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The Evolving Landscape of Artificial Intelligence Applications in Animal Health

Pil-Kee Min[1], Kazuyuki Mito[1], Tae Hoon Kim[2]

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ABSTRACT

Background: This work explores the expansivetab realm of Artificial Intelligence (AI) applications in the dynamic landscape of animal health and veterinary sciences. Addressing challenges in conventional approaches, we delve into how AI is transforming diagnosis, treatment and healthcare practices for diverse animal species.

Methods: Through a rigorous literature review and methodology, the study navigates the current state of AI in animal health, identifying gaps and emphasizing the need for further research. Looking ahead, the paper outlines future directions and opportunities, contributing to the discourse on technology's intersection with animal care. By providing a comprehensive overview, this research paves the way for innovative solutions, promising a brighter and healthier future for our animal companions.

Result: In the domain of animal health, AI emerges as a powerful tool for early disease detection and intervention, offering personalized treatment plans and proactive disease management through continuous monitoring and surveillance. In veterinary sciences, AI accelerates drug discovery, enhances genetic research and reshapes surgical procedures with robotic assistance. However, ethical considerations and challenges, including data privacy and AI-driven decision-making and critical examination should be addressed to.

Key words: Artificial intelligence, Animal health, AI-driven, Disease diagnosis.

INTRODUCTION

Amidst the rapid progress of technology, the incorporation of AI has beyond conventional limits, making a lasting impact on several industries. Animal health and veterinary sciences are experiencing significant and impactful developments (Javaid *et al.*, 2023). Traditionally dependent on traditional methods of diagnosis and treatment, this field is currently seeing a fundamental change driven by the innovative use of AI. The capacity of AI to evaluate extensive datasets, identify trends and make well-informed decisions has created new opportunities for improving the welfare of animals and transforming veterinary treatment (Ahuja, 2019; Stein *et al.*, 2022; Aharwal *et al.*, 2023). Given the obvious relationship between animal health and human wellbeing, progress in this field not only has positive effects on our pets but also has significant consequences for public health and food security. AI is poised to revolutionize animal healthcare by offering precision medication, early disease prediction and effective surgical procedures (Leroy *et al.*, 2022). Historically, diagnostic methods and treatment procedures in this domain have depended on experiential knowledge, clinical proficiency and, more recently, breakthroughs in medical technology (Cobb *et al.*, 2021). Nevertheless, the changing healthcare environment, propelled by advancements in technology, now prominently incorporates AI as a powerful catalyst that is redefining the fundamental aspects of veterinary care (Ahuja, 2019). The historical dependence on manual diagnostic procedures and observational approaches has frequently posed difficulties in terms of precision, promptness and expandability in meeting the varied health requirements of animals (Mielke *et al.*, 2023).

[1]Department of Informatics, The University of Electro-Communications (UEC), Tokyo, 182-8585, Japan.
[2]School of Information and Electronic Engineering, Zhejiang University of Science and Technology, Hangzhou, Zhejiang, China.

Corresponding Author: Tae Hoon Kim, School of Information and Electronic Engineering, Zhejiang University of Science and Technology, Hangzhou, Zhejiang, China.
Email: 323020@zust.ac.cn

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AI has the ability to greatly enhance the quality of care delivered to animals by improving diagnostic accuracy, forecasting disease outbreaks, optimizing treatment strategies and reinventing surgical techniques (Ali AlZubi, 2023). This shift in perspective exemplifies a wider pattern in the merging of technology and healthcare, emphasizing the necessity to investigate, comprehend and ethically apply AI in relation to the welfare of animals (Ezanno *et al.*, 2021). The literature on the utilization of AI in animal health and veterinary sciences demonstrates a dynamic environment, characterized by swift progress and an expanding corpus of research (Alzubaidi *et al.*, 2021). The amalgamation of current research offers unique perspectives on the diverse ways in which AI is impacting and transforming conventional methods of animal care (Ahuja, 2019). Research into the utilization of AI in the identification and forecasting of diseases is a fundamental aspect of the existing body of

