# The Application of AI Technology in the Medical Field, and Its Future Direction

Haoyu Yan[a]
*College of Engineering, University of California, Davis, U.S.A.*

Keywords: Artificial Intelligence, Surgical Robots, Application, Medical Field.

Abstract: Artificial Intelligence (AI) has become a major development direction in the medical field over the past decade. It has introduced smarter, more accurate, and more efficient technologies into medicine, and has made unprecedented progress in risk control and patient satisfaction. This paper studies the latest innovations in AI-driven surgical technology, including robotic surgical systems, AI-based assistance systems, AI-powered medical imaging, and AI-integrated conduction devices (for rehabilitation monitoring), which are respectively reflected in the clinical application of preoperative planning, intraoperative effects, and postoperative care, and are supported by medical data from review studies in the medical industry. This paper also provides cases of clinical applications of AI technologies and explores their impact on modern medical systems. At last, it also examines the ethical and safety considerations, as well as innovation challenges and future directions of AI technology in medical care. However, for new technologies in the developing stage, there are always pros and cons. AI-integrated medical technology is also facing challenges in multiple dimensions, such as data security, ethics, personal privacy, safety, and technical security.

## 1 INTRODUCTION

The application of AI technology in the medical field began with the Da Vinci system in the early 21st century. The da Vinci Surgical System, developed by Intuitive Surgical, is a groundbreaking robotic-assisted surgical platform that has revolutionized minimally invasive surgery (MIS) since it was approved by the FDA in 2000 (DiMaio, 2011). Although the system was not powered by AI in its first generation, AI has made significant progress in medicine in the 21st century. AI-powered surgical robots approved by the United States government have accomplished several surgical procedures and have helped to perform countless extremely difficult surgeries on patients in many countries around the world. This major achievement reflects the integration of advanced robotics and human expertise. AI-based medical imaging and AI-powered health monitoring devices have also been integrated into modern medical care. These AI-driven medical devices have helped many patients achieve more effective and precise treatments. Today, AI-driven medical devices provide support from preoperative preparation, and intraoperative surgical support, to postoperative recovery and other stages. AI technology is changing the medical level of traditional medicine by analyzing patient data, learning, and simulation, helping doctors achieve "impossible" medical tasks.

## 2 THE IMPACT OF AI TECHNOLOGY ON PREOPERATIVE PREPARATION

In the 21st century, AI technology has been extensively used in the medical field. It provides technical support for doctors to analyze patients' conditions and determine treatment plans before surgery (Martin, 2017). For example, the application of AI in medical imaging is one of the most significant directions of AI technology in medicine. These AI technologies can help doctors process high-intensity and repetitive image reading and improve the quality and work efficiency of the imaging

[a] https://orcid.org/0009-0000-5999-3383



Yan, H.
The Application of AI Technology in the Medical Field, and Its Future Direction.
DOI: 10.5220/0013698400004670

In *Proceedings of the 2nd International Conference on Data Science and Engineering (ICDSE 2025)*, pages 409-413
ISBN: 978-989-758-765-8

department. At present, the AI for analyzing many organs, such as the heart, bones, head, neck, and lungs, has been very mature and can achieve high-precision auxiliary diagnosis of multiple diseases. In addition, with the continuous advancement of technology, medical imaging AI of other organs of the body is also under development, and some products have gone through FDA and obtained medical device registration certificates in the United States.

Tools such as Surgery-Risk Calculator use AI machine learning in medicine to assess patients' physical risk profiles and optimize clinical judgments to help surgeons make wise decisions (University of Florida, 2022). This can help doctors assess and analyze patients' physical conditions and risks before surgery to greatly reduce the unexpected complications that patients may encounter after surgery.

AI algorithms enhance preoperative diagnosis by analyzing radiological images (CT, MRI) with remarkable precision. For example, a study published in Nature Medicine in 2023 showed that its self-developed deep learning method PANDA achieved a sensitivity of 92.9% for detecting pancreatic tumors in CT scans, which was 6.3% higher than the average performance of radiologists (Cao, 2023). Such tools enable surgeons to detect and diagnose lesions with extremely high accuracy, helping doctors to draw conclusions and ultimately find the right medical plan for their patients.

IBM Watson Health applies AI technology in a wide range of medical fields, including but not limited to oncology, cardiology, neuroscience, and diabetes management (Mishra, 2024). In in field of oncology, it can provide doctors with personalized treatment plans by analyzing patients' genomic data and clinical history (Mishra, 2024). In the fields of cardiology and neuroscience, by analyzing patients' electrocardiograms, brain scans and other data, the platform can detect potential conditions early and make intervention recommendations (Mishra, 2024). In addition, in terms of diabetes management, through real-time monitoring and analysis of blood sugar data, the platform can provide patients with reasonable diet and lifestyle recommendations to better control their condition. IBM Watson Health's AI-driven platform can predict surgical risks by analyzing electronic health records (EHRs) (Mishra, 2024).

