

Chapter 11

A Review of Computational Intelligence Technologies for Tackling Covid-19 Pandemic



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11.1 Introduction

Several epidemics invaded the world in world history until now. The World Health Organization (WHO) and a number of national agencies of the countries fight against these epidemics to date. The first case of COVID-19 was confirmed in Wuhan city of China in December 2019. Coronavirus spread in more than 185 countries infecting more than 7,145,800 persons and also causing 407,067 deaths by June 09, 2020 [1]. The novel coronavirus, Covid-19, was initiated from Wuhan and has stretched speedily across the world. WHO declared Covid-19 as a pandemic in the world [2]. The new infection spread by the virus of the corona family and at present time the globe is a threat from the Covid-19. Till now, many countries around the globe have observed huge cases of Covid-19. The main target of this virus is those people who have less immunity, old age, and have any medical problems especially linked with lungs. Till now no vaccine is available for Covid-19.

The variety of inflamed humans is growing daily with the aid of using day with inside the world due to the transmittable nature of coronavirus. The transmission of coronavirus is spread person to person contacts and also occurred in community transmission. Coronavirus can spread a range of illnesses wherein respiratory is one of them. COVID-19 symptoms may become up within 2 weeks after the infection. The only prevention is the main concern to manage the Covid-19. Covid-19 affects the daily life of human beings. It mainly affects the health, economic, and social life of human beings [3].

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The life of human beings is mostly influenced by COVID-19 and also slows down the growth of activities in the world. The detection of coronavirus near the beginning stage is very essential to control the increase of the virus because of its transmittable nature. Some characteristics of this virus are listed as [4]:

- **High spread rate:** In a few months, coronavirus spread in the world and become a pandemic globally. The movements of people globally by crossing international borders are the main reason for its spread and from human to human contact.
- **Specific Target:** Old age people are the main target because they have low immunity and other respiratory problems. People with other medical issues like diabetes, heart problem; blood pressure are also the targets of this virus.
- **Recovery Rate:** The recovery rate of coronavirus infected patients is low globally and differs from country to country.

This pandemic has affected all the domains and also modifies the way of life. Due to COVID-19, countries have a huge loss which cannot be estimated both in the economy and life of citizens. To recover this economic loss and save a life, deployment of emerging technologies is used to battle this invisible enemy. AI domain is used to pick out the COVID-19 symptoms with the usage of CT images. The high speed of the internet is needed for teleconferencing and telemedicine which is provided by 5G network technology and additionally assist to ship and receive heavy length pictures very fast. IoT tool is used to connect all the devices of hospitals with the internet and help to provide updated information to health workers. Data may be shared remotely with the help of blockchain technology in a secure manner and assist to streamline the supply chains of various types of medical equipment like face masks, PPE kits, sanitizer, etc., and many more technologies are used during this pandemic time. Section 11.2 of this chapter is clearing up the role of CI technologies in this pandemic environment and how it saves life globally. Section 11.3 summarizes the literature review of research papers written by academic researchers in the COVID-19 pandemic time on a number of CI technologies like AI, IoT, and other technologies including, blockchain, including Cloud computing, Drones, Big data, and 5G network technology.

11.2 Role of Computational Intelligence (CI) to Quash Covid-19

Pandemics have been frightening human beings again and again. The various pandemics like SARS, H1N1, Ebola, and many more have shown their teeth in the precedent but from every pandemic, human beings learn a new way to battle and save their life from these kinds of outbreaks with the help of technologies [5]. Technology refers to techniques, frameworks, and developed the many devices which are designed by the use of scientific information are useful for a practical purpose.

To combat coronavirus, various technologies play an essential role like AI technology helps to spot the patients and virus, disease tracking, and prediction [6]. IoT

technology connects all the medical equipments with the internet and helps the healthcare workers to provide the treatment remotely and diminish the physical contacts. The amalgamation of AI with medical imaging can modify the way of diagnosis. Machine learning develops algorithms that improve the decision-making process. Technology plays a critical role to deal with the COVID-19 situation by using robotics to supply food packets and medicines to the patients who are affected by this virus in the hospitals and in remotely monitoring patients. Figure 11.1 shows the number of ways that emerging technologies tackle coronavirus.

11.2.1 Preventive Measures

Coronavirus nature is transmittable means it can spread from the contacts of a healthy person with an infected person and it spreads very fast. Till now no vaccine is found for this kind of virus. The only solution is prevention. Main prevention is required in the hospitals, where health workers are performing the treatment to save lives and they come directly in contact with the infected patients. Face masks are the essential equipment used by medical examiners to diminish the threat of contact with the virus while performing their jobs. Also, great pressure on the manufacturing units of antiviral soap and sanitizers to fulfill the needs to keep the price in control. Autonomous sanitizing machines are required to deploy at affected clusters to bring the spread of the virus to an end. The most relevant solutions applied with the usage of emerging technologies that enable the faster and efficient way to battle with COVID-19 pandemic are as follows [7]:

- Disease Surveillance
- Air Filtration Systems
- Disinfectants
- Spit Disposal
- Antiviral Masks

11.2.2 Diagnostic Solutions

The WHO advised all health authorities throughout the world to test, detect, trace, and isolated coronavirus infected patients. Only social distancing is the one and only solution to diminish the spread of the virus and used home testing and diagnostic kits. Due to an increase in the number of infected patients and for the security measures, virtual medical visits and remotely diagnosis of patients are doing by the doctors. Chatbots and a number of mobile apps are used in the battle of COVID-19.

The most relevant solutions for the diagnosis of infections are applied with the usage of emerging technologies that enable a faster and efficient way to battle with COVID-19 pandemic are as follows [7]:

