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A Review on Application of Artificial Intelligence for Detection of COVID-19

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Abstract: ***COVID-19 has been a significant concern since its arrival in the world. The virus has claimed around 64 lakhs human lives and has been a major threat due to our lack of awareness and ignorance. In spite of applying techniques such as real-time polymerase chain reaction, and computerized tomography scans, we have been unable to detect a specific cure to the nefarious threat looming around our planet. The present investigation provides an early evaluation of Artificial Intelligence (AI) technique in the detection of COVID-19. The main areas where AI can contribute to the fight against COVID-19 are discussed. It is concluded that AI has not yet been impactful against COVID19 but it shows potential applications to detect COVID-19. Its utilisation is hampered due to lack of data, and by too much data. Overcoming these constraints will need a careful balance between data privacy and public health, and rigorous human-AI interaction. It is unlikely that these will be addressed in time to be of much help during the present pandemic. In the meantime, substantial gathering of diagnostic data on who is infectious will be essential to save lives, train AI, and limit economic damages.***

Keywords: COVID-19, Data Science, Artificial Intelligence, Public Health, Polymerase Chain Reaction

1. Introduction

In the end of 2019, a group of patients infected with a novel corona virus disease (corona virus disease 2019, COVID-19) was recognised in Wuhan, China. Since then, the epidemic of COVID-19 has spread around the world. COVID-19 affects people in several ways. Most infected patients develop common symptoms such as fever, fatigue and dry cough [1], and others may experience additional symptoms like aches and pains, nasal congestion, runny nose, sore throat and diarrhoea [2]. COVID-19 showcased weaknesses in the healthcare system of many countries, and the inability of healthcare systems to manage patients has caused anxiety. One of the significant reasons behind the rapid spread of COVID-19 is the lack of specificity in clinical detection protocols [3]. Molecular approaches such as quantitative real-time reverse transcription–polymerase chain reaction (rRT-PCR) [4] and other procedures such as serologic tests [5] and viral throat swab testing [6] are required and widely utilised for the detection of COVID-19. However, studies have demonstrated that chest radiographs (X-rays) [7] and chest computed tomography (CT) scans [8] can assist and reveal anomalies indicative of various lung diseases, involving COVID-19. CT scan and X-ray tests could be used as a primary detection tool to evaluate the severity of COVID-19, monitor the emergency case of infected patients and predict COVID-19 progression [9]. However, time is often constrained in such emergencies and does not allow these experiments to be performed utilising existing traditional manual diagnosis [10]. These protocols require a specialist doctor and are susceptible to human error during testing or reading and interpreting findings, which are not acceptable in critical cases. Given the recent spread of COVID-19, hospitals are filled with innumerable patients who are either improving from the viral infection or becoming worse (dying) [11]. In this case, CT scan and X-ray tests should be performed with maximum speed and efficiency to save as many lives as possible [9]. The role of intelligent technologies would effectively support in the diagnosis and classification processes [7].The utilisation of artificial intelligence (AI) has increased in different fields, especially in medical detection [12]. AI has been widely used to gain more perfect detection results and decrease the burden on the healthcare unit [13]. It can reduce the decision time associated with the detection process of traditional methods [14].The development of AI techniques to recognise the risks of epidemic diseases is considered a key factor in the enhancement of the prediction, prevention and detection of future global health risks [15]. Numerous types of AI classifiers have been reported by a few researchers with real COVID-19 datasets with different cases studies and targets [9]. Although AI techniques can be advantageous in the diagnosis and classification of COVID-19, selecting the correct AI technique that can produce accurate results is challenging [16, 17]. The large diversity amongst available AI techniques creates difficulties in deciding which of them to use in the development of COVID-19 diagnosis and classification particularly when there is no dedicated AI technique that is far better than the other. Moreover, the majority of these techniques suffer from low accuracy and computational efficiency [18]. Alternatively, the difficult part is associated with the evaluation and comparison because of the multiple evaluation criteria and conflict between them are increasing the challenge [19].

