

Technology Applications for Health Safety Decision Making under COVID-19 Pandemic Management

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Abstract—A lot of new technological applications are emerging to combat the deadly novel coronavirus. This research study gives an overview of different applications that are developed by Government Institutions, Private Firms, and Individual Citizens across the world. The applications are reviewed based on their widespread use, effectiveness, availability to the broader audience, cost to implement it, concerns regarding the privacy and information collected by these apps and systems. The major eight areas of technology applications covered in this study are Contact Tracing, Social Distancing & Mask Detection, Live-feeds based Dashboards, Information Searching, Big Data and Robotics, Web-based Disease Surveillance Tools, Patient-level Information, Doctor-Patient interaction, and Informatory Chatbots. More than 100 apps were collected for this research survey to conclude the different categories in which technology is being used for decision making. This study will be useful for various health administrators, professionals, researchers, and academicians.

Keywords—COVID-19; Coronavirus; Technology Applications; Contact Tracing; Social Distancing; Data Lakes; Chatbots

I. INTRODUCTION

Coronavirus disease (COVID-19) emerged as the public health emergency of international concern or Global Pandemic on January 30, 2020. Within the next eight months, more than 28 million infected cases were reported worldwide, with thousands of people dying and many more recovering [1][2]. Everyday life has taken a massive hit with nearly everything under lockdown state [3]. Virtually every country is fighting with the disease and is putting best efforts to prevent the spread of COVID-19. This is where technology has been a great help in managing and controlling this dreadful pandemic. Many hardware and software applications are used for decision making in the healthcare system by administrative authorities, medical institutions, health professionals, frontline workers, governments, and citizens, in various developed and developing nations [4]. However, which types of applications are used during COVID-19, is the central research question addressed in this study. The different areas of technology

applications during COVID-19 has also been answered through this study. The usage of various gadgets and applications are also shown in this study.

There are studies in the literature [5-10], which suggests the usage of Artificial Intelligence (AI), Natural language processing (NLP), Robotics, Neural Networks, Deep Learning, Machine Learning, Augmented Reality, Virtual Reality, and Blockchain Technology in fighting COVID-19. But there is a shortage of papers that can show the various applications working on different use-cases of COVID-19 management. This aspect is essential to understand from a technology progress point of view, which has been covered in this study.

II. METHODOLOGY

This study is secondary, which analyses data from various published sources concerning technology applications for COVID-19 management. The applications were searched over global search engines like Google and Yahoo. Then various international agencies like WHO and Government websites were searched for different applications. Published research papers were also referred from databases like COPUS, Web of Sciences, and Google Scholar. The main keywords used in the search were COVID-19, Coronavirus, Technology, Mobile Applications, Web Applications, Surveillance tools, Contact tracing, Artificial Intelligence, Machine Learning, Infectious disease, Global Pandemic, Epidemic, and COVID-19 management. Overall, more than 100 technology applications were found through the search, which was associated with COVID-19 having a development agency as either Public listed or a private firm. These technological applications were divided into eight major categories, as shown in Figure 1.

Contact tracing is the most developed area to date. Based on contact tracing, there are numerous applications available to identify the hotspots for the disease. Likewise, the role of application in social distancing has also been instrumental in managing this disease. Though it is hard to implement this type of application in populous countries, it is convenient in geographically small countries. Next, we took the area of Live

feeds of coronavirus cases through dashboards that are available online. It is an interactive platform for creating public awareness and share the necessary information related to COVID-19. Information searching was also the need at the initial stages of the pandemic as people were not aware of do's and don'ts as this is being a new disease. A robust surveillance device in the vicinity to govern the unfold of COVID-19 is also essential. That is why applications under surveillance-based tools are needed to be studied. This research also mentioned various patient-level applications for treatment in hospitals and home-isolation. With the help of using different technology frameworks, the patient's life during the quarantine was made more informative and precautionary. Chatbots and interactive apps between citizens and health professionals are also coming up in good numbers, as studied in this paper.

