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Chapter

Challenges and Prospective of AI and 5G-Enabled Technologies in Emerging Applications during the Pandemic

Md. Mijanur Rahman and Fatema Khatun

Abstract

5G is being implemented in the Internet of things (IoT) era. This book chapter focuses on 5G technology and the integration of other digital technologies, such as artificial intelligence (AI) and machine learning, IoT, big data analytics, cloud computing, robotics, and other digital platforms into new healthcare applications. Now, the healthcare industry is implementing 5G-enabled technology to improve health services, medical research, quality of life, and medical professionals' and patients' experiences everywhere, at any time. Technology can facilitate faster medical research progress and better clinical and social services management. Furthermore, AI approaches with 5G connectivity may be able to combat the epidemic challenges with minimal resources. This book chapter underlines how 5G technology is growing to address epidemic concerns. The study highlights many technical issues and future developments for creating 5G-powered healthcare solutions. This chapter also addresses the key challenges AI and 5G technology face in emerging healthcare solutions. In addition, this book chapter highlights perspective, policy recommendations, and future research directions of AI and 5G-enabled technologies in confronting future pandemics. More research will be incorporated into future projects, including studies on developing a digital society based on 5G technology in healthcare emergencies.

Keywords: 5G technology, artificial intelligence, COVID-19 pandemic, deep learning, healthcare, internet of things, machine learning

1. Introduction

The healthcare industry benefited from the development of a number of digital technologies in 2020. These technologies are used to address issues in conventional healthcare systems and the pandemic, including the “Internet of things (IoT)” with high-speed wireless networks [1], big data [2], “artificial intelligence (AI)” including machine learning and deep learning [3], and blockchain technology [4]. 2019 was the year that witnessed the broad deployment of the latest wireless mobile phone

technology, known as “Fifth Generation (5G).” Even though the 5G network is still in its infancy, some nations have already implemented 5G networks. These nations include China, South Korea, Japan, the United Kingdom, and the United States [5]. 5G home services and some large applications are currently being developed in many cities of the United States [6]. At the “Winter Olympics” in February of 2018, South Korea demonstrated the 5G technology. They have been expanding their 5G networks and anticipate having 5G deployment throughout the nation by 2023. China is extending 5G communication as part of its “Made in China 2025” goal in research and development initiatives. Commercial 5G networks were introduced in China in 2019, and the country is currently expanding 5G communication. In 2020, Japan launched a 5G network for commercial use. Several European countries, like Austria, Spain, and Switzerland, have already launched 5G services and are planning to extend their network capacities. Many other countries have plans to deploy 5G networks by 2025 [7]. By 2025, it is expected that the 5G cloud will support around 1.8 billion connections and cover nearly one-third of the world’s population [8, 9].

Compared to current wireless networks, 5G offers fast data rates, reduced latency, and high-volume device connectivity with excellent energy efficiency, high reliability, and support for mobility [10]. In 2019, 204 billion applications were downloaded over the Internet, and 67% of people worldwide had mobile device subscriptions, of which 65% had smartphones [11]. It was anticipated that there would be 3.8 billion people utilizing social media regularly by January 2020 [12]. Despite the constantly increasing number of digital devices connected to 5G, further research is currently being conducted to determine the level of variety in RF exposure.

Meanwhile, the world is facing a public health calamity due to the unique “2019 Coronavirus Disease (COVID-19)” [13]. Many experts researched the genetic code of COVID-19 and attempted to tackle the coronavirus pandemic health emergency when China initially identified the virus in December 2019 [14]. However, the World Health Organization (WHO) identified COVID-19, which was caused by a novel coronavirus named “severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)” in December 2019 in China [15]. On January 30, 2020, the WHO labeled the Chinese COVID-19 outbreak a public health emergency and proclaimed a global pandemic on March 11, 2020, posing a severe threat to public health systems. The COVID-19 pandemic has swept through 228 countries and territories, resulting in almost 6.6 million deaths and 637 million infected cases worldwide, reported by the “Worldometers” on November 4, 2022 (see **Figure 1**) [16]. As of October 2019, 50 cities in China had commercially

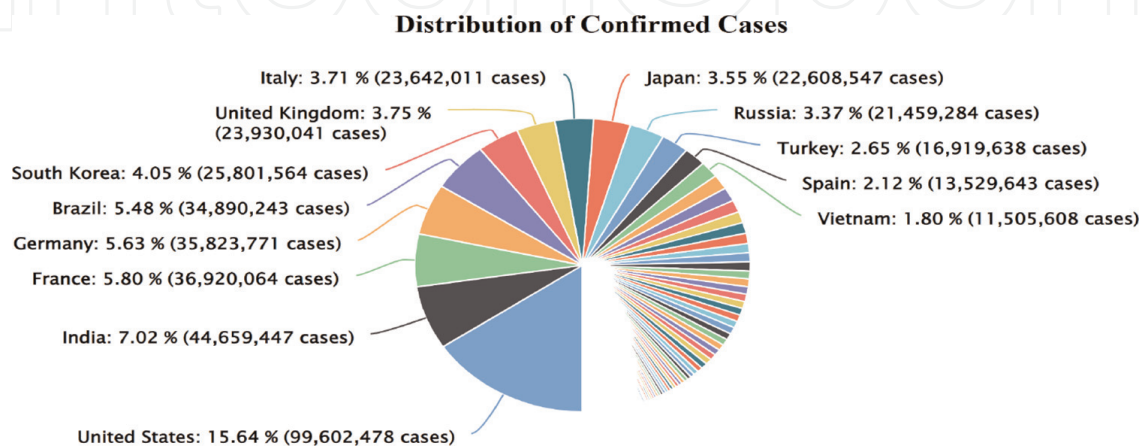


Figure 1. Country-wise coronavirus confirmed cases distribution on November 4, 2022, adapted from Worldometers [16].

provided 5G wireless networks, and several people claimed ownership of the idea of 5G connectivity with the coronavirus. In December 2018, South Korea was the first to market 5G technology using a mobile hotspot successfully. However, South Korea was not the source of just one coronavirus, which has devastated many countries that do not yet have access to 5G networks. These countries include Malaysia, India, Bangladesh, Iran, France, Singapore, and Nigeria. Thus, the 5G-coronavirus theory makes a misleading claim, and the novel coronavirus has nothing to do with 5G, and there is no scientific evidence [17, 18]. Furthermore, according to several studies, 5G-related telecommunications technologies do not affect the human immune system [19].