AI systems integrated with preoperative imaging (e.g., fluorescence-guided surgery) can provide real-time feedback. Developed by Associate Professor Eiman Azim and his team at the Salk Institute in the United States, GlowTrack technology is a non-invasive motion-tracking technique that uses fluorescent dye markers to train AI (Butler, 2023). This technology was published in Nature Communications in September 2023, and it has broad application prospects in biology, robotics, medicine and other fields (Butler, 2023). For example, in medical and biological research, GlowTrack can help doctors and scientists better understand the movement patterns of animals and humans, thereby revealing how the brain controls behavior (Butler, 2023). This may help study movement disorders such as amyotrophic lateral sclerosis (ALS) and Parkinson's disease. In the medical field, GlowTrack can be used to monitor and analyze patients' movements, thereby helping doctors diagnose and treat various movement disorders (Butler, 2023). The medical applications of this technology are expanding, especially in the fields of neurosurgery and orthopedics, where it is expected to considerably improve the surgical success rate.

## 3 THE ROLE OF AI TECHNOLOGY IN SURGERY

Take the surgical robot in the da Vinci system as an example. The da Vinci surgical robot is an advanced AI-integrated surgical technique that can help doctors perform minimally invasive surgery, including a variety of surgeries on multiple parts of the human body (DiMaio, 2011). It utilizes high-precision robotic arms and cameras to help with the surgery, which embodies a better visual field and achieves more precise operations. The da Vinci surgical robot is expected to reduce surgical trauma and recovery time, improving surgical safety and effectiveness (Iftikhar, 2024). It reflects the synergy between AI technology and medicine in surgery. Newer iterations and auxiliary technologies have begun to use AI to magnify the functions of the da Vinci surgical robot, for example: the latest advances in ML algorithms and computing power enable AI to analyze complex data sets, more accurately predict outcomes, and even assist in real-time decision-making. The da Vinci system surgical robot can assist doctors in completing extremely difficult surgeries, which not only have high requirements on accuracy, but also have strict demands on error rates. The following paragraphs elaborate on the working principles of da Vinci system and other surgical robotic systems and how the integration of AI has enhanced the utility of them:

AI-driven machine learning to improve precision. The da Vinci system uses learning algorithms to

analyze successfully performed surgeries in the past and conduct learning simulations to improve robot movements and precision.

AI-automated surgical assistance assists surgeons with fine suturing, tissue manipulation, and real-time feedback to improve surgical outcomes (Iftikhar, 2024).

AI-driven simulation environments provide surgeons with training opportunities for difficult surgeries and improve their proficiency in the da Vinci system.

AI processes surgical videos and sensor data, optimizes surgical data, and provides postoperative observations, thereby enhancing the success rate of subsequent surgeries.

Effective applications of da Vinci surgical robots in various surgical scenarios. For example, AI-assisted robotic systems can be used in minimally invasive heart surgery to shorten recovery time and reduce surgical risks. AI robots can improve the precision of complex brain surgeries and reduce the risk of damage to surrounding tissues. AI-driven robotic arms assist in orthopedic joint replacements, which improves alignment and reduces postoperative complications.

During surgery, by filtering hand tremors and providing 3D views, AI assists robotic systems which improve precision. AI also analyzes real-time medical images to guide surgeons, such as detecting nerves to avoid damage, as seen in neurological exams. This can improve accuracy, especially in complex surgeries, and while merging these systems into workflows remains a challenge, the technology currently provides surgeons with especially meticulous aid and advice.

The AI features in the da Vinci surgical system help improve patient safety, reduce hospital stays, and improve surgical outcomes. It also reduces workload for medical staff and optimizes medical resources. This makes the da Vinci surgical system the pioneer of AI technology in clinical surgery.

# 4 AI TECHNOLOGY IN POSTOPERATIVE CARE AND MONITORING

After the surgical procedure is completed, doctors need to track and guide the patient's postoperative care and monitor, as well as their vital signs status. In fact, not only patients after surgery, but also patients with chronic diseases need long-term medication counseling and body index analysis by doctors. AI technology can help doctors utilize time and space, allowing convenient and efficient monitoring and guiding for a long time.

AI models predict possible complications after surgery by analyzing vital signs and biomarkers. A study published on JAMA Network conducted experiments to predict 6-month mortality among patients with cancer (Parikh, 2019). The research team applied the Random Forest Model to achieve an experimental outcome of an AUC of 0.94 and a PPV of 51.3% (Parikh, 2019). Furthermore, 58.8% of patients flagged as high risk were considered appropriate for a discussion of goals of care and end-of-life care. This helps doctors to implement early intervention if necessary and facilitates prognostic management.

