STAWSKA, Weronika, MIŁEK, Magdalena, KWAŚNIAK, Ksenia, FORYŚ, Angelika, BANACH, Mariola, NIEMCZYK, Anna, ŚLUSARCZYK, Monika, MAGIERSKA, Agata, KOTOWICZ, Zuzanna and KMIOTEK, Weronika. The use of artificial intelligence in radiology: new possibilities for diagnostic imaging. A literature review. Quality in Sport. 2024;16:52215. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2024.16.52215
https://apcz.umk.pl/QS/article/view/52215

The journal has had 20 points in Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 06.06.2024. Revised: 25.05.2024. Accepted: 03.07.2024. Published: 07.07.2024.

The use of artificial intelligence in radiology: new possibilities for diagnostic imaging. A literature review

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ABSTRACT

Introduction and purpose: Rapid advances in technology enable innovative solutions to be implemented in modern medicine, relieving healthcare workers by speeding up diagnosis and improving the quality of treatment. The subject of this review is Artificial Intelligence (AI), an innovative form of help in the daily practice of doctors. It offers the opportunity to relieve healthcare workers by accelerating the diagnosis process and improving the quality and effectiveness of treatment.

The aim of this paper is to present the current state of knowledge, assess the effectiveness of algorithms in the recognition and interpretation of abnormalities in medical images compared to specialists in radiology and discuss the challenges associated with the implementation of AI in various medical specialties.

Brief description of the state of knowledge: Artificial intelligence, especially through machine learning and deep learning techniques, has found wide application in radiology. Many facilities around the world use advanced AI systems in the day-to-day work of radiologists, including the Mayo Clinic, Massachusetts General Hospital, and the University of Tokyo Hospital.

Summary: Studies show that while AI algorithms can perform worse than radiologists in some areas, they are at the forefront of others, especially in detecting subtle abnormalities. The effective implementation of artificial intelligence requires addressing regulatory, ethical, and training issues. Despite these challenges, artificial intelligence has the potential to play a key role in the future of radiology and revolutionize medical practice, opening new perspectives and improving the quality of health care.

Key words: Artificial Intelligence; medical imaging; radiology; deep learning; diagnostic algorithms

Introduction and objective

The rapid development of technology allows for the introduction of innovative solutions to modern medicine. As a result, we have the prospect of relieving healthcare workers by accelerating the diagnosis process and improving the quality and efficiency of treatment. An example of such innovation is Artificial Intelligence (AI), which is the subject of this review.

The development of artificial intelligence and attempts to implement it in medicine have been going on for several decades, because the first references appear in literature since the 1950s of the 20th century. In 1955, "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence" was published [1], in which the authors raised the problem of creating neural networks, "thinking machines," and the self-improvement of AI. A few years later, in the 1960s, it was used to detect changes in breast imaging [2]. Many changes have been made over the years, and today this discipline is well developed, and its applications are valuable in many fields of science, mainly because of the accuracy, objectivity, and automation that AI is able to provide [3].

The aim of the following review is to present the current state of knowledge and existing models of AI used in daily medical practice in the field of medical imaging. In addition, we are inclined toward the effectiveness of algorithms in the recognition and interpretation of anomalies in imaging studies compared to specialists in the field of radiology. At the same time, we discuss the challenges associated with the implementation of AI in various medical specialties, such as the need to adapt algorithms to specific diagnostic needs and the need for quality control and safety of patient data.

What exactly is Artificial Intelligence and how can it be used in medicine?

Artificial intelligence (AI) is an area of computer science that focuses on creating computer systems that mimic human thinking and use intelligence to perform a variety of tasks. The concept of artificial intelligence draws inspiration from the cognitive processes of the human brain, such as information processing, experiential learning, and decision-making. In radiology, various types of AI are used, which are helpful in the analysis and interpretation of medical images [Fig. 1].

