Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas

Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

THE IT FOUNDATIONS OF ROBOTIC TECHNOLOGIES IN SURGICAL PRACTICE

Ashurova Muhlisa
Tashkent State Medical University
Faculty of General Medicine No.1, student of group 113
Tashkent, Uzbekistan
Phone number: +998 97 797 68 04

Fazliddin Arzikulov
Assistant of the Department of Biomedical
Engineering, Informatics, and Biophysics at
Tashkent State Medical University

Abstract
Robotic technologies have become an integral component of modern surgical practice, significantly improving surgical precision, visualization, dexterity, and patient safety. The effective operation of surgical robotic systems is fundamentally dependent on advanced information technology infrastructures that integrate hardware, software, data processing, artificial intelligence, and secure communication networks. This article provides a comprehensive and systematic analysis of the information technology foundations underlying robotic technologies in surgical practice. Key aspects such as system architecture, control algorithms, imaging technologies, machine learning, data management, cybersecurity, and networked communication are extensively examined. The study emphasizes the role of information technology in enabling accurate surgeon–robot interaction, real-time decision support, and continuous system reliability. By elucidating these foundational technologies, the article contributes to a deeper understanding of

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

current robotic surgical systems and highlights future directions for innovation and clinical implementation.

Keywords: Robotic surgery, Information technology foundations, Surgical robotics, Artificial intelligence, Medical imaging, Cybersecurity, Human–robot interaction.

Introduction

The evolution of surgical practice has been profoundly influenced by technological innovation, with robotic-assisted surgery representing one of the most significant advancements in contemporary medicine. Since the introduction of early robotic systems in the late twentieth century, surgical robotics has progressed from experimental platforms to clinically validated tools used across multiple specialties, including urology, general surgery, gynecology, cardiothoracic surgery, and neurosurgery.

At the core of this transformation lies information technology, which enables the seamless integration of mechanical components, computational intelligence, and real-time data processing. Unlike traditional surgical instruments, robotic systems rely on complex software architectures, high-performance computing units, advanced imaging technologies, and secure data networks. These information technology foundations support essential functionalities such as motion scaling, tremor suppression, three-dimensional visualization, and precise instrument control. As robotic systems become increasingly sophisticated, understanding their information technology foundations is critical for ensuring safety, reliability, and optimal clinical outcomes. This article aims to provide an in-depth analysis of the information technology components that underpin robotic technologies in surgical practice, highlighting their roles, interdependencies, and impact on modern healthcare delivery.

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
OPEN ACCESS JOURNALS

Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

Materials and Methods

This article is based on a comprehensive review and analytical synthesis of peer-reviewed literature, international standards, and technical reports related to surgical robotics and medical information technology. Sources were selected from reputable scientific journals, academic textbooks, and professional guidelines in the fields of biomedical engineering, computer science, and clinical surgery.

The methodological approach included analysis of system architectures used in commercial and experimental surgical robots, evaluation of software frameworks and control methodologies, review of imaging, sensing, and data acquisition technologies, examination of artificial intelligence applications in surgery, and assessment of cybersecurity and data protection strategies.

The collected materials were critically analyzed to identify key information technology foundations and their contributions to the performance, safety, and scalability of robotic surgical systems.

Results

Robotic surgical systems are built upon layered information technology architectures that integrate physical hardware with sophisticated software platforms. Core components include high-speed processors, embedded controllers, robotic manipulators, and surgeon consoles. These elements communicate through real-time operating systems designed to meet strict latency and reliability requirements. Software systems govern every aspect of robotic operation, from motion control to error handling. Control algorithms such as proportional–integral–derivative control, adaptive control, and model-based control enable accurate translation of surgeon movements into precise robotic actions. Middleware frameworks facilitate interoperability between hardware components and software modules.

Advanced imaging technologies, including high-definition stereoscopic cameras and real-time image processing systems, provide enhanced visualization of surgical fields. Machine vision algorithms assist in object recognition, instrument tracking,

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
OPEN ACCESS JOURNALS

Eureka Journal of Computing Science & Digital Innovation (EJCSDI)

ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

tissue differentiation, and depth estimation, significantly improving surgical accuracy.

Artificial intelligence plays an increasingly important role in robotic surgery. Machine learning algorithms analyze large volumes of clinical and intraoperative data to support surgical planning, predict complications, and optimize procedural workflows. Artificial intelligence-driven decision support systems enhance surgeon awareness and contribute to improved patient outcomes.

Robotic surgical systems depend on secure and reliable network infrastructures for data transmission and storage. Encryption, authentication protocols, and intrusion detection systems are essential to protect sensitive patient information and ensure system integrity. Redundant communication channels and fail-safe mechanisms enhance operational reliability.

Discussion

The results demonstrate that information technology is central to the functionality and clinical success of robotic surgical systems. The integration of real-time computing, intelligent software, and advanced imaging creates a highly responsive and precise surgical environment. These systems enhance surgeon capabilities while reducing procedural variability and human error.

