What are the applications of AI in healthcare?

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**Abstract**

Rapid advancements in artificial intelligence are being applied in numerous fields, including the healthcare sector, which is receiving significant attention. This paper explores the transformative potential of this technology in the medical industry across various domains, such as disease identification and diagnosis, drug development, surgery, and medical data analysis. A literature review approach was adopted to analyze and synthesize existing research and case studies on the impact of this technology on healthcare. The findings reveal significant advancements in disease identification and diagnosis accuracy, enabling early detection of conditions like breast cancer and Alzheimer’s disease. Drug discovery has been accelerated by predicting drug properties and potential toxicities. Surgical robots and augmented reality systems have demonstrated enhanced surgical precision, contributing to better patient outcomes and safety. Additionally, medical data analysis and remote patient monitoring have facilitated proactive and personalized patient care. This paper emphasizes the potential of artificial intelligence to bring about significant changes in healthcare, providing opportunities for enhanced medical practice and improved patient care. The research contributes to the understanding of the role of artificial intelligence in healthcare and encourages further exploration of this promising field.

Keywords: artificial intelligence, healthcare, patient care

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**What are the applications of AI in healthcare?**

By 2030, it is estimated that there will be a deficit of around 10 million healthcare workers, mainly in low- and lower-middle-income countries, posing a challenge to ensure universal access to healthcare due to budgetary constraints (World Health Organization, n.d., para. 2). The shortage is exacerbated by the lengthy and demanding training process for healthcare professionals, which necessitates specialized knowledge. However, human limitations, such as the need for food, rest, cognitive biases, and high training costs, highlight the potential of artificial intelligence (AI) to fill the gap and revolutionize the healthcare industry (Douglas et al., 2023).

The application of artificial intelligence in various fields has seen significant investment and positive outcomes, including the healthcare sector. Information technology has improved the capabilities of doctors and nurses, automated diagnostic tools, enhanced medical training and practice, and streamlined administrative tasks, resulting in improved patient comfort and care.

Given these advancements, the author chose the topic "What are the applications of AI in healthcare?" to explore how AI is transforming the medical industry, from diagnosis and treatment to resource management, to address global health challenges and enhance patient care.

# AI’s integration into various sectors, including healthcare.

The idea of artificial intelligence was introduced in 1956, but notable progress occurred within the past twelve years. In the early days of artificial intelligence, the field rapidly tackled challenges that were complex for humans but relatively straightforward for computers - issues that could be described by a list of rules in mathematical language. However, the true challenge for artificial intelligence lies in solving tasks that are easy for humans to perform but difficult to describe - issues that we as humans handle intuitively, such as speech recognition or facial recognition.

One of the most notable examples of the power of AI is the success of AlphaGo, a computer program developed by DeepMind that defeated the world champion in the game of Go. This victory, made possible by advances in machine learning and neural networks that allowed AlphaGo to learn from vast amounts of data and make real-time decisions, marked a significant milestone in the advancement of artificial intelligence.

Another example of the potential of AI is ChatGPT, a natural language processing model developed by OpenAI that can generate human-like text. This technology has applications in a wide range of fields, where it could be used to develop chatbots that can assist users with their questions.

These are just two prominent recent examples that have brought significant attention to AI. In reality, AI has been present in human daily life long before. For instance, search engines like Google (utilizing machine learning algorithms to analyze and evaluate website content for accurate and relevant search results), recommendation systems (platforms such as Netflix, Spotify, and YouTube employ AI to generate content recommendations based on user's preferences and past behaviors), etc.