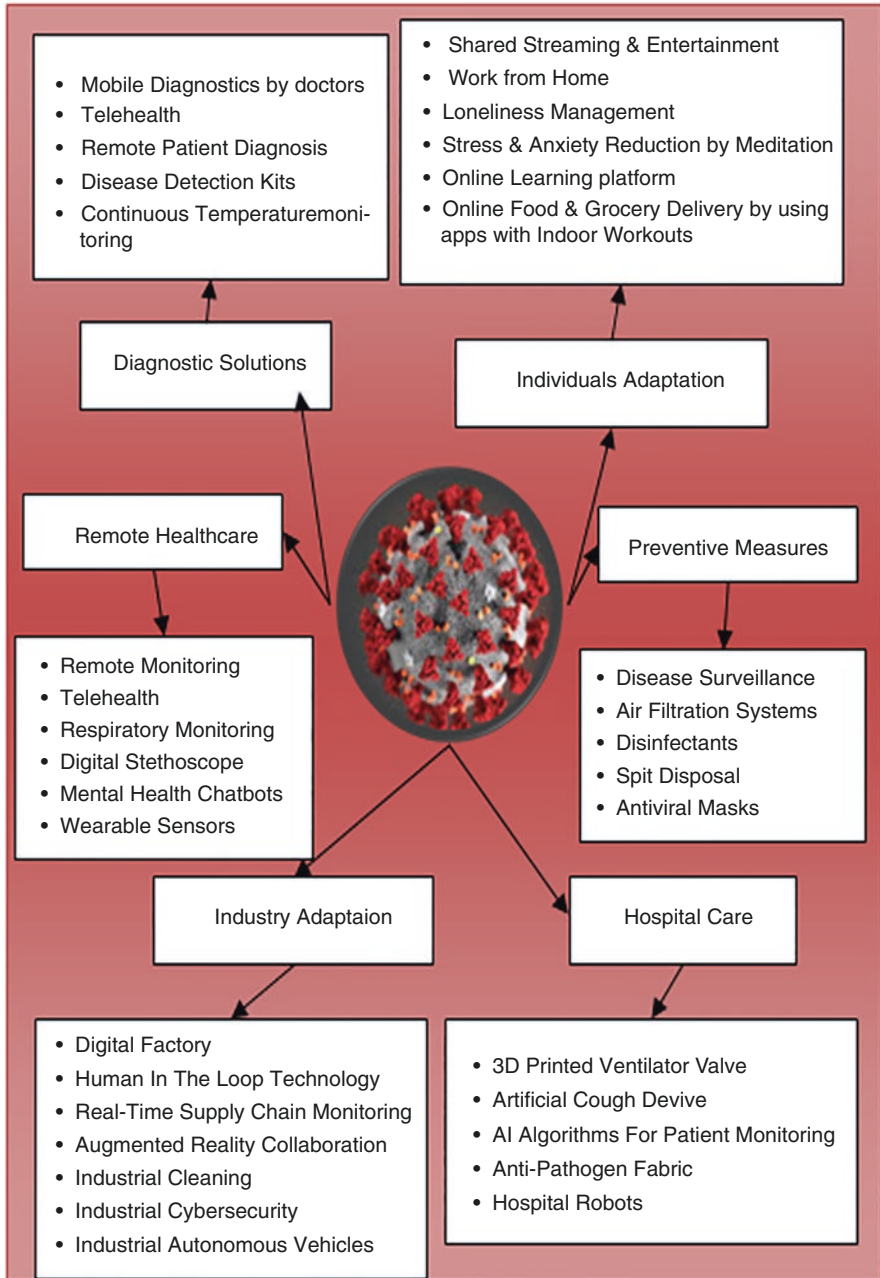


Fig. 11.1 Role of modern technology to quash COVID-19

- Mobile Diagnostics by doctors
- Telehealth
- Remote Patient Diagnosis
- Disease Detection Kits

11.2.3 Hospital Care

Hospitals are the main battlefield where health workers directly contact infected patients and provide treatment. To avoid physical contact, Robots are employed to supply food packets and pills to infected persons and help out to reduce the burden from health workers. Artificial ventilators are used to improve the patient's management. Health workers are the front line warriors who require safety goggles, PPE Kits, gloves, and surgical-grade essentials.

To battle with COVID-19 pandemic in a faster and efficient way in the hospital areas, the emerging technologies are providing the following solutions [7]:

- Hospital Robots
- 3D Printed Ventilator Valve
- Artificial Cough Device
- AI Algorithms For Patient Monitoring
- Antipathogen Fabric

11.2.4 Industry Adaptation

During this epidemic time, all the factories, industries, and businesses are locked due to the lockdown situation and result in heavy losses. To prevent the loss, many industries and businesses are circulating from bodily to virtual platforms by using the rising technologies. Robots and drones are employed to moving items from one place to another in industries and stop the stretch of the virus by minimizing social distancing. Machines and components in a factory are controlled by augmented reality to diminish the workers inside the factory. The most relevant solutions for industries adopted during this epidemic are the usage of emerging technologies that enable faster and efficient way are as follows [7]:

- Digital Factory
- Human In The Loop Technology
- Real-Time Supply Chain Monitoring
- Augmented Reality Collaboration
- Industrial Cleaning
- Industrial Cybersecurity
- Industrial Autonomous Vehicles

11.2.5 Remote Healthcare

In this pandemic time, hospitals are not able to give attention to normal patients and also it is not secure to visit the hospitals in that situation. But for their treatments, health workers are using lots of applications to provide assistance and treatment to them. The digital platform allows doctors and infected persons to remotely communicate with video conferencing and provides digital medical assistance by maintaining social distancing.

The most relevant solutions for remote healthcare are applied with the usage of emerging technologies that enable a faster and efficient way to battle with COVID-19 pandemic are as follows [7]:

- Remote Monitoring
- Telehealth
- Respiratory Monitoring
- Digital Stethoscope
- Mental Health Chatbots
- Wearable Sensors

11.2.6 Individuals Adaptation

During the lockdown and also to maintain the social distancing to prevent the spread of infection, smartphones-based applications are used to connect with each other. Due to coronavirus, schools, colleges, and universities are using the E-learning platforms to complete their syllabus and continue the teaching-learning process between the teachers and students. Offices are temporarily closed in this situation and finding innovative online tools to connect the employees remotely and provide the solution work from home to stop the spread of the virus. For entertainment, streaming and apps are used for passing time, because in this outbreak all the sources of entertainment like Malls, Cinema Halls, Gyms, Fun clubs, and many more are shutdown. Technology enables people to normally live their life by maintaining social distancing and self-isolation during this pandemic time.

The most relevant solutions for individuals adopted during the battle with the COVID-19 pandemic with the usage of emerging technologies that enable faster and efficient way are as follows [7]:

- Shared Streaming & Entertainment
- Work from Home
- Loneliness Management
- Stress & Anxiety Reduction by Meditation
- Online Learning platform
- Online Food & Grocery Delivery by using apps
- Indoor Workouts

11.3 Literature Review

The COVID-19 pandemic is dispersing all over the world and countries suffering from this infection are failed to predict the magnitude of the situation due to the heavy demand for medical care facilities broken down the top healthcare models in the world. Now activities of the person have moved to the binary platform by using emerging technologies like AI, Cloud Computing, IoT, Blockchain, 5G Network, Robotics, and Drones to prevent, diagnose, tracing of the virus, social distancing, workplace safety, and many more. These technologies get better consistency of treatment and also the power of decision making. The infected patients are increasing daily globally and at that time its need to utilize the emerging technologies in a robust, organized manner, and in an efficient way to enhance the battle against the COVID-19 pandemic. Figure 11.2 demonstrates the accomplishment of CI technologies to handle the COVID-19 pandemic situation.

