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Mini Review

How Artificial Intelligence is Transforming Healthcare: Current Applications, Challenges, and Future Perspectives

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Abstract

Artificial intelligence (AI) has revolutionized the healthcare industry in many ways. These include enhancing the efficacy of diagnoses, the use of personalized medicine, the optimal use of healthcare workflows, and the prevention of diseases. In recent times, there has been tremendous development in machine learning and deep learning algorithms for natural language processing in artificial intelligence. This has led to the use of artificial intelligence for the analysis of complex healthcare data. The healthcare data include images of healthcare and physiological data of patients. The review aims at providing an updated look at artificial intelligence and its use in the healthcare industry. The review includes the use of artificial intelligence for healthcare images, personalized and predictive healthcare, remote patient monitoring, virtual healthcare assistants, and the operation of the healthcare industry. In addition, challenges and trends faced by the healthcare industry regarding artificial intelligence have been considered. The challenges include data privacy and artificial intelligence.

Keywords: *Artificial Intelligence; Healthcare; Medical Imaging; Personalized Medicine; Remote Monitoring; Ethics; State of the Art*

Introduction

The global healthcare infrastructure is in a state of significant transformation today, with the cumulative effect of a variety of demographic, epidemiological, and economic factors. The gradual rise in life expectancy has resulted in a rapid rise in the aging population. This is accompanied by an increased incidence of chronic and multifactorial diseases such as cardiovascular diseases, diabetes, neurodegenerative diseases, and cancer. In addition, the healthcare infrastructure is challenged with issues such as an overall shortage of personnel, unequal access to care, and increasing operational costs. These factors are cumulatively threatening the sustainability and efficiency of global healthcare infrastructure.

In this scenario, artificial intelligence (AI) is an emerging technology that promises significant transformation in augmenting clinical decisions and optimizing the efficiency of the overall healthcare infrastructure. AI is a unique technology that is capable of handling and correlating huge amounts of heterogeneous data, such as images, lab results, electronic health records, and omics data. By using advanced computational algorithms such as machine learning and deep learning, it is possible to identify non-linear patterns in data that are otherwise impossible.

In the past decade or so, AI has transformed from a largely theoretical and experimental field into a practical and, in many respects, indispensable aspect of modern health care. The integration of AI into health care has been likened to a paradigm shift, reminiscent of earlier medical revolutions such as the introduction of antibiotics or imaging techniques. Rather than replacing doctors, AI is being progressively used as a powerful decision support tool, which has the potential for improving accuracy, efficiency, and reducing medical errors.

AI in medical imaging and diagnostics

Of all the various domains wherein AI is being utilized in healthcare, medical imaging is arguably one of the most advanced and tested. The advent of deep learning techniques, especially CNNs, has transformed image analysis in medicine to unprecedented levels, with computers being able to automatically identify pathological features with unprecedented precision.

AI has been found to achieve incredible results in all kinds of imaging techniques, including X-rays, computed tomography scans, magnetic resonance imaging scans, and mammograms. A study published by McKinney., *et al*. in 2020 [1] found that an AI system developed by Google Health outperformed human experts in detecting breast cancer, reducing both false positives and false negatives significantly. Such results have been found in detecting lung nodules, diabetic retinopathy, ischemic stroke, intracranial hemorrhage, etc. thereby emphasizing the power of AI-based image analysis tools.

Commercial tools, such as the Red Dot platform offered by Behold.ai, are already being utilized in clinical settings, helping radiologists with prioritization of critical cases as well as optimizing diagnostic procedures. These tools not just help with improving efficiency but also contribute to solving problems associated with delays in diagnosis, which is critical in acute cases.

However, there are still some significant challenges that need to be addressed. The challenges associated with generalization, as well as integrating such tools with existing hospital information systems, remain significant hurdles. Additionally, it is essential to understand that, at present, such tools can be seen as complementary rather than replacement tools. The term “augmented intelligence” is being preferred over “artificial intelligence”.

Personalized medicine and predictive healthcare

Personalized medicine is a paradigm shift from the conventional ‘one-size-fits-all’ approach to a more individualized form of medicine, in which the decision-making process is tailored according to the genetic, environmental, and lifestyle differences of the individual patient. AI is at the core of this shift, as it helps in the integration of the complex, multidimensional data.

Predictive analytics with the help of AI has been successful in the early identification of individuals at high risk of developing various chronic health conditions, including diabetes, cardiovascular conditions, and various types of cancer. These predictive analytics help in the implementation of early intervention strategies, thus improving the outcomes of the patients as well as reducing the overall healthcare expenses. AI platforms, such as IBM Watson Oncology, help the medical professionals by comparing the individual patient data with the vast databases of evidence, guidelines, and literature.

