BRIEF REPORT

5G in healthcare: how fast will be the transformation?

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Abstract

The 5G technology, with its low latency, high speed, enhanced high-resolution bandwidth, superior reliability, and less energy consumption, is bound to transform telemedicine and the healthcare industry as a whole. This next-generation wireless networking technology has many far-reaching implications in both preventive and therapeutic care of the patients. Remote monitoring of patients is possible with wearables facilitated by robust sensors coupled to 5G network. Virtual patient consultation; augmented reality (AR) and virtual reality (VR)-based simulated surgeries; artificial intelligence (AI)–powered robotic surgeries; real-time maintenance of ambulances and other medical devices; and dynamic huge data repository are some of the other applications of 5G technology in the health sector.

Keywords 5G · Internet of Medical Things · Telehealth · Telemedicine · Wearable medical devices

The fast-growing healthcare industry, with increasing number of remote-end applications, requires a powerful communication network to effectively connect patients, healthcare professionals, medical equipments, and among others for information sharing. The 5th Generation (5G) mobile networks, the next evolution of wireless connectivity, are bound to advance telemedicine and transform the future of healthcare delivery [1].

The key features of 5G are ultra-low latency, high capacity, high speed, seamless connectivity, high reliability, and low power consumption. The theoretical speed of 5G is about 10 to 30 Gbps, whereas that of 4G is 300 Mbps. 5G has far superior latency than 4G reaching as low as 1 ms compared to 50 ms of 4G. 5G operates at microwave frequencies (broad bandwidth); hence, it can accommodate a large number of simultaneous users (1 million users per km^2) which is almost 100 times more than that of 4G. Also, 5G uses less energy per bit than 4G; hence, the energy consumption of devices is minimized and the battery life of the devices is enhanced.

5G is not all about speed; rather, it can change the entire healthcare system bypassing all the limitations that are present with the current generation of wireless networking technology, and besides, provide an excellent user experience. The whole healthcare system can be moved towards a decentralized network (Fig. 1) [2].

Home care and remote patient monitoring

With the advancement in technologies and smartphones, several sensors can be used to monitor the vital information of the patients—the so-called Internet of Medical Things (IoMT). To connect a large number of IoMT devices and to share a large amount of data remotely, a high bandwidth 5G mobile network is required. These sensors detect the ECG signal, blood pressure, body temperature, glucose level, and among others, through the 5G-powered wearables or other remote monitoring and rehabilitative devices.

Furthermore, wearables with versatile sensors can also support in monitoring physical activity, and also in-house rehabilitation in patients with chronic ailments, including cancer, stroke, spinal cord injuries, and chronic pulmonary diseases. Non-interventional blood sample analysis (like hemoglobin concentration) and seizure prediction wearable smart devices are also in development. The IoMT can also help in monitoring drug intake in patients (with ingestible sensors); hence, compliance with pharmacotherapy can be assessed remotely [3, 4].

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Fig. 1 Scope of 5G in healthcare

Ambulance services

5G-powered sensors fitted to the ambulance and mobile health monitoring systems relay the patients' vitals in real time without any network issues to the doctors so that necessary treatments are provided to the patients on the go with the help of ambulance crew—making room for smart ambulance services. Additionally, delays due to unforeseen mechanical failure can be avoided by real-time tracking and monitoring of vehicle parts.

Virtual consultation

With HD streaming, doctors can attend to several patients without the need for a physical meeting. Doctors can prescribe based on the patients' feedback and extract the vitals from the real-time remote monitoring system without any delay. The patients can consult the doctors from the comfort of their homes and thereby reducing the travel cost. Overcrowding of the outpatients at the hospitals can be avoided, and only the patients who need immediate medical assistance are attended at the hospital. The performance-enhanced 5G network supports for seamless delivery of teleconsultation and tele-expertise—both of which are subsets of telemedicine [5].

Real-time maintenance

All the types of medical equipments are fitted with sensors that relay the condition of every part in real time to the maintenance team which not only helps in predicting the hardware failure in advance but also minimizes the repair or replacement time.

Augmented reality and virtual reality

Augmented reality (AR) glasses assist the surgeon during several medical procedures from providing vital information about the disease condition to the valuable information for the surgery. Virtual reality (VR) is very helpful in training health care professionals in simulating surgeries (simulated reality). A typical 360° VR video stream with a minimum of 10 bit per pixel requires a data rate of at least 2.1 Gbps. Furthermore, with 5G in hand, the sophistication of haptic/tactile internet can be reaped in ultra-real time and more reliably [6].

