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Research Article

Exploring Deep Learning Methods Used in the Medical Device Sector

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ABSTRACT

The healthcare sector is witnessing significant development in many aspects thanks to the effects of artificial intelligence or software, which has turned out to be the centre of attraction all over the world. This is evidence of a simple development in acquiring deep knowledge of the methods and areas in which they are used. Face detection, voice recognition, autonomous use, the defence industry, the security industry, and other fields may be displayed as examples that help complete tasks. This article surveys the impact of deep learning methods and practices in the medical device industry, and we also examine the distribution of multi-year data. It is divided into six categories: healthcare, big data and wearable technologies, biomedical code, image processing, diagnostics, and the Internet of Medical Things. As a result, the medical device industry has grown in recent years through deep learning techniques and the use of most research related to diagnosis and image processing.

1. INTRODUCTION

As the population increases throughout the year, health conditions improve dramatically, and epidemics and diseases spread [1][2]. Therefore, medical devices have a significant role in developing health institutions and enhancing the capabilities of doctors and specialists in monitoring the spread of diseases [3-5]. Humanity faces many unprecedented viruses and microorganisms, and it is expected that these viruses will develop in the future. The most famous of these is COVID-19 [6-8]. The respirators used to treat the COVID-19 pandemic also show how critical medical devices are for human health in such epidemics [9][10]. The convergence between modern technologies and healthcare services has created an electronic environment for medical diagnosis, patient care, and monitoring the spread of epidemics and viruses [11][12]. The high technological rates of medical devices have constantly been rising in recent years. With these developments, it has become possible to treat diseases that were previously considered difficult or impossible to treat, and the behaviour of these diseases cannot be predicted. One of the most critical factors in this technological development is the application of deep learning in medical devices [13-15]. Deep learning is a form of machine learning generally executed using a multi-layer neural network architecture and is a promising branch of machine learning [16][17]. In the medical sector, deep learning capabilities are being leveraged to perform tasks such as data classification or phenotyping new diseases. Deep learning is considered one of the most important artificial intelligence practices in growing the healthcare environment and increasing the efficiency and accuracy of medical devices [18-20]. Deep learning analyses huge amounts of data and studies new patterns to make accurate predictions, assist doctors and specialists in using devices skilfully, and detect diseases early. Deep learning algorithms enhance medical device performance by increasing diagnosis accuracy and customising the appropriate treatment for each patient. These algorithms deal with complex and heterogeneous data, including photogrammetry, genetic profiles, and physiological data. These algorithms significantly outperform traditional methods of analysing medical big data and extracting diverse information from the data while providing significant actionable assistance to doctors and healthcare workers. These procedures contribute to facilitating early diagnosis of diseases through the development of medical imaging devices and the detection of minute abnormalities in X-rays, MRIs, and CT scans with high accuracy and efficiency. These

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measures not only speed up the diagnosis process, but also enhance the effectiveness of treatment plans, leading to improved patient outcomes. Figure 1 illustrates the importance of deep learning in healthcare.

Fig. 1. The importance of deep learning in healthcare [21].

This study reviews the recent importance of deep learning in medical devices. The studies were divided into six categories (healthcare, big data and wearable technologies, biomedical code, image processing, diagnostics, and the Internet of Medical Things) according to the fields in which deep learning methods are employed, and the distribution of studies by years appears from PubMed database from 1987 to April 2024.

2. THE SURVEY

Machine learning is the domain that explores computational algorithms that learn from data patterns. In uncomplicated terms, it refers to creating computer programs that optimise some evaluation metrics using data as if they were thinking like humans. In recent years, thanks to the marked improvement in available devices, deep learning has contributed to improving many sectors, including the care sector. Using this approach, models discover and learn relevant representations for each problem from the data instead of manually extracting features. Convolutional neural networks (CNNs) are a type of neural network that has achieved very high performance in a wide range of AI applications [22-24]. A CNN can be considered a neural network that uses identical copies of the same neuron. This method, called shared parameters, allows the network to create large computational models while keeping the number of parameters that must be learned relatively low. In this section, we will survey the number of studies from PubMed (a free database) involving deep learning in medical devices.

