Leveraging Digital Tools and Technologies to Alleviate COVID-19 Pandemic

Sarat Kr. Chettri[1], Dipankar Debnath[2], Pooja Devi[3]

Abstract

The novel coronavirus (COVID-19) disease requires exceptional consideration on account of its potential worldwide danger. Several different digital technologies ranging from AI-driven applications built upon machine learning (ML) to blockchain technology and big data analytics along with cloud computing and Internet of things (IoT) are used to identify, control, track and manage diseases, predict outbreaks, safe knowledge exchange, data analysis and decision-making processes. The state-of-the-art and emerging innovations are providing new models for healthcare systems alongside clinical practices and treatments. The primary objective of this paper is to provide an overview and recognize the application of digital tools and technologies that have the potential to meet the healthcare requirements during this global health crisis.

Keywords: COVID-19, Artificial Intelligence (AI), Machine Learning, eHealth, Blockchain, Internet of Things (IoT), Biosensors.

1. Introduction

The spread of COVID-19 pandemic across large number of nations is an unprecedented situation in recent times. As on June 3, 2020, a total of 6,486,929 confirmed positive cases have been reported leading to 383,178 deaths spread across 213 countries [1] with US having the highest number cases and India at seventh place. In India, a total of 207,615 confirmed cases with 5,815 deaths [2] are reported so far, According to the Centers for Disease Control and Prevention (CDC) [3], people with COVID-19 reported a wide range of symptoms, ranging from mild to extreme. Flu-like symptoms are mainly reported in most countries that may appear within 2 to 14 days of exposure to the virus, although widespread population testing is still not feasible in most countries.

Coronaviruses are a large family of viruses that may cause diseases in animals or humans. In humans, many coronaviruses are known to cause respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). The most recently discovered coronavirus causes coronavirus disease (COVID-19). The disease was first detected [4] in Wuhan, Hubei

[1] Department of Computer Applications
School of Technology, Assam Don Bosco University, Guwahati, India
Email: sarat.chettri@dbuniversity.ac.in

[2] Department of Computer Science
St. Mary's College, Shillong, India

[3] Gauhati Medical College and Hospital
Srimanta Sankardeva University of Health Sciences, Guwahati, India

province, China in the mid of December 2019 and was declared pandemic on March 11, 2020 by the World Health Organization (WHO). Figure 1 shows the geographical distribution of current COVID-19 cases worldwide until May 27, 2020.

Figure 1. Global cases of Coronavirus COVID-19, as of May 27, 2020. (Source: Johns Hopkins University (JHU), Center for Systems Science and Engineering (CSSE): Coronavirus COVID-19 Global cases, May 27, 2020. https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6)

The healthcare system may be overrun by the pandemic in a short period of time, as the situation in Italy is a clear demonstration. With the unprecedented rise of the novel coronavirus patients in United States, Europe and Asia, many countries are in the verge of major shortage of doctors and health professionals. For instance, in India there is one government doctor for every 10,189 people and one nurse for every 483 people implying a shortage of six lakhs doctors and two million nurses (as per WHO's recommendation, the ratio should be 1:1000). Several measures are taken, such as lockdown and quarantine of possible COVID-19 patients to reduce the virus spread, to delay peak hospitalization and allow more time to prepare additional beds and equipment. The peak demand for COVID-19 hospitalizations in India could be as high as 18.7 lakh in a hard/moderate lockdown scenario as estimated by researchers at John Hopkins University (see Figure 2).

