Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 03 ISSUE 11, 2025

Artificial Intelligence in Medicine

Matthew N. O. Sadiku [1], Uwakwe C. Chukwu [2], Janet O. Sadiku [3]
[1] Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2] Department of Engineering Technology, South Carolina State University, Orangeburg, SC, USA
[3] Juliana King University, Houston, TX, USA

Abstract:

Artificial intelligence (AI) refers to the use of computers and technology to simulate intelligent behavior and critical thinking comparable to a human being. It is an interdisciplinary field that integrates computer science, mathematics, and related disciplines to create algorithms that can perform tasks conventionally restricted to human intelligence. It has the potential to transform healthcare and disrupt the field of medicine in significant ways. AI technologies such as machine learning, natural language processing, and robotics can help improve healthcare by enhancing medical services and research efficiency. Artificial intelligence techniques have the potential to be applied in almost every field of medicine. They have the potential to transform medicine. In this paper, you will explore the transformative impact of artificial intelligence on medicine.

Keywords: artificial intelligence, machine learning, AI, generative AI, medicine, healthcare.

INTRODUCTION

Artificial intelligence (AI) is the study of teaching technology to think and act like humans. AI has been rapidly transforming various industries, and medicine is no exception. The recent availability of AI to the public, including language models like ChatGPT, has increased the awareness of AI and its potential capabilities in medicine. For example, a doctor, with the aid of AI, can sift through vast amounts of medical data – patient histories, lab results, genetic information – in the blink of an eye. AI can compare thousands of images to uncover dangerous patterns, create ultra-high resolution scans from low-res images and see what the human eye misses. This staggering capability of artificial intelligence is not a futuristic fantasy; it is the current state of play in the field of medicine. AI has the potential to transform medicine for the better.

Artificial intelligence (AI) is perhaps the oldest field of computer science, dealing with all aspects of mimicking cognitive functions for real-world problem solving and building systems that learn and think like people. AI has gained recent public prominence with the release of deep-learning

models that can generate anything from art to term papers with minimal human intervention. The proficiency of artificial intelligent techniques has been explored in almost every field of medicine. AI enables new discoveries and improved processes in the entire healthcare continuum [1].

WHAT IS ARTIFICIAL INTELLENCE?

The term "artificial intelligence" (AI) is an umbrella term John McCarthy, a computer scientist, coined in 1955 and defined as "the science and engineering of intelligent machines." It refers to the ability of a computer system to perform human tasks (such as thinking and learning) that usually can only be accomplished using human intelligence [2]. Typically, AI systems demonstrate at least some of the following human behaviors: planning, learning, reasoning, problem solving, knowledge representation, perception, speech recognition, decision-making, language translation, motion, manipulation, intelligence, and creativity.

The 10 U.S. Code § 2358 define artificial intelligence as [3]:

1. "Any artificial system that performs tasks under varying and unpredictable circumstances without significant human oversight, or that can learn from experience and improve performance when exposed to data sets.
2. An artificial system developed in computer software, physical hardware, or other context that solves tasks requiring human-like perception, cognition, planning, learning, communication, or physical action.
3. An artificial system designed to think or act like a human, including cognitive architectures and neural networks.
4. A set of techniques, including machine learning, that is designed to approximate a cognitive task.
5. An artificial system designed to act rationally, including an intelligent software agent or embodied robot that achieves goals using perception, planning, reasoning, learning, communicating, decision making, and acting."

AI provides tools creating intelligent machines which can behave like humans, think like humans, and make decisions like humans. The main goals of artificial intelligence are [4]:

1. Replicate human intelligence
2. Solve knowledge-intensive tasks
3. Make an intelligent connection of perception and action
4. Build a machine which can perform tasks that requires human intelligence
5. Create some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

AI is not a single technology but a range of computational models and algorithms. The concept of AI is an umbrella term that encompasses many different technologies. AI is not a single technology but a collection of techniques that enables computer systems to perform tasks that would otherwise require human intelligence. The major disciplines in AI include [5]:

- ✓ *Expert systems*
- ✓ *Fuzzy logic*
- ✓ *Neural networks*
- ✓ *Machine learning (ML)*

- ✓ *Deep learning*
- ✓ *Natural Language Processors (NLP)*
- ✓ *Robots*

These computer-based tools or technologies have been used to achieve AI's goals. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. Figure 1 shows a typical expert system, while Figure 2 illustrates the AI tools. These tools are gaining momentum across every industry. Analytics can be considered a core AI capability.