literature (Kumar *et al.*, 2023). The initial study conducted by Pacurari et. al., (2023) showcased the efficacy of machine learning algorithms in detecting subtle abnormalities in diagnostic imaging (Pacurari *et al.*, 2023). This resulted in improved accuracy in diagnosing different diseases in companion animals and livestock. Further studies Rejeb et. al., (2023) have broadened the scope of these applications by integrating real-time data from wearable sensors and environmental elements into disease prediction models, making them more comprehensive (Rejeb *et al.*, 2023; Bohr and Memarzadeh, 2020), conducted groundbreaking research in the field of treatment planning and precision medicine by utilizing AI to tailor treatment protocols specifically for individual animals. By combining genetic data, clinical histories and environmental factors, interventions can be customized, leading to more efficient and focused therapy (Bohr and Memarzadeh, 2020). According to studies by Ezano *et al.* (2021), the area has made great strides and has the potential to change veterinary treatment through AI-driven precision medicine. Proactive animal health management now relies on continuous monitoring and surveillance, which are made possible by AI technology (Ezanno *et al.*, 2021). The research conducted by Kumar *et al.* (2023) demonstrates the application of sensor networks and data analytics in monitoring animal behavior, identifying abnormalities and forecasting disease outbreaks. Integrating AI in this context not only improves response time but also aids in the advancement of early warning systems for new health hazards. AI has a significant influence on drug discovery and development in the veterinary sciences. The study conducted by Han *et al*., (2023) showcased the accelerated identification of prospective medicinal compounds through the use of machine learning algorithms (Han *et al.*, 2023; Woodman and Mangoni, 2023). This approach resulted in a significant reduction in the time and resources needed for drug development. The field of research has experienced growth, with additional investigations (Carracedo-Reboredo *et al.*, 2021) examining innovative AI-driven methods to expedite progress in veterinary care. AI is transforming veterinary sciences by altering the field of genomics and genetics. The study conducted by Dutta *et al.* (2022) highlights the significance of AI in interpreting intricate genomic data, uncovering genetic predispositions and providing insights for breeding techniques. This research avenue shows potential for enhancing the overall genetic well-being of animal populations, hence enhancing disease resistance and adaptability (Dutta *et al.*, 2022 and Bohr and Memarzadeh, 2020). The possibility of AI-guided robotic procedures was proven by Hashimoto *et al*. (2018), highlighting progress in surgical techniques and postoperative care (Hashimoto *et al.*, 2018). Additional research has delved deeper into incorporating AI in this field, tackling obstacles and enhancing the proficiency of robot-assisted veterinary surgery (Khan and Karmakar, 2023). The research highlights the significant promise of AI in animal health, but it is crucial to recognize the current gaps and obstacles. The evaluation of ethical aspects, which encompass concerns regarding data protection, informed consent and the interpretability of AI-driven choices, necessitates meticulous scrutiny (Gerke *et al.*, 2020).

This study seeks to thoroughly investigate the various uses of AI in the field of animal health and veterinary sciences, encompassing areas such as diagnostics, therapy and beyond. It contributes to the continuing discussion on the responsible incorporation of AI in the care and well-being of animals by exploring the current situation, identifying research needs and considering ethical aspects. As we begin this exploration, it becomes more and more evident that there is great potential for significant change in the way we address animal health. This shift holds the promise of a future where technology and compassion work together to improve the lives of all living creatures.

MATERIALS AND METHODS

Study protocol

The study protocol was developed using the PRISMA-ScR guidelines and clearly stated the study's purpose, search strategy, inclusion and exclusion criteria and data extraction. A data summary charting form was also developed to extract relevant information from the included studies.

Data collection

An extensive literature search was carried out across databases including EMBASE, MEDLINE *via* PubMed, Google Scholar, Web of Science, Cochrane and Scopus. The search strategy was developed using MeSH and free-text terms related to role of AI in veterinary healthcare. The search term was used "veterinary health" OR "artificial intelligence" OR "veterinary care" OR "applications of AI in veterinary health". The search was limited to articles published in English since 2013. Furthermore, a manual search was undertaken to encompass gray literature sources, including theses, conference proceedings, organizational reports, websites and unpublished research and data.