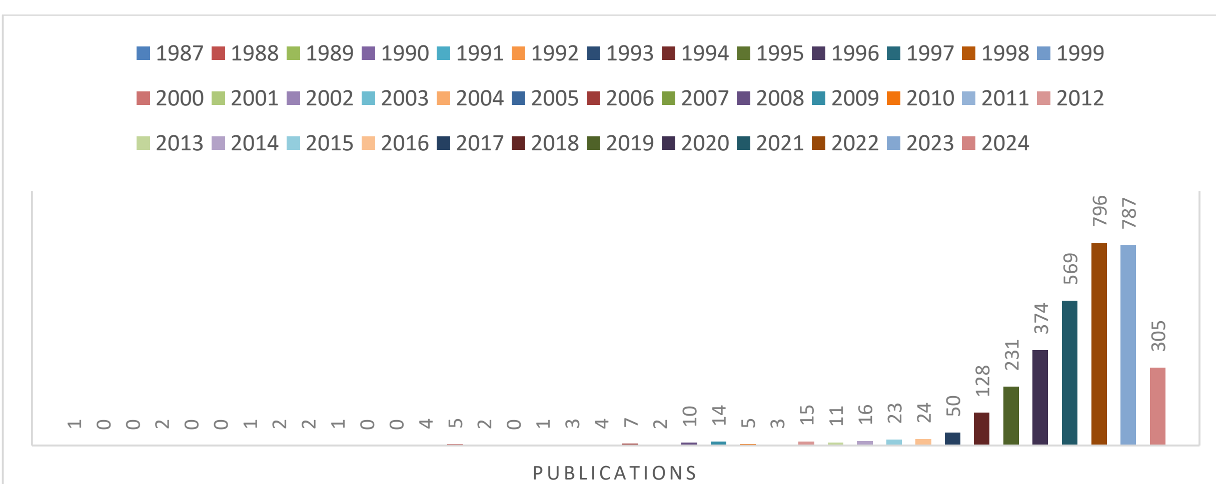

Fig. 2. PubMed database with the keywords “deep learning” and “medical device” from 1987 to April 2024.

A total of 3,038 publications were found in the search made on PubMed, the largest database related to medicine [25][26], with the keywords "(deep learning) and (medical device)". The biggest leap was made in 2022 with 796 publications. Subsequently, 787publications were made in 2023 and 305 in 2024. Figure 2 shows the distribution of publications by years from 1987 to April 2024.
When the same source is searched with the keyword "(deep learning) AND (device)", 6,424 publications appear. When the chart below is examined, it made the biggest leap in 2023 with 1756 publications (see Figure 3).