Among these challenges are "Can AI help to track and predict the spread of the infection?", "Can AI help in making diagnoses and prognoses?", "Can it be utilised in the search for treatments and a vaccine?" and "Can it be used for social control?" This paper is an attempt to provide a systematic review of how AI have so far been progressed in this regard, and to note limitations, constraints, and pitfalls. These include a lack of data, too much (noisy and outlier) data, and growing tension between data privacy concerns and public health imperatives.

2. Tracking and prediction

AI in principle can be utilised to track and to predict how the COVID-19 disease will spread over time and space. In fact, an AI-based model of HealthMap, at Boston Children's Hospital (USA), sounded one of the primary alarms on 30 December 2019, around 30 minutes earlier than a scientist at the Program for Monitoring Emerging Diseases (PMED) issued an alert [41]. For the further tracking and prediction of how COVID-19 will spread, AI needs data on COVID-19 to implement. An example of how this can be done is the case of the 2015 Zika- virus, whose spread was ex post predicted using a dynamic neural network [20]. Because COVID-19 is different from Zika, or other infections and because there are not sufficient data to build AI models that can track and forecast its spread. Most of the growing numbers of publications reporting on using AI for diagnostic and predictive purposes so far tend to use small, possibly biased, and mostly Chinese-based samples, and have not been peer-reviewed.

A number of promising initiatives have been started to gather and share data -both existing data, new data, and to train new AI models. These involve the World Health Organization's (WHO) Global Research on Corona virus Disease Database, which also provides links to other similar initiatives. One of them is the open access data of the GISAID Initiative (formerly the Global Initiative on Sharing All Influenza Data). Amongst other initiatives, perhaps the most ambitious is the joint initiative between Semantic Scholar, the Allen Institute for Artificial Intelligence, Microsoft, Facebook, and others, to make openly available the COVID- 19 Open Research Dataset (CORD-19) which includes around 44, 000 scholarly articles for data mining. Kaggle, a data science competition platform, has issued a data competition based on this data, a COVID-19 Open Research Dataset Challenge. Moreover, contributing to the need for more (accessible) data, Elsevier made publicly accessible in its Novel Coronavirus Information Center early-stage and peer-reviewed research on COVID-19 and to around 20, 000 related articles on ScienceDirect, as well as the full texts for data mining. Similarly, The Lens has made available all its data on patents in what it calls the Human Coronavirus Innovation Landscape Patent and Research Works Open Datasets to bolster the search for novel and repurposed drugs. And Chen et al. (2020a) [24] published the first public COVID-19 Twitter dataset. It is not only a lack of historical training data but also due to issues with using "big data", e.g., such as harvested from social media. The pitfalls of big data and AI in the context of infectious diseases were illustrated in the ill-famed failure of Google Flu Trends. Lazer et al. (2014) [37] referred to these as "big data hubris and algorithm dynamics". For instance, as the infection continues to spread, the social media traffic around it accumulates, so the amount of noise accumulates which has to be filtered through before meaningful trends can be discerned. Generally, and this is also bad news for AI forecasting models in other areas, involving economics and finance, since for any prediction algorithm that rely on past behaviour, a global outlier event with its mass of new and unprecedented data, such as COVID-19, can be described as Rowan (2020) [47] does as "the kryptonite of modern Artificial intelligence". In result, he concludes that over the near future "many industries are going to be pulling the humans back into the forecasting chair that had been taken from them by the models". Furthermore, scientists will require to deal with the deluge of scientific papers and new data being generated, and shift through these. More than 500 scientific articles on the pandemic now appear daily [33]. This potential information overload is, however, where data analytic tools can play a significant role. An example of an initiative in this regard is the COVID-19 Evidence Navigator by Grunewald et al. (2020) [33] which provides computer generated evidence maps of scientific publications on the pandemic, daily updated from PubMed. Due to lack of data, noisy social media and outlier data, big data hubris, and algorithmic dynamics, AI forecasts of the spread of COVID-19 are not yet very accurate or reliable [41]. Therefore, so far, most models utilised for tracking and forecasting do not use AI techniques. Instead, most forecasters prefer established epidemiological models, so-called compartmental SIR (Susceptible, Infectious and Recovered) models Song et al. (2020) [50]. For example, the Robert Koch Institute in Berlin utilises an epidemiological SIR model that takes into account containment measures by governments, such as lockdowns, quarantines, and social distancing prescriptions. Its model has been applied at China to illustrate that containment can be successful in reducing the spread to slower than exponential rates [38]. In order to track COVID-19's spread in real time, a veritable industry of data "dashboard" creation, for visualization of the disease, has emerged. The first, and most frequently used, is that of the John's Hopkins' Center for Systems Science and Engineering (CSSE) [30]. The data collected and made available through this dashboard is available on a Github Repository, at https://github.com/CSSEGISandData/COVID-19. MIT Technology Review has produced a ranking of these tracking and forecasting dashboards and to facilitate the production of data visualizations and dashboards of the pandemic, Tableau has created a COVID-19 Data Hub with a COVID-19 Starter Workbook. Song et al (2020) [50] provides a Python script to illustrate how one could extract data from the 'New York Times' COVID-19 dataset and create data visualizations of the progression of the infection. The emergence of dozens of dashboards and visualizations of COVID-19 has however also led to calls for responsible visualization of COVID-19 data, see e.g. [39].

