THE BREAKTHROUGH OF ARTIFICIAL INTELLIGENCE IN MEDICINE AND HEALTHCARE

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Abstract. *This article is an overview of artificial intelligence's historical evolution and current status in the field of medicine and healthcare. The main goal of this study is to underline and understand how artificial intelligence influences one of the most crucial domains in our lives, medicine. Thus, analyzing the current scientific literature and already available artificial intelligence solutions, we explore the development of artificial intelligence throughout history. We describe the variety of technologies and artificial intelligence-powered diagnostics platforms that help healthcare workers during diagnosis. Further, we reflect on the current relationship between the medical field and artificial intelligence. Based on that, specific applications of artificial intelligence in radiology, cardiology, and molecular medicine are discussed, highlighting its impact and potential to advance image analysis, diagnostics, and treatment. Furthermore, we also considered the obstacles and challenges surrounding artificial intelligence in healthcare, such as technological limitations, ethical considerations, and legal issues. Hence, our study achieves its main goal of presenting and exploring the complex role of artificial intelligence in medicine.*

Keywords: *AI-based technologies, deep learning, ethical concerns, image analysis, medical diagnostics, preventive care.*

Introduction

Artificial intelligence (AI) is considered to have the potential to lead to great technological innovation and fundamentally change the way we approach problem-solving and decision-making. At its core, AI refers to the development of computer systems capable of performing tasks that normally would require human skills like learning, reasoning, perception, and language understanding. As AI continues to evolve, its impact on different fields becomes more and more noticeable.

More specifically, the use of artificial intelligence (AI) in healthcare has experienced a transformative evolution, moving from its early beginnings in the 1970s to now being an integral component of modern healthcare. AI's ability to study large amounts of data, predict illness patterns, and offer custom treatment options opens a unique chance to improve healthcare as we know it. Initial applications of AI, including MYCIN, set a foundation for specialized assignments like recognizing blood infections. Yet, progress was slowed by restricted computational abilities and data scarcity. Despite these hurdles, the potential of AI within healthcare was noticeable, resulting in continuous exploration and augmentation. Recent developments in AI for medical diagnosis underline a significant change in healthcare technology. Partnerships such as those between Mayo Clinic and GE Healthcare display a united endeavor to improve diagnostic proficiency.

History of AI in Medicine and Healthcare

Artificial Intelligence (AI) was first used as a term in a proposal for the Dartmouth Summer Research Project on Artificial Intelligence in 1956. After that, until the 1960s, the first AI boom made it possible for computers to perform "exploration" and "inference". In the 1980s, a second AI boom occurred, and by putting "knowledge" into computers, AI became practical in various fields, and expert systems were created. In the 2000s, there was a third AI boom, and "machine learning", was put into practical use. Regarding the use of AI in medicine, medical expert systems began in the late 1970s [1].

The pioneering program like MYCIN, designed to suggest treatments for blood infections, highlighting the early ambitions to integrate AI into the medical field, then CASNET, Causal Associational Networks, was created as a versatile resource for constructing expert systems to diagnose and treat medical conditions. Its primary use was for diagnosing and suggesting treatment for glaucoma [2]. PIP, an abbreviation for Present Illness Program, was developed in the 1970s to mimic the actions of an expert nephrologist when gathering information about the current illness of a patient with existing renal disease. Another major example is ICHT, an Intelligent Referral System for Primary Child Health Care, developed to reduce children mortality especially in rural areas [3], [4].

In the 1980s, in Japan, it was reported that they had developed a support system for creating diagnostic imaging reports by utilizing the results of AI. In 1993, Toriwaki also introduced three-dimensional images and intelligent medical imaging systems, including surgical simulation, the possibility of morphological medical measurements, and the possibility of creating images by computer from 3D images with sufficient resolution [5]. This hinted at the further development of AI in the medical field.

However, these initial movements were constrained by the era's limited computing capabilities and technical difficulty for AI to understand all of the huge amount of information, focusing on narrow AI applications with rule-based systems encoded by expert knowledge. Despite these challenges, later, in the 2000s, as big data processing and deep learning became possible, there were expectations for significant advancements that will transform the healthcare landscape.