In healthcare, AI has achieved remarkable breakthroughs. Notable examples include the creation of an AI-based algorithm by computer scientists at Stanford for diagnosing skin cancer through a dermatoscopy (Kubota, 2017). A study published in Scientific Reports by Madabhushi, Asha Singanamalli, which utilizes machine learning algorithms with data from 149 patients to enable early diagnosis of Alzheimer's disease before symptoms manifest in the patient's daily lives (Case Western Reserve University, 2017). The combination of technology and artificial intelligence has also led to significant advancements in remote diagnosis and treatment. In late April 2016, Dr. Richard Farnam, a gynecologist in Spain and director of the Robotics Surgery Department at Las Palmas Medical Center, performed a remote surgery to remove a fibroid. In this surgery, Dr. Farnam and his team introduced an internal motion table that enabled simultaneous movement of the robotic arm and surgical table. The live surgery was broadcasted to over 200 doctors attending the Global Hysterectomy Conference 2016 in San Diego and 7,000 members of the American Association of Gynecologic Laparoscopists (Martinez, 2016, para. 3).

# Explanation of AI, machine learning, deep learning and AI’s impact on healthcare

Figure

Artificial intelligence, machine learning, and deep learning

A diagram of a machine learning

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Note. Adapted from Nadia Berchane (M2 IESCI, 2018)

Although the terms artificial intelligence, machine learning, and deep learning are often used as if they mean the same thing, they actually refer to different concepts (Figure 1).

Artificial intelligence, commonly referred to as AI, is the process of imparting data, information, and human intelligence to machines. The main goal of Artificial Intelligence is to develop self-reliant machines that can think and act like humans. These machines can mimic human behavior and perform tasks by learning and problem-solving. Most of the AI systems simulate natural intelligence to solve complex problems (Shruti, 2023, para. 12).

Machine learning is a subset of AI, “is the practice of using algorithms to parse data, learn from it, and then make a determination or prediction about something in the world” (Copeland, 2016, para. 10).

Deep learning is “a technique for implementing machine learning”, which is “inspired by our understanding of the biology of our brains – all those interconnections between the neurons” (Copeland, 2016, para. 15). However, it is merely inspired by the brain and how it functions, not an exact replica of all its functionalities.

In this research paper, any mention of machine learning or deep learning can be understood as referring to artificial intelligence.

The impact of AI on the healthcare industry is significant and far-reaching. This technology has the potential to revolutionize healthcare by improving care outcomes, increasing productivity and efficiency, and enhancing the day-to-day life of healthcare practitioners. AI can also help address some of the challenges facing the healthcare industry, such as rising demand for services, increasing costs, and a shortage of healthcare professionals. It is improbable that AI will ever fully take the place of healthcare professionals. However, AI tools can be utilized to enhance workflow and assist in decision-making.

# Applications of AI in Disease Identification/Diagnosis.

One significant advantage that the medical field can greatly gain is disease identification. By applying machine learning, physicians can detect diseases in their early stages, resulting in time-saving benefits (Smiti, 2020).

AI-based algorithms and deep learning techniques have proven to be highly effective in accurately identifying and diagnosing various medical conditions from imaging data, including X-rays, MRIs, CT scans, and ultrasound images. The ability of AI systems to analyze vast amounts of imaging data with speed and precision has shown promising results in detecting early signs of diseases, such as cancer, cardiovascular issues, and neurological disorders.

Smiti (2020) tells us that Microsoft initiated a machine learning-based project named "InnerEye" in 2010, capable of detecting brain tumors and determining their stage within minutes, a task that typically takes hours when done by humans. “The goal of Project InnerEye is to democratize AI for medical image analysis and empower researchers, hospitals, life science organizations, and healthcare providers to build medical imaging AI models using Microsoft Azure” (Microsoft, n.d, para. 1).

In 2019, William Lotter and colleagues from the University of Massachusetts Medical School conducted a research study to analyze breast cancer diagnosis and early-stage disease detection. This study involved image data from over 80,000 patient records from six different sources worldwide. The results showed that the team's model achieved an accuracy rate of over 95% in diagnosing breast cancer (Lotter et al., 2019). This is a highly impressive result as breast cancer detection is very challenging. The breast has a complex structure with various tissues and environments. A small tumor or a subtle change in a specific area of the breast can be obscured by other structures or not recognized as a sign of cancer (refer to Figure 2).

