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Digital Technology for Predicting, Preventing, and Controlling COVID-19

Deepti Sengar
Department of Information Technology, Shri Shankaracharya Institute of Professional Management and Technology, Raipur, Chhattisgarh, India

ABSTRACT

COVID-19 has become a serious threat to the world. In a very short time it has severely affected every aspect of our lives. In this situation, controlling COVID-19 is a big challenge for the medical industry and they need advanced technologies that can support their fight with COVID-19. Recently, state of the art digital technologies like artificial intelligence (AI), Internet of things (IoT), and Big data have shown very nice solutions to different type of problems. Motivated by these recent advances, this paper is aimed to provide an overview of these application areas. This early review of the field will be very important for providing a timely information to the people interested in using digital technologies for COVID-19 pandemic. We believe it will also provide the general readers with a new insight into the ways digital technologies can be used.

Keywords : COVID-19, Coronavirus, Pandemic, Artificial Intelligence (AI), Big data, Internet of Things (IoT)

I. INTRODUCTION

Coronavirus Disease 2019 (COVID-19) poses a real threat to humans all over the world. This is a highly contagious disease that cause acute respiratory distress or multiple organ failure in severe cases [1]. It started from Wuhan, a city in China in the end of 2019 and on January 30, 2020, the outbreak was declared as a "public health emergency of international concern" (PHEIC) by World Health Organization (WHO)[1]. In a very short time it has spread over 200 countries with more than 3.2 million confirmed cases and around 0.23 million deaths until now[1], [2]. Figure 1 shows how strongly COVID-19 has spread over the world. This disease is caused by a virus called, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)[3]. It belongs to the large family of coronaviruses that have been infected the world before by diseases like common cold, SARS and MARS etc. But this COVID-19 virus appears much stronger than the others specially in its ability of rapid human to human transfer[4]. This is the reason it has become a pandemic in such a short time.

In addition to the highly contagious nature, the important thing that makes COVID-19 a big threat is the unavailability of drugs or vaccines to cure or prevent this disease. This is a serious problem and it has forced almost the whole world to shut down and stay the people inside their homes. Therefore, it is not only affecting the physical health but also making a great loss to the economy. There are predictions that this crisis may lead to a historic loss of lives and a great economic recession. In this worldwide health crisis, the medical industry is looking for new technologies to fight with this COVID-19 pandemic. Digital technology is one of such technology which can support our fight in multiple ways ranging from rapid diagnosis to the discovery of drugs or vaccines.

Recently, many interesting applications and potential directions have been reported where digital

technology can contribute significantly. This review paper is aimed to summarize all such notable studies and to present the readers an overview of the use of digital technology in fight against COVID-19. We believe that this timely review of the technology will improve the understanding of the field and will be useful for the readers who plan to use it for controlling the COVID-19 pandemic.

Digital technology is an umbrella term that includes the technologies like, Artificial Intelligence (AI), Internet of Things (IoT), Big data, and Block chain etc.

Figure 1 : Situation of COVID-19 across the world as on 26 April 2020. Source: World Health Organization.

All these technologies are highly inter-related and most often work with each other. However, based on their relative use we can broadly classify the applications of three mainly used digital technologies that are IoT, AI, and Big data in fight against COVID-19[5], [6]. This classification is given in Table 1. To provide a clear and detailed understanding we plan to discuss the role of each technology one by one.

II. INTERNET of THINGS (IoT)

IoT is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction[7]. This technology is helping in the current situation in multiple ways (see Figure 2) like,

1. Real time update: The proliferation of the IoT (e.g., testing devices and medical instruments) in hospitals and clinics facilitates the establishment of a highly interconnected digital ecosystem, enabling real-time data collection of patients tests and health conditions [5], [8]. This collected data is picked from a common source and used in multiple ways like a dashboard for COVID-19 that gives a real time information about the spread of disease or it is used for doing analysis to understand the nature of spread and policy making.