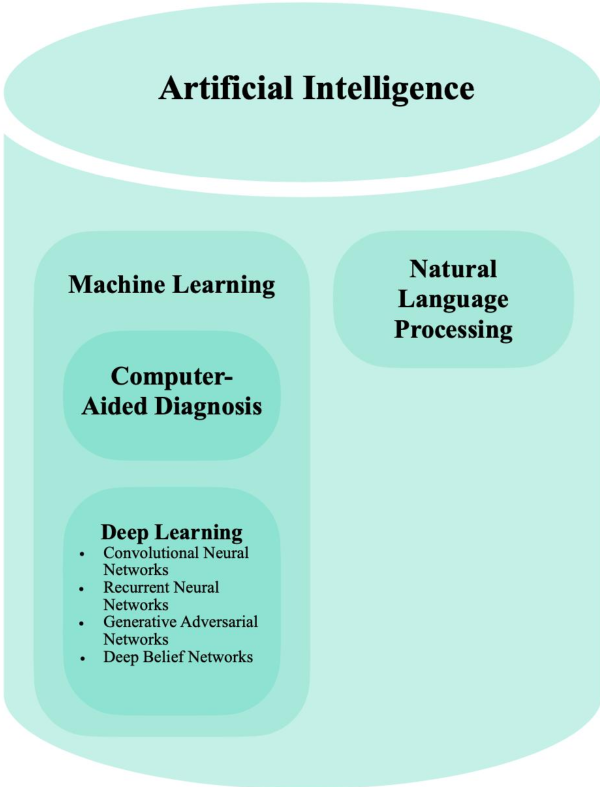

Figure 1. Relationship between AI, ML, DL, CAD, CNNs, NLP.

Machine Learning (ML) is a broad term that covers various machine learning techniques, allowing computer systems to learn based on data and make decisions without the need for explicit programming. It enables classification, analysis of medical images, assistance in diagnosis and treatment planning. Artificial multi-layer neural networks, or deep learning (DL) networks, are used to evaluate and extract complicated data, including medical pictures. It carries out automatic disease detection, picture categorization, and anatomical structure segmentation.

Computer-assisted diagnostics (CAD) systems employ machine learning algorithms to automatically evaluate medical pictures and help physicians make diagnoses. They help in the detection of pathological changes on MRI or CT images. Natural Language Processing (NLP) is a branch of artificial intelligence that enables computers to understand and process natural language, e.g. electronic medical records and medical radiological reports, and is therefore used to automatically analyze radiologic reports in order to extract relevant information and assist health workers in the diagnosis and treatment process [4]. Especially useful for image analysis are convective neural networks (CNNs), which, on the basis of a large number of data create analytical models with high precision [4]. In radiology, CNNs are commonly used for the detection, classification, and segmentation of objects on medical images.

The use of the above technologies contributes to faster analysis of images, detection of subtle pathological changes, and increased accuracy of diagnosis. From the content of the original papers and review articles of the last 5 years, it is apparent that in radiology, the technology of Deep Learning, and in particular convulsive neural networks, is at the forefront. DL provides much higher segregation accuracy and better efficiency, despite greater structural and computational complexity. As a result, DL and CNN have become the most popular methods of artificial intelligence in medical imaging applications [2, 5].

How effective are the algorithms compared to radiology specialists?

In 2022, Susan Cheng Shelmerdine et al. studied the diagnostic accuracy of algorithms using the Fellowship of the Royal College of Radiologists (FRCR) examination and compared AI (Smarturgences, Milvue) results with those of 26 specialists in radiology. The FRCR Final Examination consists of three parts: a reporting session, a quick-reporting session, and an oral examination. It is necessary to obtain positive results for all three components. The authors decided to test the capabilities of AI in a quick reporting session, as it checks the speed and accuracy of the diagnosis in the form of the evaluation of 30 X-rays in a time of 35 minutes. The condition for a positive result is the correct interpretation of 27 of the 30 radiograms, i.e., 90% [6].

The authors provided all participants with 10 trial FRCR exams, or a total of 300 radiograms. The artificial intelligence used in the study was not capable of interpreting the X-rays depicting the axis skeleton and abdominal cavity; therefore, the maximum number of possible radiograms to be interpreted was lower than for radiologists. As a result, the results of the study for AI were presented in four possible scenarios: scoring only the radiographs AI could interpret; all non-interpretable radiographs as normal; all not-interpreterable radiographs as abnormal; all non-interpretable radiographs as wrong [6]. For the purpose of creating a chart with the results, each of the four AI results and the average of the results of 26 radiologists were taken into account [Fig. 2].

