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Applications of Artificial Intelligence in Medicine. Analysis of Selected Case Studies

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Abstract: Artificial intelligence (AI) is a rapidly evolving field that has the potential to revolutionise industries, enhance human capabilities, and address complex societal challenges. This article provides an overview of the development of artificial intelligence. The article is divided into sections, focusing on literature review, technological foundations, legal and ethical dilemmas related to artificial intelligence, and practical aspects of artificial intelligence in medicine. Section 2 introduces artificial intelligence and provides an overview of technologies related to artificial intelligence. It also discusses ethical, economic, and technical perspectives. Section 3 explores the application of AI in medicine and healthcare institutions. The author's personal contributions include critical analysis of AI's technological principles, and a detailed discussion of its ethical dimensions. The author proposes tailor-made AI strategies for healthcare institutions, the aim of which is to maximise the quality of medical services and precise diagnostics while minimising the risks associated with the use of artificial intelligence.

Keywords: Artificial Intelligence (AI), AI in medicine, law and ethical AI, AI development trends

1. Introduction

Artificial Intelligence (AI) stands at the forefront of technological evolution, transforming every facet of human endeavour. The author's fascination with AI's potential to revolutionise industries, enhance human capabilities, and address complex societal challenges motivated him to delve into this field.

The primary purpose of this article is to provide an overview of AI's developments in the area of medicine. This article is organized into four sections in order to methodically examine the literature review, the technology fundamentals of the study issue, law and ethical AI dilemmas and practical aspects of the study subject, as well as provide managerial recommendations to real life business applications.

This work aims to demystify AI, outline its potential and pitfalls, and offer pragmatic insights into its practical applications in medicine.

The research methods employed in this article include literature analysis to build a theoretical foundation, comparative analysis of contemporary aspects, and case analysis to investigate AI's practical applications and reasoning. An extensive review of 18 literature and online sources was conducted to discover recent developments of AI in medicine, with main focus to practical applications in healthcare institutions and hospitals.

The article draws upon a diverse range of sources, including seminal works in AI, contemporary research papers, legal documents, and industry reports. These materials provided a multifaceted perspective on AI's evolution, ethical considerations, and commercial applications.

In summary, this article contributes to the field through analysis of AI's context, a critical examination of its technological principles, and a nuanced discussion of its ethical dimensions. Author proposed tailored AI strategies for healthcare institutions, aiming to maximize AI's benefits while mitigating its risks.

2. Introduction to Artificial Intelligence, Technology Fundamentals and Dilemmas

There are many definitions on artificial intelligence, and consensus on a common understanding of AI has been hard to reach. There are two major categories, definitions that come from AI experts, for example data or cognitive scientists, and definitions that are made by policymakers. In the first category, there are approaches that see AI in technical terms and delineate its precise functionality. In the second, the definitions often compare artificial to human intelligence and behaviour. The term 'artificial intelligence' was used for the first time in 1955 by a group of four computer and cognitive scientists, John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon (IAPP, 2023). This early definition of artificial intelligence looked at it as a replication of human intelligence, which the authors thought could be so precisely understood and described as to be reproduced by a computer.

As science evolved, so did the definition, which stopped considering human intelligence as the gold standard and saw computers improving beyond the capacity of human brains. The scientific branch of artificial intelligence had the goal to build artificial systems that will outperform humans on tasks that they currently do better, according to Rich and Knight (1991). The view of AI was based on the assumption that it no longer had to imitate human thinking and behaviour, but could reason better than humans. A relatively recent development is the call for dropping the idea of a performance race between humans and machines and focus on the way the two cooperate. This system known as human-in-the-loop sees human intervention as a necessary part of the machine learning process. Humans participate in the training

of models by labelling and structuring the data, essentially telling the computer what to do. Humans also evaluate Machine Learning (ML) models by assessing their output and rejecting errors; thus, a virtuous loop is created where ML algorithms are trained, tested, tuned, and validated. This approach generates the best of both worlds. The mathematical model continuously improves by receiving human feedback, in turn, humans improve their understanding of machine operations and real-world phenomena. Artificial Intelligence (AI) is a multidisciplinary technology that includes computer science, biology, psychology, sociology, philosophy, mathematics, and neuroscience. AI is a rapidly advancing technology in the fields of computer science and data science. It has had a global impact by creating intelligent machines and tools that have revolutionised various industries (Arora, 2025). AI encompasses the utilisation of expert systems, machine learning (ML), artificial neural networks (ANN) and deep learning (DL). Figure 1 illustrates a correlation between them.