Nevertheless, the pandemic has negatively influenced economic, medical, and political situations. Initial identification, isolation, quick management, spread prediction, and contact tracing technologies are all approaches to combat the spread of the coronavirus. The key challenges are virus tests, prescription or pharmaceutical delays, and providing services to critical zones. Modern digital technologies, such as artificial intelligence and 5G-based solutions [20], are essential for health, social, and economic outcomes to combat the coronavirus effectively. The worldwide health catastrophe brought on by this pandemic can be mitigated using these technologies, which can give improved digital solutions. With its potential effects in many industries, the use of 5G-enabled technology is overgrowing, offering more real-time services than anticipated. This study intends to highlight the perspective of AI and 5G-based solutions that can address COVID-19 difficulties in various contexts by concentrating on digital technology and existing socioeconomic issues. The chapter also examines numerous technological challenges and policies in implementing AI and 5G-powered emerging applications for handling post-pandemic issues.

2. Related works

Individuals and different industries are using multiple types of AI and 5G-powered solutions. The main application categories include diagnosis, patient treatment, administrative tasks, and services. During the global epidemic, numerous studies on AI and 5G-enabled technologies have been conducted, and they suggested many solutions in different sectors. M.M. Rahman et al. [21] aimed to describe the current technical aspects of artificial intelligence and other relevant technologies and their implications for combating COVID-19 and preventing the devastating effects of the pandemic. This study highlighted and categorized AI approaches in tackling the COVID-19 pandemic, including disease detection and diagnosis, data analysis and treatment procedures, research and drug development, social control and services, and predicting outbreaks. An early review paper [22] also discussed the role of AI in the fight against COVID-19 and its current limitations. They identified six critical areas in which AI contributed significantly during the pandemic: (i) early warnings and alerts; (ii) tracking and prediction; (iii) pandemic data dashboards; (iv) diagnosis and prognosis; (v) treatments and medication; and (vi) social control. Fei Jiang et al. [23] looked at how AI is currently being used in healthcare. This survey showed that AI could be used with different kinds of health data (structured and unstructured).

Modern AI techniques like “support vector machine” and “artificial neural network” can be used to learn from structured data. In contrast, advanced deep learning models and natural language processing are used to learn from and understand unstructured data. They talked about how AI could be used in three areas: early detection and diagnosis, treatment, predicting the outcome, and figuring out the

prognosis. In a survey report [4], the authors looked at how blockchain and AI could be used to stop coronavirus outbreaks. First, they introduced a new conceptual architecture that integrates blockchain and AI for COVID-19 fighting. Then, they talked about how blockchain and AI could help fight the COVID-19 outbreak in fundamental ways. They also looked at the most recent research on how blockchain and AI can be used in different ways to fight COVID-19.

Using the geolocation of the patients and massive amounts of data, researchers developed a system capable of detecting and predicting the early spread of an epidemic [24]. A framework [25] enabled by an AI approach was proposed to detect COVID-19 using smartphone sensors. The designed AI-enabled framework can interpret the smartphone sensor's signal readings to predict pneumonia and the disease's outcome. Due to the rapid global spread of coronavirus disease, it is desirable to develop an automatic and accurate detection method for COVID-19 using chest CT. Numerous researchers developed a model based on deep learning to identify COVID-19 on a chest CT scan [26]. Using radiology and chest radiography to screen COVID-19-infected patients effectively is a crucial task [27]. The COVID-Net is a deep neural network-based model designed to detect COVID-19 cases in chest X-ray (CXR) images. In a screening approach [28], the authors sought to develop a deep learning-based early screening model to differentiate COVID-19 pneumonia from Influenza-A viral pneumonia and healthy cases using pulmonary CT images. Deep learning-based methods, like the "Deeper-Feature Convolutional Neural Network (DFCNN)" model [29], can effectively find and rank the interactions between proteins and ligands. The DFCNN can screen people quickly through virtual means. It can discover possible drugs for 2019-nCoV protease by screening drugs against four databases of chemical compounds. Other research used three different convolutional neural network (CNN)-based models (like ResNet50, InceptionV3, and Inception-ResNetV2) to look for patients with coronavirus pneumonia in chest X-rays. In addition, models built on AI were created to enhance the critical care provided to COVID-19 patients [30]. Clinical, paraclinical, personalized medicine, and epidemiological data were included in this model. The healthcare system can use an AI-based decision-making system to defeat COVID-19 and assist in better patient management in the ICU. Seven significant applications of AI for the COVID-19 pandemic were identified by R. Vaishya et al. [31]. By gathering and analyzing historical data, this AI-based solution is crucial in determining the cluster of cases and forecasting virus infection in the future.

Additionally, it is crucial to comprehend and recommend creating a COVID-19 vaccine. Result-driven technology is employed to screen, analyze, predict, and track current and future patients. This technology has already tracked data from confirmed, recovered, and deceased cases. Furthermore, Industry 4.0 can meet the demand for personalized face masks and gloves and gather data for healthcare systems to effectively manage and treat COVID-19 patients [32]. With the proper surveillance systems, it helps to resolve pandemic-related issues and provide a daily update on an infected patient, area, age, and state-wise. The use of various AI-based automated techniques and tools, including "Brain-Computer Interface (BCI)," "Arterial Spin Labeling—Magnetic Resonance Imaging (ASL-MRI)," biomarkers, iT bra, and different machine learning algorithms, aids in reducing errors and controlling disease progression [33]. AI software, expert systems, decision support systems, and computerized diagnosis can help doctors by minimizing intra- and interobserver variability. Deep learning and machine learning methods like artificial neural network (ANN) models can uncover hidden correlations and patterns in medical data, which can be used to create efficient clinical support systems. The IoT era is ushering in the

most recent 5G technology. MM Rahman et al. [20] concentrated on 5G-based solutions that could address COVID-19 problems in various contexts. This study also offered a thorough analysis of 5G technology, incorporating other digital technologies in emerging healthcare applications to address epidemiological challenges. The adoption of 5G-based technologies in healthcare is currently taking place to support better health services, more productive medical research, improved quality of life, and better interactions between medical staff and patients worldwide.

3. AI and 5G-enabled technologies in real world

COVID-19 has introduced the capability of digital transformation. Industry 4.0 has the prospects to reshape and restore economic systems in a post-pandemic world via 5G smart infrastructure with IoT and AI, integrated automation, and cloud innovation (see **Figure 2**). All of the available technologies for Industry 4.0 are linked together with the help of 5G connectivity. Medical stakeholders can talk to each other for many different reasons, such as finding and diagnosing COVID-19, supporting healthcare equipment and logistics, remote health monitoring, improving treatment processes and care, controlling and managing COVID-19 patients, lowering the high risk of death, speeding up drug manufacturing and vaccine production, fighting local and global medical emergencies, etc., with less human physical involvement [34]. Using these technologies correctly would help to improve public health education and communication. While the school is on lockdown, these technologies assist in teaching and learning in remote places [35]. These give digital and many different places to find free educational resources. People are working from home and understanding a new office culture, work hours, virtual offices, virtual meetings, and a lot of written communication thanks to Industry 4.0 technologies. Industry 4.0 uses innovative production methods to make essential disposable items in short supply because of the COVID-19 pandemic. Industry 4.0 technologies can help people find better digital solutions during this crisis. Here are some of the ways that Industry 4.0 can help lessen the effects of the COVID-19 pandemic:

