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The Functions of Artificial Intelligence in Addressing COVID-19

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Abstract

The COVID-19 epidemic has engendered unparalleled problems globally. Artificial intelligence (AI) technologies has significant promise for addressing critical elements of pandemic management and response. This analysis examines the significant potential of AI technology in tackling the worldwide difficulties presented by the COVID-19 pandemic. This paper first examines the COVID-19 pandemic and its effects on public health, the economy, and society. Subsequently, we concentrate on pioneering uses of powerful AI technologies in critical domains such prediction, diagnosis, control, and medication development for the treatment of Covid-19.

Keywords: Artificial intelligence, COVID-19, Drug development, Machine Learning.

Introduction

The earliest report of the Coronavirus Infection (COVID-19) emerged in December 2019 in Wuhan, China, affecting over two hundred nations and regions worldwide, with 2,000,000 cases and 120,000 fatalities as of April 21, 2020. In response to this escalating catastrophe, organizations and specialists around are seeking approaches to address the challenges posed by this virus, mitigate its spread, and provide treatments for the pandemic (1). Significant apprehensions about the capacity of healthcare systems have emerged owing to the extraordinary demand for health services, particularly in underprivileged regions. In this context, methodologies that expedite diagnostic procedures, improve monitoring and tracking capabilities, forecast the evolutionary stages of contagion and its societal impacts, and simulate the outcomes of containment strategies, medical protocols, or novel molecules, can signify a transformative milestone in global efforts to address these critical events (2). The COVID-19 emergency has significantly accelerated the enhancement of current models and the creation of new prototypes to provide promising outcomes in areas such as infection tracking, diffusion prediction, and the assessment of restrictive measures' impacts (2).

Advancements in artificial intelligence (AI) are anticipated to serve as an effective approach to address these challenges: due to the extensive information provided by the emergence of ubiquitous IT and the consistently growing computational power, AI has demonstrated exceptional performance regarding the majority of the aforementioned issues (3). Its capacity to discern patterns and relationships among data has made this study domain especially appealing for jobs that involve the elucidation of intricate information and processes. Numerous successful applications of Deep Learning (DL) and Machine Learning (ML) techniques in image recognition and segmentation, time series forecasting, sentiment analysis, system control, and dynamics simulation

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are extensively documented in the literature, alongside effective robotic self-operating solutions that have demonstrated efficacy in minimizing social interactions. The positive findings illustrate the significant emphasis directed towards global research on AI as a tool to combat the COVID-19 pandemic (4). As per the Scopus database, almost 1000 peer-reviewed articles with the keywords “COVID-19” and “Artificial Intelligence” were published from the onset of the pandemic until March 1, 2021 (4).

Artificial intelligence may be used for predicting viral dissemination and creating early warning systems by pulling data from social media platforms, telephone communications, and news websites, therefore offering valuable insights into at-risk areas and anticipating morbidity and fatality rates (5). Bluedot detected a cluster of pneumonia patients and forecasted the outbreak and geographical distribution of COVID-19 using machine learning on available data. HealthMap aggregates publicly accessible data on COVID-19 to enable efficient monitoring of its dissemination. Recently, the significance of AI in the detection and prediction of COVID-19 outbreaks by the use of diverse and multimodal data was highlighted. Furthermore, artificial intelligence was used for the identification and quantification of COVID-19 instances using chest X-ray and CT scan pictures (6). Researchers have created a deep learning model named COVID-19 detection neural network (COVNet) to distinguish between COVID-19 and community-acquired pneumonia using visual 2D and 3D data derived from volumetric chest CT scans (7). The present study is on the application of AI advancements in combating the Coronavirus epidemic. It examines several technical developments used to mitigate and suppress the substantial impact of the eruption. This review seeks to evaluate the efficacy of the outlined techniques and propose their application methods. This study illustrates AI applications and offers an outline of how emerging technology may address the COVID-19 epidemic.