ARTIFICIAL INTELLIGENCE IN MEDICINE

Artificial intelligence was first introduced in medicine in the late 1950s, but several limitations prevented its widespread application in that sector. Although AI has been around since the 1950s, after the release of ChatGPT in November of 2022, it has quickly become a household topic. The first AI application in medicine concerned the early detection of atrial fibrillation. Healthcare providers already use AI to make many aspects of your medical care more personalized and effective. It is remarkable to see how medicine advances everyday with the help of artificial intelligence.

Artificial intelligence in medicine is the use of machine learning models to help process medical data and give medical professionals important insights, improving health outcomes and patient experiences. AI in medicine can be dichotomized into two subtypes: virtual and physical. The virtual part ranges from applications such as electronic health record systems to neural network-based guidance in treatment decisions. The physical part deals with robots assisting in performing surgeries, intelligent prostheses for handicapped people, and elderly care [6]. Figure 3 shows a representation of AI in medicine [7].

APPLICATIONS OF AI IN MEDICINE

There is virtually no area in medicine that is not already being touched by AI. There are numerous ways AI can positively impact the practice of medicine, whether it is through speeding up the pace of research or helping clinicians make better decisions. AI finds its application in various medical disciplines, including medical imaging, pathology, cardiology, dermatology, gastrology, neurology, cancer diagnosis, pulmonology, urology, ophthalmology, and diagnosis of rare diseases. Figure 4 shows an overview of artificial intelligence applications in medicine [8]. Common areas of application include the following [7,9-12]:

- ➢ *Radiology:* Radiology is the branch that has been the most upfront and welcoming to the use of new technology. Medical imaging is an indispensable tool in modern healthcare, enabling clinicians to visualise internal structures and diagnose a wide range of medical conditions. AI algorithms are designed to analyze medical images with the precision that allows radiologists to make accurate diagnoses. In 2020, a study was conducted on an artificial intelligence system developed to identify breast cancer. The results concluded that the AI system surpasses clinical radiologists in breast cancer prediction. AI could provide substantial aid in radiology by not only labeling abnormal exams but also by identifying quick negative exams in computed tomographies, X-rays, and magnetic resonance images. The artificial neural network has proven to be as effective as many radiologists in detecting symptoms of diseases accurately. Figure 5 shows a typical medical image [13].
- ➢ *Surgery:* One of the remarkable applications of AI in medicine is the surgical AI system, which allows surgeons to perform remote operations using robotic systems. In surgery, AI helps surgeons with precision, enhancing the success of procedures and reducing recovery time.

Robotic-assisted surgery simply means that the robot is a tool that surgeons can use to perform a more precise and reproducible surgical procedure. The robot does not do the surgery without the surgeon. AI tools can enhance the convenience and accuracy of surgery by reducing human errors. The imaging system provides high-definition 3D images of the surgical site, which can improve the surgeon's visibility and orientation. Figure 6 shows AI surgery [7].

- *Pathology:* AI automates the process of analyzing histopathological images and allows for a more comprehensive analysis of tissue samples, which speeds up the diagnostic process and improves accuracy. It helps pathologists identify various tumors and other medical conditions. Computational pathology requires access to health databases to create training data sets that are more comprehensive but the strict protection of patient privacy and personal data policies creates a barrier in that respect.
- *Cardiology:* The integration of AI into cardiology signifies a profound transformation in healthcare, offering innovative solutions to combat the significant global burden of cardiovascular disease. AI presents many benefits, including improved image interpretation, enhanced patient recruitment for clinical trials, and increased accessibility to care, thus showcasing its potential to revolutionize the field. AI can predict cardiovascular risks precisely, ensuring timely intervention and preventative care. Figure 7 shows AI in cardiology [7].
- *Dermatology:* Some studies have been documented where AI systems were able to outperform dermatologists in correctly classifying suspicious skin lesions. Dermatologists will spend less time on false alarms and focus more on treatable early-stage diseases, unconstrained by the geographic location of their patients.
- *Genomics:* AI algorithms aid in the interpretation of genetic information. They can efficiently identify genetic variants and mutations and use this genomic data to predict the risk of diseases. Similarly, these algorithms can predict how a certain type of cancer will progress in a patient.
- *Medical Consultations:* For physicians looking to incorporate AI into their daily practice, technological solutions are already facilitating the adoption of these tools. AI tools and automation help doctors manage their practices more efficiently. These solutions allow physicians to focus on clinical care, while the platform handles repetitive and administrative tasks. In this way, professionals can improve both the quality of their care and patient satisfaction. Chatbots and virtual assistants use AI to manage patient consultations outside of office hours. These systems can answer common questions, manage appointments, and provide basic medical information, freeing up time for healthcare professionals.
- *Medical Diagnosis:* One of the most promising applications of AI in healthcare is in medical diagnosis. AI algorithms can analyze medical images, such as X-rays and MRI scans, with a high degree of accuracy to detect diseases and abnormalities. This can lead to earlier and more accurate diagnoses.
- *Telemedicine:* Telemedicine, the use of technology to provide remote healthcare, has become increasingly popular during the COVID-19 pandemic. AI can enhance telemedicine by providing virtual assistants that can triage patients, provide basic medical advice, and help patients manage chronic conditions. This can reduce the burden on healthcare providers and improve access to healthcare for patients.
- *Drug Discovery:* Drug discovery is often one of the longest and most costly parts of drug development. Since the development process of new drugs is complicated, expensive, time-consuming, and challenging, computer-aided drug discovery technology is being used in the discovery and development of novel drugs to study their physiochemical and biological