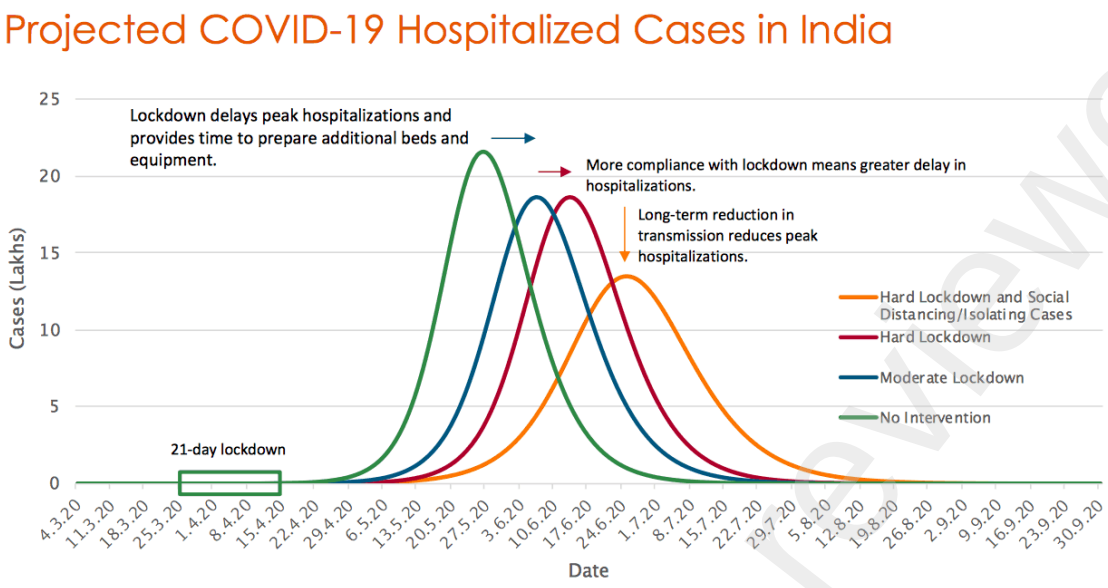

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Figure 2. Projected hospitalization cases in India by the researchers associated with the Center for Disease Dynamics, Economics and Policy (CDDEP), Johns Hopkins University and Princeton University estimate (source: https://cddep.org/covid-19/modeling-the-21-day-indian-lockdown/,May21,2020)

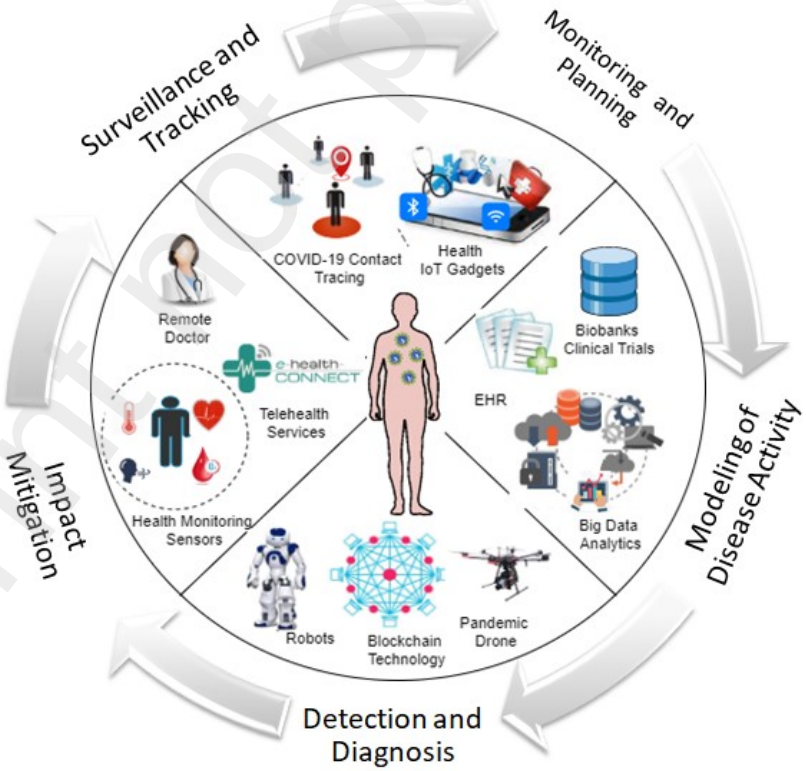

Figure 3. An overview of key enabling digital tools and technologies to tackle COVID-19 pandemic