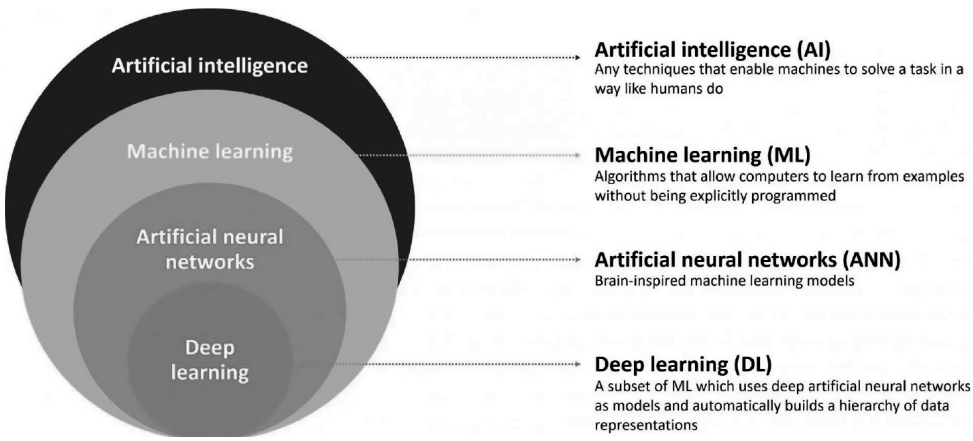

Fig. 1. Relationship between AI, ML, ANN, and DL

Source: (Mattab, 2019).

Natural Language Processing (NLP) includes various tasks such as sentiment analysis, speech recognition, and text translation (Tucci, 2024). A typical illustration of natural language processing (NLP) is spam detection, wherein the subject title and body of an email are analysed to identify the existence of undesirable content. Virtual assistants like Alexa and Siri demonstrate computer applications that assist individuals with their daily tasks. These assistants can acquire a limited number of questions from the user to figure out their needs, rather than analysing vast quantities of data in order to understand a request.

Algorithmic Bias and Fairness

An important advantage of AI is its ability to overcome human biases and limitations. Humans are prone to forming prejudices, harbouring hidden biases, and engaging in overt discrimination, whereas an AI system solely relies on data analysis. Nevertheless, it is risky and incorrect to assume that AI is necessarily unbiased. It can imitate or strengthen human prejudices, resulting in significant unfairness. Algorithmic bias is morally reprehensible and has detrimental effects on marginalised people. It has the potential to result in negative reactions from customers, and other individuals with an interest in the matter. Additionally, it could potentially result in legal proceedings.

A scientific study published in 2019 focused on a prominent academic hospital located in Boston (Obermeyer et al., 2019). Researchers discovered that the use of a care management algorithm resulted in systemic racial discrimination by directing patients of certain races to greater resources based on their high-risk status. The average black patient referred through this programme had nearly twice as many underlying conditions as the average white patient. In short, a black patient had to much sicker to receive the same standard of care. By modifying the methodology to include both white and black patients with similar levels of illness, the researchers observed a roughly threefold increase in the number of black patients who met the criteria. This problem is not isolated. Facial recognition systems have demonstrated lower accuracy rates when it came to identifying faces with dark skin. Similarly, hiring algorithms employed by corporations such as Amazon, which aim to predict job performance based on applications, have been proven to put women at a disadvantage.

There are multiple techniques available to explicitly include fairness requirements into the design of algorithmic systems or to evaluate whether they generate discriminating outcomes. Nevertheless, they are not perfect. First, it is important to note that there is no universally agreed-upon definition of fairness. Consequently, choices and compromises must be made. Systems that prioritise fairness may exhibit reduced levels of accuracy.

The General Data Protection Regulation in Europe includes an anti-bias requirement within the portions that address completely automated processing. The use of the concept is yet not fully understood. Various jurisdictions have put out a range of ideas for new legislation. The European Union has just implemented a significant new legislation on Artificial Intelligence, which has been the subject of a discussion paper. The US has put up suggestions for the Algorithmic Accountability Act, which mandates the use of bias-checking procedures. However, these approaches have not been widely implemented as of now.

