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Said Ali Hassan
Ali Wagdy Mohamed
Khalid Abdulaziz Alnowibet *Editors*

Decision Sciences for COVID-19

Learning Through Case Studies

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Editors
Said Ali Hassan
Department of Operations Research and Decision Support, Faculty of Computers and Artificial Intelligence
Cairo University
Giza, Egypt

Ali Wagdy Mohamed
Department of Operations Research, Faculty of Graduate studies for Statistical Research
Cairo University
Giza, Egypt

Khalid Abdulaziz Alnowibet
Department of Statistics and Operations Research
King Saud University
Riyadh, Saudi Arabia

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Preface

Managers, researchers, and interested readers in all disciplines especially those related to the transportation of people, materials, and products from one place to another face an endless list of complex issues every day. They must make the appropriate and most beneficial decisions about each activity they make. One of the essential managerial skills is the ability to allocate and utilize limited resources appropriately for achieving the optimal performance efficiently and, ultimately, to use the most appropriate scientific tools in various disciplines to achieve the desired objectives. That is why "decision sciences" appear at the top of the list that everyone interested in this field needs.

"Decision sciences" is a collaborative approach involving mathematical formulae, business tactics, technological applications, and behavioral sciences to help senior management and practitioners make scientific-driven decisions. Such approaches along with up-to-date technology will help businesses execute various processes in a smoother and better way. These approaches also help in day-to-day operations and projections; they will make it easier for business leaders to make smarter and more efficient decisions that will improve their work performance and the functioning of the overall marketplace. Ultimately, the decision sciences are about enhancing individual, group, organizational, societal, and national decision making in support of a better future.

This book aims to provide relevant theoretical and practical frameworks and the latest research findings in the domain of decision sciences and applications for disaster risk reduction of COVID-19. It is written for researchers, executives, and practitioners who want to enrich their scientific and practical knowledge and improve their understanding of the decision-making process in facing real-world problems in reducing the emerging disaster risk of COVID-19.

The used modern and up-to-date decision sciences techniques will make it easier for business leaders and managers in the government and in the health sector to make smarter and more efficient decisions that will improve the firms' functioning and performance.

The target audience of this book are composed of researchers, professionals, leaders, managers, and executives working in the field of decision sciences and applications in most of the application areas especially in the field of COVID-19 and similar pandemics. The book is appropriate and helpful for individual, group, organizational, and societal decision makers seeking for making better decisions and achieving optimum solutions to real-life problems. The diversity of the contained chapters related to multidisciplinary decision sciences and applications topics will benefit researchers and practitioners facing real-world problems who seek to optimize their decision-making process and enhance the performance of their works for a better future.

Giza, Egypt — Said Ali Hassan
Giza, Egypt — Ali Wagdy Mohamed
Riyadh, Saudi Arabia — Khalid Abdulaziz Alnowibet

Acknowledgment

The editors would like to acknowledge the help of each one of the respected authors involved in this book who contributed their time and expertise to this valuable work.

The editors would also like to acknowledge the valuable contributions of all the reviewers regarding the improvement of quality, intelligibility, and content presentation of the enclosed chapters.

Without the support of all mentioned persons, this book would not have become a reality; we highly appreciate their contribution.

Introduction

In December 2019, Wuhan, China was the origin of a pneumonia of unknown cause. Cases of COVID-19 were not limited to this city, and by January, confirmed cases were detected outside Wuhan. Currently, the entire world is suffering from a global epidemic of COVID-19 that has infected thousands of people in almost all countries.

Currently, the entire world is suffering from a global epidemic of COVID-19 that has infected millions of people in almost all countries. The new coronavirus (COVID-19) put humans in all countries in front of a huge danger. The major signs of COVID-19 are declared so that any individual can discover whether or not he has such symptoms.

Updated statistics indicate clearly that the current and the near future situations are not quite right in such a way that foreshadows a catastrophe for many countries of the world, if the situation continues as it is now and if strict measures are not taken at the level of governments and people.

The pandemic of coronavirus has become the talk of the whole world, and it will remain so in the coming period because of the imminent danger it poses to humanity in all countries of the world.

It is very important that this worldwide focus draw the attention of scientists and researchers in the field of optimization to the effective contribution in the optimal utilization of available resources and optimal decision making to help in reducing the emerging disaster risk of COVID-19.

In this book, authors of chapters utilize the applications of decision science techniques and tools in combating against the epidemic of COVID-19 to stand up and face the various challenges facing the whole world.

The new applications of decision science techniques can be regarded as a continuously emerging field in all areas of interest including this very important area of coronavirus pandemic which has become the focus of attention of the whole world. Managers in all disciplines face an endless list of complex issues every day. They must make decisions about each activity they make. One of the essential managerial skills is the ability to allocate and utilize limited resources appropriately in the efforts of achieving the optimal performance efficiently.

Decision sciences use a number of mathematical techniques to solve problems in all fields of study. It is helpful to aid in making decisions to achieve desired objectives and help managers do their jobs more effectively. These techniques help managers allocate resources more effectively and enable them to better optimize the performance of their works. They allow people to analyze a greater number of alternatives and constraints which results in greater confidence in the optimal choice.