Transforming Healthcare: AI Revolutionizing Medicine with Latest Changes

AI and deep learning models have introduced a "new era" for various medical domains, such as neurology, surgery, cardiology, ophthalmology, and the list goes on. The clinics profit a lot from these new technologies and try to implement in their routine as quickly as possible. Moreover, the researchers from medical field are gaining more powerful instruments to analyze more precisely what is happening in our body. As a consequence, it is quite appealing to determine what are achievements of AI in some of the branches of medicine and healthcare.

a) Diagnostics

Fast forward to the present, the landscape of medical diagnostics has been revolutionized by AI, thanks to groundbreaking collaborations and technological innovations. To give an instance, Intel's introduction of powerful processors has given a significant boost to AI's role in healthcare, enabling more efficient data analysis and support for complex diagnostic tools. In like manner, Google Cloud's Medical Imaging Suite and the alliance between Siemens Healthineers and Ohio State Wexner Medical Center are making strides in making healthcare data more accessible and improving imaging and treatment technologies.

Thus, can be seen that the use of AI is progressing. Multiple AI-equipped medical device programs are already present [6].

Examples of AI-powered Diagnostic Platforms:

- EndoBRAIN（Cybernet Systems/Olympus): software that assists in the differentiation of tumor and nontumor colorectal lesions by using ultra-magnified endoscopic images;
- CAD EYE（Fujifilm）: diagnosis support software that assists in the detection of lesions such as polyps and differentiation of neoplastic or nonneoplastic lesions during colonoscopy;
- EIRL aneurysm（LPIXEL）: diagnostic support software that detects suspected cerebral aneurysms by analyzing brain MR images using AI;
- Watson Imaging: assists radiologists in analyzing medical images for faster and more accurate diagnoses;
- Viz.ai: specializes in analyzing medical images (primarily CT scans) for stroke detection and other neurological conditions. Utilizes deep learning algorithms to identify critical imaging features and alert healthcare professionals promptly. Aims to reduce diagnosis delays and improve treatment outcomes for stroke patients;
- Regard: focuses on identifying patients at risk of developing specific diseases through AI-powered analysis of medical records. Aims to enable preventative measures by predicting potential health issues before symptoms appear.

These advancements underscore a remarkable shift from AI's initial rule-based approaches to the adoption of sophisticated machine learning and deep learning techniques, marking a new era of innovation in healthcare that promises to redefine how we approach patient care and medical research.

b) Radiology

It's also worth mentioning the revolutionary impact AI potentially can have in radiology by greatly improving image analysis and enhancing the accuracy of diagnostics. Particularly, deep learning represents a technique that teaches computers to operate with data in a way akin to how the human brain does it, and, therefore, this allows algorithms to possess the ability to acquire feature representations from large sets of data without requiring preceding definitions from humans. As a result, deep learning models are able to perceive repeating structures in images for example, and give certain predictions. In the field of radiology, deep learning is said to be extremely suitable for medical image segmentation [7].

According to the definition provided by Pim Moeskops, senior R&D engineer in deep learning for medical image analysis at Quantib, medical image segmentation consists of processing a given image (which can be an X-ray, an MRI scan, ultrasonography, etc.), finding a specific anatomic structure, and outlining it in a certain way [8].

In the study conducted by the same author, there are two ways to segment medical images using AI: contour and voxel-based segmentation. The contour-based segmentation seeks borders between the target structure and its surroundings. On the other hand, voxel-based segmentation involves a complex process in which the algorithm individually checks every voxel in the image, determining its affiliation with the structure to be segmented.

Contour-based segmentation proves itself to be more efficient, because the shape of the organ is embodied beforehand into the learning process, and the algorithm is able to accomplish accurate segmentation with only a few training images, making it exceptionally effective [8].

Overall, AI and deep learning technologies provide a useful tool for specialists in radiology. This technology will revolutionize and improve the accuracy of diagnostics, which will definitely save even more lives in the future.

c) Cardiology

Cardiology is yet another field of medicine in which AI contributes significantly to improving and development. The impact of AI in cardiology is depicted in great detail by the Mayo Clinic. Mayo Clinic is a healthcare company that's concerned with discovering methods to put

artificial intelligence into practice in such a way that will come to the aid of people who have or are predestined to heart diseases [9].

In an article published by the Mayo Clinic, it is outlined the fact that AI can be used to investigate large sets of data, analyze them methodically, and "ingest" them. Then, for example, when a patient who just suffered an intracerebral hemorrhage stroke comes into the emergency room, the computer that previously analyzed all those vast data sets swiftly processes the patient's computed tomography (CT) scan and gives a diagnosis. Lessening diagnosis time can limit potential brain damage in a situation such as this [9].

On top of that, the Mayo Clinic commented on how the applications of AI to electrocardiograms have led to the development of a cost-effective test for identifying weak-heart pump, which represents a precursor of heart failure. This clinic has a database of over 7 million electrocardiograms which the algorithm studied beforehand. With the insights it gathered, it facilitates the precision with which it detects when the heart rhythm is faulty [9].

