The Role of Emerging Technologies for Combating COVID-19 Pandemic

Atrab A. Abd El-Aziz, Nour Eldeen M. Khalifa, Ashraf Darwsih, and Aboul Ella Hassanien

Abstract The outbreak of the new coronavirus disease (COVID-19) in 2019 resulted in more than 100,000 infections and thousands of deaths. The number of deaths and infections continues to rise rapidly since the virus date of appearance. COVID-19 threatens not only human health but also many aspects of life such as manufacturing, social performance, and international relations. Emerging technologies can help in the fight against COVID-19. Emerging technologies include blockchain, Internet of Things (IoT), artificial intelligence (AI), and big data technologies, and they proved its efficiency in practical fields. These fields include the fast aggregation of multi-source big data, fast visualization of epidemic information, diagnosing, remote treatment, and spatial tracking of confirmed cases. Every country in the world is still seeking realistic and cost-effective solutions to stand against COVID-19 under current epidemiological conditions. This chapter discusses the concepts of emerging technologies, applications, and contributions to combating COVID-19. Moreover, the challenges and future research directions are reviewed in detail. Also, a list of publicly available open-source COVID-19 datasets will be presented. Finally, this chapter concludes that cooperation among government, medical institutions, and the scientific community is significant and critical. Also, there is an urgent demand for improvement in the analytical algorithms and electronic devices to combat the COVID-19 pandemic.

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1 Introduction

In December 2019, the World Health Organization (WHO) has declared a new coronavirus disease-19 called COVID-19 as a pandemic. COVID-19 was primarily appeared in the city of Wuhan in China and has grown rapidly worldwide as shown in Fig. 1. The COVID-19 pandemic has generated an unusual economic and health crisis that required a rapid response from medical professionals, government organizations, and scientists. Due to limited resources and the urgent demand for medical supplies, this crisis has required quick and innovative solutions. The innovative use of emerging technologies has been introduced to meet growing demands. The scientific response to combat COVID-19 has been much faster and more widespread. At the end of 2019, the number of published academic research including the word "coronavirus" reached 755 articles [1, 2].

Scientific researchers have brainstormed ideas that can narrow the crisis and improve the prevention of future pandemics. Not only medical specialists but also scientists assisted with digital technologies have tackled the pandemic with novel approaches. The main digital effort was obtained from the Artificial Intelligence community in the automated detection of COVID-19 using "CT" computed tomography and X-ray scans. Many efforts have been made to analyze the emotional and social behaviors using social networks, such as the detection of COVID-19 from cough samples, obtaining academic articles for semantic analysis, and automated follow-up of contacts [3].

The main objective of this chapter is to show the effectiveness of emerging technological developments that are being executed to combat the COVID-19 pandemic. This chapter surveyed cutting-edge solutions using these emerging technologies. In

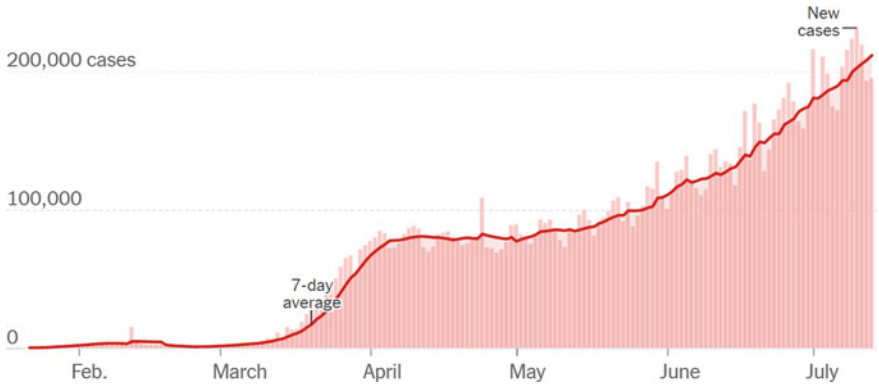


Fig. 1 Global COVID-19 trend for 11 July 2020 (*source* **NYTimes**)

addition, the challenges and problems associated with existing based approaches are highlighted. This motivates the production of a set of research directions for research communities, societies, and governments. The technologies included in this review involve Artificial Intelligence, Internet of Things, Blockchains, and Bigdata.

The chapter is organized as follows: Sect. 2 presents the background and literature review, Sect. 3 explains the open-source COVID datasets. Section 4 shows the applications of emerging technologies coronavirus. Section 5 details the challenges and limitations and Sect. 6 discusses the future research directions and finally, the chapter conclusion in Sect. 7.

2 Literature Reviews

According to the WHO, emerging digital technologies can play a vital role in promoting the public health response to the COVID-19 pandemic [4]. In the following parts, we review the background and literature contributions of the aforementioned technologies for lessening the destructive impacts of the COVID-19 pandemic.