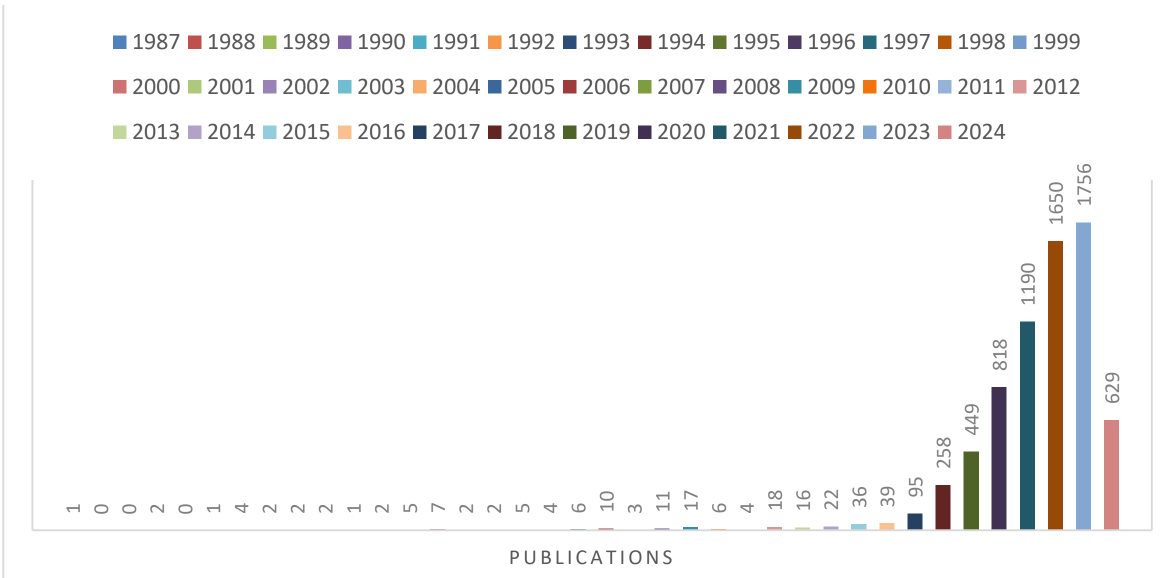

Fig. 3. PubMed database with the keywords "deep learning" and "device" from 1987 to April 2024.

When the same source is searched with the keyword "(deep learning) AND (medical)", 6,424 publications appear. When the chart below is examined, it made the biggest leap in 2023 with 7836 publications (see Figure 3). As can be seen from Figures 1,2, and 3, deep learning applications are rapidly increasing in the medical device industry.

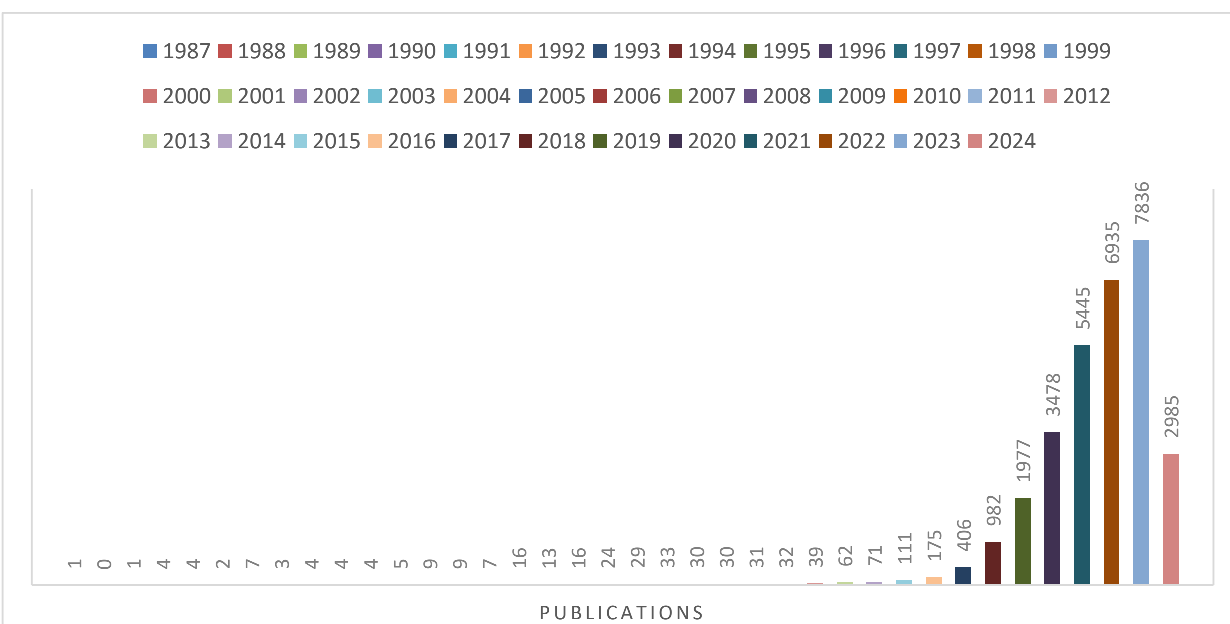

Fig. 4. PubMed database with the keywords "deep learning" and "medical" from 1987 to April 2024.