Technology refers to techniques, frameworks, and devices which are the aftereffect of scientific information being utilized for practical purposes. Emerging technologies like AI, Cloud Computing, IoT, Big data, neural network are used to handle this pandemic situation. Table 11.1 summarized the literature review of AI technology-based research papers. Table 11.2 contains the literature review of IoT technology-based research papers written on this pandemic time to handle this situation. Big data, cloud computing, fuzzy logic, blockchain, neural network-based research papers written on the COVID-19 epidemic situation are reviewed in Table 11.3.

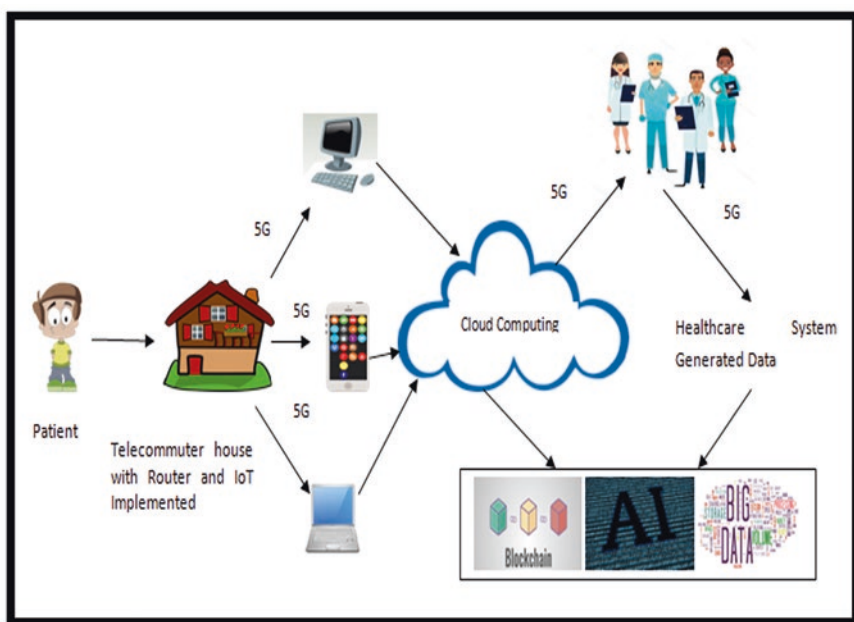


Fig. 11.2 Application of CI technologies for tackling COVID-19 pandemic

Table 11.1 Literature review on application of artificial intelligence (AI)

S. no.	Author	Study
1	[8]	AI-based mobile applications like ArogyaSetu are launched by the government of India for creating awareness among the citizens, self-assessment, and contact tracing for COVID-19 infection
2	[9]	AI-based applications play a vital role in this epidemic time. AI applications are used in the diagnosis of disease, contact tracing, and maintain social distancing for the safety of the people in the workplace
3	[10]	Many COVID-19 patients infected by coronavirus develop pneumonia which is called novel coronavirus pneumonia (NCP) and rapidly fails the respiratory system. The AI-based system is developed to identify NCP and also distinguish it from other common pneumonia by using computed tomography (CT). AI system performs quick diagnosis and helps the radiologists and physicians when the health system is overloaded
4	[11]	The collaboration of AI with pharmacology can improve the efficiency of drug repurposing. Implementation of AI technology can generate the learning prediction model and perform a quick virtual screening to accurately display output. AI technology can identify the drugs that fight against the disease like COVID-19
5	[12]	AI techniques are used in the discovery and recognition of COVID-19 medical images
6	[1]	AI technology improves the screening, prediction, tracking of contacts, forecasting, and development of drugs of COVID-19
7	[13]	AI technology plays an essential function in the processing of an enormous amount of medical data and is also used to extract the key points for several applications. For the repurposing drug, the existing datasets and mined
8	[14]	AI technology is utilized to fight this pandemic by extracting new approaches for the discovery of drugs, development of vaccines, and also spread awareness among the public. This also helps to find the new possible treatment of COVID-19 and also accelerates the process to predict the existing drugs or develop the new drug
9	[15]	AI technology is utilized to recognize marketed drugs for dealing with COVID-19. The potential of old drugs is identified by the AI platform
10	[16]	Presented the AI bases diagnosis tool named AI4COVID-19 by using the cough sound through a mobile application. By virtual testing for everyone through this tool offer unique functionality like timely, cost-effective, self-monitoring, tracing, and also control the widen of coronavirus
11	[17]	AI technology shows more potential to solve the COVID-19 problem and also increases efficiency. It is also used to manage the equipment, detection of a fault, and control the diagnosis in available facilities, to minimize the spread of infection among people
12	[18]	AI technology strengthens the power of medical images like X-ray and computed tomography (CT) to battle against the COVID-19 epidemic. It minimizes contact with patients by automating the scanning method and also recovers the efficiency of work by an accurate description of infection in the images of X-ray and CT. Radiologists take fast and accurate decisions

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Table 11.1 (continued)

S. no.	Author	Study
13	[19]	The process of diagnosis and treatment of COVID-19 disease are accelerating by the use of AI technology. A number of techniques have been developed to fight COVID-19
14	[20]	With AI technology, COVID-19 infection is identified in the early stage. AI model is designed to recognize COVID-19 infection on initial chest CT scans
15	[21]	For the recognition of COVID-19 images of the X-rays are used. Construct a model for detecting COVID-19 with high-resolution X-rays. Reduce the work pressure of radiologists and also help to stop the spread of COVID-19
16	[22]	AI is the upcoming and valuable technology to recognize the infection in an early-stage and also helpful in monitoring the infected person. It improves the treatment and decision-making process and is used to develop the proper treatment, prevention of the COVID-19, and also helps in the drug and vaccine development of COVID-19
17	[23]	Proposed a new framework that can be used by doctors and radiologists based on using only smartphone sensors at any time and anywhere. Does not require any external sensors to provide an accurate result by this framework
18	[24]	AI technology is used to design effective robots and autonomous machines for working, disinfection, and deliver food and medicines to the patients in the hospitals. AI and natural language processing (NLP) technologies are utilized to design the chatbot which helps in remotely communicate and provide consultations to the people about the COVID-19
19	[25, 26]	AI is the most used technology and if it is used properly, it should be highly effective technology against the COVID-19 pandemic time. This technology is used in disease surveillance, prediction of risk, host identification, medical diagnosis, busting fake news, and also used in the implementation of lockdown properly
20	[27]	The spread of coronavirus in real-time and plan to improve the health of people by monitoring their effectiveness. Also, help to discover new drugs and also identify the potential vaccine from the existing vaccines
21	[28]	AI is a very useful technology for helping in the outbreak prediction and detection of coronavirus. It also an attractive tool for the discovery of vaccines and drugs by using the datasets provided by healthcare organizations, governments, and also from patients
22	[29]	DL domain changes the traditional paradigm of the medical field. With this technology, doctors have more time to provide more care to patients. It increases the assessing level of satisfaction of both doctors and patients by the integration of real and binary data
23	[30]	In the machine learning domain, DL is the new branch that motivates the doctors to establish and simulate a NN for the analysis of the brain of the human being. In the medical domain, analysis of medical images for the diagnosis of the disease is a crucial part but it can be sort-out by the implementation of DL
24	[31]	Computer science branches like biomedical big data and AI play an essential role in the crucial time of the COVID-19 pandemic. Images of CT and X-rays are used for monitoring and detection of disease