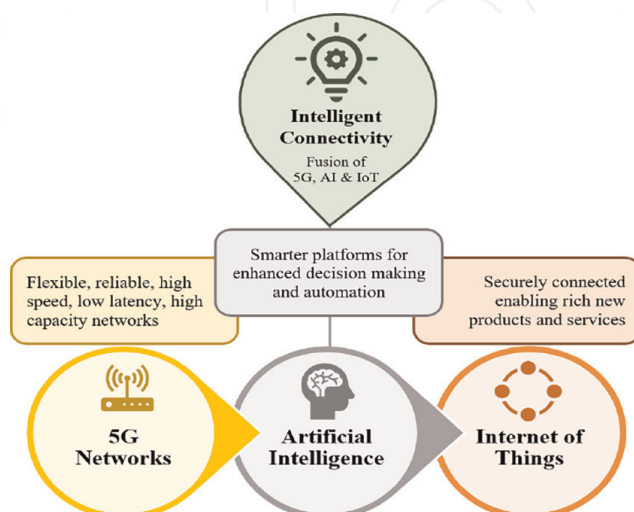


Figure 2. The intelligent wireless edge innovation, integrating 5G connectivity with IoT and AI, that brings new and enhanced services.

- Planning activities related to COVID-19; giving patients and healthcare professionals better services;
- Making medical items that have to do with the pandemic;
- Creating an intelligent healthcare system;
- Using robots to treat patients to reduce risks and make the work environment more flexible;
- Putting virtual reality and augmented reality to the test for training;
- Helping people do the work they need to do to live during the lockdown;
- Using advanced digital technologies to come up with many new ideas;
- During the pandemic, taking care of local and global public health emergencies;
- Helping students and researchers find strange information.

Artificial intelligence (AI), including machine learning and deep learning, the Internet of things, big data and e-health, virtual reality (VR) and augmented reality (AR), holography, cloud computing, robots and robotics, 3D scanning and printing, biosensor, blockchain, smart devices/sensors, online digital platforms, are some of Industry 4.0's powerful technologies that could be useful during this pandemic. Digital technology has significantly altered almost every aspect of human life in the last few years, including how we communicate, work, enjoy, travel, bank, and shop. Nowadays, advanced digital technologies allow for the explosive expansion of the potential of diverse diagnostic and therapeutic instruments and systems [36]. Implementing digital medical technologies can improve the general public's healthcare accessibility and adaptability. Digital technology is currently a great way to support teaching and learning processes in institutions like schools and colleges. Therefore, rather than being driven by a particular technology, the effective use of digital technology is determined by learning and teaching goals. It enhances interactions between teachers and students. The COVID-19 pandemic clearly illustrates online education's importance for teaching and learning. Today's communication is entirely dependent on digital technology. Many digital tools facilitate communication between two or more parties. These include email, phone calls, video conferencing, social media, blogs, news portals, forums, and chat and instant messaging via smart devices. It is the most convenient method of communication, as anyone can have a real-time conversation with people from around the world without leaving their desks. The phenomenon of the digital revolution is gaining increasing attention in tourism management. This industry is undergoing digital transformations, including Tourism 4.0 and Smart Tourism [37]. Consequently, the physical structure is labeled "smart" to describe the integration of the physical and digital worlds, such as smartphones, smartcards, smartTV, and smart cities.

Using cutting-edge technologies, media companies can create an efficient end-to-end strategy for developing digital platforms for users. With the development of computer-mediated digital technologies, significant portions of the media and entertainment industries can become a reality. Over the past few years, the entertainment

sector has undergone significant digital innovations. Future banking will be transformed by digital technology. The rise in AI, blockchain, and IoT demand has promoted the development of modernizing the banking industry. Banking is undergoing technological disruption due to increased competition from fin-tech startups and growing concern about cybersecurity. The digital revolution is a big chance for the agricultural sector to become more productive and advanced. Farmers can use digital technologies to make their farms more productive and develop long-term solutions to climate change. A smart city is a model for urban development that uses digital technologies to make city operations and services more efficient. It improves life for the people who live there and helps the environment [38]. Almost every part of our daily lives is affected by digital technology. In the last few decades, it has given us new devices like smartwatches, tablets, and voice assistants that have changed our world and daily lives. Also, digital technology improves the safety and security of our homes and lifestyles.

3.1 AI approaches

AI can contribute to the coronavirus pandemic in various ways, including early detection, tracing, forecasting, diagnosis, projection, treatments and pharmaceuticals, and social management and services [22]. In healthcare applications, AI methods can be divided into two primary categories: (i) machine learning and deep learning approaches and (ii) natural language processing approaches. AI approaches, particularly machine learning models, have the potential to benefit human civilizations and healthcare systems in the fight against the worldwide pandemic. In healthcare, machine learning techniques provide enormous prospects. These technologies can be used to develop effective strategies and aid scientists and medical professionals in addressing and resolving the difficulties presented by the coronavirus pandemic crisis. Many companies have recently introduced a range of AI skills, including those for outbreak estimation, coronavirus detection, diagnosis, analysis of data and treatment methods, drug development, research, and future outbreak prediction. Moreover, the term “AI” refers to a collection of technologies [39] that have the potential to significantly advance the field of healthcare (see **Figure 3**).

The three terms “artificial intelligence,” “machine learning,” and “deep learning” can occasionally be used interchangeably, which frequently causes misunderstanding among nontechnologists [40]. The phrase “artificial intelligence” refers to a vast, established, and highly developed area of computer science study that addresses issues relating to machine intelligence, such as simulating cognitive functions, detecting the environment, and acting independently. Robotics, vision, natural languages, learning, planning, reasoning, and other areas of study are now being studied. Deep learning, or neural network, is a machine learning model used in clinical data analysis and disease identification [41]. Moreover, data mining and statistics are involved in machine learning, where a decision model is learned rather than explicitly programmed by a person. Traditional machine learning methods can handle issues with hundreds or thousands of features, such as decision trees and support vector machines. **Figure 4** illustrates how a machine learning model works in data analysis and prediction. Problems related to computer vision, natural language processing, speech and image recognition, time series analysis, etc. have succeeded when deep learning techniques have been used. With their ability to interpret data effectively, deep learning model can improve their capacity to identify correlations and connections as they analyze additional data, basically learning from prior findings in the healthcare industry [42].