The advancements in decision sciences theory and applications can be regarded as a continuously emerging field in all areas of interest including technology, industry, energy, healthcare, education, agriculture, social sciences, and others. Managers in all disciplines face an endless list of complex issues every day; they must make decisions about each activity they make. One of the essential managerial skills is the ability to allocate and utilize limited resources appropriately in the efforts of achieving the optimal performance efficiently.

Quantitative approaches use a number of mathematical techniques to solve problems in all fields of study. It is helpful to aid in making decisions to achieve desired objectives and help managers do their jobs more effectively. These techniques help managers allocate resources more effectively and enable them to better optimize the performance of their works. The mathematical models allow people to analyze a greater number of alternatives and constraints which results in greater confidence in the optimal choice.

Quantitative techniques are the most widely applied methods; they play an important role in the operation of problem solving and this importance is likely to increase, creating the opportunity to play an even greater role. With the recent dramatic improvements in the real-time availability of computer speed and evolving of new exact and approximate solution techniques, this role will increase.

It is very necessary that this draws the attention of scientists and researchers in the fields of decision sciences and supporting decision making to the effective contribution in the optimal utilization of available resources and optimal decision making to help in contributing to the theory and in facing the real-world problems.

List of topics of decision sciences includes mathematical modeling; linear, nonlinear, integer, binary programming models; multi-criteria decision making; network optimization models; project management; game theory models; queueing theory models; inventory theory models; stochastic models; decision making under uncertainty and risk; decision support systems; modeling and simulation; statistical models; forecasting techniques; metaheuristic techniques; heuristic techniques; artificial intelligence and machine learning; data analytics; operations management; crisis management; risk management; supply chain management; business decision-making problems; leadership decision making; strategic planning; innovation and creativity; and behavioral decisions.

To this end, we included high-quality original submissions to this book that reflect the unprecedented momentum garnered by this research area.

Organization of the Book

The book is organized into seven parts with 25 chapters. Parts are as follows:

Part I: Artificial Intelligence
Part II: Forecasting Techniques
Part III: Social Sciences
Part IV: Optimization Techniques
Part V: Data Science
Part VI: COVID-19 Detection
Part VII: Economy

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About the Editors

Said Ali Hassan received his Ph.D. degree in Informatics from National Institute Polytechnic, Toulouse, France, 1981. He received two M.Sc. degrees in Operations Research Applications, Military Technical College, Cairo, Egypt, 1974, and in Management Development, Euro-Arab Management School, Granada, Spain, 2000. He received his B.Sc. degree from the Military Technical College in Cairo, Egypt, in 1971.

He is a full professor in the Department of Operations Research and Decision Support, Faculty of Computers and Artificial Intelligence, Cairo University, Egypt.

Prior to his current position, he was a staff member in the Military Technical College, Cairo, from 1971 to 1993. He was the Chairman of Operations Research Department in Maritime Research and Consultation Center (MRCC), Arab Academy for Science and Technology, Alexandria, Egypt (1993–1994). He was the Chairman of Operations Research and Decision Support Department in the Faculty of Computers and Artificial Intelligence, Cairo University (2000–2003). He was the Vice Dean, Arab Development Institute, Jeddah, Kingdom of Saudi Arabia (2004–2005). He was professor at the Industrial Engineering Dept., Faculty of Engineering, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia (2005–2018).

He has field experience in working as Scientific Manager, International Center for Systems (ICS), Zamalek, Cairo, Egypt (1986–1996); Member of the Board of Directors of the Higher Institute of Computer Science and Information Systems, 6th of October City,

Egypt, 1998; Member of the Board of Directors of the Faculty of Information Systems and Computer Science, 6th of October City, Egypt, 1999; Training Manager, Pyramids Computer Center (PCC), Nasr City, Cairo, Egypt (2001–2004); Member of the Founding Committee of Engineering Faculty, Northern Borders University, Saudi Arabia, 2009; and Member of the Academic Accreditation Committee, College of Engineering, King Abdulaziz University, 2009.

He serves as an editor and as a reviewer for many international accredited journals; he published more than 110 research papers in national and international journals and conferences, supervised more than 60 M. Sc. and Ph.D. theses in Egypt and Saudi Arabia, and participated as a PI and Co-PI in more than 30 funded projects.

His research interests lie broadly in operations research, optimization, decision sciences, forecasting, management science, strategic management, and modeling and solving of real-life applications.

Ali Wagdy Mohamed received his B.Sc., M.Sc., and Ph.D. degrees from Cairo University, in 2000, 2004, and 2010, respectively. Ali Wagdy is an Associate Professor at Operations Research Department, Faculty of Graduate Studies for Statistical Research, Cairo University, Egypt. Currently, he is an Associate Professor of Statistics at Wireless Intelligent Networks Center (WINC), Faculty of Engineering and Applied Sciences, Nile University. Recently, he has been recognized among the top 2% scientists according to Stanford University report 2019. He serves as a reviewer of more than 70 international accredited top-tier journals and has been awarded the Publons Peer Review Awards 2018, for placing in the top 1% of reviewers worldwide in assorted fields. He is an associate editor with *Swarm and Evolutionary Computation Journal*, Elsevier. He is editor of more than 10 journals of information sciences, applied mathematics, Engineering, system science, and operations research. He has presented and participated in more than 5 international conferences. He participated as a member of the reviewer committee for 35 different conferences sponsored by Springer and IEEE. He has obtained Rank 3 in CEC'17 competitions on single

