Exploiting artificial intelligence for combating COVID-19: a review and appraisal

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ABSTRACT

Machine learning algorithms immediately became critical in the battle against the COVID-19 outbreak. Diagnoses, medicine research, an illness spread predictions, and population surveillance all required the use of artificial intelligence (AI) methods as the epidemic grew in scope. To combat COVID-19, screening procedures that are both effective and rapid are required. At COVID-19, AI developers took a chance to show how AI can benefit all mankind. It was only after the employment of AI in the battle against COVID-19. AI's various and diverse applications in the epidemic are documented in this study. It is the purpose of this study to help shape the future development and usage of these technologies, whether in the present or future health crises.

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1. INTRODUCTION

Artificial intelligence (AI) conjures up images of robots with super-human learning skills and the ability to analyze enormous information for a variety of purposes, from movie recommendations to traffic management. AI, on the other hand, recalls more malicious and consequential uses of its power, such as mass surveillance [1], credit approval [2], bail decision [3], and selection for greater medical follow-up [4], [5]. There is nothing new about technological advancements that may be both beneficial and harmful. They've been around since fire was discovered, so to some, they're an old friend. AI, on the other hand, has a unique sensation for most individuals since it is unique.

The promise of AI has been most clearly shown in the aftermath of the global health crisis in 2020 and 2021. Many apps claim or recommend using AI to combat the illness since the novel coronavirus was revealed and its worldwide spread started in China. At COVID-19, AI developers took a chance to show how AI can benefit all mankind. It was only after the employment of AI in the battle against COVID-19 that existing socioeconomic inequities were highlighted and threatened to be exacerbated by the pandemic itself.

This pandemic has exacerbated health disparities, resource inequalities, and disparities in treatment quality for decades in poor and disadvantaged areas. Many factors contribute to the disparities in experience across demographic groups, including individual characteristics like gender and race, as well as socioeconomic factors like multigenerational households and employment in industries like cashiers, cleaning crews, and delivery services. As a result, they (and their family) are more vulnerable to contagion. It is complicated to adequately analyze and alter the impact of social components.

2. METHOD

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) standards were followed in the preparation of this systematic review [6]. To find published studies on AI and COVID-19, we searched PubMed, IEEE Xplore, Research Gate, Scopus, and Web of Science using the following terms: "Artificial intelligence", "Machine intelligence", "Machine learning", "Deep learning", "Predictive model", "2019 novel coronavirus disease, COVID-19", "2019 novel coronavirus infection, coronavirus disease-19," and "2019-nC.". Inclusion requirements for original research: COVID-19 was studied using AI, and subjects had COVID-19 confirmed by reverse transcription polymerase chain reaction (RT-PCR) or other laboratory tests (where applicable). A study was omitted if it was a review, case report, or remark and had one of the following three conditions: i) there were inadequate data; ii) we could not obtain the entire text of the study or its complete data; and iii) there were no data accessible.

3. COMBATING COVID-19 USING ARTIFICIAL INTELLIGENCE

The use of machine learning has grown more significant since it has shown useful in several disciplines, including the current virus epidemic [7], [8]. Individuals all across the globe are gathering and sharing knowledge on the virus now more than ever. Following are the different areas where machine learning can have a very significant role:

3.1. Forecasting

Predictive applications were the first to detect the presence of a new pathogen. At the onset of the epidemic, AI was deployed to give a range of actionable insights, and their effectiveness propelled them to the forefront of the battle. It was announced on December 31st, 2019, that a Canadian health-monitoring business named "BlueDot" has discovered a new, pneumonia-like ailment in China's Wuhan province. According to the World Health Organization (WHO) [9], this notice was made seven days before the formal alarm issued by the United States (US) centers for disease control and prevention (CDC). Using AI and enormous volumes of health and non-health data, BlueDot was able to accurately forecast. the onset of the illness and how it would spread early on, which made its early disclosure very noteworthy. When it came to predicting where the virus will be found in the following several cities, BlueDot was spot on. In February 2020, the American association for the advancement of science (AAAS) annual meeting in seattle, Washington, employed AI to envisage the spread of COVID-19 and the menace it presented [10]. A more recent study [11] confirmed this prediction, using data from early January 2020, before Chinese officials sealed down Wuhan province.

