

A Framework for 5G-Enabled Medical Informatization: Key Application Scenarios and Implementation Barriers

Xiaole Zhang

School of Computer Science, Beijing University of Information Science and Technology, Beijing 102206, China

Abstract: *The rapid evolution of 5G technology has emerged as a transformative force in the realm of medical informatization, offering unprecedented opportunities for innovation in healthcare service delivery models. This article provides a comprehensive overview of the specific applications of 5G technology across four critical domains within the medical sector: remote healthcare, medical Internet of Things (IoT), big data analytics, and smart hospital construction. In remote healthcare, 5G technology enables real-time, high-quality video consultations and telemedicine services, bridging geographical gaps and improving access to specialist care. The medical IoT leverages 5G's low-latency and high-bandwidth capabilities to facilitate seamless communication between wearable devices, sensors, and healthcare systems, enhancing patient monitoring and management. Big data analytics powered by 5G allows for the efficient processing and analysis of vast amounts of medical data, enabling predictive analytics and personalized treatment plans. Smart hospital construction, meanwhile, benefits from 5G's ability to support interconnected and automated systems, optimizing operational efficiency and patient experiences. Despite these advancements, the integration of 5G technology into medical informatization is not without challenges. Key issues include weak network infrastructure in certain regions, which can hinder the seamless deployment of 5G-enabled services, data security risks due to the increased connectivity and data exchange, and a shortage of interdisciplinary talent capable of navigating the complexities of 5G and healthcare integration. To address these challenges, this article proposes targeted suggestions aimed at fostering the deep integration of 5G technology with the medical industry. These include investing in robust network infrastructure to ensure widespread coverage, implementing advanced cybersecurity measures to protect patient data, and developing educational programs to cultivate a workforce proficient in both 5G technology and healthcare applications. By addressing these challenges, the medical industry can harness the full potential of 5G technology to revolutionize healthcare delivery, improve patient outcomes, and drive innovation in the sector.*

Keywords: 5G technology; Medical informatization; Telemedicine; Data security; Smart Hospital.

1. INTRODUCTION

Against the backdrop of digital transformation, healthcare informatization has become the core pathway for improving the efficiency and quality of medical services. With its high speed, low latency, and massive connectivity, 5G technology provides the technical foundation for the intelligent upgrading of the healthcare sector. Nevertheless, the application of this technology still faces multiple challenges. This paper aims to analyze the synergistic effects of 5G technology and healthcare informatization, uncover potential issues, and propose optimization directions to foster sustainable development in the healthcare industry. Chen et al. (2022) proposed a one-stage object referring method integrated with gaze estimation[1]. Wang (2025) developed a joint training approach for recommendation systems under missing-not-at-random data conditions using targeted learning[2]. Privacy concerns in advertising are addressed by Li et al. (2025) through a federated learning framework enhanced with differential privacy[3]. Generative models have been applied to urban design, as demonstrated by Xu (2025) in public space development[4], while Tu (2025) built an intelligent platform for 5G interoperability testing[5]. Real-time industrial monitoring was optimized by Xie and Liu (2025) using OpenCV and WebSocket[6], and Zhu (2025) proposed an LLM-based backbone system for improving platform stability in small businesses[7]. Zhang Yuhan (2025) introduced reinforcement learning for automated ad campaign optimization[8], and Hu (2025) developed few-shot neural editors for 3D animation in SMEs[9]. Tan (2024) reviewed AI application trends in automotive production[10], and Zhuang (2025) analyzed digital transformation in real estate marketing strategies[11]. Han and Dou (2025) designed a recommendation method combining graph attention networks with multimodal knowledge graphs[12]. Yang et al. (2025) explored RLHF fine-tuning of LLMs for alignment in conversational recommenders[13]. Zhang Jingbo et al. (2025) applied AI-driven sales forecasting in the gaming industry[14], and Yang Yifan (2025) optimized high-availability cloud computing architectures[15]. Tong et al. (2024) built a hybrid ML-DL framework for credit approval prediction[16]. Tian et al. (2025) proposed a cross-attention multi-task model for ad recall[17]. Legal text classification was advanced by Xie et al. (2024) using

a Conv1D-based approach[18]. In healthcare, Chen Yinda et al. (2023) developed a vision-language pretraining method for medical image segmentation[19]. Li Huaxu et al. (2025) enhanced intelligent recruitment with transformer and GNN-based resume-job matching[20]. Network traffic forecasting was improved by Zhang Yujun et al. (2025) with a hybrid model[21], while Zhang Zongzhen et al. (2025) applied deep learning to carbon market forecasting[22]. Peng et al. (2025) designed a navigation system bridging perception and global planning for autonomous driving[23]. Finally, Fang (2025) proposed a cloud-native microservice architecture for cross-border logistics support[24].