Now, an important point to be noted is that the past decade has seen tremendous development of digital tools and technologies [5], which can now be applied effectively to reduce the strain on healthcare sector and could have a positive impact on public-health strategies (see Figure 3). The World Health Organization has received an overwhelming response from a range of organizations, academics and researchers calling for digital health technology solutions such as tracking new coronavirus patients, identification and prevention, rapid disease diagnosis, infection control, clinical support, resource allocation, pandemic effect mitigation and coordination of tailored responses. The rest of the paper is organized as follows. In Section 2, we address early diagnosis of COVID-19 patients using artificial intelligence (AI). Section 3 discusses about how to minimize constant contact between healthcare professionals and COVID-19 patients. The surveillance and tracking the spread of COVID-19 using technology are discussed in Section 4 followed by how emerging digital technologies can be used to minimize impact of COVID-19 in Section 5. Proliferation of technologies in modeling of COVID-19 activity and assessment of preparedness in the war against the pandemic is addressed in Section 6. The paper concludes in Section 7.

2. Detection of COVID-19

The world is looking for solutions to the COVID-19 pandemic in terms of rapid diagnosis and treatment. It would be a positive step forward if researchers around the world could contribute to appropriate screening tools, self-assessments and early detection. Artificial Intelligence can play a significant role in the field of medicine and can aid in early and rapid diagnosis of COVID-19 patients.

Examples:

a) CT Scan based diagnosis:

The computed tomography (CT) scan was identified as the key marker for the diagnosis of COVID-19 patient at the onset of the disease. Typically, physicians can identify the disease from features like a shadow over the lungs of the patient. A single patient can have about 300 CT images, which could take a long time for a physician to examine with the naked eye. AI-based CT Scan Image interpretation systems [6-8] and deep learning based system [9,10] can analyze CT scan images within a short span of time with high accuracy rate. The Alibaba Group's research and innovation institute DAMO Academy in China has developed an AI-enabled system to diagnose COVID-19 via CT scans of the chest. In Australia, DirectED-X [11] has developed a free virtual clinic to help physicians identify the early signs of COVID-19 using CT scans. The Government of Philippines has collaborated with Lifetrack Medical Systems for AI-based decision support to assist radiologists to analyze chest CT scans. Similarly, the Ministry of Digital Economy and Society of Thailand and Malaysia's Ministry of Health has partnered with Huawei Technologies to diagnose and treat COVID-19 patients using Artificial Intelligence.

b) Audiometric based diagnosis:

COVID-19 is a respiratory disease. The novel coronavirus that infect the upper or lower part of the respiratory tract eventually infects our lungs. Around 80% of COVID-19 patients show symptoms of dry cough and sore throat.

Thus, the evaluation of cough, wheeze, crackle and speech sounds facilitates the screening of obstructive and restrictive lung disorders along with their severity [12]. Engineers, AI experts, and researchers are using automated audio capture capabilities and processing power of a smartphone to evaluate audio signals from coughs, wheezes and spoken test phrases to match individual micro-characteristics against a large database of COVID-19 positive cases. In India, the CoVawe, an AI-based screening tool is developed to diagnose COVID-19 with the sound of the cough of the probable patient. The research team at Carnegie Mellon University, Pittsburgh [13] is working with researchers around the world to develop an automated AI system that can detect signatures of COVID-19 infection in the human voice. An AI-based voice tool developed in India is being tested by the University of Tor Vergata in Rome to detect COVID-19 patients.

c) X-Ray image based diagnosis:

The chest X-ray imagery [14, 15] could be used as an alternative to CT imaging in the preliminary screening of COVID-19 patients. Visual markers associated with SARS-CoV-2 viral infection can be identified by radiologists. Researchers at the University of Waterloo and Canadian startup DarwinAI have developed an open-source convolution neural network (CNN) based tool named COVID-Net [16], which claims to detect COVID-19 through the chest X-Ray (CXR) images. Similarly, a UK-based company named behold.ai [17] has developed an AI-based tool to help radiologists diagnose CXR images of patients with COVID-19 disease.