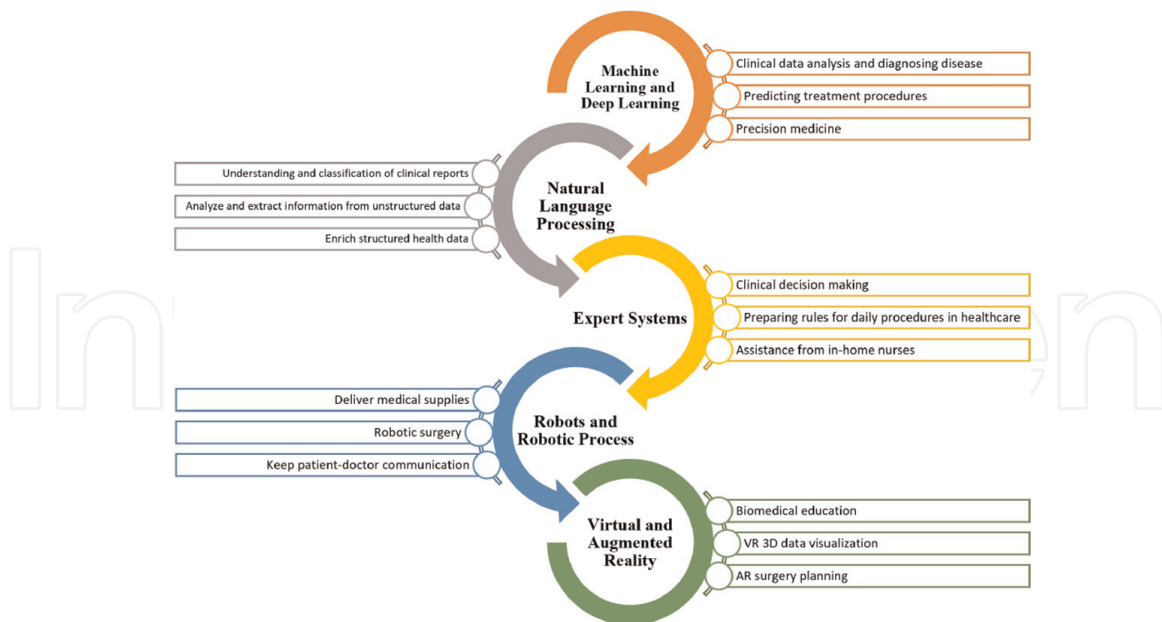


Figure 3. Major AI-related technologies in healthcare applications.

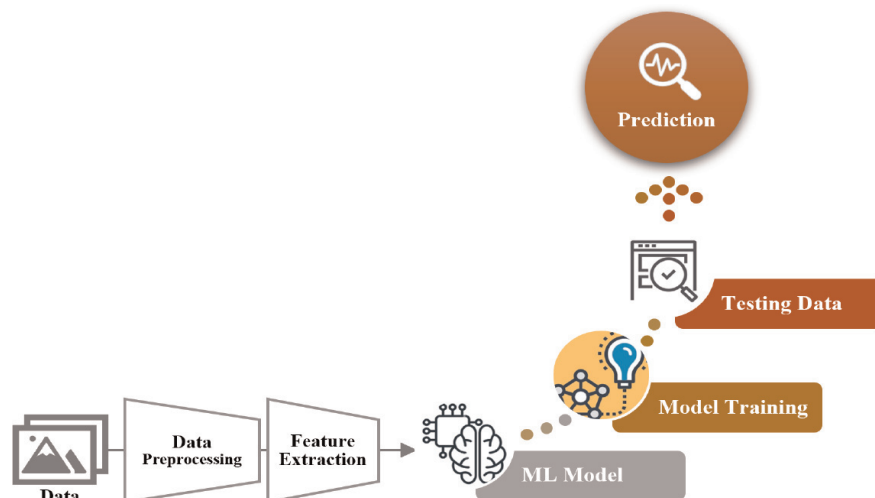


Figure 4. How does a typical machine learning model work?

A convolutional neural network (CNN) is one sort of deep learning (see **Figure 5**) that is particularly well suited to interpreting images, such as MRI data and X-rays. This CNN model can assist medical personnel in detecting health issues in their patients more quickly, accurately, and reliably. Furthermore, deep learning models can assess structured and unstructured data in electronic health records, such as clinical notes, laboratory test results, diagnoses, and prescriptions, at high speeds and with high accuracy. During the global outbreak, deep learning models were used by researchers in a variety of applications, including early COVID-19 detection and prediction, assessing chest X-ray or CT images, managing intensive care, risk analysis for COVID-19, and providing essential services.

Figure 6 illustrates the volume of text data (unstructured and structured) produced by healthcare organizations. Some of it is arranged or organized into particular

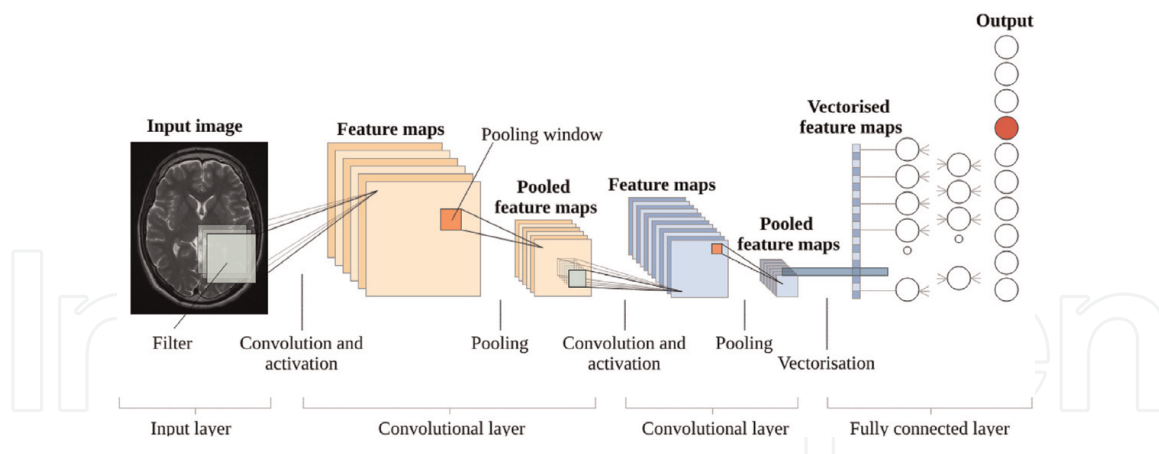


Figure 5. Basic building blocks of a typical CNN model for interpreting medical image data, adapted from [43].

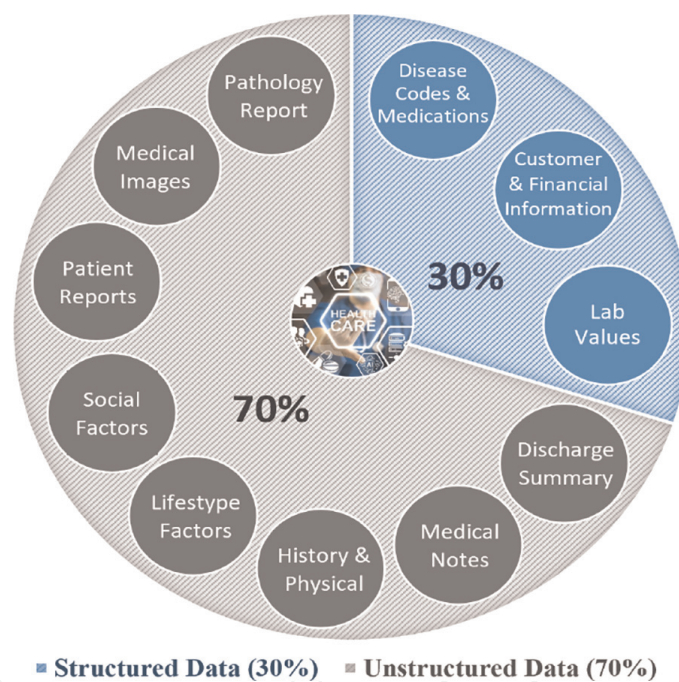


Figure 6. Unstructured and structured data generated by healthcare organizations, adapted from [44].