Ethical Artificial Intelligence

Ethics are often discussed in the media, particularly when touching topics like abortion, euthanasia, or death penalty. However, ethics are not always applicable in everyday life, both in private and professional aspects. Norms, such as habits, customs, and religions, are the first forms of regulation of interpersonal relations and codes of conduct (Nguyen et al., 2023). These norms can manifest in different formats, such as decrees, orderings, and imperatives, and primarily serve the purpose of fulfilling a duty and prescriptive function in governing social life.

Societal evolution entails the gradual expansion of punishments over time, transforming them into religious rules that persist beyond death. Legal norms have a greater sense of urgency but may lack fairness, and they have the potential to intersect and reinforce one another. Ossowska (1985) argues that the categorization of norms is flexible, where a standard that prohibits certain actions, such as lying or deceiving, can be classified as either a legal norm or a moral norm depending on the accompanying emotion. For instance, honesty is a one-sided order, while integrity is a legal norm. When examining norms, it is crucial to distinguish between individual standards and collective norms that encompass entire social groups. An individual cannot exist in isolation from society, generating fresh viewpoints and responsibilities. According to Witwicki (1957), moral behaviour is crucial in minimising conflicts and ensuring the smooth functioning of society without disrupting social order. Normative ethics is a reasonable framework that provides guidelines for the use of this 'lubricant'.

The topic of ethical intelligence has been extensively examined by Bruce Weinstein (2011), who is also recognised as The Ethics Guy. According to him, ethical intelligence is based on five fundamental concepts: do no harm, make things better, respect others, be fair, and care. These principles represent not only academic meanings but also real consequences in our everyday existence. Weinstein demonstrates that possessing ethical intelligence not only has positive effects on our well-being, but it also improves our physical health, overall happiness, and financial achievement. In the end, ethical intelligence is a significant type of intelligence that plays a crucial role in determining our professional performance, the quality of our interpersonal connections, and our self-perception (Floridi & Cowls, 2019). The goal is to enhance our ethical intelligence in all aspects of our lives.

3. Artificial Intelligence in Medicine

With the increasing adoption of artificial intelligence, the application of this technology across various industries is also expanding. Currently, researchers do not anticipate that AI will replace health care personnel in the near future. Instead, they perceive it as reinforcement and improvement the efforts of healthcare practitioners and experts in the near future.

Advanced AI Tools to Support Clinical Brain Scans Analysis – Diagnose Diseases

Hospitals around the world perform millions of brain magnetic resonance imaging (MRI) scans every year. They have the potential to fundamentally change our knowledge of numerous neurological disorders, but their analysis has not yet been possible due to their anisotropic resolution:

AL can support transforming brain scans for advanced analysis. The Al tool called SynthSR can convert clinical brain scans into high-resolution T1-weighted images. T1-weighted images are produced by using short Time to Echo (TE) and Repetition Time (TR) times. The contrast and brightness of the image are predominantly determined by T1 properties of tissue (Iglesias et al., 2023) – see Fig. 2.

This technological innovation resolves the problem of inconsistent scan quality that previously limited the use of numerous scans in advanced research. SynthSR simplifies the process of generating comprehensive 3D brain renderings by converting these scans into T1-weighted pictures which are renowned for their excellent contrast and accurate depiction of brain structure.

The experiments conducted with the use of SynthSR show strong correlations between observed volumes at both the scan and subject levels, indicating that SynthSR generates images that substantially match those produced by high--resolution T1 scans.