properties. AI can aid in drug discovery and development by analyzing large datasets of medical images to identify potential targets and assess treatment efficacy. It reduces human workload and produces quality drugs with high efficacy and fewer side effects. AI tools help researchers analyze complex datasets, identify potential compounds, predict target sites, and design drugs. Figure 8 depicts AI in drug discovery [7].

- *Emergency Medicine:* AI represents a transformative force in emergency medicine with the potential to accelerate and improve the accuracy of patient triage, diagnoses, and resource management, thereby leading to a more efficient and resilient global emergency care system. Artificial intelligence is transforming emergency medicine by enhancing triage, diagnosis, and resource management, while also facing challenges related to ethics, bias, and regulation. Machine learning models consistently demonstrate superior discrimination and performance capabilities for predicting emergency outcomes like hospital admission or intensive care unit (ICU) transfer and conditions like stroke, sepsis, and myocardial infarction. Emergency dispatchers can also utilize natural language processing to recognize conditions, such as out-of-hospital cardiac arrest, faster and more accurately, despite limitations in first-responder knowledge.

BENEFITS

Unlike humans, AI never needs to sleep. AI can help patients take more control over their healthcare journey by giving them easy access to medical information and guidance. AI can significantly help doctors in diagnosing illnesses or injuries through various applications. By leveraging powerful AI tools, doctors can improve the quality of care while saving time on tasks that can be automated with AI. Other benefits include the following [14]:

- *Automation*: Automation of tedious tasks with AI tools can lessen the burden of clinicians allowing for enhanced doctor-patient interactions. However, AI's risks of automation could threaten the careers of the country's medical professionals and blue-collar workers alike.
- *Cost Effectiveness:* There are a lot of potential ways AI could reduce costs across the healthcare industry. Integrating AI in medicine ensures cost effectiveness through resource optimization, automation of time-consuming tasks, early detection, predictive maintenance, and telemedicine.
- *Personalization:* Personalized care has now become easier with AI support. Because AI models can learn and retain preferences, AI has the potential to provide customized real-time recommendations to patients around the clock. AI offers tailored treatment solutions to patients based on their medical history, genetic information, treatment responses, lifestyle, and preferences, significantly improving patient health outcomes. Personalized medicine with AI empowers both patients and healthcare practitioners.
- *Medical Studies:* AI makes medical studies easier, more accessible, and more enjoyable. It provides personalized and interactive learning resources. It helps better understand and remember clinical diseases and practice diagnostic skills in a safe and realistic manner.
- *Improved Efficiency:* The remarkable AI technology increases efficiency in disease detection, personalized treatment, remote monitoring, and preventative care, leading to better health outcomes. AI is making healthcare better by improving accuracy, efficiency, and decision-making. It helps healthcare staff by doing boring administrative jobs, like keeping track of patient records, analyzing data, and booking appointments. This makes their work easier and reduces the chance of mistakes. The implementation of AI-powered tools enhances the overall efficiency of healthcare processes.