Table 1 5G applications in medicine

S. no.	Key healthcare components	Applicable and relevant 5G dimensions
1	Home care and remote patient monitoring	High data rate and channel capacity • Very high data rate is required to access real-time health status information of the patients from multiple IoMT. Low latency • Very low latency is required to access real-time information from IoMT. High reliability • Data loss must be minimal as ambulances/hospitals must be alerted on time. Low energy consumption • Since all wearables are battery-powered, energy consumption of data transmission must be minimal for prolonged usage. High security • Security breaches can compromise patient privacy.
2	Ambulance services	High data rate and channel capacity • Very high data rate is required to get the real-time health status information of the patient and the ambulance through multiple IoMT. High reliability • Data loss must be minimal to transmit the patient/vehicle status without interruption as the ambulance will be moving at high speed. Low latency • Very low latency is required to access real-time information from different sensors. Availability • It has to provide seamless connectivity. • Connection downtime must be minimal as ambulance service is essential round the clock.
3	Virtual consultation	High data rate and channel capacity • High data rate is required to stream HD videos and access live feed from patients' wearables. High reliability • Data loss must be minimal to get an uninterrupted streaming service and to access the patient vitals. High security • Security breaches can compromise patient privacy.
4	Real-time maintenance	Low latency • Very low latency is required to access real-time information from medical equipments. High bandwidth • High bandwidth is necessary for continuous monitoring of all the medical equipments. High security • Collection of data has to be highly secured.
5	Augmented reality (AR) and virtual reality (VR)	High data rate and channel capacity • High data rate is required to stream VR and AR contents. • High throughput. Low latency • Low latency is very critical for real-time AR High bandwidth • Very high bandwidth is necessary for high-resolution 360° immersive video streams. Availability • It has to provide seamless connectivity.
6	AI-powered robots and robotic surgery	Low latency • Low latency is very critical for haptic feedback. High data rate and channel capacity • High data rate is required for HD image streams. High reliability • Data loss must be minimal as surgery cannot be interrupted. Low energy consumption

Table 1 (continued)

S. no.	Key healthcare components	Applicable and relevant 5G dimensions
		• Battery life is very important as surgeries can go for hours and robots deployed for essential service must not drain out early. Availability • Connection downtime must be minimal as surgeries cannot be interrupted. High security • Security breach can cause life-threatening consequences.
7	Cloud computing and data repository	High data rate and channel capacity • High data rate is required to minimize the transfer time for terabytes of data between multiple sources. High reliability • Connection interruption leads to retransfer of data causing wastage of bandwidth and time. Availability • Connection downtime must be minimal as AI-powered robot relies on cloud computing. High security • Security breach can cause life-threatening consequences.

IoMT, Internet of Medical Things

AI-powered robots

Surgeons can connect to a remote robot to perform surgery with minimal latency of 1 ms. Several assistive-connected robots can be deployed at the hospitals that can aid the patients in critical care. Drones equipped with HD cameras or thermal sensors can relay key information during an emergency that can provide a go-ahead to the dispatch ambulance service or store the collected information at the data repository.

With medical robotic–assisted surgery, there could be an increase in precision and support the treating surgeons in improving postoperative outcomes. 5G-enabled telesurgery facilitates not only in the outreach of the underserved population but also in the much-needed collaboration among the surgeons across various centers in real time. This technology will indirectly help in the mutual training and upliftment of surgical expertise cutting costs and time constraints—the so-called Internet of Medical Skills (IoMS) [6].

Cloud computing and data repository

With exceptional network performance and lower energy consumption of 5G, the energy required for data computation on the battery-powered IoMT devices and robots can be minimized by using cloud processing. Large files can be transferred across the globe in a short span for remote processing. This enables several researchers to access the data in real time and aid them in scientific studies with improved data analysis. With the recent growth of AI in the medical diagnosis of diseases and prognostic study, a large repository of data is needed that holds the crucial details and a faster method to access them [7].

The electronic medical records (EMR), the hospital information system (HIS), the laboratory information management system (LIMS), the picture archiving and communication systems (PACS), and the clinical trial participant registry are some of the healthcare-based data repository systems that archive huge patient data (Table 1) [8].

Future prospects

To keep in sync with the burgeoning development of networking technologies, there is a necessity to integrate enriched-media communications into medical practice. One such focus is on the proposal of smart eHealth system with 5G network slicing, and consequently, harmonizing heterogeneous patient-related data from wide-ranging wearables—sometimes, even in the realm of the Internet of Nano Things (IoNT) [9]. A major setback with these wireless technologies in health systems is inaccessibility to human emotions. This lacuna is now being tried to be overcome by the introduction of the 5G-based cognitive system (5G-Csys) which incorporates speech emotion recognition [10].

In conclusion, the failure of technology-based health interventions, also including 5G, to take a strong foothold in this field is due to lack of proximity of these modern modalities to the major stakeholder, namely, the patients. Having said so, the march towards next-generation wireless networking

technology in healthcare settings could be delayed yet inevitable as in any other sector.

Compliance with ethical standards

Conflict of interest   The authors declare that they have no conflict of interest.

Consent for publication   Both the authors mutually agree to publish the content.

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