Table 1: Application areas of different digital technologies

Digital Technology	Internet of Things (IoT)	• Real time tracking • Mass Surveillance • Live update
	Artificial Intelligence (AI)	• Rapid diagnosis. • Identification of Drug/Vaccine and testing • Severity of illness • Predicting the people at risk • Predicting the outcome of the treatment
	Big Data	• Modeling of COVID19 spread • Modelling the preparedness • Forecast and policy making

2. Mobile Apps for Mass Surveillance: Monitoring the movement of public is very important in controlling the spread. The use of connected infra-red cameras that can sense body temperature at the public places like airport, train stations, or shopping stores has been quite successful in tracking the sick people. Recently, the development of mobile applications for tracking has shown a very good success. These contact tracing apps work over the Bluetooth network and can alert if someone has come in close proximity of a COVID-19 infected person [9], [10]. The app can also provide a real time situational awareness to the users about the area they live or work in by tracking the movement of active patients in that area.

3. Connected thermometers: The clearest symptom of COVID-19 is the rise in body temperature or fever. A safe monitoring of temperature without coming in the contact of patients is a big challenge, especially when they are staying in isolation away from the hospitals. In this direction the IoT enabled internet connected

thermometers appears to be a very useful tool[11]. Patients or people in isolation can use them and the temperature data can be transferred by thermometer to the hospital.

4. Wearable sensors: Maintaining the safe distance and contact history at work place is very important. This can be ensured using the smart wearable sensors like a wrist band. IoT device company 'Estimote' has designed different type of wearable devices with sensors like GPS for location tracking and Bluetooth for proximity sensing [12]. These devices simply keep the record of all the people that come in the contact. Companies are working on making cloud-based wearable sensor to provide constant monitoring of multiple vital signs, including temperature, heart rate and blood oxygen levels [13], [14].

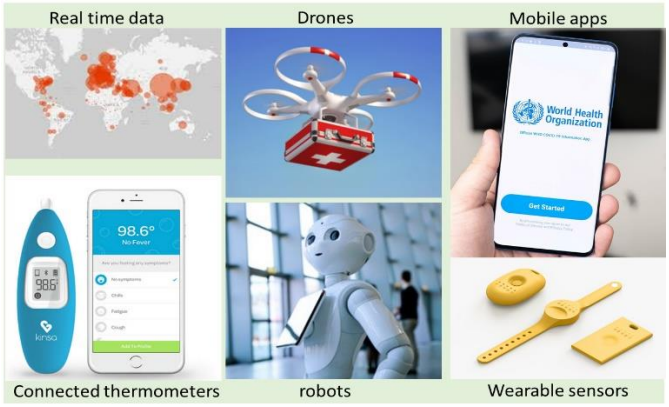

Figure 2 : Applications where the successful implementation of IoT has been shown

5. Robots: High risk of infection makes it difficult for humans to take care of patients and maintain the hospital facilities like transferring the test samples, treating bio waste or simply to maintain a good hygiene. In this situation, well programmed and properly designed robots can be a great help. Some of the hospitals have already employed them for providing necessary supplies to the patients. In some countries, robots from companies like UVD Robots and Xenex Disinfection Services are also being used to disinfect and cleaning hospital premises [15].

6. Drones: They are being used to provide a quick and safe method to deliver medical samples and supplies to and from COVID-19 hotspots. Companies like Terra drone have already shown a successful operation of drones in worst affected areas like china, and Europe [16]. Many countries are also using drones to monitor and ensure compliance with lockdown orders imposed due to the disease. Drones are also being used to spray disinfecting chemicals in public spaces and making public announcements to in the COVID-19 hotspots.

7. Contactless smart devices: Multiple smart devices which can reduce the human involvement or contact are also very important. Like a RFID based door sensor and office attendance system, contact less electronic cards for ATM operation etc. can significantly reduce the chances of spreading infection by touching the surfaces of instruments at common places.