CHALLENGES

Using AI in healthcare presents both unique benefits and challenges. Successful integration of AI in existing healthcare systems requires careful planning to avoid disruption in the workflow of healthcare setups. Cybercrimes are becoming more sophisticated, which seriously threatens the integrity of medical records and the functioning of medical services. Other challenges include the following [14]:

- *Ethical Concerns:* It is essential to ensure that AI systems are used in a fair and ethical manner. There is a lot of talk about the ethics of data stewardship and whether there is a need for the equivalent of a Hippocratic oath for the people charged with protecting and using patient data appropriately. When physicians rely solely on AI-driven choices, it may result in biased or discriminatory outcomes that directly impact patient care. It can also generate mistrust among patients and healthcare physicians. The absence of guidelines regarding AI's safe and effective use in healthcare makes it difficult to navigate its ethical use. One should conduct rigorous testing to identify potential biases in the AI model. Physicians will likely continue to play a critical role in ensuring that the ethical and moral implications of medical decisions are carefully considered and that patients receive the highest quality of care.
- *Data Privacy*: With the adoption of AI technologies to manage patient-sensitive information, the risk of data privacy becomes a prominent concern. This is because AI systems are highly susceptible to security risks and unauthorized access, leading to compromising patient confidentiality.
- *Data Quality*: AI algorithms require large amounts of high-quality labelled data to train effectively. A foundational principle of machine learning is that models are only as good as the data on which they are trained. Thus, models trained on historical health data containing latent biases, such as societal inequities or non-generalizable sampling designs, could learn and amplify these biases at scale. Data quality is crucial for reliable healthcare outcomes, so you must develop and implement strategies to eliminate data inaccuracy. These strategies help minimize errors and enhance data consistency, which aids in making precise diagnoses, increases physician-patient trust, and enhances the effectiveness of AI applications.
- *Training:* Using AI requires some training. It will take years of education to fully train medical professionals in this field. Integrating AI into routine clinical practice will require careful validation, training, and ongoing monitoring to ensure its accuracy, safety, and effectiveness in supporting physicians to deliver care. Training in artificial intelligence for medicine helps analyze medical data, make decisions, select treatments, reduce complications, and improve patient experiences and health outcomes. Healthcare staff usually have demanding schedules, which makes it challenging to manage time for comprehensive training on AI applications.
- *Over-reliance:* Over-reliance on AI algorithms is another threat in healthcare that can result in inappropriate treatments, missed diagnoses, and harmful patient outcomes. It can critically reduce the involvement of physicians in decision-making processes.
- *Transparency:* The lack of accountability and transparency in AI-driven healthcare makes it challenging to understand how decisions are made. It generates mistrust among patients and physicians and raises questions about how specific conclusions are made. It is very difficult for people to understand how these algorithms come to a decision. Ultimately, these are so-called “black box” models.
- *Regulation:* Regulatory concerns are increasingly important. As AI technologies continue to advance and become more readily accessible, policymakers, regulators, and healthcare leaders must collaborate to create robust ethical and legal frameworks that provide clear guidance on data privacy, algorithmic transparency, and legal liability. The deployment of AI in medical imaging necessitates careful adherence to regulatory standards and ethical guidelines.

- *Speculation:* There is speculation about AI eventually replacing physicians, particularly in fields like radiology, pathology, and dermatology, where AI's diagnostic ability can match or even exceed that of clinicians. However, research suggests that physician-machine collaborations will outperform either one alone. It is unlikely that AI will completely replace physicians anytime soon. Rather than fully replacing physicians, AI will likely empower the practice of medicine, with physicians leveraging the technology to enhance clinical care. Machines lack human qualities such as empathy and compassion, and therefore patients must perceive that consultations are being led by human doctors.

FUTURE OF AI IN MEDICINE

The advancements in AI technology will make a more powerful impact in the healthcare sector. AI will improve diagnostic processes by introducing specialized diagnostic expertise into primary care. Sophisticated AI tools will not replace human physicians but augment their efforts for better patient care. AI systems will become more regulated, which will enhance their credibility, and they will be given more responsibility. As advanced AI models quickly evolve, potential new models are being designed to encompass multi-modal medical information and assist doctors with complicated medical decision-making.

AI is set to revolutionize medical research in several ways. AI will play a massive role in analyzing large amounts of information quickly and accurately. AI will definitely be an integral part of medicine in the future. It is therefore important to train the new generation of medical student regarding the concepts and applicability of AI and how to function efficiently in a workspace alongside machines for better productivity [6]. In the near future, physicians may leverage medical-grade AI language models for consultations, receiving valuable insights and assistance in various aspects of patient care.