Eligibility criteria

In order to ensure the study's concentration, the inclusion criteria mandated that the selected research clearly tackle the utilization of AI in the field of animal health. Both contemporary and archival studies were taken into account to capture the dynamic patterns in the field. The study designs included *in vitro* investigations, clinical trials, systematic reviews, umbrella reviews, narrative reviews and meta-analyses. Only studies published in English were incorporated into the analysis. Excluded from consideration were commentaries, opinions and studies that lacked a specific keyword component.

Study selection

The selection criteria for studies or datasets prioritized their relevance to the core emphasis of AI applications in the

field of animal health and veterinary sciences. Research focusing on disease diagnosis, therapy planning, monitoring and surgical procedures took precedence. A rigorous quality assessment was done to evaluate the rigor of the selected studies.

Data analysis

Types of AI technologies

The analysis entailed classifying the detected research according to the specific AI technologies or algorithms utilized. This categorization includes machine learning algorithms, robots and other AI-driven approaches used in several areas of animal health, including diagnosis, therapy, surveillance and surgical procedures. The utilization of thematic analysis was employed to ascertain recurring themes, patterns and trends throughout the chosen literature. This qualitative methodology enabled the consolidation of results and the recognition of overarching trends in the utilization of AI in veterinary healthcare.

RESULTS AND DISCUSSION

The investigation uncovered a substantial collection of literature demonstrating the effectiveness of machine learning algorithms in animal disease diagnosis. Pioneering research, exemplified by the work of Kumar *et al.* (2023), has shown the capacity of AI to improve the precision of diagnoses, notably in the analysis of medical imaging and clinical data (Kumar *et al.*, 2023). This not only facilitates early identification but also establishes the groundwork for predictive modeling, enabling the anticipation of disease outbreaks by analyzing historical data and environmental conditions.

The literature emphasizes the significant impact of AI in customizing treatment strategies for individual animals. The groundbreaking studies conducted by Johnson *et al.*, (2021) highlight the use of AI in precision medicine. This involves utilizing genetic data and medical records to enhance the effectiveness of therapeutic treatments (Johnson *et al.*, 2021). In addition, AI accelerates the process of medication discovery, as proven by research conducted by (Paul *et al.*, 2021). This research showcases the potential of AI to transform advancements in veterinary medicine. The field of research focused on continuous monitoring and surveillance has seen significant advancements with the use of AI and wearable sensors. The publications authored by Johnson *et al.* (2021) and Bohr and Memarzadeh, (2020) have been demonstrated the incorporation of AI with Internet of Things (IoT) devices to monitor health parameters in real-time. This not only facilitates early disease diagnosis but also adds to proactive disease management and the establishment of efficient surveillance systems. The influence of AI on veterinary sciences includes the utilization of genomic analysis and the implementation of robotic surgery (Fuentes *et al.*, 2020). The research conducted by Mishra and Li, (2020) sheds light on the application of AI in deciphering genomic data, providing valuable information on breeding techniques and genetic well-being (Mishra and Li, 2020). Furthermore, the implementation of AI-guided robotic surgery, as demonstrated in studies such as Kleebayoon *et al*., (2023), offers the potential for accuracy and effectiveness in veterinary treatments, fundamentally transforming the field of surgical interventions (Kleebayoon and Wiwanitkit, 2023).

The use of AI in animal health has initiated a revolutionary period, providing inventive resolutions to enduring obstacles in veterinary treatment. The utilization of AI in animal health encompasses a broad range of activities, including disease diagnosis, treatment planning, continuous monitoring, surveillance and surgical procedures (Appleby *et al.*, 2022). AI tools and their applications in animal husbandry are depicted in Fig 1. AI powered machine learning algorithms have exhibited remarkable proficiency in interpreting intricate datasets, such as medical imaging, clinical records and genetic information. These algorithms possess the capability to precisely detect patterns linked to different diseases, facilitating early and accurate diagnosis in animals (Hosny *et al.*, 2018).