2.1 Blockchain Technology

Blockchain technology is a distributed data structure that is replicated and distributed among the members of a network. Blockchain started with Bitcoin. Unlike traditional database systems, Blockchain technology has several comprehensive properties to guarantee transparency, precision, and immutability in data storage. These properties incorporate the service view, logical inclusion, and architectural features. The three main components of blockchain include distributed ledger (database), data block, and consensus algorithms. How could blockchain technology address the existing challenges of COVID-19 to lessen the spread of the pandemic and prepare for future pandemics?

Recently, Blockchain technology has been the subject of wide consideration among industrialists and researchers, particularly after the appearance of Blockchain 2.0 and Blockchain 3.0. Blockchain distributed accounting technologies are very useful concerning the COVID-19 health crisis. Blockchain technology allows organizations and individuals from any area to become part of a single interconnected network that promotes the secure exchange of data. The use of blockchain consensus algorithms and smart contracts leads to a decrease in the distribution of false data and fraudulent information. COVID-19 medical data such as (decisions, cases, and patient health data) could be stored as a distributed ledger that produces a single, widely accessible source of information. These medical data records can be prepared using blockchain that offers features like validation, shared database, distributed trust, and immutable records [5]. Blockchains have two categories as shown in Fig. 2 [6].

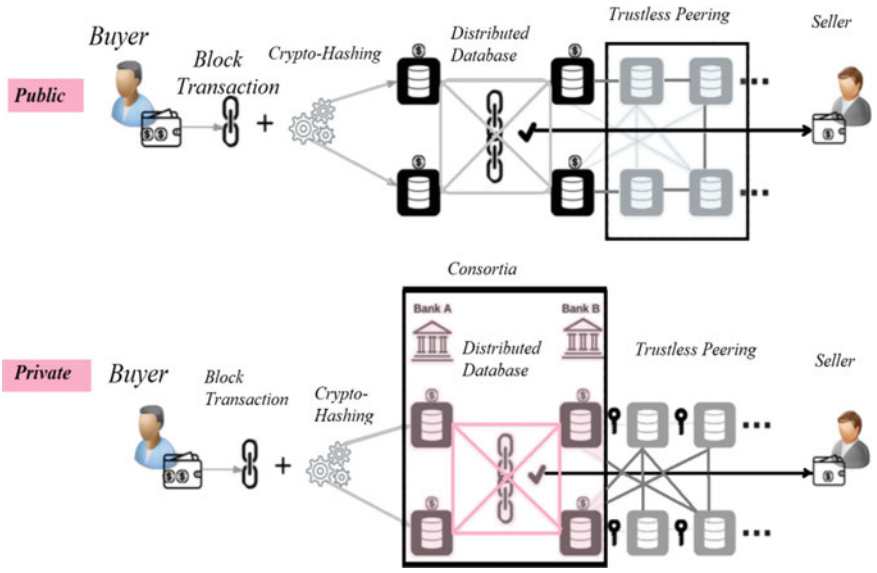


Fig. 2 Public versus private blockchain

Public blockchain: It is accessible (without permission) to everyone who can join and transact as well as participate in the agreement process. Public blockchain applications involve Ethereum and Bitcoin.

Private Blockchain: It is an invitation-only (with permission) network controlled by a central unit. A member must have permission to use a validation mechanism.

Simultaneously with the progress of blockchain, there are some innovative consensus algorithms, including the Byzantine Faulty Tolerant (BFT) and Proof of Participation (PoS). Blockchain has shown its benefit in healthcare applications. Consequently, it is likely to be implemented to solve health problems related to the coronavirus epidemic [7]. The first blockchain solution was HashLog which designed by the Georgia-based healthcare technology startup. The HashLog blockchain project was created to combat and control the spread of the coronavirus. Blockchain technology distributed ledgers ensures data logging and visualization of the coronavirus outbreak. HashLog probably offers real-time updates by tracking the movement of infected people. This allows health authorities to make decisions to fight additional infections [8]. Hyperchain is the subsequent blockchain solution for coronavirus [9]. Hyperchain has created a platform for tracking donations to help governments and healthcare institutions in China. Hyperchain can join millions of nodes where more users can reach donated and essential medical equipment. Also, this project helps to solve the lack of problems of the installation through the epidemic. VeChain is a blockchain-based platform that is designed to monitor vaccine production in China [10]. The project records and stores all activities relevant to vaccine manufacturing in the distributed books. These activities start from materials, codes to packages.

VeChain also offers a reliable method to decrease the risk of possible modifications of the vaccine information with a high-quality vaccine. Recently, Hao, et.al [11], proposed a blockchain-enabled contact tracking system called BeepTrace. The project adopts blockchain that connects the patient with authorized solvers to desensitize patient identification and location information. The proposed project records increased security and privacy with the added benefits of being battery-friendly and widely accessible.