objective bound constrained real-parameter numerical optimization in Proc of IEEE Congress on Evolutionary Computation, IEEE-CEC 2017, San Sebastián, Spain. Besides, he obtained Rank 3 and Rank 2 in CEC'18 competitions on single objective bound constrained real-parameter numerical optimization and competition on large scale global optimization, in Proc of IEEE Congress on Evolutionary Computation, IEEE-CEC 2017, Sao Paolo, Brazil. He has obtained Rank 2 in CEC'20 competitions on single objective bound constrained real-parameter numerical optimization in Proc of IEEE Congress on Evolutionary Computation, IEEE-CEC 2020, UK. He has published more than 70 papers in reputed and high impact journals like *Information Sciences*, *Swarm and Evolutionary Computation*, *Computers & Industrial Engineering*, *Intelligent Manufacturing*, *Soft Computing*, and *International Journal of Machine Learning and Cybernetics*. He is interested in mathematical and statistical modeling, stochastic and deterministic optimization, swarm intelligence, and evolutionary computation. Additionally, he is also interested in real-world problems such as industrial, transportation, manufacturing, education, and capital investment problems. 2 Ph.D. and 1 master's degrees have been completed under his supervision.

Khalid Abdulaziz Alnowibet was born on 1971, Riyadh, Saudi Arabia. Mr. Alnowibet got his B.-Sc. degree in Operations Research in 1992 from the College of Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia. In 1994, Mr. Alnowibet moved to the USA to get his M.Sc. degree in Operations Research from the School of Engineering and Applied Sciences, George Washington University, Washington DC, USA. In 2004, Mr. Alnowibet got his Ph.D. degree in Operations Research, School of Engineering, North Carolina State University, North Carolina State, USA. His dissertation title was "Nonstationary Loss Queues and Network of Nonstationary Loss Queues." Mr. Alnowibet published several papers in several research areas related to operations research such as Performance Evaluation Using Stochastic Modeling, Queueing Networks Applications, Queueing Theory and Applications, Stochastic Processes Theory and

Applications, and Modeling Communication Networks. Mr. Alnowibet now is an associate professor at King Saud University, Department of Operations Research, for more than 15 years. During his service in the university, Mr. Alnowibet was appointed to several key administrative positions in the university. He also supervised graduate students and participated in defending many theses.

Part I
Artificial Intelligence

Chapter 1
Application of Artificial Intelligence and Big Data for Fighting COVID-19 Pandemic

Joseph Bamidele Awotunde, Sakinat Oluwabukonla, Chinmay Chakraborty, Akash Kumar Bhoi, and Gbemisola Janet Ajamu

Abstract The coronavirus (COVID-19) pandemic is playing sensitive havoc in socio-communal systems, humanity and creates economic crises worldwide. Many strategies have been used to managed and curtailed the COVID-19 outbreak, but many countries are still helpless in fighting and containing the outbreak. In an increasingly knowledge-driven, healthcare innovation, and linked society, fighting COVID-19 becomes easier. The Big Data drives the digital revolution by providing solutions focused on big data analytics empowered by Artificial Intelligence (AI) to reduce the difficulty and cognitive burden of accessing and processing large quantities of data. Hence, big data and AI can have been applied in fighting COVID-19 pandemic since the use of both technologies empowered Big Data Analytics (BDA) and yielded imaginable results in combating infectious diseases globally. Therefore, this paper reviews the applicability and importance of AI and Big Data methods to data produced from the countless ubiquitously connected healthcare devices that produced entrenched and distributed information handling capabilities in fighting

J. B. Awotunde (✉)
Department of Computer Science, University of Ilorin, Ilorin, Nigeria
e-mail: awotunde.jb@unilorin.edu.ng

S. O. Folorunso
Department of Mathematical Sciences, Olabisi Onabanjo University, Ago-Iwoye, Nigeria
e-mail: sakinat.folorunso@oouagoiwoye.edu.ng

C. Chakraborty
Department of Computer Science and Engineering, Birla Institute of Technology, Mesra, Jharkhand, India
e-mail: cchakrabarty@bitmesra.ac.in

A. K. Bhoi
Department of Electrical and Electronics Engineering, Sikkim Manipal Institute of Technology (SMIT), Sikkim Manipal University (SMU), Majitar, Sikkim, India

G. J. Ajamu
Department Agricultural Extension and Rural Development, Landmark University, Omu-Aran, Nigeria
e-mail: ajamu.gbemisola@lmu.edu.ng

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COVID-19 outbreak. In the area of managing big data for real-time diagnosing, monitoring, and treating COVID-19 patients, AI enabled with big data analytics has shown tremendous potential. The technologies can also be used in the development of drugs and vaccines within the shortest of time, more than ever before.