Table 11.2 Literature review on application of internet of things (IoT)

S. no.	Author	Study
1	[32, 33]	With IoT technology, all the medical types of equipment are connected with the internet and make available information timely to healthcare workers. With well-connected devices, infected cases are easily handled remotely
2	[34, 35]	IoT technology assists the patients, physicians, healthcare workers, and hospital management to recognize the symptoms of the COVID-19 and also managed the infected cases globally. This technology also helps to minimize the complexity and time taken for effective management during this pandemic time IoT technology provides a variety of applications like telehealth, digital scanning, digital staff, and many more. IoT-based telemedicine is a way for health workers during this pandemic time to provide treatment to infected patients
3	[36]	In the current situation, the performance of IoT in the medical field helps the patients to receive proper healthcare at home and also creates a comprehensive management database for governments and healthcare workers
4	[37]	IoT-enabled applications to monitor health in real-time and improve global health. This technology develops the smart disease surveillance system to control the situation during this pandemic time
5	[38]	Cognitive internet of medical things (CIoMT) technology is used for smart health care and also helps to handle the pandemic situation. It helps in rapid diagnosis, dynamic monitoring, provides better treatment, and also controls the spread of coronavirus to others
6	[39]	IoMT develops a quality environment for smart healthcare. It helps in the monitoring and tracking of infected persons remotely and provides quality services
7	[40]	Internet of health things (IoHT) is an extension of IoT, whose main motive is to connect the infected patient to healthcare facilities to monitor and control the patient's body by using the sensors
8	[41]	With the help of IoMT, healthcare workers get relief and also ensure quarantine, implementation, and origin of pandemic. By using sensors, data can be collected and sent to a central server for analysis. It is the better method for the medical helpers and government agencies for the updated information on the COVID-19 crisis
9	[42]	Proposed the smart helmet with a mounted thermal imaging system capable to detect the COVID-19 infected person with minimum human interactions
10	[43]	IoT technology helps in the identification of risk and infection of COVID-19 and also minimizes the load of health workers and manufacturing units
11	[44]	Proposed the IoT-based framework to minimize the impact of a communicable disease like COVID-19. The records of confirmed cases of COVID-19 are used to develop an ML-based predictive model infection as well as provide the treatment responses
12	[45, 46]	IoT technology helps to monitor, tracking, delivering, and collecting of data from the users and assists the healthcare by using IoT-enabled technologies like wearables, drones, robots, IoT buttons, and smartphone application

Table 11.3 Literature review on application of other technologies like big data, blockchain, drones, cloud computing, robotics

S. no.	Author	Study	Technology used
1	[27]	Big data technology is used to handle the large amount of data produced from public health observation, monitoring of real-time epidemic, and also used in the forecasting of the situation	Big data
2	[28]	Integration of big data and AI technology helps to understand the COVID-19 in terms of tracking, the structure of the virus, its treatment, and also search and manufacturing of vaccine	
3	[47]	Big data technology is used to handle the huge amount of infected person data and helps to understand the structure and nature of coronavirus. This technology helps scientists, health workers, and epidemiologists in the decision-making process to fight COVID-19	
4	[25]	Drone technology minimizes human interaction and also reaches inaccessible areas by the people. Drone technology is adopted for crowd surveillance to maintain social distancing, to broadcast important information particularly in those areas where communication channels are lack during the lockdown period. Also used to spray disinfectants in the contaminated zones	Drone
5	[48]	With the help of blockchain technology, the public and organizations become part of interconnected networks to share secure data globally. Blockchain-based applications are used to monitor the COVID-19 patients and minimize some burden from the health workers. Algorithms help to provide real-time information and also help in the effective management of the supply chain	Blockchain
6	[49]	With blockchain technology, data of infected patients are automatically reported to the health workers at the same time when it is stored in the blockchain and data are transparent with completely open for the public without any manipulation. With the use of blockchain monetary donations become transparent and also prevent the spread of false information related to COVID-19	
7	[50]	Blockchain technology plays an essential role in the field of medicine with the management of digital medical data, biomedical research, remotely monitoring the patients, control the drugs, and pharmaceuticals supply chain management	
8	[51]	In the pandemic time, the diagnosis of infected patients is difficult because of the shortage of testing kits. Combination of blockchain with other technology helps to collect the digital data from the various sources without leakage of data and also maintains the confidentiality of data	

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Table 11.3 (continued)

S. no.	Author	Study	Technology used
9	[52]	The blockchain system generates an account for every person and contact tracing becomes easier when mobile devices of persons are connected with blockchain account. When the person comes in contact with another person, then blockchain adds the transaction with geo-location and time stamp and the healthcare official able to verify that the person makes contact with the COVID-19 infected person or not	
10	[53]	Blockchain technology is used to control the pandemic of COVID-19 with solutions like tracking, protection of user privacy, safely daily operations, medical supply chain, and also tracking the donations	
11	[54]	Designed the tracing and notification system based on blockchain with three types of tracing services based on Bluetooth, location, and health. The system will provide the remainder to the user about their previous contacts that may cause infection based on user travel and contact history	
12	[55]	Blockchain technology plays an essential role in the management of the post COVID-19 world. It is used to implement various key functions like contact tracing, sharing of patient information, E-government, online learning, management of immigration, contact-free delivery, and automated surveillance	
13	[56]	Blockchain technology has the potential to change healthcare systems. This technology provides the secure transfer of health information of patients between the healthcare workers	
14	[57]	Blockchain technology provides five perspectives as tracing the origin of the pandemic, social distancing, quarantining, smart hospitals, remote healthcare, and telemedicine	
15	[58]	A blockchain-enabled system named BeepTrace is proposed to resolve the privacy issues during the binary contact tracing for coronavirus pandemic	
16	[59]	Cloud computing technology provides the resources of the computer system over the internet like servers for the storage, database, etc. by using this technology, all the resources are faster available and flexible which minimized the processing cost and also increased efficiency	Cloud computing
17	[60, 61]	Cloud-based tools are used for the screening and also alert the authorities if quarantine is breached. Cloud-based AI-assisted services are used to identify the cases of COVID-19. The cloud application can transform the healthcare system from capital intensive to pay per usage model	
18	[62]	During the COVID-19 pandemic, patient-generated health data (PGHD) play a very important role. Coronavirus tracking apps are used in smartphones to collect and share PGHD and store them on the cloud. Users are easily checked by entering personal information on apps by comparing their data with cloud data whether the user has contact with an infected person or not	