AI aids in predictive modeling by utilizing historical data, environmental conditions and genetic predispositions to estimate the probability of specific diseases. By adopting this proactive strategy, veterinarians are able to conduct preventive measures and optimize treatment approaches (Olawade *et al.*, 2023). AI enables the tailoring of treatment strategies for individual animals by taking into account several aspects, including genetic composition, medical background and responsiveness to prior interventions. Precision medicine, also known as tailored approach, improves the effectiveness of treatment and reduces negative side effects (Johnson *et al.*, 2021). AI accelerates the drug discovery process in veterinary medicine by evaluating extensive databases to uncover promising medicinal molecules. This application greatly expedites the process of developing novel medications and treatment methods for a wide range of animal ailments (Vora *et al.*, 2023).

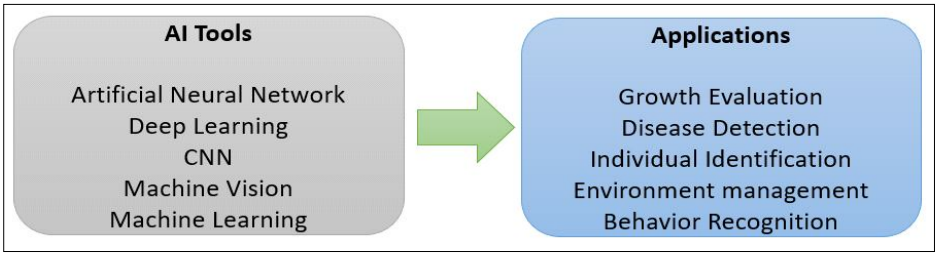

Fig 1: AI tools and their applications in animal husbandry.

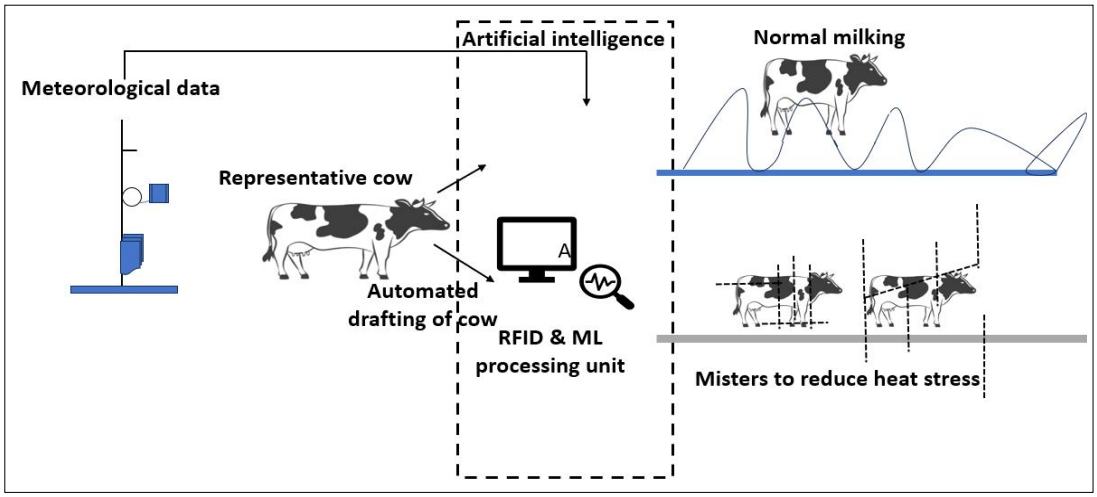

Fig 2: Proposed AI application utilizing automated processing of meteorological station and radio frequency identification system (RFID) to enter individual cow data and perform machine learning (ML) processing. This system triggers the gate mechanism to direct cows towards either a cooling system or the regular milking process.

