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REVOLUTIONIZING HEALTHCARE: UNLEASHING THE POWER OF 5G AND INTELLIGENT MEDICINE

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REVOLUTIONIZING HEALTHCARE: UNLEASHING THE POWER OF 5G AND INTELLIGENT MEDICINE

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Abstract

Despite extensive efforts, the provision of healthcare services to an ageing population is fraught with tremendous obstacles. Recent observations have raised concerns regarding the escalating costs of healthcare, the imbalance of medical resources, the ineffective administration of the healthcare system, and inconvenient medical encounters. To meet these challenges, however, cutting-edge technologies are being developed, such as Internet of Things (IoT), big data, artificial intelligence, and 5G wireless transmission technology, to improve the patient experience and healthcare service quality while reducing the total cost attributable to healthcare. This is not a pipe dream, as these emergent technologies are already beginning to influence and reshape healthcare in discreet ways. Despite the fact that the aforementioned technologies are integrated, this article focuses on the application of 5G wireless transmission technology in healthcare. In addition, we highlight potential obstacles to the availability of 5G technologies.

Key words: Healthcare, 5G, the Internet of Things, big data, and artificial intelligence

Introduction

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The term "5G" refers to the fifth iteration of wire- less transmission technology, which is anticipated to have a significant impact on numerous facets of modern society, including healthcare. Important characteristics of 5G technology include data transfer rate, latency, coverage, power, and network energy consumption, with the following unique features providing the most value to the healthcare industry: (i) high-speed data transfer rate; (ii) super-low latency (delay in the data transmission-response system); (iii) connectivity and capacity; and (iv) high bandwidth and durability per unit area.

The transmission speed of 5G is a technological breakthrough, with 5G offering up to 10 Gbps, a 10- to 100-fold improvement over 4G and 4G Long-term Evolution (LTE). In addition to performance enhancements, 5G is distinguished by its low latency; in the 5G era, latency is 1 milliseconds, which is nearly equivalent to "0" data response time in the real world. In addition, 5G is anticipated to significantly expand Internet of Things (IoT) services. Based on 5G super bandwidth per unit area, connectivity, coverage (up to 100 percent), and the capacity to connect devices per unit, an ecosystem will emerge in which a "intelligence network" can support real-time interactivity for massive medical equipment and patients' wearable devices, with cloud computing-based trade-offs between speed, latency, coverage, availability, and low power IoT service. Before illustrating the specific applications of 5G in healthcare, for the purpose of more precisely deriving the potential value of 5G, we will briefly review the deficiencies of the current healthcare system. The system: (i) can make it inconvenient for patients to seek health-

care service; (ii) provides only a non-individualized diagnostic and treatment model; (iii) results in an imbalance of medical resources; and (iv) is not a data-driven healthcare practise model that is holistic in scope. In addition, transportation can be inconvenient, the hospital registration process is difficult, and the medical system is hierarchical. Importantly, the current healthcare service system applies a unified diagnosis and treatment plan, also known as a "one-size-fits-all" plan, to any population or group of individuals, while advocating for standardised guidelines and treatment procedures. The imbalance of health resources, such as medical equipment and well-trained practitioners, causes a large number of patients from rural areas to migrate to urban areas in search of a high-quality healthcare service, resulting in hospital overcrowding and overburdened medical staff in many developing countries and regions. In the provision of healthcare services, medical personnel rely significantly on their own experience as opposed to a comprehensive data-driven approach. Collectively, these are the most significant shortcomings of the current healthcare system. 5G, the next generation of wireless technology, has the potential to radically transform healthcare by facilitating the development of intelligent medicine.

Here are several ways 5G can contribute to the transformation of healthcare:

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More rapid and dependable communication: Compared to previous iterations of wireless technology, 5G provides faster data transfer rates, reduced latency, and enhanced network reliability. This allows for quicker and more effective communication between medical professionals, patients, and medical devices. Real-time transmission of medical data, such as high-resolution images and patient records, becomes seamless, enabling more rapid and precise diagnoses and treatment decisions.