3. Monitoring of COVID-19

As the world is struggling with the rapid and global spread of the novel coronavirus virus, the healthcare workers are under extreme stress. They are overworked, depressed, and worried for their own well-being and that of their loved ones [18]. More than 22,000 healthcare workers in 52 countries have been infected by the virus until April 2020, as reported to the World Health Organization. In order to protect healthcare workers and reduce the risk of being exposed to the virus, different methods can be adopted by doctors and healthcare staff worldwide. According to a study, only severely or critically ill COVID-19 patients need to be hospitalized. Nearly 80% of COVID-19 patients show mild symptoms and do not need hospitalization and they can be handled at home or in quarantine centers, and can be monitored remotely on a regular basis [19]. Robotics, Internet of Things (IoT) and other technologies such as cloud computing, 5G wireless technology and Artificial Intelligence can be used for both in-house and remote monitoring and treatment of patients during this pandemic. It allows clinicians to monitor temperature, pulmonary function, blood pressure, and other appropriate physiology for changes in a patients disease and symptom progression, using digitally connected, non-invasive devices (e.g. body temperature sensors or thermometers, pulse oximeters and blood pressure monitors) [20]. The US Food and Drug Administration (FDA) have granted the Emergency Use Authorization (EUA) to VitalConnect, which allows its VitalPatch wearable biosensor [21] to monitor patients undergoing COVID-19 treatments. Humanoid robots are being used to minimize constant exposure between healthcare personnel and COVID-19 patients, to clean and disinfect, to monitor patient temperatures, and administer medication and food.

4. Surveillance and Tracking of the Virus Spread

Case isolation and contact tracing can be used to track and control the onward transmission of novel coronavirus [22]. The contact tracing process [23] generally involves recalling and listing of all people with whom the patient has recently been in contact with. The people identified in the contact list are asked to self-isolate. The use of mobile apps can make it easy to identify even those unknown people with whom the patient has come into contact. These applications (see Table 1) use technologies; (a) Location based, where GPS or triangulation from nearby cell towers are used to track the patient's contacts and search for others who have spent some time in the same location. (b) Bluetooth based, where encrypted tokens are exchanged between the mobile phones in close proximity via Bluetooth. This technology is generally considered to be better suited to preserving the privacy of users' personal data [24]. (c) Application program interface (API) based, where iOS and Android phones uses an API developed by Apple and Google to communicate with each other via Bluetooth. Again due to growing concerns about the privacy infringements of personal data by Apps of this kind, the privacy-preserving proximity tracing app can be designed for example the Ketzu App used in Finland. Initiatives could be taken to protect the privacy of individuals, and in this direction, the Facebook's "Data for Good" program is an effort to provide anonymized data to health researchers and non-governmental organizations (NGOs).

Country	Mobile APP Name	Technology Used
Austria	Stopp Corona	Bluetooth, Google/Apple
Bahrain	BeAware	Bluetooth, Location
China	Chinese health code sys	Location, Data Mining
Cyprus	CovTracer	Location, GPS
Czech	eRouska	Bluetooth
Finland	Ketju	Bluetooth, DP-3T
France	StopCovid	Bluetooth
Germany	Corona App	Bluetooth, Google/Apple
India	Aarogya Setu, Sahyog	Bluetooth, Location
Israel	HaMagen	Location
Iran	Mask.ir	Location
Italy	Immuni	Bluetooth, Google/Apple
Turkey	Hayat Eve Sar	Bluetooth, Location
UK	NHS COVID-19 App	Bluetooth

Table 1. Mobile Apps for Contact Tracing [25]

Data collection and development of biobanks are of great significance in this pandemic period. Such data can be used in research to provide novel insights into the genetic aspect of the disease, potentially contributing to a more personalized approach to healthcare. A smart digital internet-connected thermometer [26] coupled with a phone app developed by Kinsa Health, San Francisco has used data gathered from its more than one million consumers to produce daily fever maps. These data points can not only provide unparalleled real-time disease surveillance, they can also serve as an early warning sign for disease clusters [27]. For surveillance and tracking the spread of the

disease, unmanned aerial vehicle (UAV) can also be used. For instance, drones are used by the Governments and law enforcement agencies in China, France, Spain, and the US to track and ensure compliance with the disease-related lockdown orders. Besides surveillance, drones can be used to transmit messages and information on lockdown measures, disinfectant spraying and delivery of medicines and groceries.

