RTP115

Impact of Machine Learning and Deep Learning on Biomedical Applications and Healthcare Industry

Mr. Md Saif Kabir[1], Mr. Shahed Alam[2]

[1]Lecturer, Office of Academic Advising (OAA), Adjunct Lecturer, Department of Electrical and Electronic Engineering (EEE), BRAC University
saif.kabir@bracu.ac.bd

[2]Senior Lecturer, Office of Academic advising (OAA), BRAC University
shahed.alam@bracu.ac.bd

Abstract

A new era of innovation and change in healthcare and medical diagnostics has started as a result of the advancements in Machine Learning (ML) and Deep Learning (DL). Machine learning and deep learning are not just supplemental tools. They are also the catalysts for a paradigm shift in healthcare industry that promises more efficient and individualized healthcare solutions in the nearby future. The substantial impacts of these cutting-edge algorithms on the biomedical applications have been explored in this research paper. With the help of Artificial Intelligence (AI) and its related field, researchers and healthcare professionals now have access to technologies that can analyze large and complicated datasets, extract insightful knowledge, diagnose medical conditions and make incredibly precise predictions.

Keywords

Biomedical Engineering, Machine Learning, Deep Learning, Healthcare, Data-driven Insights, Medical Diagnostics, Artificial Intelligence

Introduction

The fusion of technology and healthcare has led to huge developments in biomedical engineering. It is revolutionizing how doctors comprehend, identify, and treat medical diseases. The two domains of artificial intelligence (AI) - deep learning and machine learning, have risen to unparalleled prominence and have proved to be revolutionary. Slowly and steadily, Machine learning and deep learning algorithms are fundamentally altering how we approach medical research, clinical practice, and establishing cutting-edge healthcare solutions. These technologies can analyze enormous amounts of complex data, extract insightful conclusions, and make predictions with astounding accuracy in a very short time.

This paper explores all the specific applications of the integration of AI in the biomedical field, such as customized medicine, drug discovery acceleration, medical imaging for better diagnostics, and predictive analytics for disease prevention. It also emphasizes the difficulties and moral issues surrounding the application of these technologies in the healthcare industry.

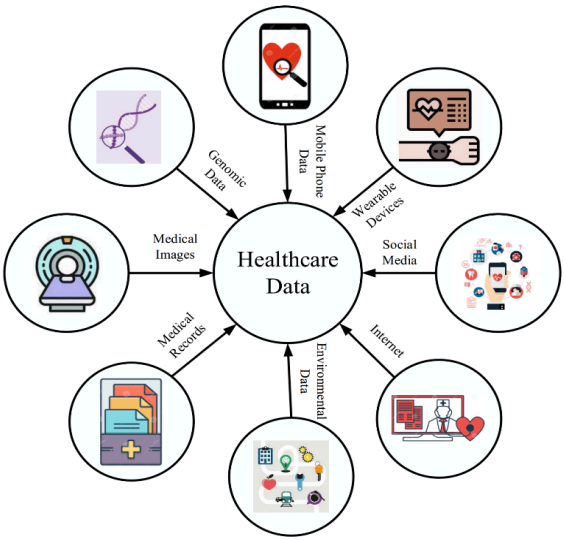

FIGURE 1: Use of machine learning (ML) and deep learning in healthcare
Source: Rahmani et al (2021). Machine Learning (ML) in Medicine: review, applications, and challenges.

Literature Review

In the field of biomedical engineering, artificial intelligence (AI) has a substantial impact. It is now used in several aspects starting from medical diagnostics to disease detection and personalized treatment. Figure 1 shows how the integration of ML have expanded over the years, starting from 1992.

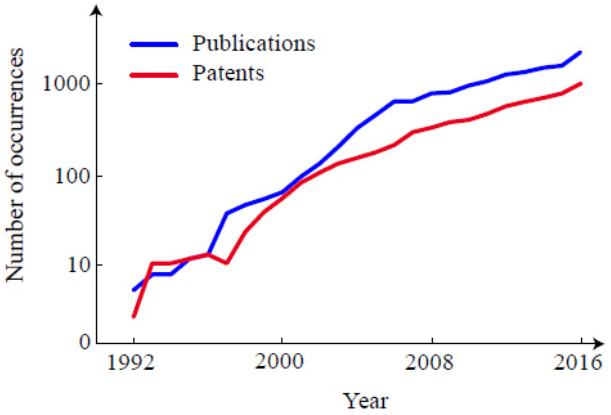

FIGURE 2: Trends in use of machine learning (ML) for biomedical sciences, 1992–2016. Source: Kording, K. P. (n.d.-b). FIGURE 1, Trends in use of machine learning (ML) for biomedical sciences, 1992–2016 - Frontiers of Engineering - NCBI Bookshelf.

Diagnostic and medical imaging: Medical imaging has been one of ML and DL's first and most significant applications in biomedical engineering. Convolutional neural networks (CNNs), in particular, have shown astounding accuracy in tasks like segmentation, object detection, and imagine classification. Rajpurkar et al. (2017) demonstrated how DL has the potential to improve diagnostic precision by presenting a model for identifying a variety of disorders in chest X-rays. Olaf Ronneberger et al. (2015) wrote a paper on U-net Convolutional Neural Network which is an extremely efficient image segmentation algorithm. Yan et al. (2018) presented a model to detect and identify lesions efficiently from images using deep learning.