EHR (electronic health record) fields [45]. With the help of this structure, medical professionals and other software programs may easily find, exchange, analyze, and utilize the data they need. However, a sizable portion of clinical data (about 70–80%) is still retained in narrative reports, patient records, observations, and other textual forms. To find the information they need from textual documents, clinicians must manually go through mountains of paperwork. It causes obstacles in administrative processes and emergencies, resulting in hiccups and delays in medical care. Additionally, EHRs receive a lot of unstructured patient data, making it challenging for a system to assist doctors in gathering this crucial information.

Another AI model, known as “natural language processing (NLP),” helps computers understand and make sense of what people say and write or what it means. NLP can help us do many things, such as extracting information, turning unstructured data into structured data, putting documents into groups, and summarizing

documents [46]. Two main types of algorithms used in NLP: (i) rule-based systems analyze text using pre-established grammatical rules, and (ii) machine learning models employ statistical techniques and acquire knowledge over time by being fed training data. NLP uses free-text medical information to figure out the best ways to treat medical conditions. The use of NLP tools in healthcare offers the ability to accurately give voice to the healthcare industry's unstructured data, yielding considerable insight into comprehending quality, refining methodologies, and improving patient outcomes. Most modern NLP techniques can understand and analyze data with little or no preprocessing [47]. The following are the critical usage cases:

- A. Text Classification: An NLP technique can assist in categorizing vast amounts of unstructured health data, such as organizing patient application forms by urgency or detecting fraudulent claims.
- B. Information Extraction: NLP tools can extract useful information from unstructured health data. The technology, for example, can tag data from patient histories, discharge summaries, or call center reports and then organize them in an EHR according to a schema.
- C. Improving Clinical Documentation: At the level of care, NLP uses speech-to-text dictation and structured data entry to extract crucial data from EHR. As a result, physicians can concentrate on treating patients with the necessary care while ensuring that clinical data is accurate and up to date.
- D. Accelerating Clinical Trial Matching: Using NLP, healthcare providers may search through massive volumes of unstructured clinical and patient data to locate qualified persons for clinical trials.
- E. Supporting Clinical Decisions: NLP enables physicians to access health-related information quickly, easily, and efficiently, allowing them to make more informed decisions at the point of treatment.
- F. Language Modeling: Using NLP techniques, one may comprehend spoken text and generate natural sounding writing. The software can transcribe medical notes accurately, summarize them, or classify and extract data.

3.2 5G-powered emerging technologies

The latest 5G mobile networks have excellent technical characteristics, including faster transfer speeds of up to 20 Gbps, ultrareliable low latency (less than a millisecond), enhanced network security, massive machine-to-machine communications, and improved device energy efficiency. The deployment of 5G networks will expand wireless broadband services far beyond mobile Internet to more sophisticated Internet of things systems. These systems have the low latency and high-reliability level required to handle critical applications in all significant industries. The advent of 5G mobile networks will facilitate the development of novel applications in the medical industry [9]. The provision of a platform for inventive uses that enable segmented degrees of latency will be made possible by enhanced broadband experiences, large-scale Internet of things networks, and mission-critical services. Even while edge computing can be employed in a 4G context, coupling this with 5G networks and AI is

likely to open up new possibilities in accelerating the adoption of Industry 4.0. The deployment of 5G networks makes it feasible to construct “smart factories” and reap the benefits of technologies such as automation and robotics, artificial intelligence, computer vision, augmented reality, and the Internet of things in various disciplines and applications.

In addition, it is projected that the 5G technology would connect billions of devices while improving their functionality. Applications that are supported by 5G have the potential to deliver transformative impacts in a variety of industries, including healthcare, education, resource management, transportation, agriculture, and other sectors, to address the challenges brought about by the current pandemic [48]. **Figure 7** depicts the industries that make the most use of 5G-powered emerging technologies and provides an estimate for the amount of income that digital markets will generate in the year 2026 [49]. Since the year 2020, the entire world has been experiencing a health disaster. The use of 5G in conjunction with other sophisticated digital technologies is an assistance in the fight against the issues posed by the coronavirus in many countries [50]. This cutting-edge 5G technology will revolutionize fast connection, storage in the cloud, billions of intelligent gadgets, and improved medical services in the healthcare field. As a result, 5G will revolutionize the healthcare industry and add more than 1.1 trillion USD to the global economy by 2035 [51].

5G technology has the potential to assist in medical research, diagnosis, and treatment, and improving healthcare services for both medical professionals and patients remotely [52]. **Figure 8** depicts a straightforward 5G-based health platform that can be useful to patients and medical practitioners. Since 5G promises superspeed with large data bandwidth and low latency (around 100 Mbs), AI technologies deployed in 5G networks can enable intelligent and autonomous functionality to control the coronavirus outbreak. According to a report by IHS Market Ltd. [53], 5G would make it possible for the global healthcare industry to sell more than one trillion dollars worth of goods and services by 2020. In addition, it is anticipated that the 5G network will accommodate approximately 212 billion sensors and about 50 billion smart devices [54]. These health gadgets, medical wearables, and remote sensors in 5G networks all efficiently contribute to healthcare to assist the health emergency difficulties that the