Nevertheless, the success of AI-based personalized medicine heavily relies on the quality and representativeness of the available data. For example, the lack of representation of some individuals in the available data could cause biases in the predictions and increase health disparities. To overcome these challenges, more diverse datasets and validation strategies must be created.

Remote patient monitoring and virtual health assistants

The integration of AI with wearable technologies and the Internet of Medical Things (IoMT) has enabled the transition to continuous monitoring from episodic monitoring. For example, wearable technologies with biosensors can continuously monitor physiological

parameters such as heart rate, blood pressure, blood glucose, and physical activity. AI algorithms process these continuous monitoring data to detect anomalies and make timely clinical interventions.

Remote monitoring of patients with chronic conditions has shown promise in the prevention of complications and reduction of readmission rates. Recent studies, such as Shaik., *et al.* [2], have demonstrated the effectiveness of AI-based monitoring systems in improving patient outcomes.

Simultaneously, AI-based virtual health assistants and chatbots are increasingly being leveraged as tools to facilitate patient engagement as well. These tools may help with medication reminders, symptom checking, appointment scheduling, as well as basic mental health services. Even though these tools help improve accessibility and patient empowerment, their implementation has to be done in an appropriate manner.

AI in healthcare operations and management

Apart from the clinical applications, AI is also having a tremendous impact on the administration of healthcare services as well as the management of operations within the healthcare industry itself. Administrative tasks, which account for a considerable portion of the resources allocated to the healthcare industry, may be significantly reduced with the help of AI, thus allowing healthcare professionals to focus on the actual task of treating patients.

Predictive analytics, as well as intelligent scheduling, may help optimize resources, minimize patient waiting times, as well as improve the efficiency of the system as a whole. In addition, AI may help predict patient needs, manage hospital resources, as well as minimize burnout of healthcare professionals. Economic studies, as presented by Becker's Healthcare [3], indicate that AI-based administrative optimization may help save a lot of money, thus adding value not just to the healthcare industry itself, but also from an economic point of view.

Ethical, legal, and technical challenges

However, despite the potential of AI to transform the healthcare sector, several ethical, legal, and technical issues arise. One of the major issues with AI in the healthcare sector relates to algorithmic bias. AI algorithms may become biased if the training data used to develop them is incomplete or biased. This may cause inequality in the delivery of healthcare services. Obermeyer., *et al*. [4], for instance, showed that a popular healthcare algorithm failed to recognize the health needs of Black patients due to bias.

Lack of transparency and explainability are other issues with AI algorithms. Most AI algorithms, especially deep learning algorithms, are "black boxes," meaning that clinicians cannot understand the decision-making process of AI algorithms. The development of explainable AI (XAI) aims to overcome this limitation of AI algorithms by improving the ability of AI algorithms to be explained.

Data privacy, as well as cybersecurity, is another major concern in this regard. With the rise of digitization of healthcare data, the risk of cyber attacks is on the rise as well. Not only is it important to comply with regulations like HIPAA and GDPR, but it is equally important to implement effective cybersecurity strategies as well.

Emerging trends and future perspectives

The future of AI in the field of healthcare is marked by rapid innovation and integration of AI in various disciplines. Newly developed techniques such as explainable AI, federated learning, and privacy-preserving machine learning are aiming to address the current limitations in data sharing, transparency, and security.

AI-assisted robotic surgeries are being used for precise surgeries, reducing surgical risk, and AI-driven drug discovery platforms are being used for the accelerated discovery of novel therapeutic compounds. *Insilico* Medicine has successfully demonstrated the capabilities of AI in reducing the time and cost associated with drug development.

The future of healthcare, in essence, will be determined by the synergistic interaction between humans and AI systems. This can be achieved through cooperation, flexibility, and continuous assessment of the effects of AI on the field of healthcare.

Limitations and Critical Perspective

While AI has tremendous potential, it is not the solution to all the ills of the healthcare system. Over-reliance on AI could cause the 'deskilling' of health care professionals, as well as decreased vigilance in the field of medicine. In addition, AI lacks basic human qualities like empathy, ethical judgment, and understanding, which are the cornerstones of patient-centered care.

Another possibility is that over-reliance on AI could damage the doctor-patient relationship, which is the bedrock of good health care delivery. The key is to ensure that AI is an augmenting, not a substituting, tool in health care delivery.

Conclusion

Artificial Intelligence is transforming the healthcare industry in ways that not only improve the accuracy of diagnoses, enable the development of personalized medicine, facilitate the monitoring of patients remotely, but also optimize the operations of the healthcare industry as well.

If harnessed well, Artificial Intelligence has the potential to be one of the most powerful tools in the arsenal of modern medicine, improving efficiency, and hence the quality of healthcare in the process. The future of healthcare delivery, therefore, lies not in the replacement of human intelligence, but in the integration of the two, i.e. artificial intelligence, to create a more responsive, equitable, and efficient healthcare industry [5-19].

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