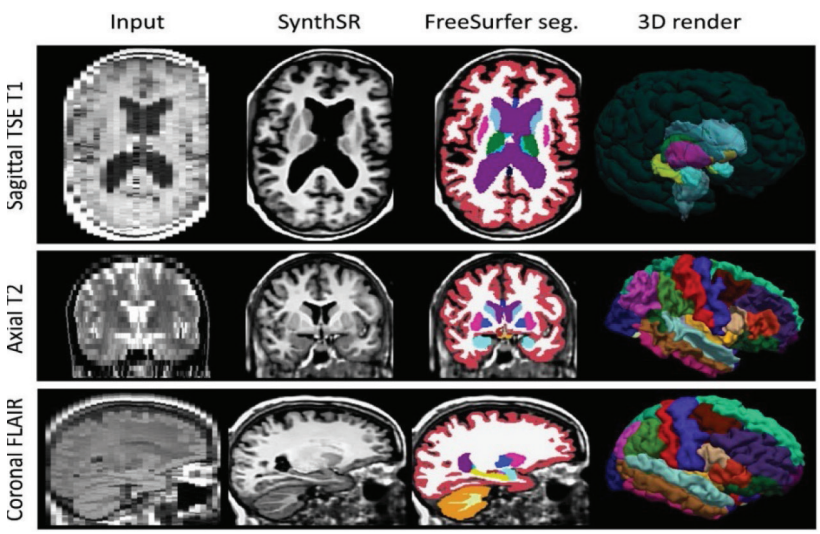

Fig. 2. Examples of inputs and outputs of SynthSR

Source: (Iglesias et al., 2023).

SynthSR is publicly available and can be used by any hospital around the world. The tool is still trained on new data coming from different research sources, mainly

from the Massachusetts General Hospital (MGH) dataset (including MRI scans, ages, and genders) available at the public server of the Martinos Center for Biomedical Imaging (Iglesias et al., 2023).

Artificial Intelligence Algorithms to Support Identification and Treatment of Glaucoma – Precision Medicine

Glaucoma, which is the primary reason for permanent blindness on a global scale, is a group of eye diseases caused by the optic nerve damage that necessitates timely identification and ongoing treatment in order to maintain vision.

Advanced algorithms can analyse retinal pictures, and machine learning models can combine risk factors to identify high-risk individuals who require diagnostic workup and careful follow-up for increased screening. In order to enhance the accurate identification of glaucoma, deep learning methods are used to identify certain patterns associated with the disease. These patterns are detected by analysing data from optical coherence tomography, visual field testing, retinal photography, and other types of ocular imaging. AI-based platforms also enable continuous monitoring, and use algorithms that examine longitudinal data to notify physicians of rapid illness advancement (Zhu et al., 2024). AI can advance precision medicine for glaucoma by using predictive analytics and patient-specific factors to make personalised treatment choices.

The company called Miranza developed a virtual assistant designed to aid professionals in making decisions regarding the treatment of glaucoma. This programme integrates cutting-edge advancements in artificial intelligence and big data to deliver personalised therapy recommendations for the most effective glaucoma treatment tailored to each individual patient. Additionally, it forecasts the intraocular pressure of patients, which is a crucial factor in glaucoma. The assistant can suggest entirely personalised treatment by selecting these criteria which are exclusive to each patient (Equipo Miranza, 2023). In addition it 'learns' from its interactions and gradually improves its performance in diagnostic tasks through usage.

Another example of practical application of AI in the treatment of glaucoma is the product called The Eagle created by Belkin Vision from Israel. Belkin Vision has developed an innovative laser platform to tackle the various difficulties involved with employing SLT (Selective Laser Trabeculoplasty) as the main treatment for mild glaucoma and ocular hypertension. The Eagle emits 120 pulses, each with an energy of 1.8 millijoules, in a systematic and continuous circular pattern (Radcliffe, 2022). The treatment process involves preparing the patient and fine-tuning the objective, while the AI algorithm takes care of the remaining tasks with a simple button press (Fig. 3).The laser is integrated with AI eye-tracking technology called SureTrac, which ensures precise targeting of the specified treatment area with every use. Currently, there are two devices in Europe, and one of them being used at the District Railway Hospital in Katowice (Okuliści w Katowicach…, 2024).