Overview of the COVID-19 pandemic

Pneumonia resulting from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection originated in Wuhan, Hubei Province, China, in December 2019. On February 11, 2020, the World Health Organization (WHO) officially designated the sickness caused by SARS-CoV-2 as coronavirus disease 2019 (COVID-19). COVID-19 encompasses a range of clinical symptoms, often include fever, dry cough, and exhaustion, frequently accompanied by pulmonary involvement (8). SARS-CoV-2 has great transmissibility, rendering the majority of the general population vulnerable to infection. Wild animal hosts and sick individuals are now the primary routes of disease transmission via respiratory droplets and direct contact. Following the outbreak, the Chinese government and scientific community swiftly identified the causal culprit, instantly disseminated the viral gene sequence, and implemented efforts to limit the pandemic (9). Despite the perception that the epidemic has concluded, the World Health Organization reports an average of 378,000 new cases everyday. A prompt collective reaction was established to inhibit the further dissemination of COVID-19. Numerous impacted nations enacted border closures and temporarily halted transit and tourism. The WHO and the Centers for Disease Control (CDC) issued worldwide standards for adherence by global and national enterprises, governments, and individuals to effectively control the epidemic (10). The CDC and WHO have delineated symptoms indicative of a potential COVID-19 infection, such as dry cough, fever, diarrhea, myalgia, and vomiting. Public awareness has been elevated globally to encourage prompt treatment in order to diminish morbidity rates. Governments have promoted and facilitated the study and development of COVID-19 vaccines. The containment of the epidemic necessitates heightened vigilance because to the rise of global COVID-19 infections (11). Reverse transcription-polymerase chain reaction (RT-PCR) is a method for identifying the COVID-19 virus. Timely and precise identification is essential for illness management; however, test results may be available within 2 to 48 hours. Numerous vaccines have been produced due to the emergence of coronavirus ribonucleic acid (RNA). These vaccines use many biological agents, including attenuated live viruses, proteins or subunits, messenger RNA (mRNA), and deoxyribonucleic acid (DNA) (12). Vaccines remain 95% effective, while they may impede the course of illness and assist individuals in developing immunity by stimulating the manufacture of optimal antibodies. Despite the availability of a vaccine, early diagnosis of coronavirus remains essential, since it enables the identification of persons who have been directly or indirectly exposed to the virus. Identifying these patients may avert the future spread of the pandemic, since COVID-19 infections present as lung illnesses. Consequently, computed tomography scans (CT) and chest X-rays are used to identify COVID-19 infection (13).

Introduction of AI

AI is a vital instrument in contemporary business, society, and healthcare, as it maintains a crucial equilibrium among patient care, administrative functions, and pharmacological entities. The notion of artificial intelligence originated in 1956 and pertains to “intelligent agents” or gadgets that assess their surroundings and enhance operations. Consequently, it is the intelligence shown by robots that replicate and augment human intellect (14). AI involves the acquisition of data, its interpretation, and subsequent learning to get the intended result. In various healthcare models, AI is clearly regarded as performing at least as effectively as, if not superior to, humans in disease diagnostics, with AI systems surpassing radiologists in detecting malignant tumors and assisting researchers in the formation of cohorts for expensive clinical trials (15). AI employs supervised and unsupervised learning methodologies; the former involves training and testing to predict fresh data samples, while the latter entails learning from data samples without supervision. It comprises several components such as neural networks, deep learning, natural language processing, rule-based expert systems, and robotics, which are essential elements of artificial intelligence (16).