CONCLUSION

Artificial intelligence is already one of the key technologies in our economy. It will bring changes similar to the introduction of the steam engine or electricity. AI research within medicine is growing rapidly. It focuses on providing a patient-centered, efficient, and adaptable healthcare system. It has become a powerful tool in medical research, enabling scientists to make groundbreaking discoveries and advancements in healthcare. AI tools have untapped growing resources and provided new opportunities to benefit patients with improved diagnostic accuracy, reliable prognosis prediction, precision treatment, and accurate operational efficiency for health systems. Although AI promises to change the practice of medicine in hitherto unknown ways, many of its practical applications are still in their infancy and need to be explored and developed better. Despite their efficacy, AI applications still require considerable human surveillance. Concerns about potential loss of control in the human-AI relationship are growing. More information on AI in medicine is available from the books in [15-22] and the following related journals:

- ✓ *The AI Journal*
- ✓ *AI Magazine*
- ✓ *Journal of Intelligence*
- ✓ *Journal of Medical Artificial Intelligence*
- ✓ *Artificial Intelligence in Medicine*

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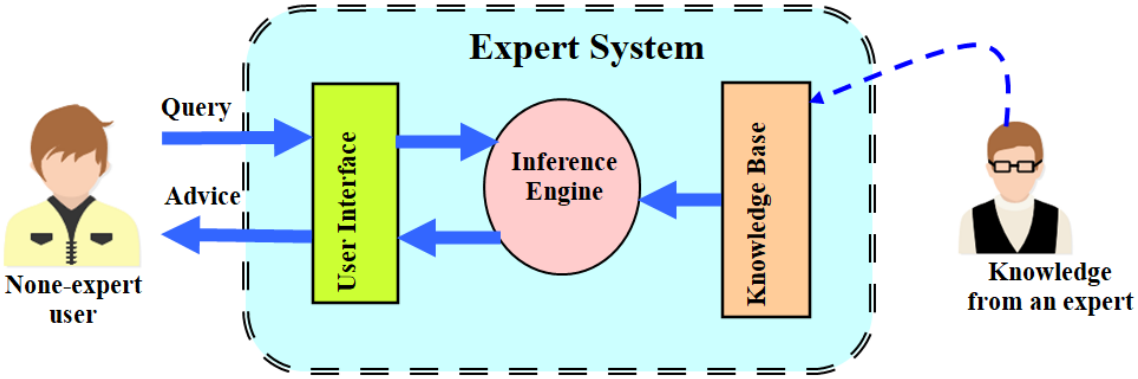

Figure 1. A typical expert system.

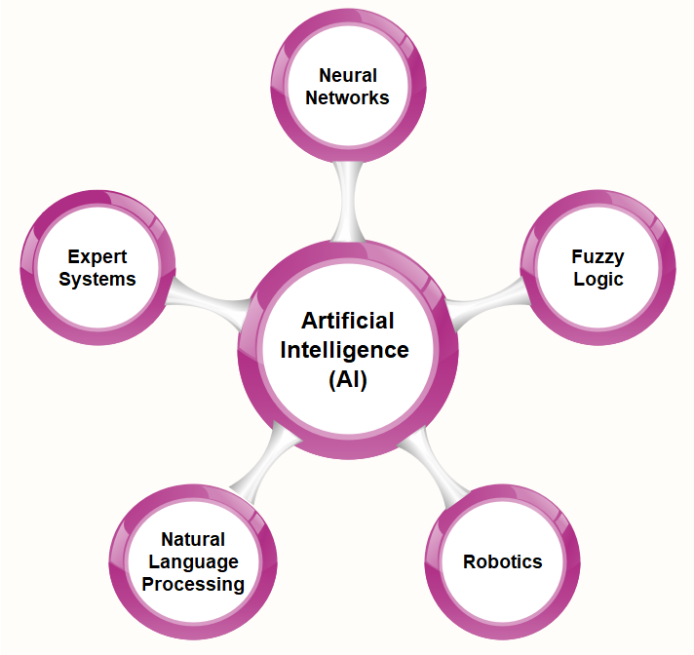

Figure 2. AI tools.

Figure 3. A representation of AI in medicine [7].