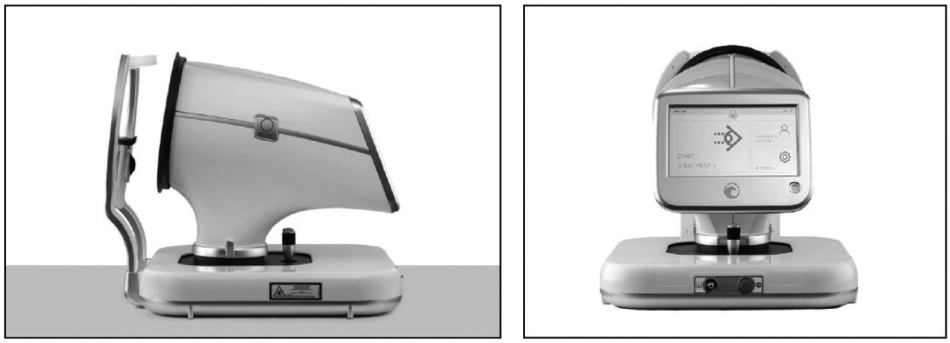

Fig. 3. The Eagle from Belkin Vision

Source: (Radcliffe, 2022).

Thanks to the application of AI the laser treatment is fully automatic and takes 2-3 seconds, while traditional solution laser treatment takes 5-10 minutes and is strongly dependent on a human operator.

CT PANDA and Other Research on Diagnostic Artificial Intelligence Use Cases

Here are couple of examples how AI can support researchers in diagnosis.

Pancreatic ductal adenocarcinoma (PDAC) is an extremely deadly cancer, frequently diagnosed at a stage where surgical treatment is no longer possible. Screening for PDAC in adults without symptoms is difficult because of its low occurrence and the potential for incorrect positive results. A Chinese research team has recently created PANDA (Pancreatic Cancer Detection Using Artificial Intelligence), an advanced AI model that can effectively identify and categorise pancreatic lesions in X-ray images. PANDA outperformed the average radiologist in sensitivity by 34.1% and in specificity by 6.3% during validation testing (Fig. 4). PANDA was evaluated in the study with a substantial number of participants – about 20,000. The results showed that PANDA had a sensitivity of 92.9% and a specificity of 99.9% (Cao et al., 2023).

Breast cancer. A comprehensive literature evaluation was conducted by searching six databases (medRixiv, bioRxiv, Embase, Engineer Village, IEEE Xplore, and PubMed) for articles published between 2012 and September 30, 2022. Studies were qualified if they used actual screening mammography examinations to authenticate artificial intelligence (AI) algorithms for prospective risk estimation alone based on pictures or in conjunction with clinical risk indicators. An evaluation was conducted to determine the quality of the investigations, and the accuracy of predictions was measured using the area under the receiver operating characteristic curve (AUC) (Schopf et al., 2024). Preliminary attempts to forecast future breast cancer risk using only mammography pictures exhibit similar or superior

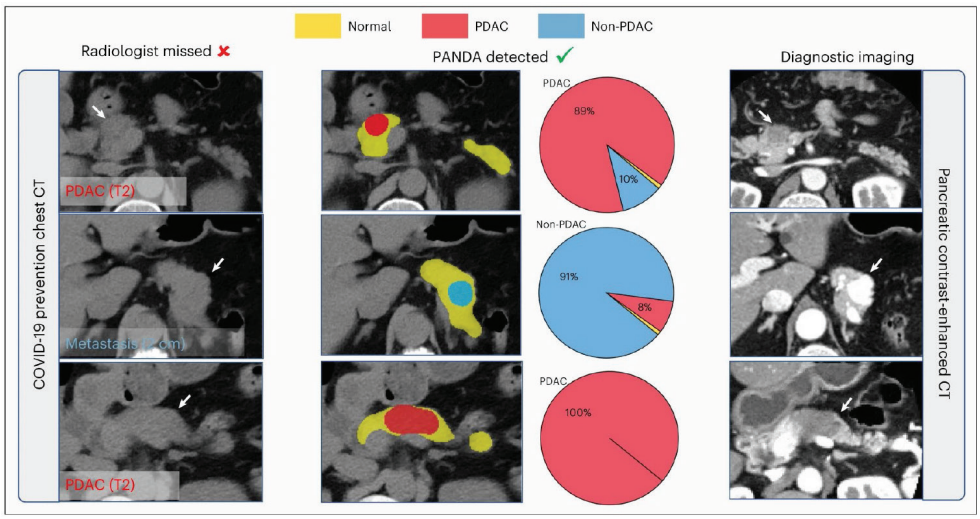

Fig. 4. PANDA detects early-stage PDACs and metastatic cancer

Source: (Cao et al., 2023).

precision compared to conventional risk assessment methods, with minimal or no enhancement when incorporating clinical risk factor data. Shifting from using clinical risk factors to utilising AI image-based risk models can result in more precise and individualised screening methods based on risk assessment.