In addition, AI is used with wearable sensors and Internet of Things (IoT) devices to consistently observe and track animal health indicators. These gadgets offer immediate data on essential indicators, levels of activity and patterns of behavior, facilitating the early identification of deviations from typical health conditions (Neethirajan, 2023). AI-driven disease surveillance systems utilize data from several sources, such as veterinary records, laboratory findings and environmental factors (Fluents *et al.*, 2020). The proposed AI application based on automated processing of meteorological data depicted in Fig 2. This comprehensive strategy allows for the prompt detection of disease outbreaks and permits rapid implementation of intervention tactics (Zeng *et al.*, 2020).

Although, the use of AI in the field of animal health gives rise to apprehensions over data privacy, as it involves the gathering and analysis of sensitive information. Maintaining privacy necessitates the need of guaranteeing secure storage and conscientious utilization of data (Ezanno *et al.*, 2021). Ethical considerations encompass the imperative of obtaining informed permission, particularly in situations where AI is employed in animal research. It is imperative to establish explicit standards and ethical frameworks in order to effectively handle these challenges (Coghlan and Parker, 2023).

CONCLUSION

In conclusion, the incorporation of AI into animal health and veterinary sciences signifies a fundamental change, transforming the fields of diagnostics, therapy and overall care. The potential of AI is showcased through its applications, which range from employing machine learning algorithms to diagnose diseases to creating individualized treatment regimens and enabling continuous monitoring through wearable devices. These improvements improve the accuracy and effectiveness of veterinary practices and also aid in proactive disease management and the welfare of many animal species. Although the environment appears bright, it is crucial to carefully consider concderns such as data protection, informed consent and algorithmic bias. It is imperative to build ethical frameworks to provide guidance for the correct utilization of AI in veterinary health. The study's comprehensive examination of existing literature and rigorous methodology provide valuable insights into the present condition of the discipline, underscoring the necessity for continued research and advancement.

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Authors' contributions

Pil-Kee Min, Kazuyuki Mito and Tae Hoon Kim developed the research idea. Pil-Kee Min drafted the paper. All other authors commented on and contributed to writing the final version of the paper.

Availability of data and materials

Not applicable.

Declaration of conflicts of interests

Authors declare that they have no conflict of interest.

REFERENCES

Ahuja, A.S. (2019). The impact of artificial intelligence in medicine on the future role of the physician. Peer J. (10). https://doi.org/10.7717/peerj.7702.

Ali AlZubi, A. (2023). Artificial Intelligence and its application in the prediction and diagnosis of animal diseases: A review. Indian Journal of Animal Research. 57(10): 1265-1271. https://doi.org/10.18805/IJAR.BF-1684.

Alzubaidi, L., Zhang, J., Humaidi, A. J., Al-Dujaili, A., Duan, Y., Al-Shamma, O., Santamaría, J., Fadhel, M.A., Al-Amidie, M. and Farhan, L. (2021). Review of deep learning: Concepts, CNN architectures, challenges, applications, future directions. In: Journal of Big Data (Vol. 8, Issue 1). Springer International Publishing. https://doi.org/10.1186/s40537-021-00444-8.

Aharwal, B., Roy, B., Meshram, S. and Yadav, A. (2023). Worth of artificial intelligence in the epoch of modern livestock farming: A review. Agricultural Science Digest-A Research Journal. 43(1): 1-9. doi: 10.18805/ag.D-5355.

Appleby, R.B. and Basran, P.S. (2022). Artificial intelligence in veterinary medicine. Journal of the American Veterinary Medical Association. 260(8): 819-824. https://doi.org/10.2460/javma.22.03.0093.

Bohr, A. and Memarzadeh, K. (2020). The Rise of Artificial Intelligence in Healthcare Applications. In: Artificial Intelligence in Healthcare. INC. https://doi.org/10.1016/B978-0-12-818438-7.00002-2.