2.2 Artificial Intelligence

AI is one of the emerging technologies that can quickly monitor the spread of the virus, classify high-risk patients, and is beneficial in regulating this infection in real-time. AI can further predict mortality risk by properly analyzing previous patient data. The fight against Covid19 through population detection, notification, medical help, and infection control suggestions can be done with the help of AI. This technology has the potential to enhance the competence of COVID-19 by focusing not only on patient treatment but also on disease control. AI has also been widely applied to find new molecules for COVID-19. Much research has been investigated using AI techniques to discover new medicines and drugs for the cure. Together with computer science researchers who focus on recognizing infectious patients by processing medical images such as CT and X-rays [12].

Many countries, such as Taiwan, inspired the national health insurance database with migration information and a customs database, thus confronting coronavirus patients for their symptoms and travel history. Also, at the beginning of the coronavirus outbreak, China focused on AI by using facial recognition cameras to track infected patients with travel history, drones to disinfect public places, and robots to deliver drugs and food.

Asif et al. [13], introduced a Deep Convolutional Neural Network (DCNN) model called "CoroNet" to automatically identify COVID-19 infection using chest X-ray images as shown in Fig. 3. The suggested model is based on Xception, which is a

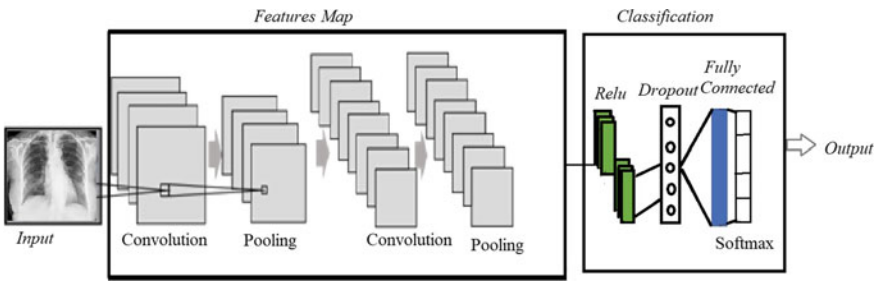


Fig. 3 DCNN structure for COVID-19

pre-trained architecture. CoroNet has achieved 98.2% accuracy for cases of 4 classes (bacterial pneumonia versus viral pneumonia versus COVID versus normal).

Pathak et al. [14], proposed a deep transfer learning classification model for patients with COVID-19. Cost-sensitive attributes with a two smoothing loss function are also employed to solve the noisy and unbalanced problems of the COVID-19 data set. The proposed technique achieves an accuracy of up to 93%. Ten popular [15] convolutional neural networks were adopted to recognize COVID-19 infection from non-COVID-19 societies. Among all networks, ResNet-101 achieved the most reliable performance. ResNet-101 achieved 99.51% accuracy.

The authors in [16] proposed an AI-based generative chemistry model to create innovative molecules that can repress COVID-19. Autoencoders and genetic algorithms were applied using molecular symbols to produce structures. Despite this, it is a hopeful approach since these AI models can exploit the great drug and automatically obtain valuable information from high-dimensional data. This method has a high potential to produce new drugs against COVID-19, as it is time-efficient and cost-effective.

The authors in [17] developed learning-based machine learning to predict the COVID-19 taxonomy. The proposed model used an unaligned method based on the decision tree approach and genomic signatures. The proposed method is a computationally economical approach that can provide a fast taxonomic classification of new pathogens by processing raw DNA sequence data.

2.3 Internet of Things Technology

Internet of Things (IoT) is a computing technology of interconnected digital and mechanical devices using the internet such as sensors, smart meters, health monitoring devices, home appliances, etc. These devices can sense, process, interact, and maintain the data transmission capacity through the defined network without any human participation as shown in Fig. 4. Each device in IoT is associated with an appropriate unique identification code. Furthermore, IoT participates in many daily applications such as smart lighting, smart home, and remote health monitoring, etc. [18].

IoT provides the integration and effective transfer of data between users and service providers. In the coronavirus epidemic, many problems occur due to ineffective accessibility to patients. Therefore, the adoption of IoT technology makes patient accessibility completely useful. IoT provides patients with remarkable care so they can have treatment safely.