Figure 2

Discrepancies between the AI system and human readersA close-up of a breast scan

Description automatically generated

Note. Panel (a) highlights a malignancy detected by the Al but missed by human readers. Panel (b) shows a malignancy caught by human readers but missed by the Al system. (From McKinney SM, Sieniek M, Godbole V, et al. International evaluation of an Al system for breast cancer screening [published correction appears in Nature. 2020 Oct)

Analyzing patient data, symptoms, and medical histories is a critical process in healthcare that plays a pivotal role in diagnosis, treatment planning, and patient care. This comprehensive evaluation of patient information is carried out by healthcare professionals to gain a deeper understanding of a patient's health status and medical conditions.

According to Naji et al. (2021), a research study was conducted to determine whether breast tumors were benign or malignant in breast cancer patients. They utilized the Breast Cancer Wisconsin Diagnostic dataset from the University of Wisconsin Hospitals, which includes features such as perimeter (circumference of the tumor), radius (distance from the center to the tumor's circumference), smoothness (local variation in radius lengths), etc. The research team built a model using basic machine learning algorithms, such as Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Logistic Regression. The accuracy achieved by the research team on the test dataset was 95%.

# Applications of AI in Drug Development.

The field of drug development has seen significant advancements with the integration of AI techniques. AI has emerged as a powerful tool to accelerate and optimize various stages of the drug discovery and development process.

By leveraging machine learning algorithms, AI models can analyze the molecular structure of potential drug candidates and predict their solubility, stability, bioavailability, and other important properties. This enables researchers to identify potential drug candidates with promise at an early stage of development, resulting in time and resource savings.

Cui and Zhu (2021) conducted a study to investigate the potential of AI in predicting the physicochemical properties (solubility, partition coefficient, dissociation constant) of various drugs, utilizing a neural network named ResNet. The results demonstrated that ResNet achieved higher accuracy in predicting the solubility of molecules compared to other non-AI-based models, leading to increased yield and reduced extraction time of polysaccharides[[1]](#footnote-2) from different sources.

AI models analyze large datasets containing information on drug interactions, side effects, and adverse reactions to predict potential toxicities. This enables researchers to identify potential safety risks associated with drug candidates before they progress to clinical trials, enhancing patient safety and reducing the likelihood of drug failures.

Pu et al. (2019) sought to employ an AI program called eToxPred to forecast the toxicity levels of diverse synthetic and biological compounds, with the aim of expediting the current process and eliminating the need for clinical trials. The outcomes revealed that the AI model achieved a high level of accuracy, accurately predicting toxic properties in over 72% of cases with an overall error rate of just 4%, suggesting its potential to serve as a viable substitute for clinical trials.

# Applications of AI in Surgery.

According to Zhou et al. (2020), “AI is gradually changing the practice of surgery with technological advancements in imaging, navigation, and robotic intervention”. The integration of AI in surgery has opened up new possibilities and advancements in the field, enhancing precision, efficiency, and patient outcomes.

Operative navigation in spinal surgery is a critical aspect, particularly in minimally invasive procedures that require precise maneuvers through small incisions. A key concern in spinal surgery is the positioning of pedicle screws, where any misplacement may lead to serious complications such as bleeding, nerve injury, or loss of fixation. To address this challenge, augmented reality (AR) systems have emerged, offering virtual planning of the screw path by marking the trajectory on computed tomography (CT) images. Notable examples of such systems are the ClarifEye system by Philips and the Xvision system by Augmedics. Both utilize intraoperative CT for path planning, and the surgeon is guided through in vivo placement using real-time tracking of instrument positions. Philips' system provides on-screen video guidance, while Augmedics' system presents a holographic overlay via an AR headset, enabling the surgeon to align the planned screw trajectory accurately.

Studies on the effectiveness of AR systems have shown promising results. Philips' initial human study demonstrated accurate screw placement in 94% of cases (Medical Device Network, 2021, para. 19), which was comparable to cases without AR guidance. Similarly, Augmedics' first human study reported 100% accuracy in screw placement (Rush et al., 2022).