III. BIG DATA

A large amount of data related to COVID-19 is being generated every day. It comes in from of patient's health record, new positive or negative tests, vaccine trails etc. During this global pandemic the amount of data is so big that it cannot be analysed using conventional techniques. Big data, a technique to analyse and systematically extract information from the data sets that are too large or complex can be very useful [17].

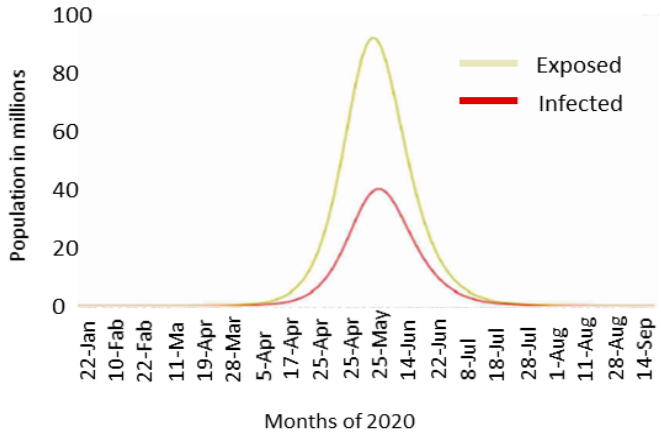

Figure 3 : Prediction of exposed and infected people around the world for a period of 240 days starting from the pandemic.

A community of researchers from around the world called 'CoronaTracker' has used Susceptible-Exposed-Infectious-Recovered (SEIR) predictive modelling for data analysis and predictions [18]. They collect the data from WHO or John Hopkins University portals or dashboards. Using their model, they predicted the spread of COVID-19 around the world (see Figure 3). If we compare with the current real growth rate, then their prediction seems quite accurate. Similar to this Big data analysis is using by many researchers for prediction and understanding of the pandemic [19]. Additionally, Big data analysis can also be used to fed up the AI frameworks to perform complicated tasks. Some of the things that can be done with AI are discussed in next section [6].

IV. ARTIFICIAL INTELLIGENCE (AI)

AI is one of the most advanced technologies which are providing notable solutions to many of our problems. In this pandemic AI can help in multiple ways like,

1. Rapid diagnosis: To control the disease, one clear strategy is to identify the infected people and keep them in isolation and provide necessary treatment. For this, we need to conduct a large number of COVID-19 tests. The conventional methods like PCR which is in common use in hospitals are expensive and take long detection time of up to 4-10 hours [20]. Moreover, it needs a significant human involvement which puts the life of health workers at risk.

Alternate strategy is analysing the chest CT scan images where symptoms of infected lungs can be identified. This is a reliable method but it needs a lot of image data to process for the careful observations where the human–based interpretation is difficult and time consuming. More than that, substantial inter-observer-variation cannot be ignored. Here researchers have shown that use of AI can greatly simplify it [21]–[23]. Like, Fu et. al. used the CT scan images of the lungs of COVID-19 positive and negative people to train and validate a classification framework based on convolutional neural network [21]. To rule out the symptoms of similar diseases, five conditions including COVID-19, pneumonia, non-COVID-19 viral pneumonia, bacterial pneumonia, pulmonary 69 tuberculosis, and normal lung were evaluated. The trained AI frame work provided the COVID-19 test results with accuracy more than 99.7 %. A scheme of this method is shown in Figure 4. This AI based CT scan analysis has become quite popular and to expedite research in this many Government agencies are funding the research in this direction.

Soares et. al. have developed an alternate strategy backed by AI to perform an initial screening of suspect COVID-19 patients [24]. They developed a machine learning classifier that takes widely available simple blood exams as input and classifies samples as likely to be positive (having SARS-CoV-2) or negative (not having SARS-CoV-2). Based on this initial classification, positive cases can be referred for further highly sensitive testing (e.g. CT scan, or specific antibodies). Other approaches to conduct the tests are also being reported like, Imran et. al. have developed an AI based mobile app 'AI4COVID-19' that can detect the COVID-19 by just analysing the cough sound[25].