3. Diagnosis and Prognosis

In addition to potentially tracking and predicting the spread of COVID-19, AI can also be utilised in the diagnosis and prognosis of the disease. In fact, this is perhaps where most of the first rush of AI initiatives focused on. Fast and accurate diagnosis of COVID-19 can save lives, reduce the spread of the disease, and generate data on which to train AI models. There is growing effort to train AI models to diagnose COVID-19 utilising chest radiography images. Based on the recent review of AI applications against COVID-19 by Bullock et al. (2020) [22], argues that AI can be as accurate as humans, can save radiologists' time, and perform a diagnosis faster and cheaper than with standard tests for COVID-19. Both X-rays and computed tomography (CT) scans can be utilised. Representative contributions in this regard involved Chen et al. (2020b) [25] and Wang and Wong (2020) [53]. The latter developed COVID-Net, a deep convolutional neural network [43] which can diagnose COVID-19 from chest radiography images. It has been trained on open repository data from around 13, 000 patients with different lung conditions, including COVID-19. On the other hand, as the authors indicate, it is "by no means a production ready solution", and they call on the scientific community to develop it further, in particular to "improve sensitivity" [43]. It is known that not all people diagnosed with COVID-19 will need intensive care, the ability to be able to forecast who will be affected more severely can help in targeting assistance and planning medical resource allocation and utilisation. Yan et al. (2020) [54] utilised Machine Learning to develop a prognostic prediction flowchart to predict the mortality risk of a person that has been infected, using data from (only) 29 patients at Tongji Hospital in Wuhan, China. And Jiang et al. (2020) [36] demonstrates an AI that can predict with 80% accuracy which person affected with COVID-19 may go on to develop acute respiratory distress syndrome (ARDS). The sample that they utilised to train their AI system is, however, small (only 53 patients) and constrained to two Chinese hospitals. Largely, the potential of AI is diagnosis is not yet implemented over into practice, although it has been reported that a number of Chinese hospitals have deployed "AI-assisted" radiology technologies. Radiologists elsewhere have showed their concern that there is not enough data available to train AI models, that most of the available COVID-19 images come from Chinese hospitals and may suffer from selection bias, and that utilising CT-scans and X-rays may contaminate equipment and spread the disease further. Indeed, the use of CT scans in European hospitals has dropped after the pandemic broke, perhaps reflecting this concern [46]. It is probably accurate as Coldeway (2020) [28] concludes, "No one this spring is going to be given a corona virus diagnosis by an AI doctor". It also looks like that comparatively less effort is on using AI for very early diagnostic purposes, for instance, in identifying whether someone is infected before it shows in X-rays or CT scans, or on finding data-driven diagnostics that have less contamination risk.