Keywords Artificial intelligence · Coronavirus · Big data analytics · Healthcare system · Decision science

1.1 Introduction

The world has changed significantly due to the spread of the Coronavirus Disease-19 (COVID-19) outbreak; this is not only affect the healthcare industry but the whole aspects of human life like education, economics, transportations, politics, among many others (Pham et al. 2020a). For instance, many school was closed globally due to this deadly pandemic, various companies and organization has to send their staff home because of the fear of COVID-19 transfer from one person to another. Several countries have to change their date of elections because of the COVID-19 outbreak, various other activities of human endeavors were also affected by the pandemic. As at the time of writing this chapter, there have been 127,877,462 confirmed cases, with 2,796,561 deaths affecting 215 countries around the world, as recorded on World Health Organization website as of 29 March 2021, and a total of 520,540,106 vaccine doses have been administered.

The transmissions of COVID-19 in human-to-human makes it much more treacherous, deadly, and easily spread than other infectious disease families. The National Health Commission of China has identified droplets, direct exposure, feces, respiratory aspirates, and aerosols transmission as a carrier of COVID-19 pandemic (Liu et al. 2020a). According to the recent report, ages between 30 and 79 years, approximately 86.60% are susceptible to COVID-19 pandemic of all patients infected so far, thus have a median age of 47 years (Guan et al. 2020). Though researches have not reported significant gender preponderance, the men are noted to exhibit a higher propensity for this outbreak (Wang et al. 2020a). Although research has not provided concrete evidence about sporadic reports about the vertical transmission of SARS-CoV-2 it has been shown that these also can be a possible way of spread COVID-19 (Kannan et al. 2020).

The efforts, assistance, and collaboration between various nations and several organizations are significantly reducing the risks and the spreading COVID-19 outbreak. For instance, Google as a search engine giant launched a COVID-19 website (ww.google.com/covid19) use for gathering useful information like frequently asked questions on COVID-19 pandemic, latest statistics, and COVID-19 map. Also, the effort of the White House in collaborations with organizations like Google, Amazon, IBM, and Microsoft designed a supercomputing system on importance researches for the COVID-19 pandemic (Wong et al. 2019). Also, various giant publishers like Elsevier and Springers offer free access to related articles on the

COVID-19-like pandemic with technical standards and other related documents on the outbreak and archival websites like bioRxiv, medRxiv, and arXiv enabled fast access to all preprints researches on COVID-19 pandemic (Lu et al. 2018).

The introduction of modern technologies has been a blessing to various fields of studies like Artificial Intelligence (AI) and Big Data (BD) in the healthcare system, AI-banking, AI-agriculture, AI-computer science, and AI-transportations, etc. The advancement of AI with various integration of devices and systems has achieved significant success in dealing with the challenges of infectious diseases like influenzas (Jang et al. 2016), SARS (Kim et al. 2016), and MERS (Brown et al. 2015). Hence, AI with Big Data can play prominent role in the global fight against the COVID-19 outbreak. In building a robust system that can be used for diagnosis, monitoring, forecast, and providing the vaccine for fighting the COVID-19 outbreak, AI plays a crucial role. The integration of several systems and devices enabled with AI mechanisms in designing various applications would require AI techniques like computational modeling, data analytics, and most importantly, machine learning models a major powerful subfield of AI. Different efforts have been made in developing systems and applications that use AI models for combatting COVID-19 outbreaks. AI makes use of the present and past data to predict patterns, actions, and activity in the future; hence, the prediction can be rendered using statistical analysis, automated AI, and quantitative questions (Adeniyi et al. 2021a). The use of AI in BDA has resulted in a knowledge-based system that transformed Big Data into big Knowledge with new approaches and visions to provide people with better understanding and information driven results (Awotunde et al. 2021c).

The Internet of Things has found it way into the healthcare systems, and the medical version is the Internet of Medical Things (IoMT). The IoMT-based devices are used to gathered huge BD, and this collected data can be used to predict and diagnose any type of disease provided that the capture data are related to the disease in question. The use of AI instruments from data collected using IoMT-based devices will create a meaningful result for both medical experts and their patients. This has resulted in the development of the wearable application that progressively adds an AI engine inside medical applications using wearable tools. Furthermore, AI aided the creation of an intelligent medical care platform using collected smartphones, IoT gadgets, websites, and wearables devices to capture data and provide fascinating decision-making for medical experts and their patients (Ahmed et al. 2020; Rodgers 2020).

The population-based researches enabled with data computing, and AI gives easy access to the big data generated in the healthcare systems; the capture data in this regard are Big Data (Priyanka and Kulennavar 2014). For researches in clinical and public health to make a great impact, there is a need for an improvement in healthcare researches for better and oriented results that will surpass the traditional methods in the healthcare system. The BD operation is very diverse from conventional treatment-oriented and narrow statistical analysis-based clinical data. Hence, it is now becoming expedient to solely depend on BD for accurate results in a heterogeneous population in the healthcare system (Abiodun et al. 2021). The use of AI on the generated Big Data has swift research environment with quick

advancement in computing technology combine collected data for making useful decision-making, and to reduce their complexity (Oussous et al. 2018).