2. Identification of Vaccine, Drugs, and antibodies: Development of vaccine needs a detail understanding of the structure and sequence of amino acids in proteins of the corona virus. Lab experiments to identify them are very difficult and take a long time. Googles company 'deepmind' have shown AI to solve this problem. They developed an AI based protein folding algorithm 'alphafold' that can quickly produce the three-dimensional structure of the proteins [26].

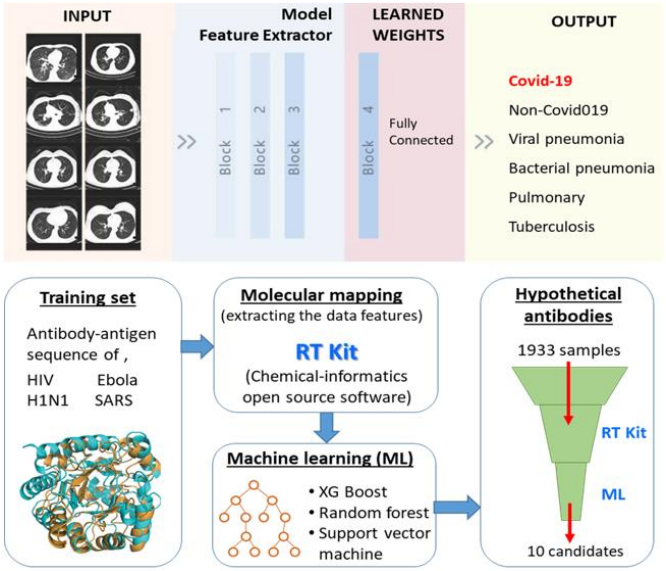

Figure 4: (a) AI scheme for rapid diagnosis of COVID-19 by analysing the CT scans. (b) AI scheme for support in identification of antibodies for COVID-19 treatment.

The discovery of vaccines or proteins take a long time in identifying the right chemical compound and its compatibility with the human body. AI can help here in identifying the drugs from a large list of chemical compounds and can also make the test runs under the simulated conditions. Recently, researchers from Australia's Flinders University have designed an AI that has, for the first time, created a drug entirely by itself [27]. They first trained the AI framework on a massive data set of chemical compounds. The researchers then developed another computer program to generate trillions of new, untested compounds. AI, using its initial chemistry training, then selected compounds from this new set which might have a positive effect on the human immune system. The research team then synthesized prototype vaccines that included these compounds and tested them on human blood cells. Similarly, Magar et. al. have shown AI to help in developing the antibodies [28]. They trained a Machine Learning model with large number of antibody-antigen sequences. Combining the molecular mapping using open software with variety of ML methods like XG Boost and Random forest etc. they successfully narrowed down the list of a large number of potential antibodies to less than 8 that can be developed for COVID-19. trained an ML model to predict the antibody response. A scheme of their approach is given in Figure 3b. In the related research, Stebbing et.al. have used the AI to identify most suitable drugs for the treatment of COVID-19 from a large database of already approved drugs. Such repositioning of drugs could be very effective in saving the money and time that we spend on finding the completely new drugs. In addition to this direct research, once drugs or vaccines will be ready, AI can also support in other important ways like, in providing safe and reliable trials in the simulated environments before testing on humans, assessing the severity of illness, predicting the people at risk etc.

V. CONCLUSION

In this paper, we have presented an overview of the digital technology solutions in the fight against the COVID-19 pandemic. First we discussed the IoT and showed the important directions like real time tracking connected sensors, and mass surveillance etc. where IoT can play an important role. Then we discussed that AI is significantly important for rapid diagnosis and identification of drugs or vaccines. In last we mentioned some crucial areas like modelling of spread of disease and preparedness using the Big data. Finally, we have highlighted importance of safe use of technology by government authorities and research communities.

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