5. Mitigating the Impact of COVID-19

The main objective of mitigation [28] of the impact of the virus is to minimize the morbidity and associated mortality. Sharing up-to-date information to the general public through digital media will help minimize the effects of this pandemic. Digital devices, if planned and efficiently implemented, will reduce the rapid spread of misinformation about the virus. Institutions such as World Health Organization and Centers for Disease Control and Prevention have begun to use chatbot (a software program) [29] to share information with the public and provide emotional support. The main idea of chatbots [30] is to reduce the psychological damage caused by fear and isolation among people. Facebook has linked up with the World Health Organization for a chatbot service. The chatbots can be trained using machine learning algorithms following the CDC guidelines. Some well-known chatbots like “Siri” from Apple, “Alexa” from Amazon, “Cortana” from Microsoft, etc. answer users' queries about COVID-19 either through text or voice in natural languages. Chatbots can be used to suggest Do's and Don’ts so as to avoid further coronavirus spread. Using Whataspp, public health information is conveyed to the general public through government agencies. Social networking platforms such as Facebook and Twitter are used by health authorities to provide the public with the latest updates on COVID-19 and to clarify any misconceptions. In addition, blockchain technology can be used to reduce the dissemination of false information about the disease. Natural Language Processing (NLP) using machine learning techniques can be used to keep a track of online news or social media feeds.

Continuing provision of primary care facilities to the community and reducing overcrowding of healthcare services, electronic clinical monitoring and telehealth services for the majority of medical appointments can be used by doctors and healthcare systems. Virtualized treatment methods (virtual clinics) [31] can be used for outpatient care and also to diagnose non-COVID-19 associated medical conditions.

6. Modeling of Disease Activity

In today's data-intensive world, big data analytics [32] can be used to comprehend and combat the virus. Machine learning and AI-driven technologies can be used to model the behavior of COVID-19 and make predictions. It helps guiding the health policy makers in different countries to enhance their preparedness for the outbreak of the disease. Organizations like Amazon Web Services and Google Cloud have made free access to open datasets for researchers to help them develop COVID-19 solutions. AI and big data analytics may be used to validate assumptions made by researchers in the clinical trials. Big data technology and Geographic Information Systems (GIS) [33] can play an important role in the battle against new coronavirus disease, including rapid collection of huge amount of data relevant to COVID-19 from multiple sources, data visualization, spatial tracking of COVID-19 cases and the spatial segmentation of the epidemic risk, among others. The big data analytics supports in decision-making processes,

interventions, and evaluating the efficacy of multiple approaches implemented by healthcare agencies to monitor and control COVID-19 incidents.

Due to unprecedented growth in the number of COVID-19 cases, hospitals require huge quantities of much-needed masks, clothing and other personal protective equipment (PPE). The health authorities are looking for multiple suppliers to meet the huge demand for essential medical equipment, yet they are skeptical about the reliability of manufacturers and quality of medical supplies. Blockchain technology [34, 35] can build a robust supply-chain and seamless communication across healthcare system by bringing in transparency, reliability, immutability and decentralization. IBM has recently launched a blockchain-based network to help healthcare organizations address equipment shortages by helping them identify alternative suppliers and allowing faster payments and remittances in a secure environment. The blockchain can also help to ascertain the validity of insurance claims made by customers suffering from COVID-19. Interestingly, Ant Financial has unveiled a blockchain-based platform in China providing loans to small and medium-sized companies and start-ups to help them cope with the financial stress in this pandemic.

7. Conclusion

The value of digital technology vis-à-vis the COVID-19 pandemic on its role in tackling it is presented and discussed in this paper. An overview of the various tools and technologies namely artificial intelligence (AI), deep learning, machine learning (ML), Internet of things (IoT), biosensors have been made and how it can be leveraged to alleviate COVID-19, thus, minimizing mortality and morbidity. The paper explores the current scenario and potential of digital resources and technologies to address the issue of early disease detection and diagnosis, in-house and remote patient monitoring, tracking and surveillance, data protection, data security and traceability, understanding health trends and modeling disease behaviour to predict outcomes, among others. The paper also highlights the proliferation of big data analytics along with cloud computing, 5G wireless technology and blockchain to add value to the health ecosystem as a whole.

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