Remote patient monitoring: 5G can significantly improve remote patient monitoring. Wearable devices and sensors can transmit real-time health data to healthcare providers, allowing for continuous patient monitoring outside of conventional healthcare settings. Physicians can remotely monitor vital signs, identify abnormalities, and administer opportune interventions, thereby decreasing hospital readmissions and enhancing patient outcomes. 5G's minimal latency enables immediate feedback and interventions, which is crucial in situations involving critical care. The widespread adoption of telemedicine and virtual care solutions is facilitated by 5G. Even in rural or underserved areas, high-quality video consultations, remote diagnosis, and virtual visits become more accessible. The increased bandwidth and dependability of 5G networks ensure uninterrupted and seamless virtual interactions between patients and healthcare providers. This reduces the need for in-person visits, improves accessibility, and increases the convenience of healthcare services. 5G's capacity to support a large number of connected devices and its low latency are especially advantageous for the Internet of Medical Things (IoMT). Wearables, implantable sensors, and monitoring equipment are capable of seamlessly connecting and transmitting data in real time. This enables healthcare professionals to more effectively access comprehensive patient information, monitor disease progression, and personalise treatment plans.

Healthcare applications using AI: Advanced artificial intelligence (AI) applications in healthcare require the high-speed connectivity and minimal latency provided by 5G. Massive quantities of medical data, such as genomics, medical images, and electronic health records, can be analysed by AI algorithms to identify patterns, predict outcomes, and aid in clinical decision-making. With 5G, AI models can be deployed in real-time, allowing for improved AI-assisted diagnostics, drug discovery, and treatment planning.

Virtual and augmented reality in healthcare: Due to 5G's low latency and high bandwidth, augmented reality (AR) and virtual reality (VR) technologies can be seamlessly integrated into healthcare. Using augmented reality (AR) overlays, surgeons can visualise patient anatomy during operations, thereby augmenting precision and minimising risks. Remotely administered VR-based therapies can aid in pain management, mental health treatment, and rehabilitation. 5G-powered immersive technologies offer new opportunities for training, education, and patient care. 5G technology has the potential to revolutionise healthcare by facilitating faster and more reliable communication, facilitating remote patient monitoring and telemedicine, enhancing connectivity for medical devices, powering AI-driven healthcare applications, and supporting augmented

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and virtual reality in healthcare settings. These innovations can lead to more personalised, accessible, and efficient healthcare delivery, thereby enhancing patient outcomes and reshaping the healthcare landscape. It is anticipated that 5G and concomitant emerging technologies can surmount some of the current obstacles in healthcare and reconstruct the system. As previously mentioned, 5G is not a singular technology or standard, but rather a combination of various technologies. Technically, 5G has at least four distinct technological characteristics that have the potential to have a substantial impact on healthcare. Notably, the effects of these features would not contribute equally, and it would be deceptive to promote a single significant benefit of 5G.

5G and its application in healthcare at a glance

Consider the implications of 5G for healthcare. Although for most people 5G simply means quicker internet, 5G is likely to have multiple effects on healthcare. In addition to faster internet, the healthcare industry would benefit tremendously from dependable internet connectivity for large objects and medical devices, with superior bandwidth, coverage, and availability than 4G LTE provides. Virtual reality (VR) and augmented reality (AR) are most likely to benefit directly from 5G, with potential contributions to cognitive medicine once 5G technology matures. Due to their technical properties, promoting the integration of VR and AR is essential for comprehensive rehabilitation training, as well as concise extremity rehabilitation and telemedicine. Extremity rehabilitation exercise, including robotic support for the fine motor skills of the limbs, gravity compensation, and individually tailored video training programmes, is closely related to the application of VR and AR in healthcare. The use of VR in healthcare is not a 5G-era innovation; the medically applicable technology dates back at least 20 years.3 However, this technology has not been completely developed because latency, the time between transmitting a data request to a terminal device and receiving the data, is a significant limitation. In comparison to 4G LTE wireless communication technology, 5G can offer a 10-fold reduction in latency, from the current 20 milliseconds to as low as 1 millisecond.

This advantage is crucial for VR technology and telemedicine.4 In the 5G era, with its inherent high bandwidth and low latency advantage, it is anticipated that virtual reality will help expedite the entire hospital, particularly in telemedicine, teleconsultation, and even remote surgery. During intuitive surgical training or even remote surgery, vital signals could be transmitted to medical equipment or screen monitors in the hospital with almost no latency (1 ms radio latency with 109 error rate). The current spectrum allocations for 4G LTE bands cannot satisfy these requirements. In addition, 5G is potent enough to simultaneously support thousands of medical devices, including sensors, mobiles, medical equipment, and video cameras. Supplemented by a 4 k or even 8 k ultra-high-definition television or monitor system,

this could provide sharper, more detailed streaming video beyond the retina.