In the era of advanced digital technology and the COVID-19 pandemic, the use of IoT in smart healthcare is taking on great importance in coping with the current situation. The IoT and, more especially, the Internet of Medical Things (IoMT) can offer a solution to the challenges of monitoring, detection, and control of this disease [19]. IoMT refers to a network of interconnected medical equipment and software

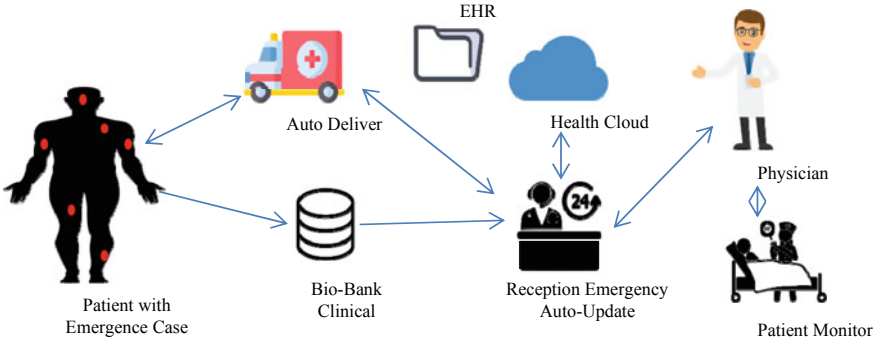


Fig. 4 IoT for healthcare

applications in the healthcare industry. One of the most emerging IoT applications is smart healthcare monitoring that is most relevant during this COVID-19 pandemic [19].

2.4 Big Data Technology

With the rapid expansion of IoT, there was a vast explosion of data generated from universal portable devices and sensors. The expansion of data volumes related to improvements in analytical techniques has led to the emergence of an era of big data. Big Data technology has been applied in a wide range of industrial application domains.

Healthcare where Automated Healthcare Records (EHR) are used using the application of smart analytics to assist medical services. Big data can be produced from various sources, such as IoT sensors, mobile devices, online social graphics, and public data in many forms, such as text or images or videos [20]. Big Data is characterized by three primary properties which called 3 V's and two additional properties (Veracity and Value) to become 5 V's as shown in Fig. 5 [21]:

- **Volume**: This feature explains the large volume of data that can vary from terabytes to exabytes.
- **Variety**: refers to the heterogeneity of the data.
- **Velocity**: refers to the data generation rate that can be estimated in the time or frequency domain.
- **Veracity**: This feature check the credibility, accuracy and quality of data sources for use.
- **Value:** This feature measures the usefulness of the data for decisions making.

Big data plays an important role in supporting the fight against infectious diseases COVID-19. Big data potentially offers promising solutions to help combat the

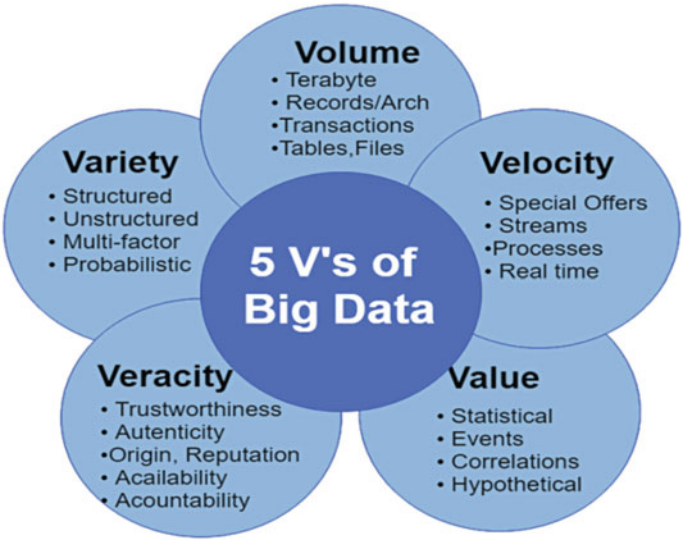


Fig. 5 Big data 5 V's characteristics

COVID-19 epidemic. Big data plays an important role in providing anti-COVID-19 strategies for drug manufacturing.

Li et al. [22], proposed a solution based on molecular coupling for drug investigations. The results proved that fifteen of the twenty-five approved medications exhibited significant inhibitory potencies and inflammatory responses and helped reposition the drug toward COVID-19. Another large data-based drug repositioning scheme was presented in [23]. The essential objective of this scheme is to implement ML to merge both the literature and the knowledge graph for the development of the COVID-19 vaccine.

The additional role of big data is tracking the spread of COVID-19. This is of utmost importance to successfully control the coronavirus pandemic [24]. Many recently emerging solutions have been introduced to assist in the process of monitoring the spread of COVID-19 using big data.

For example, the authors in [25] proposed a great data-based technique to track the spread of COVID-19. They used a large data set obtained from the China National Health Commission. Many linear models are constructed using the local population and air passengers to quantify the variance of the cases established in the cities of China. They applied a Spearman correlation analysis for daily user traffic. Another contribution on facilitate data acquisition and integrate heterogeneous data from health data resources is presented in [26]. The authors studied the fusion of large data for spatial analysis methods and Geographic Information Systems (GIS) technology.