The virtualization approach provided by cloud computing allows effective data processing on the Big Data generated from medical devices, thus turn the medical sectors into a BD generations production. Nevertheless, the great improvement in modern technologies coupled with the generation of data from various sources has greatly helped in the creation of BD in the healthcare system in recent years. The healthcare industries are in the era of BD, touching every aspect of human life, especially in the areas of patient diagnosis, monitoring, and treatment in this twenty-first century (Olaronke and Oluwaseun 2016). The moving away from conventional medical records to Electronic Health Record (EHR) systems has resulted in an unprecedented increase in generated data in the healthcare system (Hulsen et al. 2019).

To make evidence-driven decisions-making in enhancing patient diagnosis, monitoring, and treatment, BD has been proved very useful and offers the great prospect for consultants, epidemiologists, and specialists in medical fields (Austin and Kusumoto 2016). In the search for new knowledge by medical experts, the BD paradigm is an imperative weapon that needs grasped and seen as a modern reality in the healthcare industry (Galetsi et al. 2019). Therefore, this chapter discusses the possible application of AI and Big Data to tackle the COVID-19 pandemic by improving conventional approaches using to diagnose, control, manage, and identify infected patients (Awotunde et al. 2021d). The various applicability and challenges of using AI and BD were also discussed in this chapter. The use of AI and Big Data has been identified as a weapon to fight the COVID-19 outbreak globally (Awotunde et al 2021d).

Overall, AI is used to classify, monitor, and anticipate occurrences, as well as assist in virus diagnosis. It is used in the analysis of health services. Drones and robots are used to distribute food and drugs, as well as to disinfect public spaces. Using supercomputers, AI is assisting in the development of drugs and a coronavirus vaccine (Lacroix 2019). AI is also designing detection technology, such as surveillance wristbands, to aid in the identification of people who are breaking the prohibition law. Fever and contagious patients can also be detected using mobile devices and Automation thermal cameras (Bullock et al. 2020a). Several scientists are using AI to discover new treatments and therapies for cures, with some software engineers concentrating on identifying contagious patients using biomedical imaging techniques like X-rays and CT scans (Nguyen 2020). Countries such as Taiwan have integrated their public healthcare insurance database with data from immigration and customs, revealing COVID-19 patients based on their travel history and symptoms (Bhattacharya et al. 2021). To fight the COVID-19 outbreak, AI focuses primarily on patient and virus identification, radiology, disease monitoring, and assessment. On the other hand, it also involves internet-based alerting, public knowledge, and social regulation.

The contribution of the chapter is as follows: The chapter presents the effectiveness use of AI and BD in combatting COVID-19 outbreak; related state-of-the-art papers that used these two technologies are discussed. The challenges and associated

issues with AI and BD techniques are presented to understand their applications better. Some papers from several sources like Elsevier, Springers, IEEE Xplore, and some preprints archived websites are reviewed for a better understanding of their applications. The remaining part of this chapter is organized thus: Sect. 1.2 discusses the application AI to fight COVID-19 Pandemic. Section 1.3 presents applications of BD and analytics to battle the COVID-19 pandemic. Section 1.4 discusses the problems of using AI and BD to combat the COVID-19 Pandemic. Finally, Sect. 1.5 concludes the chapter.

1.2 Applications of Artificial Intelligence in Combat COVID-19 Pandemic

In the battle against the COVID-19 outbreak, AI has been proved useful and allows computer-based models for diagnosis, monitoring, treatment, and used for optimization utilizing Machine Learning, machine vision, natural language processing, robotics, and automation for the development of the useful applications. Also, AI is very useful in the areas of pattern recognition, forecasting, description, and classification of medical data. COVID-19 infections are being predicted, diagnose, forecasted, treat, and optimized to generate useful decision-making by the medical experts, government, and other policymaking by AI and data science researchers. AI cannot substitute scientific knowledge, but it can help with COVID-19 patient detection, predicting, preventing, and monitoring outbreaks, sterilizing environments, assisting in the production of immunotherapies and therapies, health administration, business, and trade, greater accountability and policymaking, and more. Figure 1.1 shown some areas of applicability of AI-based models during the COVID-19 pandemic.

1.2.1 The Diagnosis and Prediction of COVID-19 Outbreak Using Artificial Intelligence

The early diagnosis and prediction of the COVID-19 outbreak are one of the effective and prominent ways of combating the pandemic. The reverse transcription polymerase chain reaction (RT-PCR) detection technique is currently the gold standard for classifying respiratory viruses. There have been various works in response to the COVID-19 outbreak, and some work has gone into improving this strategy (Rao and Vazquez 2020) as well as looking for other options (Wang et al. 2020b). These methods are characterized by time consuming, very costly, imprecision, require specific equipment, instruments, and materials, coupled with low true positive rate. Also, there are insufficient and lack of testing kits in various countries due to limited resources and techniques. Hence, there is need for a standard