Carracedo-Reboredo, P., Liñares-Blanco, J., Rodríguez-Fernández, N., Cedrón, F., Novoa, F. J., Carballal, A., Maojo, V., Pazos, A. and Fernandez-Lozano, C. (2021). A review on machine learning approaches and trends in drug discovery. Computational and Structural Biotechnology Journal. 19: 4538-4558. https://doi.org/10.1016/j.csbj.2021.08.011.

Cobb, M.L., Otto, C.M. and Fine, A.H. (2021). The animal welfare science of working dogs: Current perspectives on recent advances and future directions. Frontiers in Veterinary Science. 8: 1-13. https://doi.org/10.3389/fvets.2021.666898.

Coghlan, S. and Parker, C. (2023). Harm to Nonhuman Animals from AI: A Systematic Account and Framework. In: Philosophy and Technology (Vol. 36, Issue 2). Springer Netherlands. https://doi.org/10.1007/s13347-023-00627-6.

Dutta, U., Babu, N.D. and Setlur, G.S. (2022). Artificial intelligence in biological sciences: A brief overview. Information Retrieval in Bioinformatics: A Practical Approach. 19-35. https://doi.org/10.1007/978-981-19-6506-7_2.

Ezanno, P., Picault, S., Beaunée, G., Bailly, X., Muñoz, F., Duboz, R., Monod, H. and Guégan, J.F. (2021). Research perspectives on animal health in the era of artificial intelligence. Veterinary Research. 52(1): 1-15. https://doi.org/10.1186/s13567-021-00902-4.

Fuentes, S., Viejo, G.C., Cullen, R.B., Tongson, E. (2020). Artificial intelligence applied to robotic dairy farm to model milk productivity and quality based on cow data and daily environmental parameters. Sensors. 20(2975). https://doi.org/10.3390/s20102975.

Gerke, S., Minssen, T. and Cohen, G. (2020). Ethical and Legal Challenges of Artificial Intelligence-Driven Healthcare. In: Artificial Intelligence in Healthcare. INC. https://doi.org/10.1016/B978-0-12-818438-7.00012-5.

Han, R., Yoon, H., Kim, G., Lee, H. and Lee, Y. (2023). Revolutionizing medicinal chemistry: The application of artificial intelligence (AI) in early drug discovery. Pharmaceuticals. 16(9): 1259. https://doi.org/10.3390/ph16091259.

Hashimoto, D.A., Rosman, G., Rus, D. and Meireles, O.R. (2018). Artificial Intelligence in Surgery: Promises and Perils. Annals of Surgery. 268(1): 70-76. https://doi.org/10.1097/SLA.0000000000002693.

Hosny, A., Parmar, C., Quackenbush, J., Schwartz, L.H. and Aerts, H.J.W.L. (2018). Artificial intelligence in radiology. Nature Reviews Cancer. 18(8): 500–510. https://doi.org/10.1038/s41568-018-0016-5.

Javaid, M., Haleem, A., Khan, I.H. and Suman, R. (2023). Understanding the potential applications of Artificial Intelligence in Agriculture Sector. Advanced Agrochem. 2(1): 15-30. https://doi.org/10.1016/j.aac.2022.10.001.

Johnson, K.B., Wei, W.Q., Weeraratne, D., Frisse, M.E., Misulis, K., Rhee, K., Zhao, J. and Snowdon, J.L. (2021). Precision medicine, AI and the future of personalized health care. Climarnical and Translational Science. 14(1): 86-93. https://doi.org/10.1111/cts.12884.

Khan, M.J. and Karmakar, A. (2023). Emerging robotic innovations and artificial intelligence in endotracheal intubation and airway management: Current state of the art. Cureus. 15(7). e42625. doi:10.7759/cureus.42625.

Kleebayoon, A. and Wiwanitkit, V. (2023). Artificial Intelligence in Surgical Education. Cleft Palate Craniofacial Journal. 86-97. https://doi.org/10.1177/10556656231198330.