Deep learning scans made via PubMed are divided into 6 different classes according to where they are used with medical devices. Since PubMed is a global database, detailed searches for each field were carried out through this database. As a result, there are 253 publications in the field of healthcare, 438 in the field of big data (65 publications) and wearable technologies (373 publications), 577 in the field of biomedical signals, 800 in the field of image processing, 2117 in the field of diagnosis and finally 30 in the field of the Internet of Medical Things (IMoT) (see Figure 5). When publications in these fields are collected, 1,4215 publications are obtained. The chart below shows the distribution of publications, and as can be seen, the largest slice of this cake is the use of deep learning methods for diagnostic purposes, with a rate of 50.%.

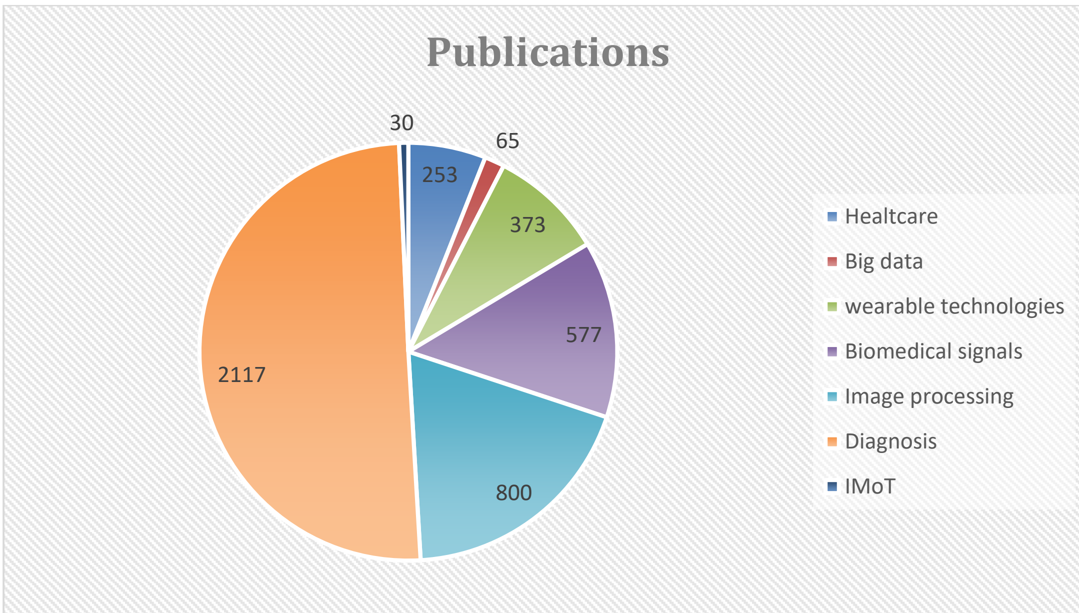

Fig. 5. Publication distribution according to categories.

3. THE IMPORTANCE

Recently, there has been a lot of talk about artificial intelligence (AI), especially after the emergence of many applications such as ChatGPT and others [27][28]. For some, it is talking about robots and science fiction films such as Transcendence, Ex Machina, Matrix, WALL-E, and I Robot, and others, and for others, it is still a matter of thought and discussion about its importance. Although there is some everyday basis where they diverge towards various tracks to make this type of film at some point, artificial intelligence concentrates on other goals, such as machine learning, deep learning, and developing platforms and applications. Understanding these technologies will give us a clear vision of the future. Where is artificial intelligence headed today, and what is its primary purpose?. Comprehending artificial intelligence and how it can be emulated was a great event, mainly due to Alan Turing's contribution. Thanks to the Turing Test, it is possible to get a general view of its capabilities. Turing defined intelligent behaviour as achieving human-level performance in all cognitive and scientific tasks. Subsequently, the traditional concept of artificial intelligence was formulated in the Dartmouth Summer Research Project on Artificial Intelligence, based on the proposal of a group of scholars who gathered to establish the basic rules for the operation of artificial intelligence methods. Learning and intelligence properties that machines can simulate. Artificial intelligence aims to develop machines that behave as if they were intelligent and can be divided into different categories, such as systems that think and act like humans and systems that think and act rationally. In addition, these machines can perform various tasks, such as natural language processing, knowledge representation, automatic reasoning, machine learning, computer vision and robotics, which have characterized the path of artificial intelligence over time in developing applications supporting complicated tasks.