Currently, Mayo Clinic researchers and engineers persist in advancing their studies to explore new practices of artificial intelligence in cardiology and other healthcare domains. This demonstrates how versatile AI-based technologies can be and how they can improve during patient treatment in urgent situations.

d) Molecular Medicine

Artificial intelligence (AI) proved its potential not only in analyzing several medical data about the work of internal organs, but also in medical domains that investigate the impact of components less visible to our eyes — genomes, DNA, and many more.

The correlation between AI and molecular medicine is not completely novel. The interaction started when Hidden Markov Models were developed. These models initially found their application in speech recognition and have since been widely utilized in the examination of biological sequences starting from the late 1980's [10] [11].

Furthermore, various technologies have been employed to advance the research in this medical field. In fact, according to Russ B. Altman, Professor at Stanford University, several AI technologies helped in the investigations such as neural networks, clustering analysis of genetic sequences and models, genetic programming, and numerous other methodologies [2]. As a result, modern-day scientists can predict a wide range of patterns, behaviors, and structures, of certain cell parts in the human body.

For instance, by analyzing a liquid biopsy, artificial intelligence can determine with an accuracy of 91% if the individual is affected by cancer. This is achieved via the existence of cell-free DNA, that floats freely in the blood. Its structure and pattern will differ depending on whether the patient is healthy or not, which helps AI detect the differences and diagnose cancer effectively [12].

For this reason, machine learning algorithms are extremely innovative, making the studies of the human body, and, as a consequence, medicine and healthcare even better. It allows operating with a large amount of data that is time-consuming to analyze manually, and also can assist in detecting patterns in different structures or parts of the cell. All of this can significantly make a difference in diagnostics, preventive care, and treatment of several diseases.

Challenges of Using AI in Medicine

The rapidly evolving domain of AI and its relation with countless medical fields demonstrates that machine learning solutions can be considered "the fourth industrial revolution" [13]. Medical AI shifts the capabilities of diagnostics and treatment to a new degree, making the everyday tasks of medical professionals even more effortless to accomplish. Innovative robots, apps that detect diseases, virtual medical assistants, and many more technologies imply a trend to use even more AI-based algorithms.

However, it is crucial to understand that every technology has its challenges and flaws, and AI is not an exception. According to a study, people recognize various concerns about using AI in medicine, such as technological, ethical, and legal issues. Technological concerns revolve around communication barriers and the performance of artificial intelligence. Doubts about privacy, mistrust, and prejudices are considered ethical concerns, which influence the interaction between technology and humans immensely. Legal problems, known as regulatory challenges, include supervision of the AI and infringements like violation of intellectual property rights [14].

More concerning is that artificial intelligence, even though learns fast, it lacks full precision and proofreading. According to another research, between 2000 and 2013, medical care providers reported 144 deaths and 1,391 injured patients caused by surgical robots [15]. It is normal for technologies to not be perfectly accurate, but in the case of human lives, every error matters. Moreover, AI technologies are usually trained on sorted and perfected data. However, encountering real-life data may drastically change the performance of the AI, which can lead not only to misdiagnoses but also to potentially detrimental treatment. AI can also start performing certain autonomous maneuvers that can be harmful during diagnosis or have the potential to be vulnerable to any unforeseen influences [16].

There are a multitude of challenges that can occur when working with advanced technologies such as artificial intelligence. However, it is possible to address the risks and make the results of AI models even better. That includes legal and ethical guidelines, rigorous test procedures, ensuring transparency and explainability, focusing on high-quality input data, and son on. Knowing the steps that can be taken to improve the prediction and analysis efficiency, we can ensure that AI will be not only useful but also safe for choices related to human lives.

Conclusions

The journey of AI in healthcare that were earlier depicted builds a timeline of quick progression. It starts from basic applications and ends with playing a vital part when it comes to precise diagnoses and treatment methods. The developments previously discussed pinpoint a new era for medical diagnoses as well as patient care. However, the path toward fully applying AI's potential in healthcare requires a common effort among researchers, engineers, and healthcare workers. This process demands not only innovation, but also the commitment to ensure that all these transformations that are yet to come remain accessible, equitable, and maintain the human touch. It's clear that AI in healthcare and medicine is not just about innovations and technological transformations, it's also about improving the way patients are cared for and making their treatment experience as smooth as possible. The journey of AI in healthcare and medicine is far from complete, but its trajectory points to a future where technology, as well as human expertise, merge to create a better healthcare system.

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