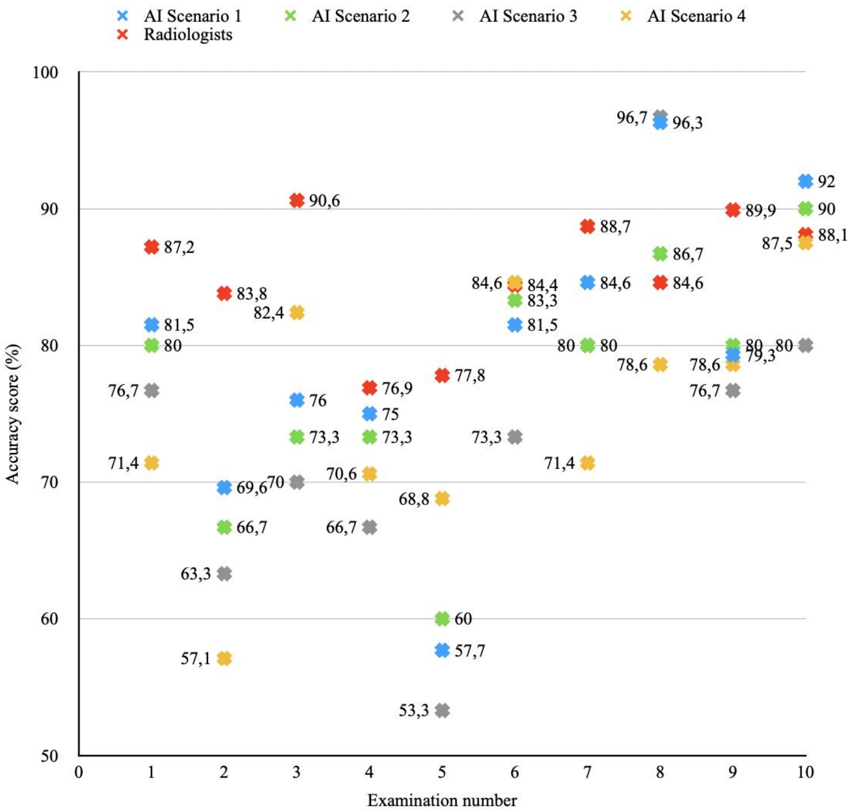

Figure 2. AI and Radiologist readers' accuracy score (%) [6].

In the best scenario, scenario 1, an AI candidate would pass 2 out of 10 FRCR trials. In addition, he obtained the best score from Exam No. 8, placing first in the ranking of all participants. Apart from this isolated case, AI scores were in the final part of the ranking table at as much as 60%. The average score from all approaches placed AI at 26 out of 27 places in the ranking. By comparing the results of radiologists to AI, doctors scored much better in up to 80% of approaches, which allowed them to pass an average of 4 out of 10 FRCR test tests. In addition, the range of results was relatively narrow for most approaches; the standard deviation values ranged between 3.9 and 10.7 [6]. The authors compared the data of both groups of participants in the form of values of sensitivity, specificity, and overall accuracy [Table 1].

	Radiologists	AI
Sensitivity (%)	83,6	84,1
Specificity (%)	75,2	87,3
Overall accuracy (%)	79,5	85,2

Table 1. Comparative table of

sensitivity, specificity and overall accuracy of the diagnostic test in the two study groups [6].

Due to the high level of difficulty of the exam cases, AI has done relatively well. The authors stress that AI correctly diagnosed half of the images, which most radiologists misjudged. They represented small joints and muscular and bone elements of the hands and feet. Potentially, the evaluation of discrete changes in the musculoskeletal system, due to the complexity and fatigue of this process, will be more effective and accurate in the case of AI than the human eye. The authors of the study proved that the introduction into medical work of an artificial intelligence algorithm that will be properly trained can be an effective tool to support radiological diagnosis, especially in the evaluation of routine and, with time, also more difficult cases, increasing the efficiency, speed, and accuracy of the radiologist [6].

For comparison, the OpenAI generative transformer evaluated by Yiliang Zhou et al. in a promising study on GPT-4V proved to be a method of low efficiency in the evaluation and interpretation of chest radiograms [7].

What system changes are required to introduce AI algorithms into everyday medical imaging practice?