4. Treatments and Vaccines

The third area where AI can potentially make a contribution in the fight against COVID-19 is in identifying possible treatments and vaccines. Even long before the COVID-19 outbreak, AI was acclaimed for its potential to contribute to new drug discovery, [27, 31, 48 , 49]. In the case of COVID-19, a innumerable research labs and data centres have already indicated that they are recruiting AI to search for treatments for and a vaccine against COVID-19. The hope is that AI can implement both the processes of discovering novel drugs as well as for repurposing existing drugs. A number of researchers have already reported discovering drugs for repurposing. These involves Beck et al. (2020) [21] who report results from utilising Machine Learning to identify that an existing drug, atazanavir, could potentially be repurposed to treat COVID-19, and Stebbing et al. (2020) [51], who identified Baricitinib, used to treat rheumatoid arthritis and myelofibrosis, as a potential treatment for COVID-19. It is not very likely that these treatments (in particular a vaccine) will be available in the near future, at least to be of much use during the current pandemic. The reason is that the medical and scientific checks, trails, and controls that need to be performed before these drugs will be approved, once they have been identified and screened, will take time—according to estimates up to 18 months for a vaccine [44].Also Vanderslott et al. (2020) [52] explained a method of a potential anti-COVID-19 drug.

5. Social Control

A fourth role for AI in fighting the COVID-19 pandemic is in social control. AI has been argued to be required to manage the pandemic by using thermal imaging to scan public spaces for people potentially infected, and by enforcing social distancing and lockdown measures [45].For example, as explained by Chun (2020) [26] "At airports and train stations across China, infrared cameras are used to scan crowds for high temperatures. They are sometimes used with a facial recognition system, which can pinpoint the individual with a high temperature and whether he or she is wearing a surgical mask." It is reported that these cameras can scan 200 persons per minute and will find those whose body temperature exceeds 37.3° C [29]. Thermal imaging has, however, been criticized as being insufficient to identify from a distance a fever in people who are wearing glasses (because scanning the inner tear duct gives the most reliable indication) and because it cannot identify whether a person's temperature is raided because of COVID-19 or some other reason [23].

However, as Chun (2020) [26] worryingly reports, "This system is also being used to ensure citizens obey self-quarantine orders. According to reports, individuals who founded the order and left home would get a call from the authorities, presumably after being tracked by the facial recognition system". This type usage is not constrained to China. A USA computer vision-based start up is already offering "social distancing detection" software, which uses camera images to detect when social distancing norms are breached, after which it will send out a warning [40]. Most advanced economies have been considering and/or testing different contact tracing apps and related tools to provide social control [32].

Whereas utilising AI to predict and diagnose COVID-19 is hampered due to lack of historical training data, AI tools such as computer vision and robots are not. Hence, we are more likely over the short term to see this type of AI being used and used moreover for social control. Related technologies, such as mobile phones with AI-powered apps or wearable that harvest location, usage, and health data of their owners, are also more likely to be employed. According to Petropoulos (2020) [42] such apps can "enable patients to receive real-time waiting-time information from their medical providers, to provide people with advice and updates about their medical condition without them having to visit a healthcare unit in person, and to notify individuals of potential infection hotspots in real-time so those areas can be avoided".

Useful as these are, the fear is that once the outbreak is over, that erosion of data privacy would not be rolled back and that governments would continue to utilise their improved ability to survey their populations- and use the data obtained in the fight against COVID-19 for other purposes. Harari (2020) [34] warns "Even when infections from corona virus are down to zero, some data- hungry governments could argue they needed to keep the biometric surveillance systems in place because they fear a second wave of corona virus, or because there is a new Ebola strain evolving in central Africa, or because…you get the idea".