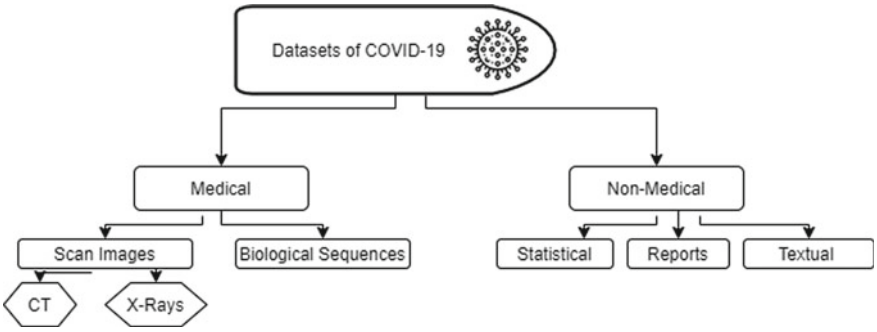


Fig. 6 COVID-19 datasets category

3 COVID-19 Datasets

This section reviews the most commonly available data sources of COVID-19. We can conclude that COVID-19 data sets are classified into two categories, medical and non-medical datasets as shown in Fig. 6.

The medical dataset includes images such as Chest (CT) or (X-ray) or biological sequences like genome. These data must preserve the privacy of patients. Non-medical data sets include daily reports and text data that include data from scientific articles and posts on social media such as Twitter. These data can be used to analyze common sentiment regarding the COVID-19 keywords and predict the COVID-19 spread rate for each region based on reported cases. Table 1 includes many sources of COVID-19 data sets used in scientific research and Fig. 7 displays samples of medical datasets.

4 Applications of Emerging Technologies in COVID-19

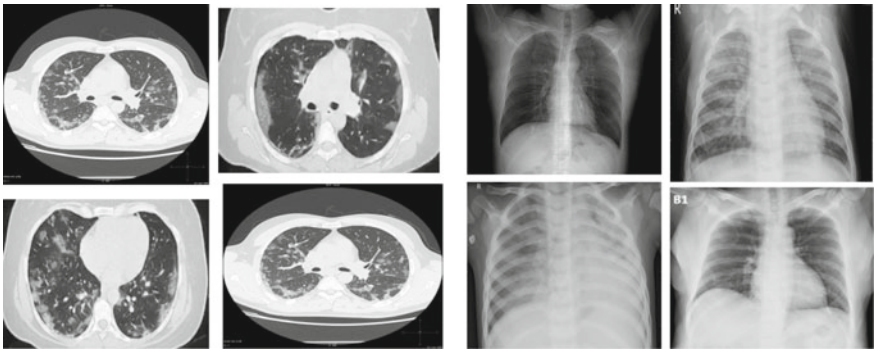
According to the WHO, digital technologies have many essential roles in promoting public health to combat the COVID-19 pandemic. In this section, we investigate the major applications of digital technologies to mitigate the disastrous effects of the COVID-19 pandemic as shown in Fig. 8.

4.1 Application of AI Against COVID-19

Considering its initiation, AI has confirmed to be a historic technological advance. AI becomes a very effective tool to face the COVID-19 pandemic. Below are some of the real and possible approaches where AI can help combat the COVID-19 pandemic:

Table 1 COVID-19 sources

Source	Type	Description
Medical		
[27]	X-ray and CT-scans	More than 125 images taken from various online patients
[28]	CT scans	Consisting of a total of 275 CT scans, including 183 positive and 146 negative cases
[29]	CT scans	A total of 453 confirmed cases from china hospitals
[30]	3D CT images	10 confirmed cases for scientific purposes
[31]	X-ray scans	A total of 13,800 chest radiography
[32]	X-ray scans	A total of 1341 images
[33]	SARS-CoV-2 sequences	NCBI GenBank
[34]	SARS-CoV-2 sequences	The GISAID Initiative
[35]	COVID-19 sequence database	China National GeneBank
Non-medical		
[36]	Twitter chatter	Georgia State University's Panacea Lab
[37]	Textual data	Measuring emotions
[38]	Articles	–
[39]	Statistical reported cases	–



(a) (b)

Fig. 7 Samples of **a** CT [30] Dataset and **b** X-Rays [32] dataset

Medical Detection and Diagnosis: Early treatment and prediction of COVID-19 are one of the most practical solutions for combating the coronavirus pandemic. Currently, the standard method is not adequate to meet the demands of rapid detection and monitoring during the COVID-19 pandemic. Since then, these techniques have often been expensive, time-consuming, and have a low true positive rate. An