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Table 11.3 (continued)

S. no.	Author	Study	Technology used
19	[63]	Doctors are the first line of defense to slow the spread of the virus by maintaining social distancing and provide the services by call or video conferencing with patients. 5G technology is the main source of telemedicine. 5G provides the high bandwidth required for video conferencing	5G network technology
20	[25]	Hospitals with 5G enabled medical imaging platforms are used to real-time diagnosis of COVID-19 patients and also reduce the load of healthcare warriors	
21	[64]	5G smartphones are used as the virtual communication device between the patients and doctors by reducing healthcare costs and also maintaining the social distancing in this pandemic tie	
22	[65]	By the integration of the fractal dimension and fuzzy logic system, the proposed hybrid intelligent approach for accomplishing the efficient and accurate forecasting of the COVID-19 time series	Fuzzy logic
23	[66]	The fuzzy logic-based model is used to find the appropriate conditions for the growth of COVID-19 infection. The spread of COVID-19 disease decreases with higher temperature and low RH and on the other hand, lower temperature with high RH provides an enviable atmosphere for coronavirus	
24	[67]	Introduced the COVID-net named system based on a neural network for the detection of coronavirus cases from the CXR images. It is open-source and easily available to the public	Neural network
25	[68]	Proposed a deep learning approach to identify COVID-19 infected cases by the usage of radiography images named CoroNet based on a neural network	

11.3.1 Applications of Artificial Intelligence

- Used to identify the COVID-19 infection through chest CT images.
- COVID-19 suspected patients are detected with signs and symptoms.
- Mobile applications based on AI are used to spread awareness and tracing for COVID-19 infection.
- Improve the discovery of COVID-19 drugs.
- Reducing the workload of health workers.

AI technology is playing an essential role in the fight with COVID-19 and also provides quick solutions to prevent this virus. Many applications are designed on AI technology like ArogyaSetu App in India which is used to create awareness, self-assessment, and also help to trace the contacts for COVID-19 infection. During this pandemic time, front line worriers are facing overload problems due to the huge increase of infected patients and have limited health workers. AI technology-based systems help to minimize the burden by performing quick diagnosis. It also helps in

prediction and detection of coronavirus. AI technology is used to design and develop robotics and drones. Robotics is used for the supply of food packets and medicines to the infected patients in the hospitals and help to maintain social distancing. Drones are used to spray the disinfectant in the quarantine zones and help to stop the spread of coronavirus.

11.3.2 Applications of IoT

- IOT technology helps in remote monitoring of self-quarantine and self-assessment and sends the data to health workers for the assessment.
- IOT technology helps in the rapid diagnosis of a human being with a history of traveling in COVID-19-affected countries.
- Support remote consultations between healthcare workers and patients with smart video conferencing and telemedicine.
- Smart thermometers are used to check the temperature of the person.

In the pandemic time, IoT technology has been used in the medical domain and also gives a positive result to handle this disease. IoT technologies are used in three phases including early identification, quarantine time, and after recovery. IoT-enabled devices like wearable, drones, robots, IoT buttons, and smartphone applications are used in fighting with COVID-19 [45].

IoMT is the extended version of IoT in the field of medicine. IoMT technology helps to provide an integrated network of medical equipment to healthcare workers to battle this pandemic situation and automatically convey a message to the medical staff. With this technology, infected cases are easily handled in a remote location with well-connected teleservices. IoMT technology excellently screens the infected patients and also handles all the cases smartly. A better environment can be created with the proper accomplishment of this technology which helps to fight this invisible enemy.

11.3.3 Applications of Other Technologies

- Big data is used to track COVID-19 cases and provides a large amount of space to store data.
- Drones are used for disinfecting and sterilizing COVID-19 contaminated areas.
- Autonomous robots are used to provide medicines and food to COVID-19 patients and reduce health worker's risks of infection.
- With the help of blockchain, verification and validation of COVID-19 data are done in an easy way.
- Facilitates the secure sharing of data.
- 5G technology supports real-time sharing of health data and high-quality video conferencing.

- Home quarantine patients are tracked using GPS and mobile phones.
- Reduce the load of healthcare warriors.
- Help in the recognition of coronavirus cases with radiography images.

Other technologies like Cloud computing, Blockchain, 5G network technology, Big data, and many more are playing a vital role during this epidemic time. In the current situation, a large amount of data are collected from various sources like applications used on smartphones, patient's records from hospitals, and Government released data are stored on the cloud which helps to provide the updated information. To maintain social distancing, a number of activities are moved from physical to virtual platforms with the help of 5G network technology. 5G network technology provides the high bandwidth of the internet which helps to video conferencing, teleconferencing, and sharing of videos and images of huge size at very fast speed.

11.4 Challenges During Implementation of CI Technologies

CI technologies provide new inventions in the binary world. By using CI technologies, simulated expertise is to develop and design which is to some extent similar to the real-time situation. These technologies are given a number of applications in various domains that are used in daily work. But as usual, every coin has two sides, one side of CI technologies is very useful in every domain but on the other side, these technologies face several challenges during the implementation which highlight in Fig. 11.3. Some of them are listed as:

1. **Lack of Awareness:** Generally users are not aware of the applications of CI technologies. The value of CI technologies is best understood when mass users adopted these technologies.
2. **Network Load:** In some applications of CI technologies environment, data are streaming live over the internet with minimum local caching of frequently used data.
3. **Congestion in Communication:** In CI technologies, communication can be occurring in between servers and the asset cluster and which causes congestion problems in communications.
4. **Cost:** The initial cost to develop the CI technologies-based environment is so high. A large scale of people is not able to afford these technologies in their daily routine.
5. **Internet:** The Internet is the main source to implement the CI technologies-based environment. So 5G internet bandwidth is required but still, 5G internet service is not fully implemented in most areas.
6. **Experience issue:** Users are not skilled in how to use the applications based on CI technologies and sometimes users do not easily adopt the new technologies because of less experience.