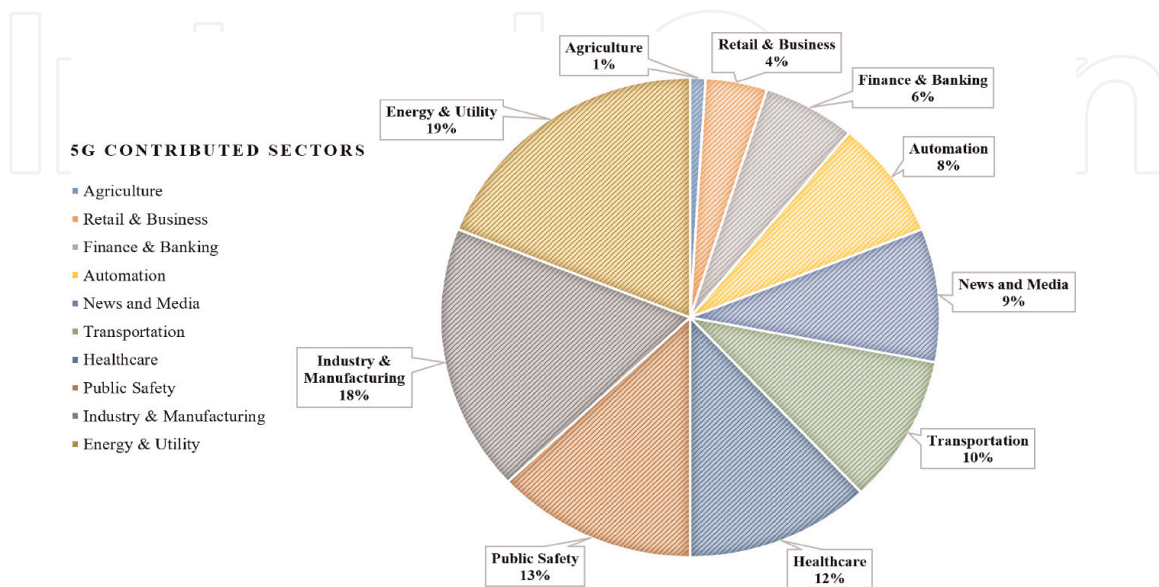


Figure 7. Industries that make the most use of 5G-powered emerging technologies, adapted from [49].

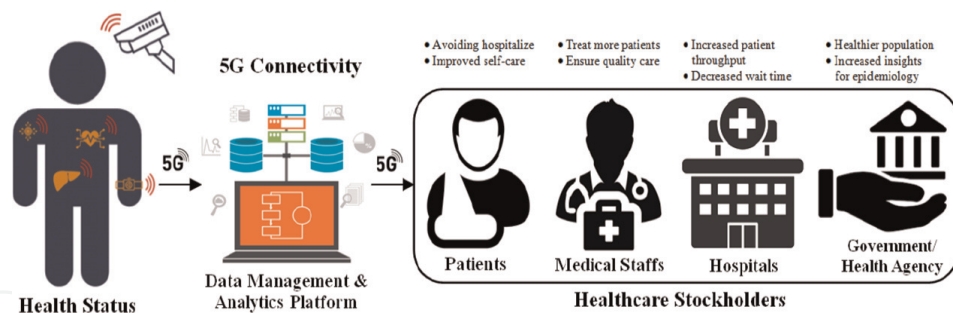


Figure 8. A typical 5G-powered health framework for distant treatment and services, adapted from [20].

COVID-19 outbreak has produced. Now, the healthcare industry is implementing digital technologies with 5G connectivity that can provide health services and improve the quality of life and the experiences of medical personnel and patients. It is anticipated that the expansion of this technology will achieve a compound annual growth rate of 16.5% from 2019 until 2023 [55].

5G connectivity is improving healthcare services in various ways [56], including facilitating home healthcare, digitizing pathological analysis, managing patient information files, robotic surgery and medications, training, and therapeutics, securing staff-patient communication and management, etc. The favorable characteristics of 5G also significantly impact future healthcare research and the advancement of treatment. In today's world, cutting-edge digital technologies are transforming the healthcare industry. The promising digital technologies powered by the 5G standard have aided the public health schemes to fix the shortcomings in healthcare services and to confront the coronavirus epidemic [57]. **Figure 9** illustrates some of the characteristics of the 5G technology that can bring about significant breakthroughs in the medical field [58]. The following paragraphs provide further explanations of these aspects.

A. Telemedicine: It demands a network connection that is dependable as well as speedier, and it must be able to provide high-quality video and real-time conversation. 5G standards make it possible to create a suitable telemedicine environment, enhancing online health consultancy [59]. The market for telemedicine in the healthcare sector is anticipated to expand at a rate of 16.5% each year from 2017 to 2023 [55].

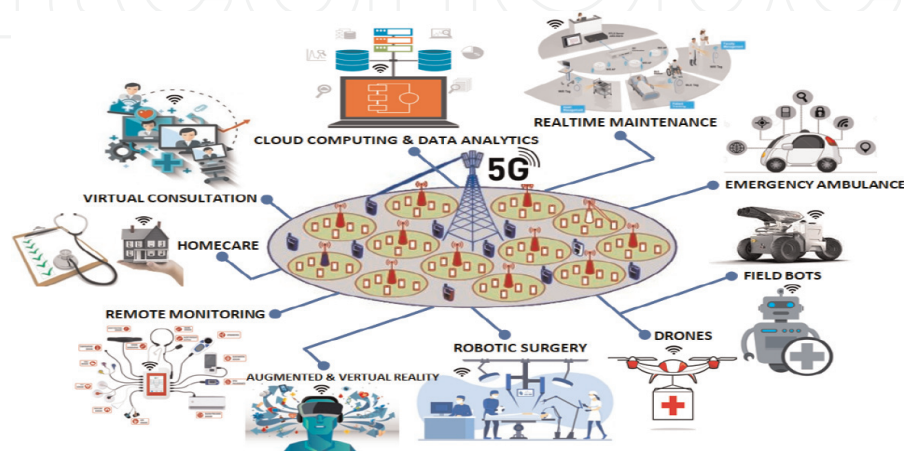


Figure 9. Few aspects of 5G interconnected technologies in healthcare to tackle the pandemic, adapted from [20].

- B. Telesurgery: Telesurgery and other forms of remote medical care are made possible by 5G's extremely low latency and lightning-fast speeds. A health surgeon in China was the first to undertake a 5G-assisted remote surgery utilizing "da Vinci surgical robots" [60] in January 2019 that was performed on an animal. In China in March of 2019, telesurgery was conducted remotely on a human brain utilizing a 5G mobile network.
- C. Internet of Medical Things: The infrastructure of 5G networks can connect one billion digital devices and wearable medical equipment, also known as the "Internet of medical things (IoMT)" objects, which creates a bridge between the digital and physical worlds and enables real-time analytics to improve patient's health. It can collect important health data, store it in the cloud, and make it available online for users, medical professionals, and researchers [61].
- D. Remote Diagnosis and Treatment: 5G connectivity assists healthcare professionals in continuously monitoring contagion and a remote diagnosis from any location throughout the pandemic [62]. In January 2020, China was the first country to develop a 5G-powered remote diagnosis and treatment system. During the pandemic, this device can assist with the diagnosis and treatment of patients remotely.
- E. 5G-Powered Digitized Platforms: Numerous technologically established nations, including the United States, China, Japan, and South Korea, are rapidly launching their own specific 5G wireless networks for digitalized, data-driven, and cloud-based emergency platforms [63]. These digital platforms aid healthcare in various ways, including accelerated reaction times, remote monitoring, data analysis and diagnosis, resource allocation, and many others.