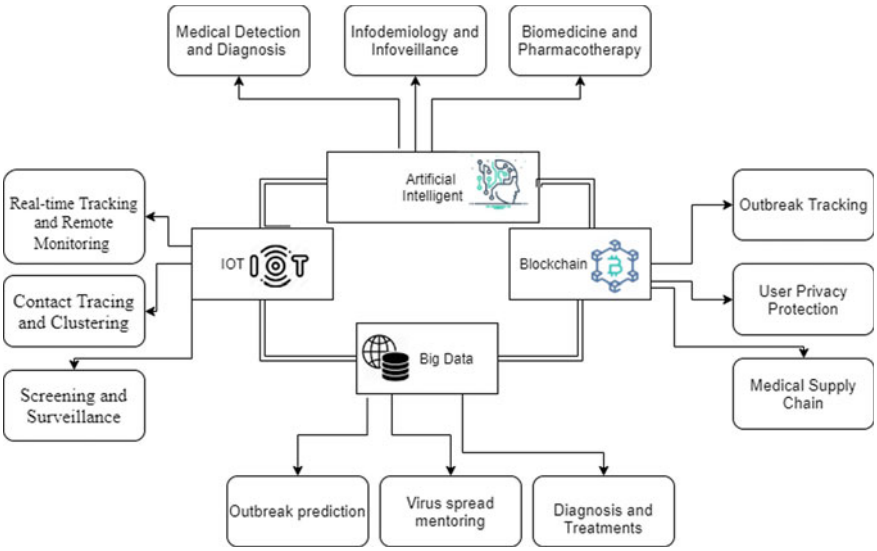


Fig. 8 Applications of emerginging technology for COVID-19

additional directive for COVID-19 detection is to employ AI methods for medical imaging processing and prediction, which has recently been developed in many investigations [40, 41].

Infodemiology and Infoveillance: The quality of information from social media platforms and the Internet is becoming very accessible, so further research can be done for the data collected and processed correctly. AI techniques have been used to produce a better understanding of the dynamics of social networks and to develop the COVID-19 situation [42]. AI applications in this area include:

- Track people's behavior using Twitter data.
- Search for health-seeking behavior of the COVID-19 explosion.
- Public attitude towards the COVID-19 revolution.

Biomedicine and Pharmacotherapy: The world has witnessed competition for efficient vaccines and treatments to combat the COVID-19 virus. This requires many efforts from health and computer science with the cooperation of AI. But, how could AI help biomedical research? The large volume of biomedical data has triggered the adoption of AI in various sectors of the biomedicine and pharmaceutical industries. Deep learning can manipulate unstructured and high-dimensional data with nonlinear relationships. These features are fitting with biomedical data like proteomics. Additionally, DL's capabilities in extracting top-level features make it a potential candidate for linking, analyzing, and understanding medical data heterogeneity like DNA microarray data. AI applications for biomedicine research include [43]:

- Genomic sequence analysis [44]
- Classification and prediction [45]

- Biomarkers [46]
- Structural biology and chemistry [47]
- Multiplatform data processing [48]
- Drug discovery and repurposing [49].

4.2 Application of IoT Against COVID-19

The health sector has recognized the potential benefits of IoT technologies due to its ability to process health data effectively. During the current COVID-19 pandemic, this section explores various IoT applications that have a potential impact on the COVID-19 pandemic.

Real-time Tracking and Remote Monitoring: The global daily real-time update in COVID-19 cases can be tracked using IoT technology. Daily updates incorporate the number of deaths, the number of patients cured, and the number of actual cases in different locations. The IoT aids doctors monitor the patient's health status remotely with medical data such as glucose level, heart rate, blood pressure level, etc. Real-time communication using IoT for medical data saves time and effort [50].

Contact Tracing and Clustering: The categorization and grouping area of the regions such as buffer zone, containment zones, red zone, green zone, orange zone, etc. it can be instantly updated based on the number of cases confirmed through IoT. The number of confirmed cases by location can be obtained in real-time when medical and healthcare systems are interconnected through IoT. The government can come up with these data and alert about health check-ups in the affected area and this can be done quickly [51].

Screening and surveillance: Facial recognition data based on thermal images can be obtained by the public and health authorities through IoT at multiple entry positions of airports, railway stations, etc. for detection and surveillance purposes. This automatic surveillance of suspected and determined cases can serve to regulate the extent of the infection [52].

4.3 Application of Big Data Against COVID-19

The escalation of big data in the healthcare sector revolutionized the medical industry by affording better patient health information. In these paragraphs, some big data applications regarding COVID-19 are provided.

Outbreak prediction: Big data has a major role in fighting COVID-19 for its significant ability in predicting the outbreak of large-scale data analysis. The outbreak prediction can be found in using the public dataset to visualize geographic areas with a possible outbreak [24].

Virus spread mentoring: Big Data is important in the process of monitoring the spread of COVID-19. That is a prevailing concern not only for healthcare organizations but also for governments in the successful management of the coronavirus pandemic. Currently, several recently emerging solutions that employ big data have been proposed to help track the spread of COVID-19 [53].