6. Conclusion

The COVID-19 pandemic has an enormous impact on the life of people around the world, and the number of infected patients has considerably increased. COVID-19 quickly achieved a foothold and nations, governments and scholars are attempting to address this worldwide crisis. In conclusion, AI technique has the potential tool in the fight against COVID-19 and similar pandemics. However, from the above rapid scan of the current state of play, one has to concur with as Petropoulos (2020) [34] that "AI systems are still at a preliminary stage, and it will take time before the results of such AI measures are visible". Bullock et al. (2020) [22] in one of the first surveys of AI models utilised against COVID19 agrees, concluding that "very few of the reviewed [AI] systems have operational maturity at this stage." Clearly, data is central to whether AI will be an effective tool against future outbreak and pandemics. The fear is that public health concerns would trump data privacy concerns. The mission creep may happen, with governments continuing the extraordinary surveillance of their citizens long after the pandemic is over. Therefore, concerns about the erosion of data privacy are justified. Given the public health threat posed by the pandemic, the European General Data Protection Regulation (GDPR) permits personal data collection and analysis, as long as it has a clear and specific public health aim [35]. Flexibility to collect and analyze big data promptly is important in combating the pandemic, even if it may require that the authorities gather more personal data than many people would feel comfortable with. Therefore, it is essential that the authorities take particular care in their handling of such data and their justifications and communications to the public at large. The threat is that the people could lose trust in government, which will, as [35] pointed out, "make people less likely to follow public-health advice or recommendations and more likely to have poorer health outcomes". Finally, although AI's utilisation has so far been rather limited, the pandemic and the policy responses to it may accelerate the digitalization of the economy, involving the move towards greater automation of human labour, the re-shoring of production activities, and growing market dominance by a few large digital platform firms. As such, the innovations in AI technology that may be an outcome of the current crisis may need society to make faster progress to lay down appropriate mechanisms for the governance of AI.

7. Future Scope

As we all know the COVID19 can spread from a person to person so medical staff is at high risk of being infected but medical robots are preventable to cross infections and this can be revolutionary in cases of viral outbreaks. The world has witnessed one case in the US already where a person who was infected with the COVID19 was being treated by a robot. The robot has a visual screen such as TV which permits physicians to communicate with the patients and it is also equipped with stethoscope helping doctors take the man's health report while reducing exposure of medical staffs to the patients and of course patients who are in quarantine could be treated better with medical robots. Further drones can also play a essential role in stopping the outbreak of this infection by bolstering the medical deliveries in quarantine zones as they can safely collect the medicine and deliver it to people who are in need .In the last decade, AI has gained exceptional momentum in smart healthcare and if harnessed in the right way, it can contribute to efficiently fighting against the COVID-19 pandemic. On the contrary, along with positive contributions, many challenges required to be worked on. The application of AI in COVID-19 diagnosis is in the budding stage. It needs AI-literate lab technicians to handle the case. Though AI-based diagnosis is faster and safe, it gives partial information about COVID-19 patients and may give negative results in the early stage, so the clinical testing protocols need to be integrated for better detection and diagnosis of COVID-19 patients' .Also, there are ethical, social and human rights challenges of AI in public health. The diagnostic data sharing needs consent of the involved population and trust towards various entities involved. Since AI is mainly data-driven, the privacy and genuineness of the data sets can be challenging. For example, in India assigning a unique identification code to every individual and linking it for medical records and relating it for health benefits pose a social and legal challenge. The challenges of privacy, transparency, consent, and trust need to be managed by consensus-based guidelines .The other important challenge is that AI-based techniques such as Artificial Neural Network, Machine Learning considered as 'black box', hence the internal parameters cannot be tuned rather only the outputs are obtained according to the input datasets. Hence, it is difficult to translate highly sensitive AI models according to the clinical situation. Also, the efficacy, fairness and stability of the AI models need to tested frequently to ensure its validity before the actual deployment. Adequate availability of the data sets for training and validation is an inherent limitation of the AI-based models. Another challenge is that even though the AI based design programs are powerful functions , these are vulnerable to security attacks which can lead to error and hamper the health of the patient. AI-based contact tracing and surveillance system also raises the privacy issues. Therefore, responsible deployment of the AI based techniques and robust modelling can help to overcome such limitations

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