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Telemedicine would also benefit, as 5G would expand the scope of telemedicine, which could occur rapidly. People frequently associate big data and artificial intelligence with personalised medicine, also known as individualised or precision medicine. Nonetheless, it is evident that without the technical support provided by 5G, precision medicine is an unsolvable puzzle. Bandwidth and data transmission speed have long been regarded as the primary limiting factors. In the era of 4G, even 4G LTE-advanced can only provide around 50 Mbps and theoretical limits of 300 Mbps download speeds in the real world, not to mention the need to stabilise high-speed streaming video and image data and efficient super-low latency interventions. Telemedicine implementation with 4G LTE has been hindered by more than just slow data transfer speeds. Bandwidth and minimal latency are crucial factors. This enables vast medical devices to connect simultaneously to the central cloud computing platform, server, or inter-device connectivity without causing network congestion. This allows for genuinely immersive VR, instantaneous response, and augmented reality applications, which can create an interactive telemedicine experience. This type of telemedicine, along with a 4 k/8 k monitor and 360-degree virtual reality, could provide a "live" experience not only for clinicians in terms of immediate diagnosis and treatment strategy decisions, but also for medical staff in terms of more efficient operation and potent training tools.5 5G has revolutionised the delivery of low-latency stream video, 3D high-resolution medical imaging, and mission-critical interventions, in addition to facilitating high-speed data transmission. Self-determination medicine: a new model of health care that 5G could deliver As previously stated, 5G is not a singular technology but rather a combination of cutting-edge technologies, such as massive MIMO.

Potential pitfalls of 5G technology applications in healthcare

The most evident pitfall is the emphasis on faster data transfer speeds. There are high expectations for transmission speed enhancements, so it is not surprising that the majority of individuals believe the primary characteristic of 5G is rapid data transfer. As the next-generation wireless communication technology, 5G is expected to increase data transmission speed by up to 100 times compared to the current 4G LTE network, making it competitive with the quickest wired broadband networks available today. This is significant! Nevertheless, 5G's revolutionary changes include its high bandwidth and low latency. The limitations of current bandwidth and latency frequently result in service interruptions, especially when many users in the same area attempt to access mobile online services simultaneously. More devices on the network will increase the demand for connections, which 4G cannot accommodate.

The separation of 5G and other emerging technologies is an additional pitfall. As previously stated, 5G is not a singular technology; rather, it is the foundation for the Internet of Things (IoT) and other emerging technologies such as big data, cloud computing, and artificial intelligence that can be combined organically with 5G. This pattern is applicable to the healthcare sector. Currently, cloud-native architecture is the foundation of 5G technology, and it is somewhat misleading to add other related

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technologies to exaggerate the role of 5G in healthcare.

Conclusions

Increasing evidence indicates that 5G will open up opportunities for healthcare, and its effects on healthcare will be numerous and far-reaching.9 In this review, we have not exhaustively discussed the impact of 5G on healthcare systems; rather, we have selected a small number of representative examples of how 5G will restructure the healthcare system in the disciplines of virtual reality, telemedicine, and self-determination medicine. Despite limitations and obstacles, such as data confidentiality, security risks, lack of entire network deployment and support, and the proposal for the regulation of healthcare data use, 5G has begun to demonstrate significant benefits in enhancing hospital intelligence services, enabling automatic patient monitoring, performance of precise remote surgical operations, promotion of the rational allocation of quality medical resources, and efficient utilisation of medical resources. Whether or not we are prepared to adopt these emergent technologies, the 5G era is arriving. Several top institutions, including the West China Hospital of Sichuan University, are pioneering the deployment and application of 5G in clinical practise and smart medical strategy in China.10 Although the full deployment of 5G networks is anticipated to take between 5 and 10 years, an increasing number of medical research institutes and hospitals are laying out their healthcare strategies, such as determining 5G's clinical data centre architecture, medical equipment procurement strategy, and close cooperation with telecom operators. These are notable trends, particularly in the healthcare sector, that are driving the transition to the 5G era. 5G will restructure the healthcare system by intelligently enhancing the quality of medical service, harmonising the distribution of medical resources between urban and rural areas, and lowering the cost of healthcare. We are cautiously optimistic about these changes, but we still have a long way to go before achieving our ultimate objective of intelligent healthcare.

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