ML, a prevalent kind of AI, employs a statistical methodology for model fitting and training using data to facilitate learning. According to the 2018 Deloitte poll of 1,100 U.S. managers from enterprises using artificial intelligence, around 63% of the companies were implementing ML in their operations (17). Precision medicine is a prevalent use of machine learning in healthcare, focusing on predicting the success of treatment protocols based on patient characteristics and treatment factors (17). Most ML and precision medicine parameters depend on a training dataset, which requires prior knowledge of an outcome, such as illness start. This is termed guided learning. Neural network technology, a complicated aspect of ML, has been used in healthcare systems for decades, relying on neuronal signal processing to ascertain the likelihood of a patient developing a given ailment (18). DL and neural network models are essential components of ML, potentially including several latent variables, facilitated by graphics processing units and cloud architectures. DL plays a pivotal role in cancer radiology, radiomics, and the detection of substantial clinical data that surpasses human visual perception (19). The integration of DL with radiomics has significant applications in diagnostics, surpassing the previous generation of image analysis tools, such as computer-aided detection (CAD). A notable use of DL is to its capacity for voice recognition, particularly within natural language processing (NLP), which encompasses text translation, processing, generation, categorization, and comprehension of published research, clinical documentation, and other language-related tasks. Natural Language Processing (NLP) is a crucial component of artificial intelligence focused on the study of human language, a pursuit of AI researchers since the 1950s. NLP consists of two primary components: statistical and semantic, with the former relying on ML, DL, and NLP, necessitating a substantial corpus of languages for training (18, 20).

The study focuses on the use of AI characteristics in the treatment of infectious illnesses, particularly in relation to the ongoing COVID-19 epidemic. The use of AI technology in the diagnosis, prediction, classification, analysis, treatment, and detection of coronavirus infection is of paramount significance due to its rapid global dissemination. The AI programs employ Industry 4.0 technologies, information technology, the Internet of Things, ML algorithms, mobile applications, deep and convolutional neural networks, and digital healthcare systems to optimize time efficiency, address the shortage of healthcare personnel, accurately document cases of infection, recovery, and mortality, and facilitate public information dissemination aimed at expediting recovery and mitigating the COVID-19 pandemic. Concurrently, these programs assist researchers in vaccine development, disease diagnosis, symptom reduction, and comprehending the transmission cycle and genomic sequence of the virus.

Applications of AI in COVID-19 diagnosis and detection

Monitoring of outbreaks

Biosurveillance is the scientific discipline focused on the early identification and prevention of disease outbreaks within a community (21). Analytics, ML, and NLP are being utilized for biosurveillance. Analyzing social media, news articles, and other internet information may facilitate the early detection of localized disease epidemics prior to their escalation into pandemics (22). The Canadian firm Blue Dot efficiently utilized ML algorithms to identify early COVID-19 infections in Wuhan, China, before late December 2019 (23). The study of extensive medical records and satellite imagery, such as the clustering of vehicles near a hospital, are other methods used in the past for the detection of localized epidemics using big data analysis. Google Trends has already been used to identify the emergence of Zika virus infections in communities using dynamic forecasting algorithms (24).

Sentiment analysis is the use of NLP in social media to discern the positive and negative feelings of the populace. Unsupervised sentiment analysis has been suggested as a technique for the early identification of infectious illnesses within the population. Sentiment analysis may serve as a significant instrument for comprehending public responses, including overreactions, to illness outbreaks and may provide critical insights to the government for guiding public education initiatives. These sentinel biosurveillance approaches would facilitate the early detection of pandemics, so affording the health system critical time for preparation and treatment (25).

Forecast of dissemination

Diverse statistical, mathematical, and dynamic forecasting methods have been utilized to effectively forecast the magnitude and dissemination of infectious illnesses within the population. In contrast to conventional epidemiological predictive models, big-data-driven models possess the advantages of adaptive learning, trend-based recalibration, flexibility, and the capacity for enhancement based on evolving insights into the disease process, as well as the assessment of intervention impacts, like social distancing, in mitigating its transmission (26, 27). The predominant approach used is the Susceptible-Exposed-Infectious-Recovered (SEIR) model, currently utilized to forecast the regions and magnitude of COVID-19 transmission. These tools may help ascertain other characteristics of the pandemic, including case under-reporting, intervention efficacy, and testing procedure accuracy (28). A modeling program sought to replicate the circumstances under which Ebola may proliferate inside Chinese society, assessing the efficacy of four tiers of state actions in these scenarios (29). Comparable models have endeavored to forecast the emergence and proliferation of the Zika virus in real-time throughout the Americas, achieving around 85% accuracy in quantitative assessments. An evaluation of several machine learning methods revealed that the backward propagation neural network (BPNN) had the greatest prediction accuracy in modeling Zika virus transmission (30).