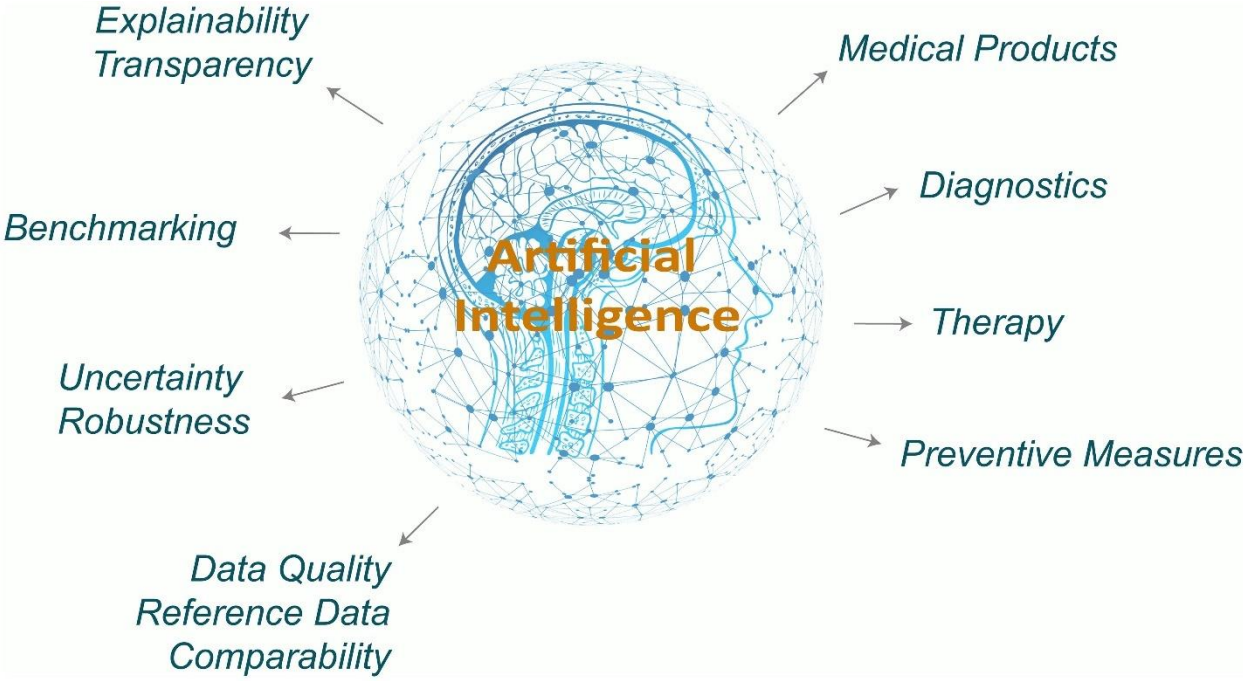

Figure 4. An overview of artificial intelligence applications in medicine [8].

Figure 5. A typical medical image [13].