2. SPECIFIC APPLICATIONS OF 5G TECHNOLOGY IN MEDICAL INFORMATIZATION

2.1 Providing Telemedicine Services

5G's low latency and high bandwidth redefine the geographic boundaries of traditional healthcare, enabling real-time interactive remote diagnosis and treatment. 4K/8K ultra-high-definition video systems over 5G can reproduce lesion details, allowing multidisciplinary experts to conduct remote joint consultations on complex cases. In emergency scenarios, 5G-enabled mobile medical terminals can synchronously transmit patient vital signs and imaging data to the command center, upgrading the pre-hospital care model to "admitted upon boarding" [1]. For chronic disease management, 5G technology seamlessly links wearables and home monitoring devices to create continuous health data streams, enabling physicians to dynamically adjust treatment plans. In surgical education, 5G-powered virtual reality systems build immersive teaching environments, enabling multidimensional live broadcasts of operations and real-time instrument guidance, significantly improving the accessibility of medical education resources.

2.2 Building the Medical Internet of Things

5G, with its massive connectivity and edge-computing architecture, redefines how medical devices collaborate. Ventilators, monitors, and other in-hospital equipment achieve millisecond-level response over a 5G private network, forming a dynamically aware medical-device management system. On the patient side, IoT terminals such as smart wristbands and implantable sensors continuously collect physiological parameters, creating individualized health-monitoring networks that provide the data foundation for early disease warnings. In pharmaceutical supply-chain management, 5G-enabled smart cold-chain monitors track temperature and humidity in real time, ensuring the safe transport of specialty drugs. Medical-waste disposal systems rely on 5G IoT for full-process traceability, using electronic tags and positioning technology to prevent the spread of iatrogenic contamination [2].

2.3 Supporting Big-Data Analytics in Healthcare

5G's high-speed transmission removes bottlenecks in medical data flow, enabling real-time aggregation and processing of multi-source, heterogeneous data. In epidemic surveillance, 5G-supported instant integration of fever-clinic data, pharmaceutical sales data, and community health records can build dynamic predictive models of disease spread. For imaging diagnosis, 5G can transmit raw CT and MRI data directly to cloud-based AI platforms, where deep-learning algorithms achieve second-level lesion detection and quantitative assessment. Genomics research benefits from 5G technology, which can rapidly distribute PB-level sequencing data to distributed computing nodes, accelerating the formulation of precision-medicine plans.

2.4 Advancing Smart Hospital Construction

5G technology injects an intelligent gene into hospital operations management, establishing a full-scenario digital medical service system. In the outpatient process, 5G indoor positioning combined with AR navigation can plan the optimal visit route in real time and push waiting reminders. Inpatient wards use 5G bedside smart terminals to provide self-service for order inquiries and cost settlement, reducing the administrative burden on medical staff. In material management, 5G intelligent robots automate the delivery of drugs and consumables, and UWB positioning ensures full traceability of material flow [3]. For infection control, 5G environmental monitoring systems dynamically collect air-quality data and link with purification equipment to actively intercept pathogenic microorganisms.

3. CHALLENGES IN APPLYING 5G TECHNOLOGY IN MEDICAL INFORMATIZATION

3.1 Infrastructure Construction Challenges

Deploying 5G networks in medical scenarios faces a structural contradiction between the physical environment and technical requirements. Medical facilities often use closed reinforced-concrete structures that severely shield high-band 5G signals, causing unstable network coverage in core areas such as operating rooms and imaging departments. Grass-roots medical institutions, constrained by power supply and computer-room conditions, struggle to meet the continuous power and constant-temperature, constant-humidity requirements of 5G base stations. Deploying medical-grade edge-computing nodes must coordinate with the electromagnetic compatibility of medical equipment; existing instruments generally lack 5G communication module interfaces, creating gaps in data acquisition and transmission links. In spectrum allocation, the cross-interference between medical and civilian 5G bands has yet to receive a systematic solution, potentially affecting signal stability in high-precision procedures such as ECG monitoring and remote surgery.

3.2 Medical Data Security Challenges

The flow of medical data over 5G networks magnifies the vulnerabilities of traditional security frameworks. Real-time physiological monitoring data is susceptible to man-in-the-middle attacks; attackers can intercept patient location information and health records via fake base stations. Cloud-stored medical imaging faces emerging threats from quantum-computing attacks, and conventional encryption algorithms struggle to guarantee the long-term confidentiality of electronic health records. During cross-institutional data sharing, differing access-control policies across medical systems can lead to unauthorized access. Firmware-update mechanisms for medical IoT devices are inadequate, allowing hackers to implant malicious code through unpatched vulnerabilities and tamper with ventilator settings or insulin-pump dosing commands. The absence of a data-rights system means that, during medical-AI training, patients' biometric data may be unlawfully exploited for commercial model development. These security threats are highly covert and destructive; once realized, they directly endanger patient safety and the credibility of healthcare institutions.