Artificial intelligence techniques contribute to analysing the behaviours and patterns of data, including medical data. Among the sources of big data available in medicine are clinical and administrative registries and records, biometric data, patient-reported information, medical images, vital signs data, prospective studies, and clinical trials [29][30]. Laboratories, hospitals, insurance companies, and pharmaceutical industries can contribute significant financial, disease, and drug data. From the nature of this data, various challenges appear for the use of big data in healthcare, such as the desire to share it, the appropriate legal and ethical agreements to do so, the large volume of information inputs that will be available, and the personalisation of big data. Patient data, sources vary, and even their periodicity, as some will provide data every second, while others will be updated monthly or annually. It is also necessary to evaluate the challenges confronted by individuals as diverse as medical and nursing professionals, administrators, insurance and pharmaceutical company employees, and others in collecting data and information. This contributes to the enormous variety of data that can be input into AI algorithms [32][33]. These algorithms will contribute to improving the performance of healthcare workers, developing healthcare systems, and building an integrated electronic environment.

Fig. 6. Artificial intelligence in filmmaking and game engines [33].

In addition to the diversity of actors organising medical data, it is necessary to consider standardisation processes that allow the information recorded for each patient to be transcribed in both handwritten texts and digital texts of medical reports and images. Data is generated over time as a clinical case evolves and is saved in various formats, for instance, images, insurance claims and even comments made on social media, from the diagnosis stage until the closure of each patient case. All the above, within the framework of legality, rules of ethics, transparency, confidentiality, and the protection and privacy of personal data, which require patients' consent and the processes of depersonalisation of said information, as the diversity of laws involved in each nation can be a factor preventing the implementation of projects of international scope. Through heterogeneous datasets, big data applications in medicine can promote outstanding benefits, such as preventing diseases, evaluating health care costs, assessing the effectiveness of drugs, planning improvements, and making appropriate diagnoses for each patient. Data that medical experts can leverage to involve big data techniques is organised in a range of learning analytics from explicit student actions, such as completing assignments and taking tests, and implicit actions, including online social interactions, extracurricular activities, and online messaging. Creating discussion forums and integrating artificial intelligence applications into important productions are vital. One of the benefits of the electronic medical record is that it integrates all patient care episodes regardless of where and when they occur. It is interoperable with other systems, such as administrative and clinical management, economic and financial management, and knowledge management. It can be accessed at any time and place where it is necessary for patient care, with limitations arising from the safeguards provided by personal data protection legislation. This register is essential and is permitted to be used by researchers, planners, service quality assessors, and authorised persons. These people must be secure; all log access must be recorded, including who has access and what information has been entered or modified. The implementation of electronic medical records has become a necessity because, often, people move from one place to another. Different healthcare professionals see it throughout their lives. As a result, it contains more than one medical record, distributed on computer and paper files in various locations and with different identification numbers. The electronic health record (EHR) should be a guiding tool for improving the significance and efficiency of health and social services, with the patient's needs at the centre [34][35]. Correspondingly, it is essential that the patient can access the electronic health record at any time.

Recently, health institutions in many countries have been seeking to develop and pay attention to medical records by developing mechanisms that contribute to improving their quality. Various practices have been employed to reduce in-person data entry time, such as preventing the physician from becoming an employee recording administrative data required for billing services; this makes physicians spend approximately four times more time and leads to delays in medical services for patients and a lack of growth of health institutions. Physicians who employed documentation support interacted with patients more than those who did not use these documentation services. Moreover, the increasing use of AI in medicine reduces manual work, saves primary care physicians time, and increases productivity, accuracy, and usefulness. The clinical history can only be visualised by considering the dataset. Most IT solutions for medical techniques do not rely on algorithms that learn from data. Instead, they use systems created by specialists (computer and medical scientists) to survey data and recommend treatments. The algorithms required to develop this AI must be made by programmers collaborating with those who know about health issues, namely physicians and healthcare workers.