4. Challenges and prospective

AI technologies are growing as emerging digital innovations in the healthcare industry. In addition, the 5G network's real-time superspeed and extremely low latency offer a variety of new prospects to serve developing healthcare applications. In the context of healthcare services during the current pandemic, the following subsections discuss the principal difficulties and opportunities presented by AI and 5G-enabled technologies.

4.1 Key challenges faced by AI

Though AI, including machine learning, has fantastic capabilities in healthcare in fighting against the epidemic, this field also has a few limitations or challenges in improving the current healthcare systems. Therefore, this study also addresses some challenges faced by AI in healthcare that are listed below:

- A. Require a high volume of relevant data for AI: Finding rich health data is one of the biggest challenges of using AI in healthcare. AI algorithms cannot be fully trusted until they are built and trained on a large amount of relevant data in healthcare applications. Thus, AI depends on various data gathered from millions of people who have suffered from similar conditions. It must require

sufficient data on a particular group of such patients in AI databases to make the correct comparison. But enough data on patients is often challenging to find from a specific background. Moreover, medical data has a sensitive nature and ethical constraints that make it challenging to collect. In this case, AI will make an inaccurate diagnosis with insufficient data, and doctors might make a mistake in taking proper treatment.

B. Need a better understanding of applying AI: AI models are becoming increasingly complex to achieve better results. Because of its intricacy, AI sometimes operates in a “black box,” which makes it more challenging to comprehend how the model functions. Therefore, healthcare professionals must frequently understand how and why AI produces specific results to behave appropriately. The absence of explanation raises concerns about reliability for individuals and the healthcare companies they use. Methods of “Explainable Artificial Intelligence (XAI)” [64] can tackle this issue and develop trust between humans and computers by clarifying the processes through which they arrive at particular solutions.

C. Need more testing and verification of AI: Though AI can offer more accurate diagnostics, there is a chance of making mistakes. So, it causes individuals and companies to falter about implementing AI approaches in diagnosis. For example, hundreds of AI systems and tools have been built during the pandemic to diagnose COVID-19 cases. But many of them failed to provide accurate diagnosis results or caused errors [65]. Moreover, if the AI models are not adequately trained or trained on poor-quality data, these do not accurately represent its underlying real-world process to prevent diagnostic errors. Thus, proper testing and verification with the right and representative data must be ensured without underfitting or overfitting against the training data [66].

D. Invest in data privacy mechanisms for AI: Patient data includes sensitive data, such as medical history, identity, and payment information. So, people who use AI systems need to keep in mind that they are dealing with machines. AI systems have enabled the tracking of a patient’s personal information and health/test reports. A person can promise privacy between a doctor and a patient, but machines cannot do that, and machines can break down. This problem can cause the system to fail or cause data to be lost. It can also hand over control of the system to the wrong people, who can easily use the information against the people involved. It often happens when the AI system is not safe enough from hackers. The healthcare industry needs to use technologies that improve privacy to get the most out of AI while minimizing the risks [67].

E. Require training or education for AI: Though the rise of AI technology replaces routine tasks and opens up new job opportunities, it causes a slowdown in the industry’s adoption of AI. Even though AI tools can make many technical and nontechnical jobs more efficient, they still require human expertise. Some diagnostic procedures, for example, are hard to understand and require a lot of work. So, healthcare organizations should give their workers the training they need to learn more about machine learning and how it can be used. On the other hand, when people see new technologies and tools, it can make them think twice. Another big problem with using AI in healthcare is that patients do not

always want to use it. For example, in the early stages of the pandemic, patients did not feel comfortable with online checkups. So, it needs to teach patients about the benefits of AI in healthcare to help them feel more comfortable with it.

4.2 Key challenges faced by 5G technology

As we move toward a 5G world, we'll have to deal with many problems. Compared to older wireless technologies, 5G needs a new standard to provide customers with high-speed, low latency, reliable, and safe services. Because of this, the design, development, and implementation of 5G networks are full of big problems. Here are some other issues that have been found in the literature:

- A. **Health Risks:** Concerns have been raised regarding possible adverse effects on human health caused by radiofrequency from 5G networks [68]. Rural residents are raising esthetic concerns and anxieties about the superfast network's effects on their communities. However, a large number of institutions, such as the US "National Institutes of Health" and "Food and Drug Administration," as well as the "World Health Organization" and the "Federal Communications Commission," concluded that the concerns were unfounded.
- B. **5G's Range and Coverage:** The range of the 5G network is reduced when there are obstructions in the network. Therefore, to obtain a better 5G signal, 5G networks need a more significant number of smaller devices or antennae spaced closely together. It is tough to set up 5G connectivity in rural areas because of this, which are the places with the least developed healthcare systems.
- C. **Deployment Costs:** For 5G-enabled health solutions to work well, there needs to be a good setup for patients, doctors, and clinics. So, the costs of setting up 5G, buying related devices, developing the infrastructure, and paying more for maintenance are big problems in 5G-powered applications. As a result, it makes sense that the patient will have to pay more for their treatment.
- D. **Training and Adapting New Technology:** 5G-powered health solutions are gradually being implemented using intelligent devices and tools. However, healthcare personnel and patients require knowledge and skills to implement new technology and practices. As a result, sufficient training is required for patients and medical personnel to understand how to use these new platforms. Moreover, many developing countries cannot ultimately adopt an innovative healthcare solution based on the 5G standard, particularly in rural locations where building 5G networks is challenging.
- E. **Security and Privacy Threats:** Because 5G is gifted with the quickest data transmission and provides other healthcare services remotely, there is a continuous rise in the variety of potential security and privacy threats. As a result, it is necessary to pay additional attention to the concerns regarding the security of 5G networks, such as the protection of data, devices, and infrastructure; the filtering of data and the management of digital rights; the confidentiality of patient data; national security, network security, cybersecurity, and the protection of cybercrime [69, 70].

4.3 Prospective of AI and 5G-enabled technologies

AI and 5G-enabled technologies are concurrently expanding and enhancing efforts to improve global healthcare. Patients throughout the world benefit from more advanced healthcare systems that include intelligence and 5G standard in their practices. Thus, the fundamental aspects of healthcare could be entirely reimaged by the capabilities of 5G. 5G-powered technologies may prove helpful in many facets of today's healthcare, such as telehealth, remote surgery, the transfer of substantial medical records, tracking patient activities and real-time monitoring, and providing patients with proper treatment and support. This technology can provide vital services on a massive scale that are precise, efficient, convenient, and cost-effective. The following are many significant prospects that explain why technology enabled by 5G ought to be a component of every healthcare system across the globe.