X-ray interpretation. Artificial intelligence (AI) systems for automated chest X-ray interpretation have the potential to standardise reporting and reduce delays in health systems due to shortages of trained radiologists. Performance achieved by AI X-Raydar tool are similar to historic clinical radiologist reporters for multiple clinically important finding s (Cid et al., 2024). The open-sourced neural networks can serve as foundation models for further research and are freely available to the research community and any hospital interested in such tools.

The broad adoption of AI highlights a clear message for professionals in all industries: accepting and utilising AI is crucial for achieving growth and success. Adopting AI is essential for maintaining a competitive edge in any industry, including data science, healthcare, education, or business leadership.

4. Conclusions

As we approach a new era in artificial intelligence, it is crucial that we consider the path that has led us to this point. As the primary goal of the article, the author has explored the vast expanse of AI in medicine and its potentials in healthcare institutions and hospitals. The article has thoroughly analysed the development

progress, technology, ethical dilemmas, and pragmatic uses of AI in medicine, offering an in-depth examination of its advancement.

This article confirms the profound impact of AI on our daily life and emphasises the need for a careful and knowledgeable approach to its integration. In the future, AI is expected to progress rapidly, driven by developments in quantum computing, neuro-symbolic AI, and autonomous systems. The integration of AI with other emerging technologies, like as blockchain and the Internet of Things (IoT), holds the potential to generate innovative synergies and prospects.

In the end, the future of AI is determined by the decisions and actions we make now, which collectively form a complex and interconnected web. The future is full of great potential and significant obligations. As we progress, let us do so with excitement, self-respect, and a constant commitment to the improvement of civilization.

References

Arora, S. K. (2025). *What is Artificial Intelligence? Definition, Examples and Future.* hackr.io. https://hackr.io/blog/what-is-artificial-intelligence

Cao, K., Xia, Y., Yao, J., Han, X., Lambert, L., Zhang, T., Tang, W., Jin, G., Jiang, H., Fang, X. Nogues, I., Li, X., Guo, W., Wang, Y., Fang, W., Qiu, M., Hou, Y., Kovarnik, T., Vocka, M., … & Lu, J. (2023). Large-scale Pancreatic Cancer Detection via Non-contrast CT And Deep Learning. *Nature Medicine*, *29*(12), 3033-3043. https://doi.org/10.1038/s41591-023-02640-w

Cid, Y. D., Macpherson, M., Gervais-Andre, L., Zhu, Y., ranco, G., Santeramo, R., Lim, C., Selby, I., Muthuswamy, K., Amlani, A., Hopewell, H., Das Indrajeet, Liakata, M., Hutchinson, C. E., Goh, V., & Montana, G. (2024). Development and Validation of Open-Source Deep Neural Networks for Comprehensive Chest X-ray Reading: A Retrospective, Multicentre Study. *The Lancet. Digital Health*, *6*(1), E44-E57. https://doi.org/10.1016/S2589-7500(23)00218-2

Equipo Miranza. (2023). *Miranza Leads the Development of a Virtual Assistant for the Indication of Glaucoma Treatment Using Artificial Intelligence*. https://miranza.es/en/news/miranza-is-developing-an-ai-based-virtual-assistant-that-helps-in-decision-making-and-predicts-results-in-the-treatment-of-this-disease/

Floridi, L., & Cowls, J. (2019). A Unified Framework of Five Principles for AI in Society. *Harvard Data Science Review*, *1*(1). https://doi.org/10.1162/99608F92.8CD550D1

IAPP. (2023). *International Definitions of Artificial Intelligence*. https://iapp.org/resources/article/international-definitions-of-ai/

Iglesias, J. E., Billot, B., Balbastre, Y., Magdamo, C., Arnold, S. E., Sudeshna Das, Edlow, B. L., Alexander, D. C., Golland, P., & Fischl, B. (2023). SynthSR: A Public AI Tool to Turn Heterogeneous Clinical Brain Scans into High-resolution T1-weighted Images for 3D Morphometry. *Science Advances*, *9*(5). https://doi.org/10.1126/sciadv.add3607