3.2. Diagnosis

Rapid illness detection and screening are essential at the start of each pandemic. Nguyen *et al.* [12] numerous AI-based apps were developed to speed up diagnostics. Rapid diagnostics make it possible to allocate and triage patients in hospitals quickly and efficiently. During the pandemic, several AI-based diagnostic methods were suggested. In most cases, they have only been tested on a limited scale and not on a big scale at all. Using data that does not match the demographic mix is challenging to train good AI models. Many diagnostic applications employ image recognition algorithms to speed up lung X-ray and computed tomography (CT) scan interpretation. In March 2020 in China [13] and April 2020 in Italy [14], several research were published in MedRxiv and bioRxiv. Most of these applications employ convolutional neural networks (CNNs), either alone or in combination with recurrent neural networks (RNNs) [15] or other neural network methodologies. AI can recognize COVID-19 chest X-rays and other illnesses like influenza pneumonia [13]. Coughing is a significant COVID-19 symptom [16]. Because the goal of the test is not to cure, but to swiftly assess whether more screening and medical treatment are necessary, first-degree triage of a person conducting a cough test via mobile application may be done remotely [17], [18]. This application may help prevent unnecessary hospitalizations and overuse of precious medical resources while also improving access to timely medical treatment. Not an exact diagnosis, but a medically valid screening application. The software had to work with any phone, including landlines, for Patel and his partners (not necessarily a smart phone). The use of medical applications on smart phones may be inaccessible to those who only have a landline or a mobile phone. Over 40% of Americans aged 65 and older own a mobile phone but not a smart phone.

3.3. Containment and monitoring

As the virus progressed, several AI-based tactics were or were utilized, including tools to track the disease's spread and prospective reach, as well as methods to regulate people's mobility. People who are not directly impacted by the condition may benefit from this kind of application. The body temperature of an infected individual is a sign of any illness. In South Asian nations, widespread temperature checks in public locations were one of the first methods undertaken. As recommended by Alsarhan *et al*. [18] drones may monitor people's temperatures, although most control points were built at railway stations, building entrances and other public locations. There were no exceptions for anybody with even low fevers. In the early stages of the illness, fewer than 44% of persons experience a fever [19]. Chinese authorities plan to use an individual quick response (QR) code to monitor population movements as early as February 2020 [20]. It was a combination of self-reported data and access to a person's medical information that created the code, which resulted in a red, yellow, or green light for the phone's user. For others without smart phones, the QR code heightened their fear of the sickness. Due to lack of access to modern technologies, the sickness had a double effect on the elderly in China, making them both more susceptible and less able to safely leave their homes [21].

Despite the virus' novelty, asymptomatic people may spread it. Due to this issue, most governments worldwide have enforced lockdowns and other restrictions on movement for the whole population. As the disorder gained recognition, people started to relax their adherence to safety standards, leading to requests for stricter enforcement. Drones might monitor people's body temperatures, or facial recognition algorithms and heat maps could enforce social distance [12]. Many countries utilize global positioning systems (GPS) monitoring, often known as "geo-fencing," to enforce quarantine [22], [23]. Some favor computer-aided sickness prediction and prevention. Initially, travel data, flu-like transmission procedures, and even wastewater [10] monitoring were used. Social media monitoring has also been used to predict COVID-19 hotspots [24], [25]. Contact tracing, a public health tool used since the 1918 influenza pandemic, is one of the oldest tools against viral transmission [26], [27]. Human-intensive research to an AI-based algorithm was rushed for COVID-19. Extensive border and population restrictions were rapidly implemented in South Korea. Contact tracing via mobile phone data is intriguing since it is quick and efficient, even when individuals are unaware of the others they may have infected with their virus. Contact tracing may be done using simple GPS tracking or potentially private Bluetooth technologies. The government is increasingly creating and implementing these apps since they need a large staff.

3.4. Drug development and treatments

COVID-19's most promising AI application is a method of developing new medications or identifying existing ones that can be turned into new vaccines and therapies, using the computational capacity of the machine. There has always been a long process involved in developing medications and vaccines, which incorporates many different fields of fundamental science such as pharmacology and biology [28], [29]. Ho [30] there is a summary of the prospective AI uses in this area. The repurposing of existing medications has been one of the more hopeful avenues. For example, this means that drug approval may be expedited by using already-approved medications with known side effects. In this instance, the approval is solely dependent on the drug's efficacy when used in a manner different than that for which it was first authorized. According to Richardson *et al.* [31] the usage of a rheumatoid arthritis medication named baricitinib has been recommended by a start-up leveraging AI for drug development and discovery as early as February 2020. AI also influences vaccine development. The lack of demographic diversity in the datasets used by the algorithm causes serious issues, making pre-defined criteria even more important. Some medicines may not function or be dangerous when taken on a population that does not respond to the biomarker used to create or verify the drug [32].