Researchers from Johns Hopkins University created a COVID-19 prediction model derived on an earlier stochastic metapopulation epidemic framework. A comparison between the model's predictions and actual data revealed gaps in the comprehension of the virus's dynamics and the model's constraints (31). Nonetheless, the efficacy of a prediction model is contingent upon the quality of its underlying data, and during a worldwide pandemic, the sharing of data across communities is critically essential. This was a significant impediment in understanding and simulating the Ebola virus spread from 2013 to 2016. The World Health Organization (WHO) has advocated for a consensus on accelerated data sharing on the COVID-19 epidemic to enhance inter-community learning and analysis in this domain (32).

Prevention measures and vaccine formulation

Artificial Neural Networks (ANN) were used to forecast antigenic areas characterized by a high concentration of binders (antigenic hotspots) in the viral membrane protein of Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) (33). This knowledge is essential for vaccine development. Employing ML for this objective facilitates the swift analysis of the whole viral proteome, so expediting and reducing the cost of vaccine development. Reverse vaccinology and ML were effectively used to discover six prospective vaccine target proteins within the SARS-CoV-2 proteome. ML has previously been employed to forecast the influenza virus strains likely to infect a population in the forthcoming year, thereby informing the composition of the seasonal influenza vaccine (34). Successful predictions regarding the future proliferation of minor subtrees of hemagglutinins (HA) within the viral antigenic repertoire were achieved by training on H3N2 and testing on H1N1, utilizing a reconstructed temporal phylogenetic tree. Additionally, machine learning can predict the hosts of newly identified viruses through the analysis of nucleoprotein and spike gene sequences, serving as a valuable supplementary tool for tracing viral origins, particularly when dealing with extensive datasets where comparative analysis is challenging or labor-intensive (35).

Proactive identification and monitoring of cases

Timely patient identification, isolation, and mitigating community exposure are essential components in the management of an epidemic like COVID-19. Mobile phone surveys may facilitate the early detection of illnesses, particularly inside isolated populations. These strategies have shown efficacy in Italy for detecting influenza patients using an online poll (36). Unlike conventional survey and analytic approaches, AI applications can gather and analyze extensive data, spot patterns, stratify patients by risk, and offer remedies for populations rather than individuals. Digital phenotyping is the innovative approach of gathering smartphone-based active (surveys) and passive (text, speech, location, screen use) data to generate an individual phenotype (37). This approach may be used to acquire several data points and facilitate the stratification of people according to their risk levels. The Government of India has introduced a mobile application named "Aarogya Setu" that monitors users' exposure to those possibly infected with COVID-19, using Bluetooth technology to detect nearby smartphone users. If a patient tests positive, the data from the mobile application may be used to identify every app user with whom the patient interacted in the last 30 days (38). Digital phenotyping approaches may be executed on basic cellphones and would be particularly advantageous in poor and middle-income nations as a cost-effective means of risk stratification, owing to the widespread availability of smartphones (39).

The close geographical and economic closeness to China should have led to elevated morbidity and death rates from COVID-19 in Taiwan. Nonetheless, via the use of ML, they successfully reduced the number of infected patients to far lower levels than previously anticipated (40). They promptly recognized the problem, activated their national health insurance database, and used customs and immigration records to provide extensive data for analysis. ML applied to this extensive dataset enabled the stratification of the population into lower and greater risk categories based on many characteristics, including travel history. Individuals at elevated risk were confined to their residences and monitored via their mobile devices to verify compliance with quarantine protocols. The use of big data, along with proactive case identification initiatives, resulted in case numbers far lower than previously projected. DL algorithms have been used to discern patterns of infectious illness in imaging findings, including CT and MRI scans. CT scanning demonstrates strong associations with PCR-positive COVID patients, indicating that such methods are very effective in identifying COVID-19-related abnormalities in CT imaging (41).