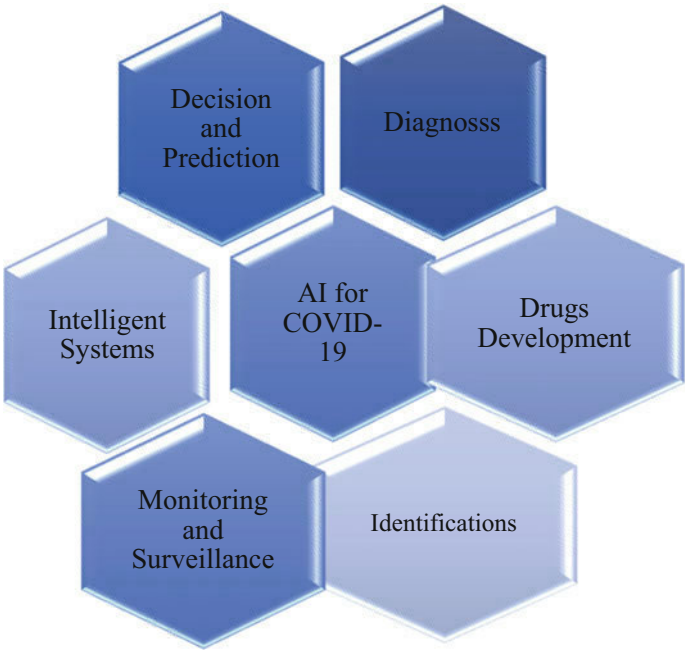

Fig. 1.1 Some basic roles of artificial intelligence in fighting COVID-19 pandemic

technique to meet the needs for a fast diagnosis and monitoring during the COVID-19 pandemic since the present methods cannot meet these requirements. The use of smart devices enabled with AI models can provide a low-cost and simple solution for COVID-19 diagnosis and prediction (Fomsgaard and Rosenstierne 2020; Rao and Vazquez 2020), referred to as mHealth technologies in the literature (Silva et al. 2015). The use of smart devices is very useful in this direction since they are using daily for various purposes. The emergence of edge and cloud computing will reduce the limitation of mobile devices in the area of computing capacities, storage, and battery lifespan (Pham et al. 2020b).

There are various AI-based models for the diagnosis, monitor, and treatment of COVID-19 cases using clinical signs and radiological images and several methods have been suggested in these directions (Li et al. 2020) and many others. An AI-based architecture based on a cell phone-based survey was proposed to classify COVID-19 cases faster and more automatically (Apostolopoulos and Mpesiana 2020). In terms of diagnosis and prediction, radiological images like X-ray with AI-based models have been proposed (Nguyen 2020; Apostolopoulos and Mpesiana 2020) that have been published in the literature. CT scan (Li et al. 2020), which uses a variety of various computational techniques. There have been systematic reviews on the diagnosis and prediction of the COVID-19 pandemic recently (Awotunde et al. 2020).

The application of AI-based models on COVID-19 datasets for diagnosis, prediction, monitoring, and forecasting is a work in progress in a larger population. The use of X-ray, CT, and MRI has been used to generated medical images and has made AI the prominent method in the fight against COVID-19 outbreaks (Wynants et al. 2020). The CT scan reports revealed the presence of the COVID-19 virus in the lungs (Bernheim et al. 2020), as well as claims that the CT scan reports could diagnose COVID-19 faster than current RT-PCR tests. It is worth noting that COVID-19's imaging characteristics were somewhat close to those of other forms of pneumonia, making a proper diagnosis complicated. The study's main aim was to study current AI algorithms, use significant features incorporating medical image processing applications from COVID-19 CT scan images, and then minimize prediction errors to improve the accuracy of potential estimations in order to reduce this challenge.

The use of AI in the COVID-19 outbreak is a fundamental instrument to recognize devices proficient that can offer accuracy in the diagnosis of these infectious diseases. AI techniques can provide useful policymaking for medical experts, government, and the patients themselves by breaking systematic difficulties capture data into useful information. The techniques can still be used to examine the performance of diverse AI models for the categorization of COVID-19 samples (Albahri et al. 2020). Diverse categorization performance capacities have been employed for the assessment of the performance of CI approaches. Six commonly used CI approaches are as follows: Artificial Neural Network (ANN), Support Vector Machine (SVM), linear regression, *k*-Nearest Neighbor (*k*-NN), multilayer perceptron and classification algorithm. By analyzing medical imaging, AI can help develop COVID-19 detection, provide various methods to study disease development using appropriate instruments, and produce infection spread opportunities to expand on complex predictive analysis, including electronic health information. AI can be used for epidemiological exploration modeling, experiential statistics, and forecasting the number of cases based on various public policy options from a social perspective (Awotunde et al. 2020).

Through collecting and investigating all past records relevant to this epidemic, AI plays a crucial role in determining the collection of cases and forecasting the place where this disease will spread in the future. This technology can identify disease characteristics and predict its existence based on information gathered from social media and other digital or print media channels, such as the potential for contagion and the nature of its spread. In addition, based on relevant data and knowledge, it can forecast the number of infected cases and deaths in any given region (Vaishya et al. 2020). Magdon-Ismail (2020) presents an ML study of the COVID-19 pandemic that is based on data from the early stages of infection dynamics. The aim is to extract useful information for a better understanding of community health. The likelihood of disease spread, the rate at which a mild infection becomes a severe infection, asymptomatic approximations for infections, and predictions of new infections over time are all examples of these understandings. The AI models were widely used in prediction and diagnosis, filtering social networks, and computational biology, hence, considered to be effective techniques for analyzing COVID-19

outbreak. AI can use to scrutinize the abnormal symptoms as well as other "obvious signs" swiftly and alerts patients and medical officials (Haleem et al. 2020a).