AI-driven surgical robots have emerged as a valuable tool in performing delicate soft tissue surgeries with greater precision and dexterity. These robots utilize AI algorithms and advanced sensors to mimic the movements of skilled surgeons, enabling them to execute intricate tasks with high accuracy and stability. The robotic assistance offers enhanced control and reduces hand tremors, allowing for more precise tissue manipulation during surgeries.

Surgical robots have made significant advancements in the field of soft tissue surgery, with the Da Vinci Surgical System being a pioneering example. FDA-approved in 2000, the Da Vinci System revolutionized laparoscopic robotic platforms, thanks to its wristed instruments that enable dexterous movements in confined spaces like the pelvis. Operated by a human surgeon seated at a console, the Da Vinci system offers potential enhancements through computer assistance, including magnification, a 3D view from the binocular camera, tremor reduction, and intraoperative alerts (Strickland, 2016, para. 8).

# Applications of AI in Medical Data Analysis.

With the integration of AI algorithms and machine learning techniques, healthcare professionals can harness the power of data to make more informed and precise decisions, ultimately improving patient outcomes.

The Regenstrief Institute (2022) has developed an AI-based approach aimed at enhancing the care provided to patients dealing with complex type 2 diabetes. This innovative method assists in determining the most suitable drug regimen for each individual patient. Initially, the AI algorithm categorizes patients based on their disease states and examines their treatment patterns and clinical results. Subsequently, it matches the patient of interest with the relevant disease state groups and forecasts the potential outcomes for the patient considering different treatment options. To assess the effectiveness of this approach, the researchers evaluated its performance in predicting successful outcomes with drug regimens used for diabetic patients in Utah and Indiana (United States). The results demonstrated that the algorithm can aid in selecting appropriate drugs for over 83% of patients, even when multiple drugs are administered in combination.

Moreover, AI has enabled significant advancements in patient monitoring and remote care. With the integration of wearable devices and IoT[[2]](#footnote-3) (Internet of Things) technologies, continuous health data can be collected and transmitted in real-time. AI algorithms can analyze this data to detect anomalies and changes in patient’s health conditions, allowing for early intervention and proactive care. Remote patient monitoring enhances patient comfort and convenience, particularly for those with chronic conditions, elderly patients, or those living in remote areas. By utilizing AI for remote care, healthcare providers can provide timely feedback, guidance, and support, reducing hospital readmissions and improving patient satisfaction.

Medplus is an example of how AI technology is being used to improve patient care through remote monitoring. In a survey conducted by Gîştescu and colleagues (2021) on Medplus, involving doctors, nurses, and patients, all participants agreed that data collection and interpretation are highly appealing and can facilitate remote patient monitoring. Additionally, automated assessment and detection of abnormalities benefit both patients and doctors (Gîştescu et al., 2021).

# The Next Steps for AI in Healthcare.

The integration of AI technology in the field of medicine has brought about remarkable advancements that hold immense promise for the future of healthcare. As demonstrated in this research paper, AI has proven to be a valuable ally in enhancing medical practice across various domains, from disease identification and drug development to surgical precision and patient monitoring.

Collaboration among medical professionals, researchers, data scientists, and AI experts will be pivotal for successfully integrating AI into medical practice. By fostering interdisciplinary collaborations, we can leverage the full potential of AI and address complex healthcare challenges with innovative and sustainable solutions.

In conclusion, AI technology holds the key to unlocking unprecedented advancements in healthcare. By embracing the opportunities presented by AI and working together, we can usher in a new era of medical excellence, providing better healthcare access, improved patient outcomes, and a brighter future for global health.

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1. Polysaccharides are complex carbohydrates found in many plants, animals and have many beneficial effects on human health, such as improving the immune system, fighting against cancer, reducing blood sugar, etc. [↑](#footnote-ref-2)
2. The Internet of Things (IoT) is a term used to describe a network of physical objects (such as electronic devices, sensors, and machinery) that are connected to each other and to the Internet. IoT enables these objects to communicate, exchange information, and perform tasks without the need for human intervention. [↑](#footnote-ref-3)