The advantages of artificial intelligence and its potential applications in the medical industry can be discussed on many pages. However, an important topic to be addressed is the issue of the challenges and difficulties associated with the implementation of AI into existing hospital systems so that it becomes a full-fledged medical device, as well as the appropriate training of medical personnel, the security of personal data, and the ethical and legal aspects of this undertaking.

The time it takes to implement artificial intelligence to automate medical tasks is estimated to be several to several decades, with the initial focus being on solving the most common medical problems for which a large database is available. Unfortunately, none of the existing AI systems are multifunctional and capable of detecting abnormalities throughout the human body, which poses a major challenge for future scientists and may take longer to implement medical programs using AI [5].

Another potentially problematic aspect, mainly for medical personnel, is the randomly diagnosed, often clinically irrelevant, research results generated by AI algorithms [8]. Since the average incidence of these cases is 23.6% and is higher in CT scans, this is not uncommon [9]. In this situation, it is difficult to ignore such results, especially in the absence of verification of each examination by a qualified radiologist. In order to avoid this problem, it is important to implement the best possible programmed system, for example, deep learning algorithms, which will eliminate random results and visualize only clinically relevant and correctly classified images [8]. Bear in mind that you should never trust algorithms 100%, even those that are properly trained and programmed to work with detection, change assessment, and radiological diagnostics.

Hosny et al. highlight the problem of deep learning algorithms as a “black box." This is explained by the opaque operation of these systems and the inability to verify their exact operation due to the complexity of the decisions taken by deep neural networks, whose systems are practically impossible to examine and disassemble into parts. In view of the above, there is a concern of a regulatory nature as to whether challenging the activities of these entities will not be a problem for the Food and Drug Administration (FDA) during the process of approving medical systems using AI. However, it is known that the FDA has already approved software solutions with unclear mechanisms of action. It is therefore important to introduce appropriate guidelines, allowing the adjustment of subsequent solutions using deep learning [5].

An example of an ethical problem is the use of patient data to learn AI systems and the potential risk of leaking that data. Often, the flow of information between databases in hospital networks and AI systems is not adequately secure. The solution is, for example, the proper encryption of patient personal data and its anonymization during storage and transmission. [5, 10]. It is also important to keep in mind the proper training and supervision of personnel dealing with sensitive data and the regular monitoring of possible cyber-security threats [10, 11].

One often hears about replacing radiologists with AI, which is unlikely. Artificial intelligence will solve basic tasks on its own, allowing doctors to focus on higher-level tasks that are beyond the capabilities of AI algorithms [12]. The realistic scenario is the goal of integrating AI systems into daily medical practice with the aim of reducing costs, automating often time-consuming procedures, and increasing system efficiency [13, 14].

There is a need to ensure further research and development of AI technology, continuous collaboration between AI developers, radiologists, and other medical professionals to improve algorithms, and the development of clear ethical and regulatory guidelines to ensure the safety and privacy of patients. This will enable us to take full advantage of AI as an excellent tool for improving the process and quality of diagnosis, relieving the healthcare sector, and increasing access to specialist healthcare.

Conclusion

In conclusion, artificial intelligence has enormous potential for transforming radiology and other areas of medicine. The results of the comparative study showed that AI can be an effective tool to support the work of radiologists, especially in the analysis of medical images. Despite the challenges associated with the implementation of AI, such as the need for adequate staff training and ethical issues, the benefits of its application are significant. AI can help improve diagnosis accuracy, speed up the diagnosis process, and reduce healthcare costs. In the future, the further development of AI technology, combined with continuous collaboration between developers and medical professionals, can lead to even greater advances in medicine, benefiting both patients and health workers.

Disclosure

Authors do not report any disclosures.

Author's contribution

All authors contributed to the article.

Conceptualization, WS, and MM; methodology, WS, AF, and KK; software, WS, AN, WK, and ZK; check, WS, MŚ, and AM; formal analysis, MB, WK, and MM; investigation, WS, MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; resources, WS, MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; data curation, WS, MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; writing - rough preparation, WS, MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; writing - review and editing, WS, MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; visualization, WS,

MB, AN, MM, WK, ZK, KK, AM, AF, and MŚ; supervision, WS, KK, and AF; project administration, WS, MM, and AN.

Receiving funding: the study did not receive any external funding.

All authors have read and agreed with the published version of the manuscript.

Conflict of Interest Statement

The authors declare no conflict of interest.

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The drawings/figures were made independently.