3.5. Medical and social engagement

In this section, we go through some of the ways AI has been put to work organizing the voluminous output of COVID-19 and handling public impressions and inquiries concerning the epidemic. As the initial point of contact between the general public and health authorities, these apps have the potential to have a substantial influence on vast segments of the community long after the COVID-19 issue has passed. Researchers from all around the globe were able to immediately exchange expertise and information on any element of study related to COVID-19 thanks to this AI-powered website. The COVID-19 data visualizations supplied by Microsoft (a CORD-19 partner) enable anybody to examine the raw data. The Asian development bank offers a variety of disease spread visualization tools, enabling comparisons across countries, economies, and responses to the pandemic as a whole. During the pandemic, AI-based algorithms are utilized to screen individuals outside hospitals, screen healthcare professionals, and offer telehealth visits unrelated to COVID-19 [33]–[37]. The epidemic uses just two AI-based algorithms: chatbots and natural language processing (NLP). The pandemic also improved the medical supply chain and resource allocation, as demonstrated in the progress and adoption of remote-health care [37], [38].

4. MACHINE LEARNING MODELS

Since the outbreak of the virus, machine learning has proved to be a vital tool in the battle against the viral pandemic. Unlike any other time in history, individuals from all around the globe are working together to gather and disseminate information on the virus. The major purpose of this study is to put a light on their efforts, demonstrating the usefulness of machine learning in the fight against SARS-CoV-2 as depicted in Figure 1.

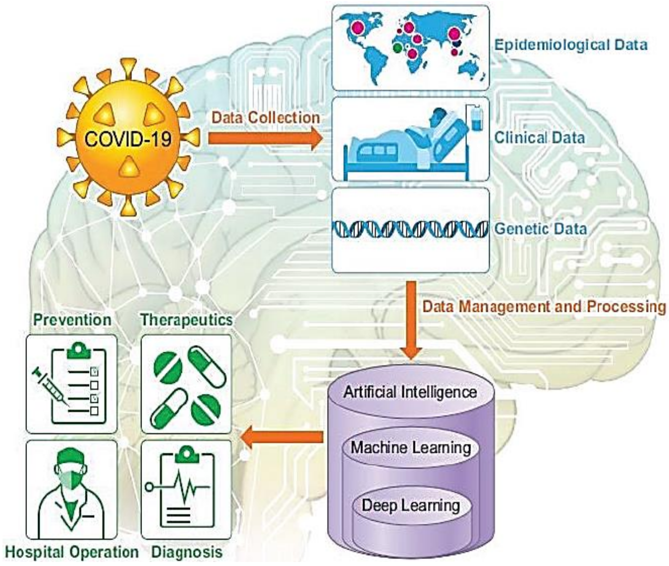

Figure 1. Role of AI in COVID-19 fight

Several machine learning approaches effectively predicted COVID-19 spread. Many researchers have tried to forecast the spread of COVID-19 across a nation using machine learning models ranging from classics like the autoregressive integrated moving average (ARIMA) model to more robust deep learning models like multilayer perceptron (MLP) and long short-term memory (LSTM) [39], [40]. Furthermore, researchers have also performed comparative studies observing multiple different machine learning models simultaneously and comparing their prediction results. Tian *et al.* [41] assessed the performance of the hidden markov chain model (HMM), hierarchical bayes model, and LSTM [42].

Given the nature of this specific time-series forecasting problem, graph neural networks (GNNs) are starting to become more popular due to their ability to capture spatial relations within their models. This is relevant to COVID-19 as the disease's impact varies depending on the observed location as different locations have different populations, and health regulations. Several GNN based learning methods have been evaluated including a spatio-temporal GNN for next day COVID-19 case count predictions at the county level as well as a spatio-temporal attention network (STAN) to capture geographic and temporal trends to predict COVID-19 case counts at the county level for a fixed period of time into the future [43]. These two GNNs also incorporated mobility data in their models to aid in predictions.

5. DEEP LEARNING APPLIED TO COVID-19

One of the most advanced neural network learning architectures is CNN, which can accept pictures as input and analyze enormous amounts of data. A strong deep learning architecture, deep convolutional neural networks (DCNNs) have been extensively used in many practical applications. Furthermore, it is extensively used in the field of medical imaging analysis because to its excellent performance in the field of computer vision and image analysis such as object identification, semantic segmentation and recognition [44], [45].