4. CONCLUSIONS

This paper presents statistics of publications in which deep learning methods were used in the medical device industry. It is divided into sections according to the fields in which they are used. Statistics show that in the last years, from 2018 until now, deep learning has been of great importance, especially in diagnosis and image processing. In addition, deep learning is being integrated into radiology, body segmentation, and the IMoT, which is vital in improving electronic healthcare services. Upon examining the literature, it is noticed that deep learning methods are attracting increasing interest in the medical device industry. Deep learning will continue to make a significant impact through algorithms that contribute to decision-making and support for healthcare workers. From the results, medical devices have come last in the field of the Internet, and deep learning methods have become widely spread in the medical field and the medical device industry.

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Conflicts Of Interest

The author's disclosure statement confirms the absence of any conflicts of interest.

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References

[1] M. F. Myers, D. J. Rogers, J. Cox, A. Flahault, and S. I. Hay, "Forecasting disease risk for increased epidemic preparedness in public health," *Advances in Parasitology*, vol.47, pp.309-330, 2000, https://doi.org/10.1016/S0065-308X(00)47013-2

[2] P. Hay, P. Aouad, A. Le, P. Marks, D. Maloney, et al., "Epidemiology of eating disorders: population, prevalence, disease burden and quality of life informing public policy in Australia—a rapid review," *Journal of Eating Disorders*, vol.11, no.23, pp.1-46, February 2023. https://doi.org/10.1186/s40337-023-00738-7

[3] M. Niaz and U. Nwagwu, "Managing Healthcare Product Demand Effectively in The Post-Covid-19 Environment: Navigating Demand Variability and Forecasting Complexities," *American Journal of Economic and Management Business*, vol.2, no.8, pp.316-330, 2023. https://doi.org/10.58631/ajemb.v2i8.55

[4] H. B. Mamo, M. Adamiak, and A. Kunwar, "3D printed biomedical devices and their applications: A review on state-of-the-art technologies, existing challenges, and future perspectives," *Journal of the Mechanical Behavior of Biomedical Materials*, vol.143, pp.105930, July 2023. https://doi.org/10.1016/j.jmbbm.2023.105930

[5] S. Rani, A. Kataria, S. Kumar, and P. Tiwari, "Federated learning for secure IoMT-applications in smart healthcare systems: A comprehensive review," *Knowledge-Based Systems*, vol.274, pp.110658, August 2023. https://doi.org/10.1016/j.knosys.2023.110658

[6] R. Al-Tohamy, S. S. Ali, M. Zhang, T. Elsamahy, E. A. Abdelkarim, H. Jiao, S. Sun, and J. Sun, "Environmental and Human Health Impact of Disposable Face Masks During the COVID-19 Pandemic: Wood-Feeding Termites as a Model for Plastic Biodegradation," *Applied Biochemistry and Biotechnology*, vol.195, pp.2093–2113, November 2022. https://doi.org/10.1007/s12010-022-04216-9

[7] X. Liu and B. Hu, "Mask device as a new wearable sampler for breath analysis: what can we expect in the future?," *Analytical and Bioanalytical Chemistry*, vol.415, pp,3759–3768, April 2023.https://doi.org/10.1007/s00216-023-04673-z

[8] E. J. Chow, T. M. Uyeki, and H. Y. Chu, "The effects of the COVID-19 pandemic on community respiratory virus activity," *Nature reviews microbiology*, vol.21, pp.195–210, October 2022. https://doi.org/10.1038/s41579-022-00807-9

[9] J. Zeng, P. Lu, Y. Wei, X. Chen, and K. Lin, "Deep reinforcement learning based medical supplies dispatching model for major infectious diseases: Case study of COVID-19," *Operations Research Perspectives*, vol.11, pp.100293, December 2023. https://doi.org/10.1016/j.orp.2023.100293

[10] M. M. Mijwil, AH. Al-Mistarehi, A. M. Z. Alaabdin, M. E. Ike, G. B. Mensah, and A. Addy, "Beyond the Pandemic: The Interplay and Biological Effects of COVID-19 on Cancer Patients -A Mini Review," *Al-Salam Journal for Medical Science*, vol.3, no.1, pp.22–27, December 2023. https://doi.org/10.55145/ajbms.2024.03.01.005