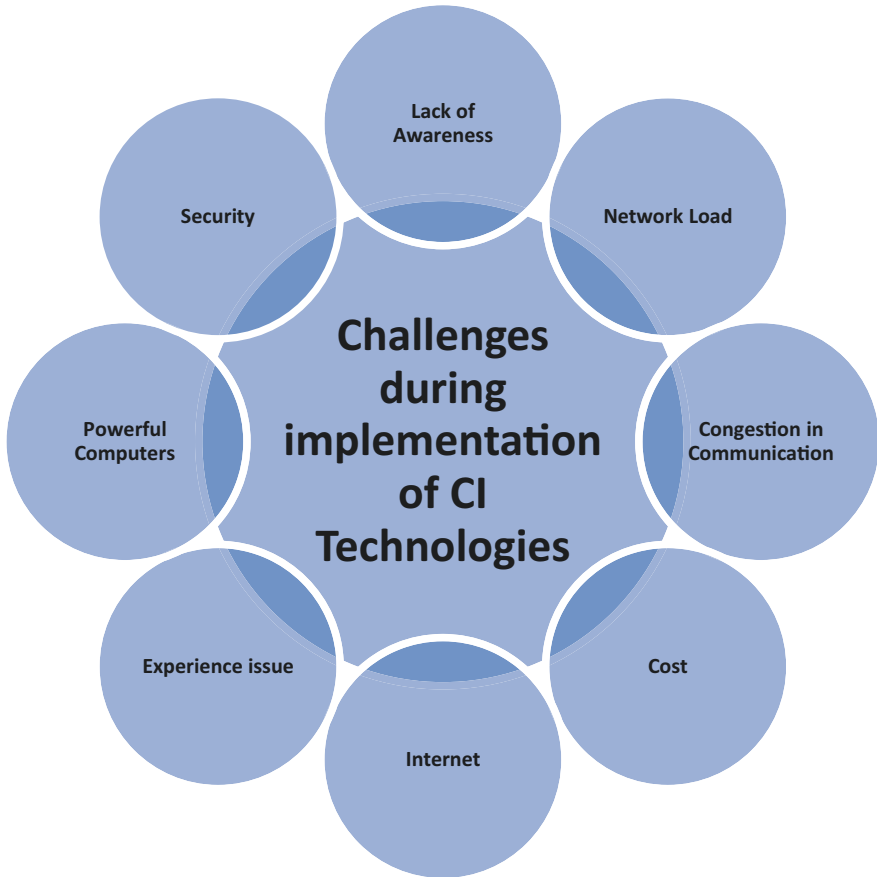


Fig. 11.3 Challenges during the implementation of CI technologies

7. **Security:** Cybersecurity and data privacy are sensitive issues in the digital platform. Due to these reasons, some users are not using these technologies even do not try to adopt them.
8. **Powerful Computers:** To use the CI technologies, the main necessity is powerful computer systems with a high power processor with high configuration and resolution.

11.5 Conclusion

COVID-19 pandemic is a public health emergency globally and has become the most challenging area for global researchers. Academic research helps to a proper understanding of COVID-19. Researchers are investigating each and every possible

option to battle the COVID-19 pandemic and a new way is opened by the emerging technologies. Now technologies have become an important part of the life of people to execute their day-to-day activities and help to save a life. This chapter talks about the symptoms and preventions against the COVID-19. It also highlighted the emerging technologies used to fight COVID-19. IoT technology is used to integrate the medical equipment with the internet and provide remote treatment to the infected patients and many more technologies are highlighted. Emerging technologies like IoT, AI, Blockchain, 5G, and many more give complementary efforts to the world to fight against the COVID-19 and future pandemics.

References

1. Lalmuanawma, S., Hussain, J., & Chhakchhuak, L. (2020). Applications of machine learning and artificial intelligence for Covid-19 (SARS-CoV-2) pandemic: A review. *Chaos, Solitons and Fractals*, 139. <https://doi.org/10.1016/j.chaos.2020.110059>.
2. Montemurro, N. (2020). The emotional impact of COVID-19: From medical staff to common people. *Brain, Behavior, and Immunity*, 1591, 1–2. <https://doi.org/10.1016/j.bbi.2020.03.032>
3. Haleem, A., Javaid, M., Vaishya, R., & Deshmukh, S. G. (2020). Areas of academic research with the impact of COVID-19. *The American Journal of Emergency Medicine*, 38, 1524–1526. <https://doi.org/10.1016/j.ajem.2020.04.022>
4. Shaw, R., Kim, Y., & Hua, J. (2020). Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Progress in Disaster Science*, 6, 100090. <https://doi.org/10.1016/j.pdisas.2020.100090>
5. Manjunath, B. S. (2020, April). Covid-19: 8 ways in which technology helps pandemic management. IT News, ET CIO.
6. Kumar, A., Gupta, P. K., & Srivastava, A. (2020). A review of modern technologies for tackling COVID-19 pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(4), 569–573. <https://doi.org/10.1016/j.dsx.2020.05.008>
7. Startus Insight. (2020). 8 ways emerging technologies tackle the global coronavirus pandemic.
8. Ransing, R., Nagendrappa, S., Patil, A., Shoib, S., & Sarkar, D. (2020). Potential role of artificial intelligence to address the COVID-19 outbreak-related mental health issues in India. *Psychiatry Research*, 290, 113176. <https://doi.org/10.1016/j.psychres.2020.113176>
9. Sipior, J. C. (2020). Considerations for development and use of AI in response to COVID-19. *International Journal of Information Management*, 55, 102170. <https://doi.org/10.1016/j.ijinfomgt.2020.102170>
10. Zhang, K., et al. (2020). Clinically applicable AI system for accurate diagnosis, quantitative measurements, and prognosis of COVID-19 pneumonia using computed tomography. *Cell*, 181(6), 1423–1433.e11. <https://doi.org/10.1016/j.cell.2020.04.045>
11. Mohanty, S., Harun, M., Rashid, A. I., Mridul, M., Mohanty, C., & Swayamsiddha, S. (2020). Application of artificial intelligence in COVID-19 drug repurposing. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(5), 1027–1031. <https://doi.org/10.1016/j.dsx.2020.06.068>
12. Albahri, O. S., et al. (2020). Systematic review of artificial intelligence techniques in the detection and classification of COVID-19 medical images in terms of evaluation and benchmarking: Taxonomy analysis, challenges, future solutions and methodological aspects. *Journal of Infection and Public Health*, 13, 1381–1396. <https://doi.org/10.1016/j.jiph.2020.06.028>