Wearable sensors that are paired with AI can analyze patients' mobility, patients' pain level after discharge, and their postoperative recovery. It can also detect the physical condition of patients with chronic diseases and warn of the incidence of chronic diseases through body biomarker indicators.

AI technology can monitor patients' emergency status in real time in the future. Once the patient is in danger, AI devices can take measures to rescue the patient and quickly call emergency services for the patient.

After surgery, AI monitors the patient's recovery status, thereby helping to better recover and possibly speed up recovery. For training, AI simulators like LapSim provide a realistic practice environment and offer trainees with tracking feedback, which can standardized postoperative care skills and help boost rehabilitation levels of patients across the institution.

# 5 ETHICAL AND SAFETY CONSIDERATIONS

In today's society, although the integration of AI into medical care brings about many conveniences and benefits, it also raises issues such as data privacy and security risks. The system needs to comply with regulations to protect patient information. The training data should be accurate and representative. The training algorithm of AI should be transparent. Data should conform to standardization and interoperability (He, 2019). Explicit attention should be paid to patients' safety. It is crucial to keep in mind that AI is not adequate to deal with unique cases, that is, for specific special patients or cases with body structures different from ordinary people, AI might not be able to offer special treatments. There is also a

risk of bias in AI predictions, which may affect the completion of the operation. The safety risks of AI medical technology could also result from the mistakes of developers and manufacturers during the design and production process. Moreover, the technology is not likely to be transparent to the public, so it cannot be openly supervised by society. In this case, all supervision responsibilities are fully borne by the government. However, against the backdrop of the rapid advancement of AI technology, the government was not yet clear about its responsibility guidelines in the early stage. So from the perspective of ethics and safety, AI-driven medical technologies should be jointly supervised by relevant industries and government departments, highlighting the necessity of transparent and collaborative human-computer interaction.

The ethical considerations caused by AI medical technology are also reflected in the initial trial stage of AI. A large number of volunteers, patients and deceased people are required to cooperate and support the experiment and development of AI medical technology. Whether they have full knowledge of relevant experiments and fully understand their risks, and whether these experiments comply with local laws (considering that new technologies are not necessarily regulated by sound laws and regulations) all raise ethical and safety considerations. If an uncontrollable medical accident occurs, whether the patient and the surgeon can discover and interrupt treatment in time and have good remedial measures, this may not be fully guaranteed during the experiment.

The application of AI technology may cause an increase in the unemployment rate of medical staff or a reduction in the wages of some medical staff, bringing risks related to ethics and social stability (Joseph, 2025).

# 6 CHALLENGES AND FUTURE DIRECTIONS OF AI TECHNOLOGY IN THE MEDICAL INDUSTRY

As mentioned above, medical technology based on artificial intelligence (AI) has developed swiftly, but clinical applications have not yet been fully popularized, and some key practical issues still exist in the application of AI to existing clinical settings, including data privacy, algorithm transparency, and so on. These pose a major challenge for the future of AI technology in the medical community. When data sharing and privacy cannot be guaranteed, a large amount of medical data stored in network systems will face the risk of being hacked and leaked, while at the same time, the data may be used for other research or other commercial purposes, contrary to the patient's wishes (He, 2019). If the regulatory authorities in governments around the world fail to provide effective and safe implementation standards, the future of AI medical technology is subjected to vulnerabilities and ethical risks. Ethical issues have always accompanied AI since its inception. In the field of medical care, the main concern is accountability, because any decision-making mistakes could lead to serious consequences. Since medical professionals do not create or supervise algorithms, it does not seem fair to hold them responsible. However, on the other hand, it does not seem fair to hold AI technology developers responsible because they are excluded from contributing in the clinical decision-making process (Joseph, 2025). Therefore, in response to this situation, in some countries, AI cannot legally make any medical decisions without human involvement, and those who do so will be held accountable. Another major issue is "whether it violates the patient's right to know." This happened in 2018 when DeepMind, an AI-based research lab, was acquired by Google (Mountain View, California, USA). It was discovered that the National Health Service (NHS) provided 1.6 million patients' data to DeepMind servers to train its algorithms without having the patients to know [10, (Martin, 2017)]. Their application Streams has an algorithm for managing patients with acute kidney injury, which was criticized for collecting data without consent and was therefore considered a data leak. This is also a challenge for AI technology itself, because no matter what field AI is applied to, it should be based on the safety of people, the regulatory system, and the protection of nature.