[11] S. Sim and M. Cho, "Convergence model of AI and IoT for virus disease control system," *Personal and Ubiquitous Computing*, vol.27, pp.1209–1219, June 2021. https://doi.org/10.1007/s00779-021-01577-6

[12] B. S. Shukur, M. K. A. Ghani, and B. B. M. Aboobaider, "Digital Physicians: Unleashing Artificial Intelligence in Transforming Healthcare and Exploring the Future of Modern Approaches," *Mesopotamian Journal of Artificial Intelligence in Healthcare*, vol.2024, pp.28–34, 2024. https://doi.org/10.58496/MJAIH/2024/005

[13] F. Tettey, S. K. Parupelli, and S. Desai, "A Review of Biomedical Devices: Classification, Regulatory Guidelines, Human Factors, Software as a Medical Device, and Cybersecurity," *Biomedical Materials & Devices*, vol.2, pp.316–341, August 2023. https://doi.org/10.1007/s44174-023-00113-9

[14] A. Padhi, A. Agarwal, S. K. Saxena, and C. D. S. Katoch, "Transforming clinical virology with AI, machine learning and deep learning: a comprehensive review and outlook," VirusDisease, vol.34, pp.345–355, September 2023. https://doi.org/10.1007/s13337-023-00841-y

[15] X. Wu, C. Liu, L. Wang, and M. Bilal, "Internet of things-enabled real-time health monitoring system using deep learning," *Neural Computing and Applications*, vol.35, pp.14565–14576, September 2021. https://doi.org/10.1007/s00521-021-06440-6

[16] S. Dargan, M. Kumar, M. R. Ayyagari, and G. Kumar, "A Survey of Deep Learning and Its Applications: A New Paradigm to Machine Learning," *Archives of Computational Methods in Engineering*, vol.27, pp. 1071–1092, June 2019. https://doi.org/10.1007/s11831-019-09344-w

[17] S. Carta, A. Corriga, A. Ferreira, A. S. Podda, and D. R. Recupero, "A multi-layer and multi-ensemble stock trader using deep learning and deep reinforcement learning," *Applied Intelligence*, vol.51, pp.889–905, September 2020. https://doi.org/10.1007/s10489-020-01839-5

[18] L. Tan, K. Yu, A. K. Bashir, X. Cheng, F. Ming, L. Zhao, and X. Zhou, "Toward real-time and efficient cardiovascular monitoring for COVID-19 patients by 5G-enabled wearable medical devices: a deep learning approach," *Neural Computing and Applications*, vol.35, pp.13921–13934, July 2021. https://doi.org/10.1007/s00521-021-06219-9

[19] U. J. Muehlematter, P. Daniore, and K. N. Vokinger, "Approval of artificial intelligence and machine learning-based medical devices in the USA and Europe (2015–20): a comparative analysis," *The Lancet Digital Health*, vol.3, no.3, pp.e195-e203, January 2021. https://doi.org/10.1016/S2589-7500(20)30292-2

[20] H. Rathore, A. Mohamed, and M. Guizani, "Deep learning-based security schemes for implantable medical devices," *Energy Efficiency of Medical Devices and Healthcare Applications*, pp.109-130, 2020. https://doi.org/10.1016/B978-0-12-819045-6.00006-6

[21] O. Gerasymov, "Why Deep Learning In Healthcare Is Your Best Bet To Invest," *Code IT*, May 2021. https://codeit.us/blog/why-deep-learning-in-healthcare-is-your-best-bet-to-invest

[22] S. Kiranyaz, O. Avci, O. Abdeljaber, T. Ince, M. Gabbouj, and D. J. Inman, "1D convolutional neural networks and applications: A survey," *Mechanical Systems and Signal Processing*, vol.151, pp.107398, April 2021. https://doi.org/10.1016/j.ymssp.2020.107398

[23] Q. Zhang, M. Zhang, T. Chen, Z. Sun, Y. Ma, and B. Yu, "Recent advances in convolutional neural network acceleration," *Neurocomputing*, vol.323, pp.37-51, January 2019. https://doi.org/10.1016/j.neucom.2018.09.038