Ahammed *et al.* [46] studied X-rays of healthy and COVID-19-infected people. They employed support vector machine (SVM), random forests, k-nearest neighbours, logistic regressions, Gaussian and Bernoulli Naive Bayes, and decision trees to categorise the data (n=17). Several pre-trained deep neural networks (DNNs) and other deep learning classifiers were used, as well as various convolutional and DNNs (ResNet50). Compared to other suggested classifiers, the CNN has the greatest accuracy (94.03%), receiver-operator characteristic (ROC) curve (95.53%), area under curve (AUC) (94.03%), F-measure (94.03%), sensitivity (94.03%), and specificity (94.03%), (97.01 %).

Shibly *et al.* [47] conducted another study in which deep neural network techniques were used in conjunction with radiological imaging to identify COVID-19 illness. The goal of this project was to help alleviate the problem of a physician shortage in rural areas by providing resources to help fill the gap. With the use of an open-source dataset, the authors of this paper developed a VGG-16 network-based quicker areas with CNN framework to detect COVID-19 patients from chest X-ray pictures.

6. DISCUSSION

A three-pronged strategy is needed to attack COVID-19: testing, isolation and contact tracking. In order to develop effective chemotherapeutic drugs against COVID-19, it is vital to use the existing knowledge base and draw on lessons learned from previous outbreaks. All aspects of illness prevention and therapy must be accelerated, since there is no silver bullet to cure the condition. To avoid future epidemics, we need to work on identifying the molecular mechanism of SARS-CoV-2 and other corona viruses, as well as raising our readiness by expanding our capacity for dealing with future outbreaks. Response to this epidemic was greatly enhanced by the use of different digital technologies and AI. In the diagnosis and finding of drugs for COVID-19, AI was shown to be on par with human specialists and even more accurate. A legal framework and ethical concerns for data sharing are required before AI can take the lead in diagnostics and other fields. We need more data to train AI models. clinical and epidemiological data availability and sharing, computing resources, scalability, privacy/ethical issues are among the present hurdles to AI's full potential. A comparative analysis of literature reviewed in this work is shown in Table 1.

Table 1. Comparative analysis

Ref.	Purpose	AI methods	Results
[13]	Infectious disease surveillance with new coronaviruses	YOLOv3 for lesion detection, VGGNet for lesion level classification	96% of NCP lesions were 1 cm or bigger, with 76.8% having intensity below–500 Hu.
[14]	Chest X-ray used to diagnose COVID-19	ensemble of ten CNNs	Area under the curve of 0.78, sensitivity of 0.82, and specificity of 0.89
[15]	COVID-19, pneumonia, and normal X-ray samples were divided into three distinct groups for analysis	InceptionResNetV2, VGG19, DenseNet121, InceptionV3, and InceptionV3 combined with a CNN and RNN architecture	99.01% and 97.74% are the best training and validation results, respectively
[18]	To address the COVID-19 dissemination issue, a wireless method was devised	Optimum signal-aware UAV trajectory learning with reinforcement learning	Results reveal the proposed architecture is scalable and helpful in remote and highly packed epidemic regions where system connectivity is crucial for effective contact monitoring
[41]	Models' ability to forecast COVID-19 case outcomes	Hierarchical Bayes model, long-short-term memory model, and HMM	Six nations' COVID-19 pandemic paths were accurately predicted by LSTM
[43]	Deep learning model integration of pandemic transmission dynamics	Visualize the temporal and spatial patterns of illness dynamics in order to forecast the number of new cases.	More accurate predictions than previous deep learning algorithms and less overfitting in the early stages of a pandemic
[46]	Chest X-ray pictures may diagnose coronavirus using machine learning and deep learning	Machine learning using CNN	There was an AUC of 95.52%, f-measure of 94.03%, sensitivity of 94.33%, specificity of 97.11%, and a fallout of 4.48% and a miss rate of 2.98% using CNN model
[47]	COVID detection from chest X-Ray	VGG-16, Faster R–CNN	accuracy of 97%, sensitivity of 97%, and precision of 98.82%

7. CONCLUSION

Scientists and physicians are exploring for new technologies to screen infected patients at different stages, discover the best clinical trials to restrict the spread of this virus, produce a vaccine to cure sick people, and track their contacts. In this circumstance, data science must speed things up. To combat COVID-19, screening procedures that are both effective and rapid are required. This research aims to apply AI in a variety of methods in the fight against the COVID-19 pandemic. Results of this research might provide new insights into this virus's pathogenesis and medical diagnostics, as well as suggestions on how to improve such methods via the use of AI and machine learning. The scholarly literature has identified a slew of issues and constraints that will need attention in the years ahead. There is still a long way to go, though, before the COVID-19 pandemic can be predicted and forecasted using ML, but this is already a major improvement over current medical practice.

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