Mattab. (2019, May, 17). *Artificial Intelligence, Enough of the Hype! What Is It?* Hewlett Packard Enterprise. https://community.hpe.com/t5/hpe-blog-uk-ireland-middle-east/artificial-intelligence-enough-of-the-hype-what-is-it/ba-p/7046672

Nguyen, A., Ngo, H. N., Hong, Y., & Dang, B. (2023). Ethical Principles for Artificial Intelligence in Education. *Education and Information Technologies*, *28*(4), 4221-4241. https://doi.org/10.1007/s10639-022-11316-w

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations. *Science*, *366*(6464), 447-453. https://doi.org/10.1126/science.aax2342

Okuliści w Katowicach leczą jaskrę laserem wspomaganym przez sztuczną inteligencję. (2024). *Puls Medycyny*, June 11. Retrieved 2 March 2025 from https://pulsmedycyny.pl/medycyna/okulistyka/okulisci-w-katowicach-lecza-jaskre-laserem-wspomaganym-przez-sztuczna-inteligencje/

Ossowska, M. (1985). *Normy moralne. Próba systematyzacji*. PWN.

Radcliffe, N. (2022). Direct Selective Laser Trabeculoplasty. *Glaucoma Today*, November/December. https://glaucomatoday.com/articles/2022-nov-dec/direct-selective-laser-trabeculoplasty

Rich, E., & Knight, K. (1991). *Artificial Intelligence* (2nd ed.). McGraw-Hill.

Schopf, C. M., Ramwala, O. A., Lowry, K. P., Hofvind, S., Marinovich, M. L., Houssami, N., Elmore, J. G., Dontchos, B. N., Lee, J. M., & Lee, C. I. (2024). Artificial Intelligence-Driven Mammography-Based Future Breast Cancer Risk Prediction: A Systematic Review. *Journal of the American College of Radiology*, *21*(2), 319-328. https://doi.org/10.1016/J.JACR.2023.10.018

Tucci, L. (2024). *A Guide to Artificial Intelligence in the Enterprise*. https://www.techtarget.com/searchenterpriseai/Ultimate-guide-to-artificial-intelligence-in-the-enterprise

Weinstein, B. (2011). *Ethical Intelligence: Five Principles for Untangling Your Toughest Problems*. New World Library.

Witwicki, W. (1957). *Pogadanki obyczajowe*. PWN.

Zhu, Y., Salowe, R., Chow, C., Li, S., Bastani, O., & O'Brien, J. M. (2024). Advancing Glaucoma Care: Integrating Artificial Intelligence in Diagnosis, Management, and Progression Detection. *Bioengineering*, *11*(2). https://doi.org/10.3390/BIOENGINEERING11020122

Zastosowania sztucznej inteligencji w medycynie. Analiza wybranych studiów przypadków

Streszczenie: Sztuczna inteligencja (AI) to szybko rozwijająca się dziedzina, która może zrewolucjonizować przemysł, zwiększyć możliwości ludzkie i sprostać złożonym wyzwaniom społecznym. Autor wprowadza w świat sztucznej inteligencji i dokonuje przeglądu wybranych technologii z nią związanych. Następnie przedstawia zastosowanie sztucznej inteligencji w medycynie, analizując aktualne trendy na rynku sztucznej inteligencji i podając praktyczne przykłady jej zastosowań w instytucjach opieki zdrowotnej. Wykorzystuje różnorodne źródła literaturowe, w tym przełomowe prace dotyczące sztucznej inteligencji, współczesne artykuły badawcze, dokumenty prawne oraz raporty branżowe. Dokonuje dogłębnej analizy kontekstu sztucznej inteligencji, krytycznej analizy jej zasad technologicznych oraz prowadzi dyskusję na temat jej wymiarów etycznych. Autor proponuje ponadto szyte na miarę strategie AI dla instytucji opieki zdrowotnej, mające na celu poprawę jakości usług medycznych, precyzyjną diagnostykę i minimalizację ryzyka związanego z zastosowaniem AI.

Słowa kluczowe: sztuczna inteligencja (AI), AI w medycynie, prawo i etyka AI, trendy rozwoju AI