Drug Discovery and Development: The speeding up of drug discovery and development has been made possible imperatively by machine learning. The application of ML algorithms to anticipate drug-target

interactions, expedite drug screening procedures, and more effectively identify possible therapeutic candidates has been emphasized in studies by Stokes et al. (2020). The paper discussed how DL models can accelerate the process of discovering antibiotics. Cai et al. (2020) mentioned how transfer learning can leverage existing data to improve predictive models.

Personalized Medicine: With the use of ML and DL, personalized medicine, which is catered to a person's genetic make-up and medical background, has gained popularity. According to Miotto et al. (2018), deep learning can be used to anticipate how patients will react to particular therapies, allowing for personalized therapeutic interventions and minimizing side effects. Jared L. Katzman et al. (2018) introduced DeepSurv, a DL model to suggest tailor-made treatment plans, based on patients' data.

Early Disease Prediction and Prevention: Using predictive analytics powered by ML algorithms, disease outbreaks and personal health concerns can be predicted. In order to improve patient care and resource allocation, Obermeyer et al. (2016) investigated the potential of ML to forecast patient deterioration in healthcare settings. Ryan Poplin et al. (2018) focused on the possibility for extensive screening and proposed deep learning model for the identification of diabetic retinopathy. Kangrok Oh et al. (2021) focused on the early detection techniques of diabetic retinopathy, which is even more effective in saving a patient suffering from glucoma.

FIGURE 3: Artificial Intelligence in global healthcare market (USD BILLION)
Source: Artificial Intelligence (AI) in healthcare market size 2022-2030. (n.d.). https://www.precedenceresearch.com/artificial-intelligence-in-healthcare-market

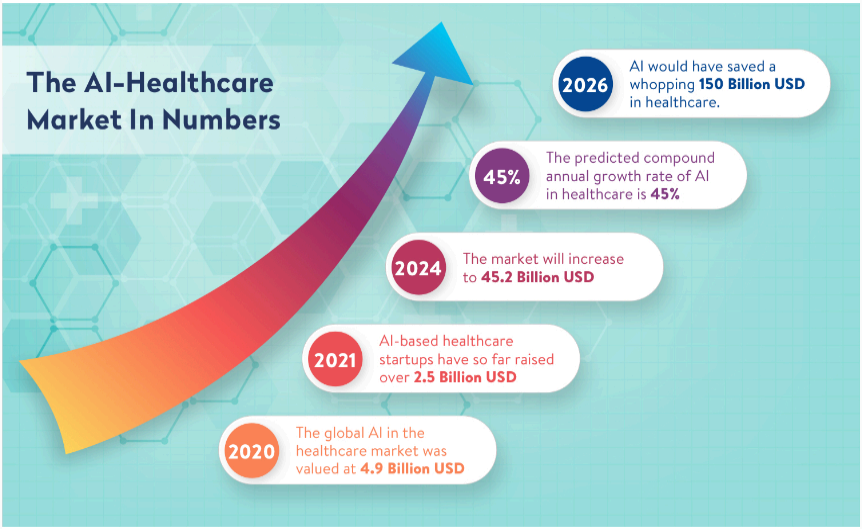

FIGURE 4: The evolution of AI in healthcare. Source: Shivaswamy, S. (2023). The evolution of AI in healthcare. CodeGlo Journal

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Figure 2 and 3 shows the current global market and its projection. It is undeniable that AI is revolutionizing the healthcare industry. Other than the avoid mentioned applications, AI is employed in several other applications – Wearable health monitoring devices, robot assisted surgery, bioinformatics, virtual health assistants and so on.

Challenges and Future Directions

Ethical and regulatory issues have surfaced as ML and DL applications in biomedical engineering grow more widespread. The current challenges include protecting the patient privacy, accountability of new ML and DL models and ensuring proper data quality bias mitigation. To overcome these difficulties and make sure that AI technologies offer the desired advantages while preserving ethical norms and patient rights, the researchers, healthcare practitioners, and AI developers must collaborate.

Although ML and DL have a lot of potential, there are still issues with scalability, interpretability, and data quality. To overcome these difficulties and make sure that AI technologies offer the desired advantages while preserving ethical norms and patient rights, the researchers, healthcare practitioners, and AI developers must

collaborate. For secure and accessible health data management, research is also being done to combine AI methods with other cutting-edge technologies, such as blockchain (Chang et al., 2021).

Conclusion

It is clear that machine learning and deep learning have a significant impact on biomedical engineering. These technologies are at the forefront of medical innovation, advancing everything from diagnostics to individualized treatment plans and redefining the study of medicines. But as we proceed on this revolutionary journey, addressing ethical issues and overcoming technical difficulties are also crucial.

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Authors' Biography

Mr. Md Saif Kabir is currently working as a lecturer in BRAC University. He completed his M.Sc. in Nuclear Engineering and Thermal Physics from National Research Nuclear University (NRNU)- Moscow Engineering Physics Institute (MEPhI), Russia. Prior to that, he obtained his BSc. degree in Electrical and Electronics from Islamic University of Technology (IUT). His current research interest involves deep learning, machine learning, neural networks, biomedical imaging, power electronics and renewable energy.

Mr. Shahed Alam is currently working as a senior lecturer in BRAC University. He did his Master of Science from Tampere University of Technology on Electrical Engineering, Finland. The major of his M.Sc. was on Radio Frequency Electronics focusing on Antennas and Minor was on Wireless Communication. His current research interest involves wireless communication, deep learning, machine learning, and internet of things.