[24] A. -A. Tulbure, A. -A. Tulbure, and E. -H. Dulf, "A review on modern defect detection models using DCNNs – Deep convolutional neural networks," *Journal of Advanced Research*, vol.35, pp.33-48, January 2022. https://doi.org/10.1016/j.jare.2021.03.015

[25] Z. A. Michaleff, L. O. P. Costa, A. M. Moseley, C. G. Maher, M. R. Elkins, et al., "CENTRAL, PEDro, PubMed, and EMBASE Are the Most Comprehensive Databases Indexing Randomized Controlled Trials of Physical Therapy Interventions," *Physical Therapy*, vol.91, no. 2, pp.190–197, February 2011. https://doi.org/10.2522/ptj.20100116

[26] O. E. Karpov, E. N. Pitsik, S. A. Kurkin, V. A. Maksimenko, A. V. Gusev, N. N. Shusharina, and A. E. Hramov, "Analysis of Publication Activity and Research Trends in the Field of AI Medical Applications: Network Approach," *International Journal of Environmental Research and Public Health*, vol.20, vo.7, pp.5335, March 2023. https://doi.org/10.3390/ijerph20075335

[27] E. Sadıkoğlu, M. Gök, M. M. Mijwil, and I. Kösesoy, "The Evolution and Impact of Chatbots in Social Media: Comprehensive Review of Past, Present, and Future Applications," *Veri Bilimi*, vol.6, no.2, pp.67-76, December 2023

[28] P. Rivas and L. Zhao, "Marketing with ChatGPT: Navigating the Ethical Terrain of GPT-Based Chatbot Technology," *AI*, vol.4, no.2, pp.375-384, April 2023. https://doi.org/10.3390/ai4020019

[29] D. S. J. Ting, R. Deshmukh, D. S. W. Ting, and M. Ang, "Big data in corneal diseases and cataract: Current applications and future directions," *Frontiers in Big Data*, vol.6, pp.1-14, February 2023. https://doi.org/10.3389/fdata.2023.1017420

[30] N. S. Gupta and P. Kumar, "Perspective of artificial intelligence in healthcare data management: A journey towards precision medicine," *Computers in Biology and Medicine*, vol.162, pp.107051, August 2023. https://doi.org/10.1016/j.compbiomed.2023.107051

[31] L. Fu, J. Li, and Y. Chen, "An innovative decision making method for air quality monitoring based on big data-assisted artificial intelligence technique," *Journal of Innovation & Knowledge*, vol.8, no.2, pp.100294, June 2023. https://doi.org/10.1016/j.jik.2022.100294

[32] H. Yu, R. Zhang, and C. Kim, "Intelligent analysis system of college students' employment and entrepreneurship situation: Big data and artificial intelligence-driven approach," *Computers and Electrical Engineering*, vol.110, pp.108823, September 2023. https://doi.org/10.1016/j.compeleceng.2023.108823

[33] J. Kanatt, "Future of the Film Industry: 14 Ways Artificial Intelligence and Game Engines Will Shape Film industry," *Linkedin*, 2023. https://www.linkedin.com/pulse/future-film-industry-14-ways-artificial-intelligence-game-kanatt-wzcsc/

[34] A. M. Amponin and M. C. Britiller, "Electronic Health Records (EHRs): Effectiveness to Health Care Outcomes and Challenges of Health Practitioners in Saudi Arabia," *Saudi Journal of Nursing and Health Care*, vol.6, no.4, pp.123-135, April 2024. https://doi.org/10.36348/sjnhc.2023.v06i04.002

[35] D. Cella, S. Garcia, S. Cahue, J. D. Smith, B. Yanez, et al., "Implementation and evaluation of an expanded electronic health record-integrated bilingual electronic symptom management program across a multi-site Comprehensive Cancer Center: The NU IMPACT protocol," *Contemporary Clinical Trials*, vol.128, pp.107171, May 2023. https://doi.org/10.1016/j.cct.2023.107171