Looking into the future, an important application of AI in the medical field is the integration of AI into medical imaging and medical surgery. This represents a major transformation in medicine. Although traditional surgery is effective, it is inherently limited by factors such as fatigue of surgeons, current medical level and surgical ability, and traditional medical equipment. AI technologies, including machine learning (ML), deep learning (DL), and medical imaging, are addressing these limitations through, for example, fine-tuning detection, surgical precision, reducing complications, and personalized patient care. According to a 2024 report by Grand View Research, the global medical artificial intelligence market is expected to reach $187.7 billion by 2030 (Grand View Research, 2024). With the development and

popularization of AI technology, AI-integrated surgical robots may possess the potential to replace doctors to accomplish high-precision, high-complexity surgeries in the future that human power cannot do. These robots may be able to serve poor countries with underdeveloped medical levels and tackle practical problems related to medical care that these countries cannot handle. AI-based medical signal transmission devices can also achieve "In-home medical care." Patients who need constant monitoring by doctors for their illness or rehabilitation status can use AI-based medical transmission devices to detect and upload their own conditions to doctors to achieve home medical care. In particular, patients with chronic diseases, such as hypertension and diabetes, can utilize these devices to get medical examinations at home and get immediate personalized feedback from the device. Then this record, including the patient's data and AI's feedback will be simultaneously uploaded and sent to the doctor. This can greatly reduce the workload of doctors, help ease the imbalance of the doctor-patient ratio in some countries, reduce unnecessary medical expenses for hospitals and families, and help patients achieve simple modern medical care.

## 7 CONCLUSION

In the 21st century, AI technology has made outstanding contributions in the medical field, like improving diagnostic accuracy, improving medical efficiency, improving surgical success rate, promoting the development of personalized medicine, helping to optimize medical resources, and accelerating the progress of medical technology. It not only marks the sustainable development of AI technology in the future, but also marks a major change in medicine. The two influence and complement each other. However, for new technologies in the developing stage, there are always pros and cons. AI-integrated medical technology is also facing challenges in multiple dimensions, such as data security, ethics, personal privacy, safety, and technical security. Whether AI technology can be further improved in the medical field requires not only the support from the government and the general public, but also the confirmation from modern science and medicine to prove that these technologies meet various safety and ethical standards. It requires the progress of human civilization, the progress of science and technology, and the improvement of laws and regulations.

## REFERENCES


Butler, D.J., Keim, A.P., Ray, S. et al., 2023. Large-scale capture of hidden fluorescent labels for training generalizable markerless motion capture models. Nat Commun 14, 5866. https://doi.org/10.1038/s41467-023-41565-3

Cao, K., Xia, Y., Yao, J. et al., 2023. Large-scale pancreatic cancer detection via non-contrast CT and deep learning. Nat Med 29, 3033 - 3043. https://doi.org/10.1038/s41591-023-02640-w

DiMaio, S., Hanuschik, M., Kreaden, U., 2011. The da Vinci Surgical System. In: Rosen, J., Hannaford, B., Satava, R. (eds) Surgical Robotics. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1126-1_9

Grand View Research, 2024. AI In Healthcare Market Size To Reach $187.7 Billion By 2030. https://www.grandviewresearch.com/press-release/global-artificial-intelligence-healthcare-market

He, J., Baxter, S.L., Xu, J. et al., 2019. The practical implementation of artificial intelligence technologies in medicine. Nat Med 25, 30 - 36. https://doi.org/10.1038/s41591-018-0307-0

Iftikhar, M., Saqib, M., Zareen, M., Mumtaz, H., 2024. Artificial intelligence: revolutionizing robotic surgery: review. Annals of Medicine & Surgery 86(9), 5401-5409. https://journals.lww.com/annals-of-medicine-and-surgery/fulltext/2024/09000/artificial_intelligence__revolutionizing_robotic.69.aspx

Joseph, G., Bhatti, N., Mittal, R., Bhatti, A., 2025. Current Application and Future Prospects of Artificial Intelligence in Healthcare and Medical Education: A Review of Literature. Cureus 17(1). https://assets.cureus.com/uploads/review_article/pdf/329078/20250211-240072-dywnuc.pdf

Martin, A., 2017. Google received 1.6 million NHS patients' data on an "inappropriate legal basis." https://news.sky.com/story/google-received-1-6-million-nhs-patients-data-on-an-inappropriate-legal-basis-10879142

Mishra, R., 2024. AI Revolutionizing Healthcare: A Look at IBM Watson's Impact in the Healthcare Industry. WeAreCommunity. https://wearecommunity.io/communities/healthcare/articles/5012

Parikh, R.B., Manz, C., Chivers, C. et al., 2019. Machine Learning Approaches to Predict 6-Month Mortality Among Patients With Cancer. JAMA Network Open 2(10), e1915997. https://doi.org/10.1001/jamanetworkopen.2019.15997

University of Florida, 2022. UF study uses AI to predict postoperative complications, improve patient care. https://surgery.med.ufl.edu/2022/01/06/uf-study-uses-ai-to-predict-postoperative-complications-improve-patient-care/