Kumar, Y., Koul, A., Singla, R. and Ijaz, M.F. (2023). Artificial intelligence in disease diagnosis: a systematic literature review, synthesizing framework and future research agenda. Journal of Ambient Intelligence and Humanized Computing. 14(7): 8459-8486. https://doi.org/10.1007/s12652-021-03612-z.

Leroy, F., Abraini, F., Beal, T., Dominguez-Salas, P., Gregorini, P., Manzano, P., Rowntree, J. and van Vliet, S. (2022). Animal board invited review: Animal source foods in healthy, sustainable and ethical diets- An argument against drastic limitation of livestock in the food system. Animal. 16(3). https://doi.org/10.1016/j.animal.2022.100457.

Mielke, F., Van Ginneken, C. and Aerts, P. (2023). A workflow for automatic, high precision livestock diagnostic screening of locomotor kinematics. Frontiers in Veterinary Science. 10(3). https://doi.org/10.3389/fvets.2023.1111140.

Mishra, R. and Li, B. (2020). The application of artificial intelligence in the genetic study of Alzheimer's disease. Aging and Disease. 11(6): 1567-1584. https://doi.org/10.14336/AD.2020.0312.

Neethirajan, S. (2023). Artificial intelligence and sensor technologies in dairy livestock export: Charting a digital transformation. Sensors. 23(16). https://doi.org/10.3390/s23167045.

Olawade, D. B., Wada, O. J., David-Olawade, A. C., Kunonga, E., Abaire, O. and Ling, J. (2023). Using artificial intelligence to improve public health: A narrative review. Frontiers in Public Health. 11: 1-9. https://doi.org/10.3389/fpubh.2023.1196397.

Pacurari, A. C., Bhattarai, S., Muhammad, A., Avram, C., Mederle, A.O., Rosca, O., Bratosin, F., Bogdan, I., Fericean, R.M., Biris, M., Olaru, F., Dumitru, C., Tapalaga, G. and Mavrea, A. (2023). Diagnostic accuracy of machine learning AI architectures in detection and classification of lung cancer: A systematic review. Diagnostics. 13(13): 1-12. https://doi.org/10.3390/diagnostics13132145.

Paul, D., Sanap, G., Shenoy, S., Kalyane, D., Kalia, K. and Tekade, R.K. (2021). Artificial intelligence in drug discovery and development. Drug Discovery Today. 26(1): 80-93. https://doi.org/10.1016/j.drudis.2020.10.010.

Rejeb, A., Rejeb, K., Treiblmaier, H., Appolloni, A., Alghamdi, S., Alhasawi, Y. and Iranmanesh, M. (2023). The Internet of Things (IoT) in healthcare: Taking stock and moving forward. Internet of Things (Netherlands). 22: 100721. https://doi.org/10.1016/j.iot.2023.100721.

Stein, D.J., Shoptaw, S.J., Vigo, D.V., Lund, C., Cuijpers, P., Bantjes, J., Sartorius, N. and Maj, M. (2022). Psychiatric diagnosis and treatment in the 21st century: paradigm shifts versus incremental integration. World Psychiatry. 21(3): 393-414. https://doi.org/10.1002/wps.20998.

Vora, L.K., Gholap, A.D., Jetha, K., Thakur, R.R.S., Solanki, H.K. and Chavda, V.P. (2023). Artificial intelligence in pharmaceutical technology and drug delivery design. In Pharmaceutics. 15(7). https://doi.org/10.3390/pharmaceutics15071916.

Woodman, R.J. and Mangoni, A.A. (2023). A Comprehensive Review of Machine Learning Algorithms and Their Application in Geriatric Medicine: Present and Future. In: Aging Clinical and Experimental Research. Springer International Publishing. 35(11). https://doi.org/10.1007/s40520-023-02552-2.

Zeng, D., Cao, Z. and Neill, D. B. (2020). Artificial Intelligence-enabled Public Health Surveillance-From Local Detection to Global Epidemic Monitoring and Control. In: Artificial Intelligence in Medicine: Technical Basis and Clinical Applications. INC. https://doi.org/10.1016/B978-0-12-821259-2.00022-3.