial intelligence in radiology push the frontiers of the field, they also present new challenges and risks [31]. Testing and validation of the effectiveness and impact of AI applications in radiology is one of the most important challenges to the realization of the potential of artificial intelligence in the field. X claims that validation is the key to ensuring AI applicability and performance in a real-world clinical setting [24]. However, according to van Leeuwen *et al.*, while many commercially available AI products for radiologists show promise, peer-reviewed evidence for their efficacy is lacking for the majority of software tools (64%) [5]. Kelly *et al.* further report that most studies of AI applications in radiology rely on retrospective cohort studies with limited external validation and high potential for bias [32].

The validation and successful use of AI in radiology requires multidisciplinary knowledge which is more than can be managed by a single radiologist, report Cellina *et al.* [24]. This represents a challenge for small organizations which may lack the resources to recruit non-medical professionals to support AI research and applications. In the absence of additional training and education, this can potentially lead to uneven use of AI across organizations and countries.

TABLE I: Artificial Intelligence Applications in Radiology Subspecialties

Field of activity/subspecialty	Applications
Abdominal radiology	Liver segmentation [9], segmentation of genitourinary structures, other segmentation; detection of lesions, detection of incidental pulmonary emboli at the lung bases, free intraperitoneal air, vertebral compression fractures, or aortic dissection [10], characterization of focal liver lesions [11], adrenal lesion characterization [12].
Neuroradiology	Lesion detection [13], detection of stroke and hemorrhages, detection of aneurysms, assessment of brain anatomy [14], segmentation and parcellation of cortical and subcortical structures [15].
Chest radiology	Detection of lung nodules [16], detection of pneumonia, pneumothorax and rib fractures, detection of lines and tubes, detection of obstructive lung disease, quantification of emphysema [17].
Cardiovascular radiology	Coronary calcium scoring, coronary angiography, fractional flow reserve, plaque analysis, left ventricular myocardium analysis, diagnosis of myocardial infarction, prognosis of coronary artery disease, assessment of cardiac function, and diagnosis and prognosis of cardiomyopathy [18], [19].
Musculoskeletal radiology	Detection of fractures in the proximal humerus, hand, wrist, and ankle, detection of hip osteoarthritis, quantitative bone imaging for the assessment of bone strength and quality [7], [20].
Oncologic imaging	tumor characterization, tumor segmentation [21], detection of pulmonary nodules, tumor delineation, staging/classification of lung cancer, differentiating benign and malignant lesions or lymph nodes [22].
Breast radiology	Lesion detection, classification and characterization, breast density estimation [14], characterizing mammographic abnormalities, differentiation of malignant breast lesions and nodules [23].
Emergency radiology	Detection of intracranial hemorrhages, large vessel occlusions, fractures, abdominal free fluid, small bowel obstruction, intussusception [24].
Urogenital radiology	Autonomy segmentation, whole-gland detection/zonal segmentation, lesions segmentation, volume estimation, tumor detection, cancer localization, tumor grade estimation [25].
Head and neck radiology	Target delineation, segmentation of lesions and anatomical structures, localization of lesions [26], classification of lesions, segmentation and classification of lymph nodes [27].
Oral and maxillofacial radiology	Detection of dental caries, periapical pathologies, root fracture, periodontal/peri-implant bone loss, and maxillofacial cysts/tumors, classification of mandibular third molars, skeletal malocclusion, and dental implant systems, localization of cephalometric landmarks [28].

Professional uptake represents another significant challenge. A study by Sit *et al*. shows that radiologists who have little to no knowledge of artificial intelligence fear the new technology [33]. According to Bi *et al*., radiologists are specifically concerned about the potential threat posed by AI to their profession [34].

While AI is unlikely to replace radiologists, radiologists who use AI may replace radiologists who do not, according to Langlotz [35]. However, the successful adoption of AI applications in radiology requires not only professional uptake but also education and further training of the workforce. According to Jungmann *et al*., radiologists who do not understand how AI works are reluctant to use the technology in their work [36], which represents a significant barrier to AI.

Nevertheless, the interpretative and non-interpretative applications of AI in radiology provide many opportunities for the development of the field. Despite some concerns, the potential of artificial intelligence in the discipline has created much enthusiasm and dynamism in the field, according to Pesapane *et al*. [37]. The rising scientific interest in AI applications in radiology is evidenced by the large number of studies outlining and testing new applications. A search for "artificial intelligence in radiology" yields 23,482 results in PubMed, including 17,717 results in the last 5 years (2019–2024). Hence, artificial intelligence offers the opportunity to significantly advance innovation in radiology.

AI innovations in radiology can offer many practical benefits to practitioners, too [24]. According to Jalal *et al*., artificial intelligence can reduce diagnostic errors, decrease workload, free up radiologists' time and allow professionals to focus on patient care and communication [38]. Similarly, Mello-Thoms and Mello claim that AI can greatly complement case interpretation to reduce intra-and inter-reader variability and burnout among radiologists due to high workloads and expectations [7].

Perhaps most importantly, AI applications in radiology can improve the accuracy of interpretation and diagnosis. According to a systemic review of 535 studies of AI applications in radiology, artificial intelligence technologies across the sample achieved Dice of 0.89 (range 0.49–0.99), AUC of 0.903 (range 1.00–0.61) and Accuracy of 89.4 (range 70.2–100) [32], indicating positive performance by AI. While many of the challenges outlined above persist, AI-assisted radiologists can achieve consistently more accurate diagnoses and ultimately deliver better patient care and outcomes with the aid of new technologies.

4. Conclusion

This article provides an overview of the applications of AI in radiology and the opportunities and challenges they present to the field. The uses of artificial intelligence in the field have grown massively in the last five years, generating significant interest from scientists and practitioners. The growing applications of AI in radiology provide opportunities for greater focus on patients, reduced burden for radiologists and overall improved accuracy in interpretation and diagnosis. Despite this, artificial intelligence use in the field is still nascent and successful adoption requires the radiology community to overcome risks related to AI validation and the challenges of professional uptake.

While this article aims to offer a wide variety of perspectives from different subspecialties and on a global level, it is not an exhaustive list of all uses, opportunities and challenges. Instead, it aims to bring attention to key themes in the hopes of facilitating further discussion among the scientific and professional radiologist community.

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Conflict of Interest

Author declares no conflict of interest.

Abbreviations

AI	Artificial intelligence
CT	Computer tomography
NLP	Natural language processing
MRI	Magnetic resonance imaging

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