Forecasting prognosis

Machine learning techniques have already been used to forecast prognosis in individuals afflicted with the MERS Co-V virus. The patient's age, illness severity at presentation to the healthcare institution, healthcare worker status, and existence of pre-existing comorbidities were found as the primary predictors of the patient's recovery (42). These results align with the presently reported trends in COVID-19. A smartphone application, Ebola CARE (Computational Assignment of Risk Estimates), was created using the data visualization tool Mirador to predict patient outcomes after Ebola infection. The instrument found 24 medical and laboratory indicators that may influence a patient's prognosis. There is an urgent need to modify these algorithms to aid clinicians in their decision-making process for COVID-19 management. Recovery prediction tools assist in resource allocation, triage, treatment decisions, and health system readiness (43, 44).

Development of therapeutic interventions

ML technologies have been used in drug research, drug testing, and drug repurposing. They facilitate the interpretation of extensive gene expression profile datasets to propose novel applications for existing pharmaceuticals (45). Deep generative models, referred to as AI imagination, may create innovative medicinal molecules with potential desired efficacy. These techniques facilitate the reduction of costs and time in drug development, assist in the creation of innovative therapeutic agents, and anticipate potential off-label use for certain therapeutic medicines. Bayesian ML methods have been used to create therapeutics targeting Ebola in in-vitro environments, with the results effectively translating to in-vivo contexts (46).

Future prospects and concluding remarks

This review summarizes the unique use of AI approaches in combating the COVID-19 outbreak. Improved ML and DL models show great potential for solving the critical difficulties raised by the global health crisis. AI-driven predictive analytics use medical, epidemiological, and omics information to produce precise estimates of disease dissemination patterns and individual predictions. Deep neural networks provide fast diagnosis using medical imagery. Intelligent systems that integrate risk assessment, decision support, and social sensing facilitate pandemic management and influence public health policy (47). Furthermore, AI-driven virtual screening may enhance therapeutic drug development and repurposing prospects. This analysis emphasizes that the use of AI in combating COVID-19 remains in its nascent phase. Significant advancements have been achieved in estimation, identification, and drug discovery. Nonetheless, prediction systems need further confirmation via empirical evidence. Diagnostic algorithms must go from binary classification to the measurement of infection severity. Although structural biology and bioinformatics models have identified various treatment options, extensive research investigations are required to test their security and efficacy (48).

Despite the great promise demonstrated by AI throughout the COVID-19 outbreak, various challenges remain in translating evidence of concept into concrete real-world consequences. A fundamental restriction is the lack of vast, high-quality, standardized datasets required for the construction of robust AI models, especially during the early phases of the pandemic when accurate testing was not available (49). Differences in demographics, procedures, and information forms may make it difficult to generalize models across different populations and settings. In addition, the relationship between existing clinical practices and legacy information technology systems creates barriers to adoption, which is worsened by a lack of AI knowledge among the initial stages healthcare personnel. Significant difficulties remain concerning scaling, economics, and inherent prejudices when AI is deployed on a big scale (50). The opacity of deep learning models impedes interpretability and accountability for AI-driven decisions. The pandemic response's necessity and unpredictably heighten these challenges, since relying on inaccurate projections or direction from undeveloped AI might endanger the lives of people and destroy confidence in society. To maximize the benefits of

AI in COVID-19 management, broad approaches including technical, medical moral, and societal aspects will be required (51).

Finally, ethical concerns about privacy, justice, and responsibility have to be solved, especially when AI is utilized for directing vital decisions like hospital triage. Transparency regarding data sources and model features is critical for building trust with the public and suppliers. To avoid disproportionate impacts on underrepresented communities, results must be thoroughly examined for biases and assessed on a regular basis. Finally, AI ought to enhance rather than substitute human abilities and expertise in handling pandemics (52). To summarize, transforming prospective AI applications into concrete real-world consequences necessitates considerable advancement in technological, medical, moral, and operational aspects. In spite of advances in algorithms and data, cooperation, facilities proof, and confidence are critical enablers for leveraging AI's ability to aid people around the world throughout the COVID-19 outbreak and beyond.

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