1.2.2 Artificial Intelligence in COVID-19 Outbreak Epidemiology

The AI is very important in the epidemiology of COVID-19 outbreaks like viral forecasting, spread dynamics and control of the pandemic and other related infectious diseases. The epidemiological research is critical for stopping the spread by tracing infectious trails and identifying link chains that contribute to the rapid spread. The COVID-19 outbreak, on the other hand, was aided by the high movement of citizens during China's most important traditional carnival, which exacerbated the virus's spread while also greatly amplifying the epidemiological investigation's challenges (Zhong et al. 2020). When making decisions on how to cope with a health crisis, it is important to keep an eye on and predict the progression of the outbreak. In this case, the AI model has gotten more attention and consideration in epidemiological studies. Forecasting and predicting the spread of COVID-19 will enable the nation, healthcare providers, businesses, and individuals plan, prepare, and handle the pandemic.

AI techniques can be used to forecast and model the spread of the COVID-19 outbreak in real-time. AI-based model can be used to trained available demographic and COVID-19 outbreak data to predict the spread of the infectious disease. But, due to the lack of huge data and various noisy and outlier data, AI-based predictions of viral spread are not yet very accurate and reliable (Elmousalami and Hassanien 2020). As a result, most of the models used to monitor and forecast the COVID-19 outbreak, such as SIR epidemiological models (Ogundokun et al. 2020), SEIR (Cui et al. 2021), SIRD (Gunawan 2021), expanded SIR model integrating quarantine protocols like isolation policies, and community-level micro inspection steps (Wang et al. 2020c), and ARIMA model (Joseph et al. 2021).

There are various AI-based models that have been reported and applied by several researchers, some of them are multilayer feedforward ANN for COVID-19 outbreak forecast (Ballı 2021); for transmission dynamics a modified stacked autoencoder was used (Raza 2020); the affected, deaths, and recovered was predicted using non-linear hybrid cellular automata classifier (Ayo et al. 2020a); for the prediction of growth and containment strategy of COVID-19 outbreak, an agent-based artificial intelligence simulation platform (EnerPol) was used (Kafieh et al. 2021); to predict the cumulative number of confirm cases, a multi-input deep CNN was on COVID-19 dataset (Khan et al. 2020a); to generate similarity map of transmission dynamics, topological autoencoder was used (Osman et al. 2021); the viral spread dynamics was predicted using Differential Evolution as parameter estimator with SEIR-SD (with social distancing) model (Rica and Ruz 2020); an hybrid AI was used for the forecasting of COVID-19 outbreak using Support Vector Regression (SVR),

Polynomial Regression (PR), deep feedforward neural network, and Long Short Term Memory (LSTM) network (Khan et al. 2020b).

A hybridized deep learning with fuzzy rule method was used to forecast COVID-19 outbreak included limited data in early Composite Monte-Carlo (Fong et al. 2020), and the prediction of the COVID-19 peaks and size of the outbreak was performed using modified SEIR-LSTM model (Yang et al. 2020). The major issue in using AI in the COVID-19 outbreak globally is the limitation of available data and datasets, but as huge relevant data is available, the accuracy of AI-based models will greatly improve. There is no doubt that AI place prominent roles in combatting the COVID-19 pandemic in heightening several strategies used, making the vital decision, and in medical diagnosis, however, the most critical step now is to forecast to know whether or how the second wave of this pandemic will hit China, or other parts of the nations will still have suffered COVID-19 pandemic.

1.2.3 Artificial Intelligence in the Vaccine Development for COVID-19

The most effective way to combat the COVID-19 outbreak is developing a vaccine or therapeutic agents, and AI is one of the most appropriate and faster methods in the development of these drugs. In the development of an effective solution for novel drug candidate-specific against COVID-19 pandemic, AI has shown an encouraging solution (Ortega et al. 2020). The application of AI and in silico has been applied to the repositioning of existing atazanavir drugs for fighting and treating COVID-19 patients (Beck et al. 2020). Also, to design good vaccine contestants against other immunogenic protein fragments and most especially SARSCoV-2 spike protein AI and immunology models have being used. To properly understand the 3Dstructure of protein with the COVID-19, Google's DeepMind developed AlphaFold using AI models, and in proposing a new drug design, the models provided advantageous information. Benevolent AI-based system a UK-based start-up is another queue AI technique to generate and design drug for the treatment of COVID-19 outbreak (Stebbing et al. 2020). The foundation and definition for COVID-19 vaccine and drugs have been provided (Ong et al. 2020) with the establishment of Vaxigen Reverse Vaccinology equipment embedded into AL methods.

The process in developing vaccines was time consuming, challenging, and expensive, but in a situation like this, there is an urgent need for vaccine and drugs production for COVID-19 within the shortest possible time for their development. Current game-changing developments like AI, and Big Data, and IoT, combined with a deep understanding of molecular and structural biology, basic virology, and immunoinformatics, have aided in the development of vaccines for the COVID-19 pandemic. AI has been proved to be one of the fastest methods that can aid the development of vaccines and drugs during this urgent period of the pandemic (Bharadwaj et al. 2021).