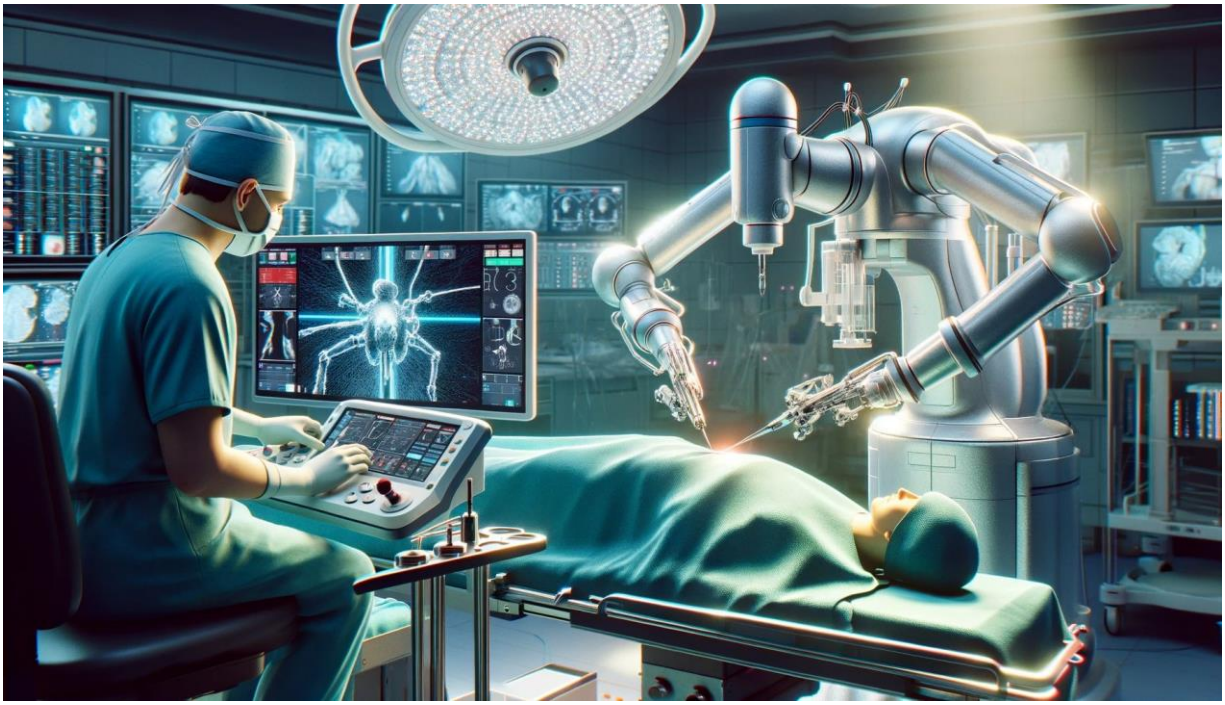

Figure 6. AI surgery [7].

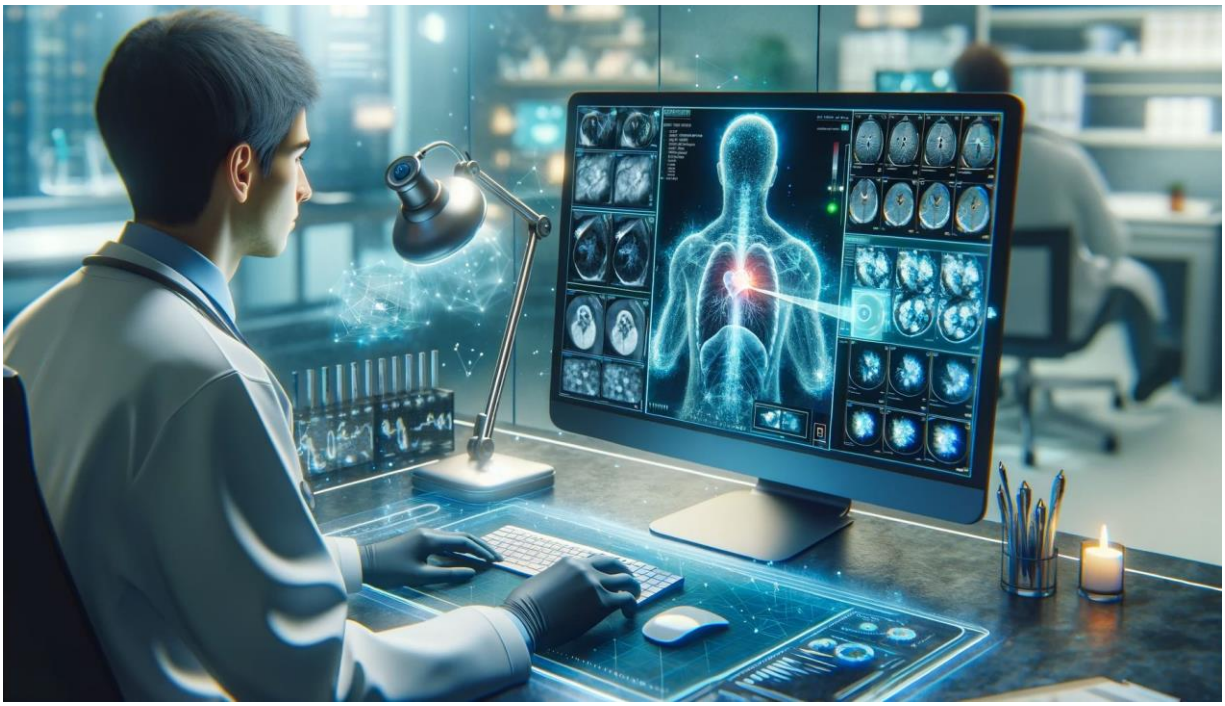

Figure 7. AI in cardiology [7].

Figure 8. AI in drug discovery [7].