Diagnosis and Treatments: Big Data can be used to support the diagnostic and treatment processes of COVID-19. Regarding the diagnosis and treatment of COVID-19, Big Data has implemented many solutions, such as multiplex polymerase chain reactions that can diagnose SARS-CoV-2 and a method of molecular diagnostic for genomic analysis of SARS-CoV-2 strains [54].

4.4 Blockchain Applications Against COVID-19

In recent years, blockchain has got substantial attention from the healthcare industry. Blockchain has gained interest to improve transparency and authenticity of healthcare data starting from obtaining electronic health record permits to streamlining claims processing. This section discusses different applications of blockchains for the crisis.

Tracking of Outbreak: Blockchain can afford probable solutions to track the coronavirus outbreak. Certainly, blockchain can present data visualization tools for dangerous coronavirus monitoring. In the epidemic of coronavirus, blockchain is viable to preserve the thousands of victims of COVID-19 by immutably saving the signs of infection of the patients. Additionally, it can track patient bits, direct combat efforts, and store real-time data of affected regions. Tracking the spread of coronavirus is highly essential for since some patients can voluntarily report wrong their symptoms for bypassing hospital appointments. This could drive to patient quarantine failure. Blockchain helps governments and healthcare organizations monitor potential patients with high reliability, safety, and precision at every stage [55].

Protection of User privacy: In emergencies similar to coronavirus pandemics, patient privacy must be balanced with other concerns, such as protecting lives. Equalizing the value of supporting public care in the fight against central viral infections and the power to protect the privacy and individual rights of individuals is paramount to any health policy in this epidemic. Blockchain is an insurance solution to address privacy guarantee concerns during coronavirus combat. Blockchain can track data operations to uncover any illegal access or malicious use of data [56].

Medical supply chain: In this pandemic emergency, having an endless number of medicine and food stores has become a demand for the health sector. Blockchain technology can enhance supply chain partnerships by realizing a rapid flow of supply by tracing the flow from origins to the target in a committed and reliable way. Lately, China has developed a blockchain-based platform that allows people to follow the market and supply chains of medical supplies. This consists of reporting and tracking coronavirus-fighting materials, such as gloves, masks, and other emergency equipment. Therefore, while an outbreak happens, fast response and quick supply chain are the essential weapons governments have to catch the problem [57].

5 Challenges

Despite the various benefits that emerging technologies can contribute to health crises, such as the COVID-19, they are challenged by many limitations and certain challenges as shown in Fig. 9.

5.1 Shortage of Standard Datasets

Significant challenges arise from the absence of standard and large data sets. However, The authors in [58, 59] have applied the GAN network to overcome the limited size of datasets by producing more X-rays images for COVID19 detection with high detection accuracy, more datasets are required. Since then, many algorithms and technology platforms have been introduced, but they have not experimented with the same data set. To use the features and applications of emerging technologies as reliable real-time solutions to combat the COVID-19 virus, standard data sets are required [60].

Fig. 9 Main challenges for fighting COVID-19

5.2 Regulation Reflection

Government authorities play an important role in determining policies that can support the participation of various entities and overcome any barrier and restriction on how to stop the COVID-19 disease. Since the explosion of confirmed cases, many strategies have been practiced to regulate this explosion. These strategies include social distancing, large-scale testing, and confinement. Consequently, the adoption of emerging technologies, e.g. IoT, blockchain, Big-data, and AI in the fight against coronaviruses must be carefully studied with regulatory laws. While these technologies may cause advantages, they also pose legal challenges. Especially legal issues related to personal information should be considered, such as concerns with copyright defamation [61].

5.3 Security

The security of personal data is still necessary and should be reviewed. In the Covid19 pandemic, authorities can ask people to share their personal information, such as CT scans and diagnostic reports that require up-to-date policies and prompt monitoring. There is a tradeoff between security, privacy, and performance. However, Blockchain is popularly considered as a secure platform for health applications. Modern research has shown blockchain security weaknesses that are relevant to healthcare systems, such as alterations of patient data information or medical transactions, increasing privacy concerns [62].

5.4 Privacy Preservation

In coronavirus tracking apps, preserving people's privacy is extremely crucial. Governments can use mobile location to better track the spread of the virus blast. This solution should guarantee the privacy of user data. Government agencies may force privacy laws on user tracking to ensure public safety. Many healthcare organizations are now collecting patient data through electronic healthcare records. In these healthcare activities, the dispute between data collection and user privacy is necessary and must be resolved by laws and the reinforcement of related authorities [63].

6 Future Directions

Finally, current future directions and trends to investigate emerging technologies in the evolution of the health crisis are discussed in these paragraphs as shown in Fig. 10.