Since the production of a new vaccine takes too long, drug repositioning is the best and expedient way to treat COVID-19 infected patients. On the other hand, the development of long-term drug targets is to find inhibitors that target the replication processes linked to this disease and inhibit main coronavirus proteins, as well as what could be used as starting points for drug development (Liu et al. 2020b). Several studies have used AI to establish a COVID-19 therapeutic strategy and drug design. According to Savioli (Savioli 2020), glycosylated spike (S) protein extracted from the Heptad Repeat 1 (HR1) has the least flexibility, making it a promising target. The used of a Siamese Neural Network (SNN) to train the entire 2019-nCoV protein sequence resulted in the discovering that virus proteins had knowledge of peptide linkage. A huge proportion of there was examined against the particular region of HR1 in 2019-nCoV, with the peptidyl-prolyl cis-trans isomerase (PPlase) peptide exhibiting a high affinity for HR1, potentially opening up new research avenues.

Chenthamarakshan et al. (2020) proposed CogMol, a DL multiplicative model system, to developed customized particular protein sequence target drug candidates. This was used on three 2019-nCoV proteins, namely: replicase the primary protease, S protein's receptor-binding domain (RBD), and non-structural protein 9 (NSP9). Beck et al. (2020) used a Molecular Transformer-Drug Target Interaction (MT-DTI) based on DL-based drug-target interaction model to reposition drugs used in treating HIV and discovered that atazanavir is an antiviral drug that has the best inhibitory potency against 2019-nCoV 3C-like proteinase, and their findings suggest that several antiviral drugs, such as Kaletra (lopinavir/ritonavir), can bind to the replication complex components of 2019-nCoV with sufficient inhibitory potency. AI-based models have also been used by other researchers for drug repositioning (Mohapatra et al. 2020), and the models have been proved very useful in this direction. Table 1.1 discusses the different approaches of ML and DL and their key findings in some existing researches discussed in this study.

The repurposing of proven licensed drugs, such as ritonavir, lopinavir, and others, to treat COVID-19 is ineffective. As a consequence, discovering novel chemical compounds to fight this deadly virus is crucial and urgent. Tang et al. (2020) built an advanced deep Q-learning network with fragment-based drug design (ADQN-FBDD) to identify possible lead compounds for 2019-nCoV's 3CL. They presented work lead compounds that were completely developed using the ADQN-FBDD model. To create novel drug-like compounds, a deep learning-based drug discovery platform has been created (Zhavoronkov et al. 2020). Other reviews based AI-based assisted drug designing and production for COVID-19 can be find in (Ogundokun et al. 2021). In previous research works, AI has been used in medical and in the biomedical field (Ayo et al. 2020b; Oladele et al. 2020), for the involvement of heart disease and diabetes (Oladipo et al. 2020), Berglund et al. (2006) investigated diabetes proteins. Academics have used ANN, SVM, Fuzzy Logic Systems, K-means classifier, and many other AI methods (Oladipo et al. 2021).

Table 1.1 Summary of ML and DL only approaches

S/N	Study	Dataset, classes	Classes	ML and DL	Key findings
1	Jiang et al. (2020)	Text	ARDS, COVID-19	L R, *k*-NN ($k = 5$), DT, RF and SVM	SVM and *k*-NN performed best with 80% accuracy on the classification of COVID-19.
2	Brunese et al. (2020)	CXR	COVID-19, TB, Healthy	VGG-16 on ImageNet dataset	Average COVID-19 detection time was 2.5 s with 97% accuracy
3	Sharifrazi et al. (2021)	CT scan	COVID-19, pneumonia and normal	SVM	ResNet+SVM obtained the best metric based on accuracy, sensitivity, FPR and F1-score of 95.33%, 95.33%, 2.33% and 95.34% respectively
4	Barstugan et al. (2020)	CT scan	coronavirus/non-coronavirus	SVM	Accuracy of 99.68% with the GLSZM.
5	Tartaglione et al. (2020)	CXR	CORDA, CORDA&CXR, CORDA&RSNA, CORDA&COVID-CXR, COVID-CXR	ResNet-18, ResNet-50 and COVID-Net	Resnet 18+ COVID-19 + CXR obtained an accuracy of 100%
6	Abbas et al. (2021)	CXR	COVID-19, normal and SARS	ImageNet and DeTraC on ResNet 18, PCA	DeTraC+ ResNet18 achieved the highest Accuracy, Sensitivity, and Specificity 95.12%, 97.91% and 91.87% respectively.
7	Pereira et al. (2020)	CXR	Normal, COVID-19, MERS, SARS, Varicella, Streptococcus, and Pneumocystis	*k*-NN, SVM, MLP, DT, and RF	Multi-classification: F1-Score of 0.65 with MLP + LBP Hierarchical Classification: F1-Score of 0.89 with clustering+BSIF +EQP + LPQ+ SMOTE +TL.
8	Folorunso et al. (2022)	CXR	Normal, PTB, and COVID-19	HOG, PCA, Extra Trees	ROC value of 0.97, Precision value of 0.81