13. Park, Y., Casey, D., Joshi, I., Zhu, J., & Cheng, F. (2020). Emergence of new disease: How can artificial intelligence help? *Trends in Molecular Medicine*, 26(7), 6–8. <https://doi.org/10.1016/j.molmed.2020.04.007>
14. Ahuja, A. S., Reddy, V. P., & Marques, O. (2020). Artificial intelligence and COVID-19: A multidisciplinary approach. *Integrative Medicine Research*, 9(3), 100434. <https://doi.org/10.1016/j.imr.2020.100434>
15. Ke, Y. Y., et al. (2020). Artificial intelligence approach fighting COVID-19 with repurposing drugs. *Biomedical Journal*, 43(4), 355–362. <https://doi.org/10.1016/j.bj.2020.05.001>
16. Imran, A., et al. (2020). AI4COVID-19: AI enabled preliminary diagnosis for COVID-19 from cough samples via an app. *Informatics in Medicine Unlocked*, 20, 100378. <https://doi.org/10.1016/j.imu.2020.100378>
17. Wang, B., Yang, Z., Xuan, J., & Jiao, K. (2020). Crises and opportunities in terms of energy and AI technologies during the COVID-19 pandemic. *Energy AI*, 1, 100013. <https://doi.org/10.1016/j.egyai.2020.100013>
18. Shi, F., et al. (2020). Review of artificial intelligence techniques in imaging data acquisition, segmentation and diagnosis for COVID-19. *IEEE Reviews in Biomedical Engineering*, 1–13. <https://doi.org/10.1109/RBME.2020.2987975>
19. Jamshidi, M., et al. (2020). Artificial Intelligence and COVID-19: Deep Learning Approaches for Diagnosis and Treatment. *IEEE Access*, 8, 109581–109595. <https://doi.org/10.1109/ACCESS.2020.3001973>
20. Mei, X., et al. (2020). Artificial intelligence-enabled rapid diagnosis of patients with COVID-19. *Nature Medicine*, 26(8), 1224–1228. <https://doi.org/10.1038/s41591-020-0931-3>
21. Salman, F. M., Abu-Naser, S. S., Alajrami, E., Abu-Nasser, B. S., & Ashqar, B. A. M. (2020). COVID-19 detection using artificial intelligence. *International Journal of Computer Engineering Research*, 4(3), 18–25.
22. Vaishya, R., Javaid, M., Khan, I. H., & Haleem, A. (2020). Artificial intelligence (AI) applications for COVID-19 pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(4), 337–339. <https://doi.org/10.1016/j.dsx.2020.04.012>
23. Maghdid, H. S., Ghafoor, K. Z., Sadiq, A. S., Curran, K., & Rabie, K. (2020). A novel AI-enabled framework to diagnose coronavirus COVID 19 using smartphone embedded sensors: Design study (pp. 1–7).
24. Nguyen, T. T., Waurn, G., & Campus, P. (2020). Artificial intelligence in the battle against coronavirus (COVID-19): A survey and future research directions. Researchgate.Net (pp. 1–13). <https://doi.org/10.13140/RG.2.2.36491.23846.Artificial>
25. Chamola, V., Hassija, V., Gupta, V., & Guizani, M. (2020). A comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain, and 5G in managing its impact. *IEEE Access*, 8, 90225–90265. <https://doi.org/10.1109/ACCESS.2020.2992341>
26. Sohrabi, C., Alsafi, Z., Neill, N. O., Khan, M., & Kerwan, A. (2020, January). Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19. The COVID-19 resource centre is hosted on Elsevier Connect, the company’s public news and information.
27. Barragán, D., & Manero, J. (2020). *How big data and artificial intelligence can help against COVID-19* (pp. 4–11). IE Business School.
28. Pham, Q. V., Nguyen, D. C., Huynh-The, T., Hwang, W. J., & Pathirana, P. N. (2020). Artificial intelligence (AI) and big data for coronavirus (COVID-19) pandemic: A survey on the state-of-the-arts. *IEEE Access*, 8, 130820–130839. <https://doi.org/10.1109/ACCESS.2020.3009328>
29. Piccialli, F., Di, V., Giampaolo, F., & Cuomo, S. (2021). A survey on deep learning in medicine: Why, how and when? *Information Fusion*, 66, 111–137.
30. Wong, K. K. L., Fortino, G., & Abbott, D. (2020). Deep learning-based cardiovascular image diagnosis: A promising challenge. *Future Generation Computer Systems*, 110, 802–811. <https://doi.org/10.1016/j.future.2019.09.047>
31. Amini, A., Chen, W., Fortino, G., Li, Y., Pan, Y., & Wang, M. D. (2020). Editorial: Special issue on ‘AI-driven informatics, sensing, imaging and big data analytics for fighting the COVID-19 pandemic. *IEEE Journal of Biomedical and Health Informatics*, 24(10), 2731–2732. <https://doi.org/10.1109/JBHI.2020.3025594>

32. Singh, R. P., Javaid, M., Haleem, A., & Suman, R. (2020). Internet of things (IoT) applications to fight against COVID-19 pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(4), 521–524. <https://doi.org/10.1016/j.dsx.2020.04.041>
33. Rahman, A., Hossain, M. S., Alrajeh, N. A., & Alsolami, F. (2020). Adversarial examples – Security threats to COVID-19 deep learning Systems in Medical IoT devices. *IEEE Internet of Things Journal*, 1–1. <https://doi.org/10.1109/jiot.2020.3013710>
34. Oyeniyi, J., Ogundoyin, I., & Oyeniran, O. (2020, June). Application of internet of things (IoT) to enhance the fight against covid-19 application of internet of things (IoT) to enhance the fight against covid-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 14, 521–524.
35. Alam, T. (2020). Coronavirus disease (Covid-19): Reviews, applications, and current status. *SSRN Coronavirus & Infectious Disease Research eJournal*. <https://doi.org/10.2139/ssrn.3660497>.
36. Yang, T., Gentile, M., Shen, C. F., & Cheng, C. M. (2020). Combining point-of-care diagnostics and internet of medical things (IOMT) to combat the Covid-19 pandemic. *Diagnostics*, 10(4), 4–6. <https://doi.org/10.3390/diagnostics10040224>
37. Rahman, M. S., Peeri, N. C., Shrestha, N., Zaki, R., Haque, U., & Hamid, S. H. A. (2020). Defending against the novel coronavirus (COVID-19) outbreak: How can the internet of things (IoT) help to save the world? *Health Policy Technology*, 9, 136–138. <https://doi.org/10.1016/j.hlpt.2020.04.005>
38. Swayamsiddha, S., & Mohanty, C. (2020). Application of cognitive internet of medical things for COVID-19 pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(5), 911–915. <https://doi.org/10.1016/j.dsx.2020.06.014>
39. Pratap, R., Javaid, M., Haleem, A., Vaishya, R., & Ali, S. (2020). Internet of medical things (IoMT) for orthopaedic in COVID-19 pandemic: Roles , challenges , and applications. *Journal of Clinical Orthopaedics and Trauma*, 11(4), 713–717. <https://doi.org/10.1016/j.jcot.2020.05.011>
40. Kamal, M., Aljohani, A., & Alanazi, E. (2020). IoT meets COVID-19: Status, challenges, and opportunities.
41. Tsikala Vafea, M., et al. (2020). Emerging technologies for use in the study, diagnosis, and treatment of patients with COVID-19. *Cellular and Molecular Bioengineering*, 13, 249–257. <https://doi.org/10.1007/s12195-020-00629-w>
42. Mohammed, M. N., Syamsudin, H., Al-Zubaidi, S., Sairah, A. K., Ramli, R., & Yusuf, E. (2020). Novel covid-19 detection and diagnosis system using iot-based smart helmet. *International Journal of Psychosocial Rehabilitation*, 24(7), 2296–2303. <https://doi.org/10.37200/IJPR/V24I7/PR270221>
43. Kumar, M. S., Raut, D. R. D., Narwane, D. V. S., & Narkhede, D. B. E. (2020). Applications of industry 4.0 to overcome the COVID-19 operational challenges. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(5), 1283–1289. <https://doi.org/10.1016/j.dsx.2020.07.010>
44. Otoom, M., Otoum, N., Alzubaidi, M. A., Etoom, Y., & Banihani, R. (2020). An IoT-based framework for early identification and monitoring of COVID-19 cases. *Biomedical Signal Processing and Control*, 62, 102149. <https://doi.org/10.1016/j.bspc.2020.102149>
45. Nasajpour, M., Pouriyeh, S., Parizi, R. M., Dorodchi, M., Valero, M., & Arabnia, H. R. (2020). Internet of things for current COVID-19 and future pandemics: An exploratory study. *Journal of Healthcare Informatics Research*, 4, 325–364.
46. Prabhu, J., et al. (2020). IoT role in prevention of COVID-19 and health care workforces behavioural intention in India - an empirical examination. *International Journal of Pervasive Computing and Communications*, 16(4), 331–340. <https://doi.org/10.1108/IJPC-06-2020-0056>
47. Haleem, A., Javaid, M., Khan, I. H., & Vaishya, R. (2020). Significant applications of big data in COVID-19 pandemic. *The Indian Journal of Orthopaedics*, 54(4), 526–528. <https://doi.org/10.1007/s43465-020-00129-z>
48. Vaishya, R., Haleem, A., Vaish, A., & Javaid, M. (2020). Emerging technologies to combat the COVID-19 pandemic. *Journal of Clinical and Experimental Hepatology*, 10(4), 409–411. <https://doi.org/10.1016/j.jceh.2020.04.019>