6.1 Covid19 Datasets

Currently, the available Covid19 data sets are saved in different formats and criteria. This could limit the extent of research contributions using emerging technologies. Therefore, the future direction is to create free benchmarking COVID-19 data sets. These benchmarks must be created according to standard protocols. Repository data sets are essential as they will help accelerate beneficial findings to incur the disease. Additionally, the available data sets are limited in size. Larger data sets are demanded to allow more useful insight and precision for deep learning algorithms in the diagnostic process. Different metrics are used for evaluation purposes. Consequently, there is a great need to generate a reference data framework. This framework will be used for evaluating and comparing existing methods. Furthermore, it should assist in universal data sets, including corresponding patient bands, data preprocessing methods, and evaluation criteria for all methods that are estimated.

6.2 AI Against Covid19

Enhance artificial intelligence algorithms for more useful analytical precision: The effectiveness of intelligent data analysis in healthcare is essentially dependent on

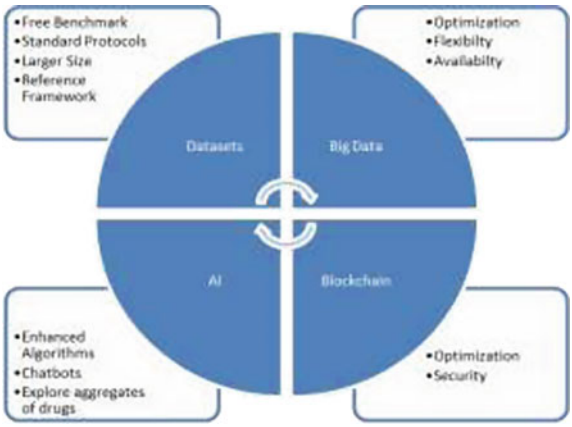


Fig. 10 Future direction of emerging technologies

artificial intelligence algorithms. Improving AI models focused on medical applications could be the solution to give the facility and the ability to manipulate multimedia healthcare data. Future research investigations are essential required in AI models. These investigations contribute to the differentiation of COVID-19 and other pneumonia types. Additionally, they could help clinicians and radiologists become aware of the virus' insight and explore upcoming coronavirus X-ray and CT images more productively. Chatbots systems can be developed using AI and NLP technologies. These chatbots can remotely allow people and patients to discuss coronavirus. Furthermore, AI can be employed on social media platforms to exterminate fake news and ensure accurate and reliable information. In the fields of medicine and biology, AI has been applied to recognize COVID-19 and explore different aggregates of drugs against the virus. AI can encourage scientists to become aware of the coronavirus quickly.

6.3 Blockchain Against COVID-19

Blockchain optimized for better implementation: Blockchain platforms' factors need to be optimized for more reliable returns. These factors include higher performance, reduced network latency, and increased security. Optimized factors can assist blockchain to become a perfect choice for healthcare emergency applications, especially the COVID-19 virus.

6.4 Big Data Against COVID-19

Since big data is the key to development, the optimization of big data algorithms for better diagnosis and treatment of COVID-19 by improving the precision and reliability of data analytics.

6.5 Merge with Other Emerging Technologies

To achieve greater efficiency in solving problems related to the epidemic, blockchain, Big Data, and AI could be incorporated with other technologies such as 5G and Drones to offer new practical solutions for fighting COVID-19 and create a complete healthcare system. Many efforts have been investigated in the way of improving solutions to provide more precise COVID-19 [64] prediction. Considering the COVID-19 outbreak, many tech Solutions have been offered to alleviate its impact. Nonetheless, to obtain the transformative potential of these technologies, there is a great need for a cellular network. This network can overcome the latency, bandwidth, and flexibility

issues essential to today's network technology. Finally, some possible future directions have been pointed out. This chapter will shed valuable light on researching digital technologies to fight COVID-19. Also, it will motivate researchers to make more efforts to combat future coronavirus-like epidemics.

7 Conclusion

Emerging technologies provide comprehensive functions and efforts for healthcare to compete and alleviate the impact of the COVID-19 pandemic. In health crises, these technologies are useful for maintaining quality surveillance with real-time information. Technologies adopted in this study in terms of diagnosis, monitoring, tracking, prediction, and treatment of COVID-19. Modern developments have shown that collaboration between medical researchers, government authorities, and engineers is essential to the evolution of rapid and less expensive approaches to tackling the pandemic. We started with a comprehensive review of the characteristics of emerging technologies, methodologies, and the contributions of researchers for fighting against the COVID-19. Following this, a concise discussion of the challenges and future directions of emerging technologies to eliminate the disastrous impact of COVID-19 are presented. Research communities and healthcare specialists must continue to collaborate and share experience to provide quick solutions in crisis. Recognized treatments using emerging technologies must also support standard clinical trials.

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