- A. Fastest and Precise Health Services: The fastest 5G network is equipped to provide the speedy and dependable delivery of significant amounts of medical data. The reduced latency feature of 5G technology can allow surgeons to do remote robotic surgery and give patients quicker and more dependable treatment that can be delivered remotely. In addition, AI can forecast potential health issues that a person may have in the future.
- B. Real-Time Advancements in Healthcare: The advent of 5G technology has the potential to provide individualized and preventative medical care. Telemedicine enabled by AI and 5G networks make it possible to receive immediate medical advice and treatment for medical emergencies. Therefore, with the 5G network, AI approaches can give surgeons real-time information about patients who are now undergoing treatment. In addition, a completely operational 5G network will improve medical processes and management and deliver a high-quality treatment experience to patients and doctors.
- C. Integration of Innovative Technologies: The use of AI models, with the "Internet of medical things," "augmented reality," and "virtual reality," is now permitted in healthcare apps that run on 5G networks. They can improve real-time treatment and diagnosis operations, as well as provide healthcare facilities that are novel and transformative. Besides, robot-assisted or robotic surgery powered by 5G is becoming an emerging thing of the future in the medical field.
- D. Meet Service Quality and Cost-Effectiveness: 5G-powered technologies like "mHealth technology," "telemedicine," "Internet of medical things," "wearable devices," and "digital health platforms" can help patients in both cities and rural areas get medical help from afar. It will save money by preventing costly trips to the hospital without lowering the quality of care. It will also let doctors help with the diagnosis from a distance and meet the service standards needed for a complete medical exam. AI and machine learning can also help doctors diagnose by finding biomarkers [71]. If practitioners use AI to make an accurate diagnosis, it will be less cost-effective, and individuals will not have to undergo expensive lab tests anymore.
- E. Advancements in Intervention Management and Administrative Operations: 5G-enabled healthcare systems will bring new insights to the healthcare industry, allowing for uninterrupted data entry and querying. As a result, it is an annoying

procedure while documenting medical data. Making available critical healthcare facilities and equipment, like operating rooms and electrocardiogram (ECG) monitors, improves intervention management. These invaluable resources aid in the administration of government operations and guarantee their security and efficacy.

F. Improving Accessibility of Healthcare Worldwide: The World Bank and the WHO have released reports indicating that at least half of the world population does not have access to elementary healthcare services. In addition, people living in rural areas of countries that lack a developed healthcare infrastructure do not have access to healthcare facilities. Many organizations utilize cutting-edge technology powered by 5G to provide medical treatment to underserved communities. These solutions are both cost-free and applicable even in rural areas for serving medical treatment.

5. Policy recommendations to the states

Universal accessibility of 5G-enabled technologies depends on the state's positive measures and various factors (such as socioeconomic, geographic location, and digital ecosystem). Currently, a number of organizations are creating digital frameworks and other ideas to bridge the digital gap. For considering the post-pandemic, we are suggested a few recommendations to the states, listed below.

A. Enhancing digital literacy programs: From a human rights point of view, the states need to speed up the process of making short-term and long-term public policies to improve digital literacy programs. During the pandemic, it will also support digital health-education-works measures that make it possible for everyone to be self-sufficient, independent, and responsible when using AI and 5G-enabled technologies. But digital technologies could limit the right to privacy and other fundamental freedoms. So, states must ensure that laws set up a guideline for the digital environment.

B. Diminishing risks of increased digital devices and activities: During the pandemic, one's spending time with digital devices (like smartphones, computers, television, or video game console) is increasing. In case of problematic usages of digital technologies, it needs practical recommendations to help reduce the risks of increased use of digital devices and online activities. Professionals and policymakers must convey these recommendations to their clients and the general population.

C. Improving safety and security: The coronavirus pandemic has demonstrated the transformative power of the Internet, and digital technology has saved millions of lives by allowing them to work, study, and interact online in safety. Unfortunately, the epidemic has also exacerbated the digital divide and the negative aspects of technology, such as the rapid dissemination of misinformation, cybercrime, cyberbullying, and digital violence. It requires maintaining a high emphasis on security in government policies and regulations. Authorities and network operators should protect online data flows and maintain Internet users' and organizations' trust. Therefore, states and policymakers must guarantee a secure digital environment for the public.

D. Ensuring permanent and sustainable accessibility: Since 2019, the pandemic has highlighted the significance of digital technologies during a crisis. The internet platform has enabled millions of individuals to work and study remotely. We may emerge from this crisis with the knowledge that appropriate digital policies can promote global economic recovery and ensure that no one is left behind. States and officials must ensure that access is permanent and enduring, eliminate obstacles to community-driven connectivity, and make it easy for all groups to access resources.

6. Conclusion

In healthcare, using 5G networks to integrate other digital technologies (such as AI and machine learning, IoT, big data analytics, and cloud computing) is now a reality. The results of this study are summed up, and a deep connection with 5G-enabled technologies, especially artificial intelligence and machine learning. This study aims to find out the existing technological facets of AI strategies that can be used in healthcare to deal with the pandemic. This book chapter addresses several challenges faced by implementing AI and 5G-enabled technologies in medical services and highlights the prospects of emerging technologies. AI has played a significant role in combating the coronavirus pandemic and assisting researchers in developing systems to limit human interaction in afflicted areas, provide services, and manage health emergencies. In addition, they can help with the legal and ethical difficulties associated with producing medications in response to public health emergencies.

Future pandemic concerns and public health issues will necessitate the most effective and convincing AI methods, AI-based searching strategies, probabilistic models, and supervised learning. Thus, professionals must thoroughly understand the system they are utilizing and be aware of its security measures. Even if artificial intelligence and 5G-enabled technologies have many benefits for healthcare, AI will not replace doctors or other professionals; instead, it will improve their performance. Additionally, 5G-enabled digital technologies have been utilized to control the COVID-19 outbreak and enhance public health plans in 2020. Some advanced technology leaders are studying 5G-related applications to tackle the health hazards associated with undesired diseases. The 5G network will give a comprehensive road to a smart society with numerous potentially beneficial applications in the field of healthcare when combined with the latest technology advancements.

When deploying the 5G network in healthcare, some issues need to be considered since it is a new field of research. These issues include the development of infrastructure, the establishment of technical standards, the implementation of efficient regulations and policies, the safeguarding of personal information, and the accessibility of research data. More studies need to be done on how to expand a digital society based on 5G while addressing some challenges such as safety, security, privacy, availability, accessibility, and integrity, and improving resilience to future health crises, which lead to the following research directions in fighting against future pandemics:

- To develop the specialized AI and 5G-based architectures, along with the Internet of things and big data that will solve issues related to epidemics and build a comprehensive system to respond to crises similar to the COVID-19 pandemic.
- To modernize the medical industry that will be aided by applying AI and 5G-enabled technologies to support decision-making, drug development and

therapy, administrative automation, and storing patient information in private clouds.

- To digitize the patients-doctors communication by implementing natural language processing, speech recognition, and text recognition that could be used to assist patients and physicians in communicating with one another and analyzing clinical records during remote treatment.
- To build centralized and comprehensive databases that will be helpful for the investigation of technical issues and for constructing intelligent systems for predicting, diagnosing, forecasting, transmissibility, pathogenicity, and treating the disease.

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Conflict of interest

The authors declare no conflict of interest.

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