49. Chang, M. C., & Park, D. (2020). How can blockchain help people in the event of pandemics such as the COVID-19? *Journal of Medical Systems*, 44(5), 102. <https://doi.org/10.1007/s10916-020-01577-8>
50. Mashamba-Thompson, T. P., & Crayton, E. D. (2020). Blockchain and artificial intelligence technology for novel coronavirus disease-19 self-testing. *Diagnostics*, 10(4), 8–11. <https://doi.org/10.3390/diagnostics10040198>
51. Kumar, R., et al. (2020). Blockchain-federated-learning and deep learning models for COVID-19 detection using CT imaging. 14(8), 1–12.
52. Bansal, A., Garg, C., & Padappayil, R. P. (2020). Optimizing the implementation of COVID-19 ‘immunity certificates’ using Blockchain. *Journal of Medical Systems*, 44(9), 19–20. <https://doi.org/10.1007/s10916-020-01616-4>
53. Nguyen, D. C., Ding, M., Pathirana, P. N., & Seneviratne, A.. (2020). Blockchain and AI-based solutions to combat coronavirus (COVID-19)-like epidemics: A survey (pp. 1–15).
54. Song, J., Gu, T., Feng, X., Ge, Y., & Mohapatra, P. (2020). Blockchain meets COVID-19: A framework for contact information sharing and risk notification system.
55. Kalla, A., Hewa, T., Mishra, R. A., Ylianttila, M., & Liyanage, M. (2020). The role of blockchain to fight against COVID-19. *IEEE Engineering Management Review*, 48, 85–96. <https://doi.org/10.1109/EMR.2020.3014052>
56. Alam, T. (2020). Internet of things and blockchain-based framework for coronavirus (COVID-19) disease. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3660503>.
57. Dai, H.-N., Imran, M., & Haider, N. (2020). Blockchain-enabled internet of medical things to combat COVID-19. *IEEE Internet of Things Magazine*, 3, 52–57.
58. Xu, H., Zhang, L., Onireti, O., Fang, Y., Buchanan, W. B., & Imran, M. A. (2020). BeepTrace: Blockchain-enabled privacy-preserving contact tracing for COVID-19 pandemic and beyond (pp. 1–13). <https://doi.org/10.13140/RG.2.2.25101.15849/1>.
59. Javaid, M., Haleem, A., Vaishya, R., Bahl, S., Suman, R., & Vaish, A. (2020). Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(4), 419–422. <https://doi.org/10.1016/j.dsx.2020.04.032>
60. Whitelaw, S., Mamas, M. A., Topol, E., & Van Spall, H. G. C. (2020). Applications of digital technology in COVID-19 pandemic planning and response. *Lancet Digital Health*, 2(8), e435–e440. [https://doi.org/10.1016/S2589-7500\(20\)30142-4](https://doi.org/10.1016/S2589-7500(20)30142-4)
61. Kumar, P. (2020, June). Literature based study on cloud computing for health and sustainability in view of covid19. *Core.Ac.Uk*.
62. Ye, J. (2020). The role of health technology and informatics in global public health emergency: Practices and implications from the COVID-19 pandemic (preprint). *JMIR Medical Informatics*, 8, e19866. <https://doi.org/10.2196/19866>
63. Vidal-Alaball, J., et al. (2020). Telemedicine in the face of the COVID-19 pandemic. *Atencion Primaria*, 52(6), 418–422. <https://doi.org/10.1016/j.aprim.2020.04.003>
64. Iyengar, K., Upadhyaya, G. K., Vaishya, R., & Jain, V. (2020). COVID-19 and applications of smartphone technology in the current pandemic. *Diabetes and Metabolic Syndrome: Clinical Research & Reviews*, 14(5), 733–737. <https://doi.org/10.1016/j.dsx.2020.05.033>
65. Lalmuanawma, S., Hussain, J., & Chhakchhuak, L. (2020). Applications of Machine Learning and Artificial Intelligence for Covid-19 (SARS-CoV-2) pandemic: A review. *Chaos, Solitons Fractals*, 139, 110059. <https://doi.org/10.1016/j.chaos.2020.110059>
66. Chowdhury, M. A., Shah, Q. Z., Kashem, M. A., Shahid, A., & Akhtar, N. (2020). Evaluation of the effect of environmental parameters on the spread of COVID-19: A fuzzy logic approach. *Advances in Fuzzy Systems*, 2020.
67. Wang, L., Lin, Z. Q., & Wong, A. (2020). COVID-Net: A tailored deep convolutional neural network design for detection of COVID-19 cases from chest x-ray images. *Scientific Reports*, 1–12.
68. Khan, A. I., Shah, J. L., & Bhat, M. M. (2020). CoroNet: A deep neural network for detection and diagnosis of COVID-19 from chest x-ray images. *Computer Methods and Programs in Biomedicine*, 196, 105581. <https://doi.org/10.1016/j.cmpb.2020.105581>