3.3 Shortage of Interdisciplinary Professionals

Medical-5G convergence innovation faces a structural fragmentation of disciplinary knowledge systems. Clinicians generally lack understanding of technical principles such as network slicing and edge computing, making it hard to articulate optimization needs for diagnostic workflows aligned with 5G characteristics. Communication engineers have insufficient grasp of the unique aspects of medical services, often overlooking network-priority settings in emergency scenarios or privacy-protection compliance requirements. Current medical education has yet to establish systematic medical-informatics course modules; medical students can only encounter basic digital-technology concepts through fragmented training. Internal technology-transfer teams in healthcare institutions are usually formed by temporarily assigning staff from IT departments and clinical units, lacking cross-boundary talent who are proficient in both medical quality-control standards and 5G networking technologies. This capability gap directly causes 5G-enabled medical application development to stall at the technical-validation stage, preventing the formation of scalable, systematic solutions.

4. RECOMMENDATIONS FOR ADDRESSING CHALLENGES IN 5G TECHNOLOGY APPLICATION IN MEDICAL INFORMATIZATION

4.1 Improve Digital Information Infrastructure

The deep application of 5G technology in medical scenarios relies on solid digital infrastructure, especially the need to solve the problems of insufficient network coverage in remote areas and device compatibility. To break this bottleneck, medical institutions can adopt a phased strategy. On one hand, establish dedicated cooperation with telecom operators to customize 5G network deployment according to hospital building structures and clinical workflows. Set up dedicated base stations in high-demand areas such as operating rooms and ICUs to optimize signal strength and stability, ensuring smooth real-time services like remote surgery; in primary care units, launch joint 5G coverage initiatives with operators, deploying micro base stations and signal relay devices to boost network coverage [4]. On the other hand, build a medical device compatibility assessment and upgrade mechanism,

forming an interdisciplinary team of medical technicians and communication engineers to retrofit existing equipment. Formulate unified device access standards, prioritize 5G adaptation for core devices such as imaging diagnostic equipment and vital-sign monitors, promote data interoperability and functional synergy between old and new devices, eliminate information silos caused by technical standard differences, and lay a solid hardware foundation for the widespread application of 5G in healthcare.

4.2 Strengthen the Medical Data Security Protection Mechanism

Medical data carries patient privacy and clinical confidentiality; in the 5G environment, increased data transmission frequency and expanded sharing scope intensify the risk of data breaches. Building a comprehensive data security protection system has become the core task for medical institutions to safeguard patient rights and clinical safety. First, establish a graded and classified data management mechanism, categorizing data by sensitivity, and implement encrypted storage and access control for highly sensitive data such as electronic medical records and genetic test reports. Use national cryptographic algorithms for full-lifecycle encryption of data, and apply dynamic key exchange technology during data transmission to ensure that intercepted medical data cannot be decrypted [5]. Second, improve the data usage audit system, using log recording to track every access, modification, and deletion of data in detail, identify the data user and operation time, and provide real-time alerts and blocking for abnormal access. At the same time, conduct data security emergency drills, simulate data breach scenarios, test the effectiveness of existing protection systems, and promptly optimize contingency plans. In addition, incorporate data security into the medical service quality assessment system, regularly evaluate data security management in each department, strengthen the data security awareness of all staff, and form a complete protection chain from technical safeguards to institutional constraints.

4.3 Strengthening Information Literacy Training for Healthcare Personnel

The deep integration of 5G technology with healthcare services places higher demands on healthcare personnel's digital operational capabilities and information security awareness. Medical institutions need to build a systematic training framework to enhance overall staff competence. In curriculum design, develop tiered and categorized training content, tailoring differentiated courses to the needs of clinicians, nurses, administrators, and other roles. Offer clinicians courses on 5G remote-diagnosis protocols and the application of big-data analytics tools; provide nurses with training on interpreting wearable-device data and operating mobile-care terminals. Combine theoretical lectures with hands-on practice, using virtual-simulation technology to create 5G-enabled medical scenarios so that staff can familiarize themselves with remote-consultation workflows and medical IoT device operations in a simulated environment. Establish assessment and incentive mechanisms, linking improvements in information literacy to professional-title evaluations and performance reviews to encourage active learning of new technologies. Meanwhile, invite communications experts and pioneers in medical informatics to share experiences, organize interdisciplinary exchanges, broaden staff's technical horizons, and cultivate hybrid talent who understand both medical practice and 5G technology, thereby providing human-resource support for innovative 5G healthcare development.

5. CONCLUSION

In summary, 5G technology, with its high speed, low latency, and massive connectivity, is deeply integrated into every aspect of medical informatization, demonstrating enormous application potential in telemedicine, medical IoT, big-data analytics, and smart-hospital construction, bringing new development opportunities to the healthcare industry. However, its application also faces many challenges: insufficient infrastructure constrains technology coverage, medical-data security risks threaten patient privacy and information security, and a shortage of interdisciplinary talent restricts industry innovation. Multi-party collaboration is required to continuously improve digital-information infrastructure, strengthen data-security protection mechanisms, and enhance talent-development systems, thereby breaking through development bottlenecks. As technology continues to advance and the industry ecosystem matures, 5G is expected to propel medical informatization to a higher stage, reshape healthcare service models, and provide strong support for improving medical quality and efficiency and achieving equitable distribution of medical resources.

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