However, increasing system complexity introduces significant challenges. Cybersecurity vulnerabilities, interoperability limitations, and the need for specialized technical expertise can hinder adoption. Ethical and legal considerations related to data privacy, algorithmic decision-making, and clinical accountability must also be addressed. Future research should focus on standardized system architectures, explainable artificial intelligence, and resilient information technology infrastructures to support safe and scalable robotic surgery.

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

Conclusion

Information technology foundations form the backbone of robotic technologies in surgical practice. Through the integration of advanced hardware architectures, sophisticated software systems, real-time data processing, artificial intelligence, and secure communication networks, information technology enables robotic surgical systems to achieve exceptional levels of precision, safety, and efficiency.

These technologies not only enhance the technical capabilities of surgeons but also contribute to improved clinical outcomes, reduced complication rates, and shorter recovery times for patients. As robotic surgery continues to expand across medical specialties, a deep understanding of its information technology foundations becomes essential for clinicians, engineers, and healthcare organizations.

Sustained interdisciplinary collaboration, continuous investment in secure and scalable information technology infrastructures, and adherence to international technical and ethical standards will be critical for the future development of robotic surgery. Strengthening these information technology foundations will ultimately support the evolution of intelligent, data-driven, and patient-centered surgical care.

References

1. Taylor R H, Menciassi A, Fichtinger G, Dario P. Medical robotics and computer-integrated surgery. Springer Handbook of Robotics. Springer; 2016.
2. Siciliano B, Khatib O. Robotics: Modelling, Planning and Control. Springer; 2016.
3. Yang G Z, Cambias J, Cleary K, et al. Medical robotics—regulatory, ethical, and legal considerations. Science Robotics. 2017;2(4).
4. Deguet A, Balicki M, Kazanzides P. Software frameworks for medical robotic systems. International Journal of Medical Robotics and Computer Assisted Surgery. 2018;14(3).
5. Peters B S, Armijo P R, Krause C, et al. Review of emerging surgical robotic technology. Surgical Endoscopy. 2018;32(4):1636–1655.

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

6. Camarillo D B, Krummel T M, Salisbury J K. Robotic technology in surgery: Past, present, and future. Annual Review of Biomedical Engineering. 2004;6:377–401.
7. Hockstein N G, Gourin C G, Faust R A, Terris D J. A history of robots: From science fiction to surgical robotics. Journal of Robotic Surgery. 2007;1(2):113–118.
8. Intuitive Surgical Inc. Robotic-assisted surgery systems: Technical overview. Sunnyvale; 2020.
9. Russell S, Norvig P. Artificial Intelligence: A Modern Approach. 4th ed. Pearson; 2021.
10.Topol E. Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. Basic Books; 2019.
11.Satava R M. Surgical robotics: The early chronicles. Journal of Robotic Surgery. 2008;2(1):1–4.
12.Lanfranco A R, Castellanos A E, Desai J P, Meyers W C. Robotic surgery: A current perspective. Annals of Surgery. 2004;239(1):14–21.
13.Hashizume M, Tsugawa K. Robotic surgery and cancer: The present state, problems, and future vision. Japanese Journal of Clinical Oncology. 2004;34(5):227–237.
14.Cleary K, Nguyen C. State of the art in surgical robotics: Clinical applications and technology challenges. Computer Aided Surgery. 2001;6(6):312–328.
15.Peters T M, Cleary K. Image-guided interventions: Technology and applications. Springer; 2008.
16.Marescaux J, Rubino F. The ZEUS robotic system: Experimental and clinical applications. Surgical Clinics of North America. 2003;83(6):1305–1322.
17.Riviere C N, Thakor N V. Effects of tremor on microsurgical performance. Proceedings of the IEEE. 1996;84(4):480–498.
18.Dupont P E, Lock J, Itkowitz B, Butler E. Design and control of continuum medical robots. IEEE Transactions on Robotics. 2010;26(2):318–334.

Eureka Open Access Journals
Open Access | Peer Reviewed | International Journals | Multidisciplinary Areas
Eureka Journal of Computing Science & Digital Innovation (EJCSDI)
ISSN 2760-4993 (Online) Volume 2, Issue 1, January 2026

https://eurekaoa.com/index.php/10

19.Okamura A M. Haptic feedback in robot-assisted minimally invasive surgery. Current Opinion in Urology. 2009;19(1):102–107.
20.Abiri A, Packard R R S, Ding Y, et al. Artificial intelligence in robotic surgery. Advanced Intelligent Systems. 2020;2(5).
21.Hashimoto D A, Rosman G, Rus D, Meireles O R. Artificial intelligence in surgery: Promises and perils. Annals of Surgery. 2018;268(1):70–76.
22.ISO 13485:2016. Medical devices—Quality management systems—Requirements for regulatory purposes. International Organization for Standardization; 2016.
23.IEC 62304:2006. Medical device software—Software life cycle processes. International Electrotechnical Commission; 2006.
24.FDA. Technical considerations for medical devices with artificial intelligence. U.S. Food and Drug Administration; 2021.
25.van der Putten J, Dankelman J. Surgical ergonomics and human factors in robotic surgery. Surgical Endoscopy. 2018;32(4):1797–1806.