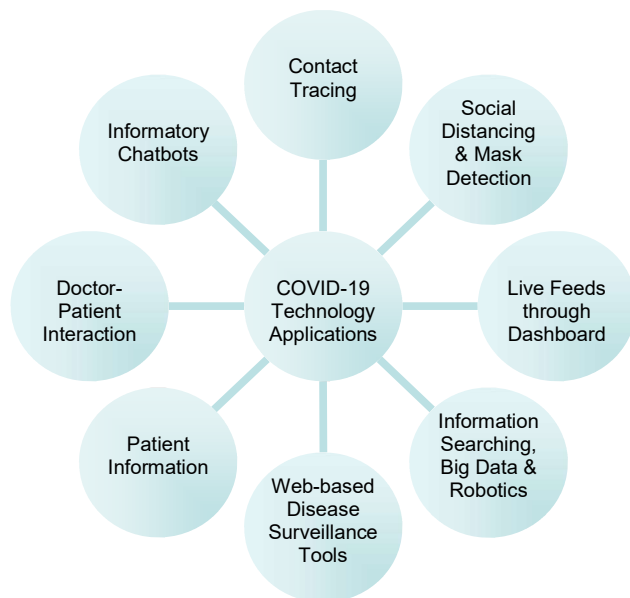


Fig. 1 Technology Application areas under this study

III. FINDINGS

A. Contact Tracing Apps

Contact tracing [11] is the process of finding and distinguishing the people who may or may not have been infected from the virus by monitoring their activities. When applied correctly, contact tracing can be the most effective way to prevent the spread of the coronavirus as it is one of the few technologies that can alert users about the infected person in advance. Contact tracing for COVID-19 requires the monitoring of a person's activities for the last 14 or more days to identify their chances of being infected by taking into account their travel history, health reports, and all the people he/she has come in contact with. These Contact Tracing Apps collect information from users and send alerts to nearby users and health authorities. It works on GPS or Bluetooth technologies. Digital tools used for contact tracing are Outbreak response tools, Proximity tracing tools, and Symptom tracking tool. Some common Contact Tracing Apps are *TraceTogether* (Singapore), *COVIDSafe* (Australia),

CoronaMap (Saudi Arabia), *BeAware* (Bahrain), *CoronApp* (Columbia), *HaMagen* (Israel), *Aarogya Setu* (India). More than 100 countries are now using such apps. However, the effectiveness of these apps is debatable as the number of people downloading these apps to the population is very small [12][13]. Privacy issues have made news with the majority of Apps due to data leak and unwanted surveillance.

B. Social Distancing & Mask Detection Apps

Social distancing means maintaining a safe distance between two persons to reduce the spread of COVID-19 [15]. Many applications have been developed and used in many countries to detect appropriate social distancing norms.

FinePose Social Distancing App

AI for Singapore (AISG) has built up a social separating application to urge people to maintain social distance [16]. The App, based on human pose estimation & distance projection heuristics, identifies the distance between two individuals in real-time and helps the authorities to keep a check over the crowd.

Samsung Wearables

Samsung provides social distancing solutions with their new watches, giving an automated alert to the user in real-time social distancing proximity of their device. The watches use an App from Radiant RFID, which provides anonymous contact tracing and real-time distancing notifications. The App immediately detects the proximity of 7-10 people with their distance and quantity. It sends alerts to all the affected persons, and the data collected is transferred to Radiant's cloud-based processing system for analysis [17][18].

Sodar by Google

Sodar makes an augmented reality two-meter range rings around one to follow social distancing rules. The circle around is used for visualization as to maintain a proper distance between individuals. The generous use of WebXR technology in this application enables the cell phone camera to form a virtual bubble embracing the person such that it gives a range of approximate 6 feet of distance [19].

Ipoin5 & DROR

United Nations Technology Innovation Labs developed a social distancing App known as *Ipoin5*, compatible with different platforms and devices. It checks nearby devices and alerts the user when another device comes in the proximity of the user device. The App uses a Bluetooth RSSI signal band that provides custom distance options up to 2m [19]. *DROR*, another App developed by a private firm in India, is like a personnel safety assistant providing features like 24x7 emergency helpline, roadside assistance service, ambulance services, and a "Track My Trip." *DROR* informs users when they come in contact with someone and crosses the social distance, based on Bluetooth Technology [19].

Mask Detection

Mask is an essential tool to prevent coronavirus from spreading as the SARS-CoV-2 virus can remain for 1-3 hours in droplet aerosols [20]. Many countries like Germany, the

United Kingdom, France, and Italy have made mask-wearing in public necessary [21]. Face Mask Detection apps help identify whether a person is wearing a face mask or not. One such application is created by Hanwha Techwin's innovation accomplice A2 Technology, which is based on an open-stage Wisenet X arrangement cameras and utilizations inventive video investigation to recognize if an individual entering a zone isn't wearing a mask. This will trigger an audio alert message to inform/ warn an individual to wear a mask [22]. The challenge with such Apps is that face detection technology is hard to implement as it requires high-end hardware, which is expensive, making it less accessible by ordinary people.

C. Live Feeds through Dashboards

Live feeds are real-time data dashboard that shows multiple information like the number of infected persons, recovered persons, number of deaths, and many other Growth Parameters. This live feed keeps the authorities & public aware of the situation and helps people take the necessary precautions. The user is provided with a cross-platform application (mobile/web) with an efficient UI/UX, which requests data from the client-side. In the backend, there is a database maintained by the relevant authority. *Worldometer* is one such live dashboard providing real-time statistics around the world [23]. The government of India also provide the live feed for the current updates on the novel coronavirus [24]. Informatory dashboards are helpful for the government to inform the people in the particular region about the rise and fall of patient numbers and accordingly implement different policies. With these dashboards, information to the masses can be broadcasted faster, making people aware of the situation.

D. Information Searching, Big Data & Robotics

Different apps are developed for searching COVID related information and managing them through Big Data structures like Data Lake. Every day new articles and research papers are getting published. Therefore, information is increasing exponentially related to COVID-19, but searching it with other areas on general search engines is becoming difficult. Hence, specialized searching platforms like *Collabovid[dot]org* [25] has been developed, which provides a platform for searching and identifying the most relevant information by using Natural language processing. With numerous COVID-related filters, one can explore the categories section with several categories, including research papers related to the transmission of disease, mechanism of the virus, treatment, diagnosis, prevention, and a lot more. One can also explore which country has published how many papers on COVID. But as the information is growing, Big Data technology is getting into consideration. Enterprise AI software company C3.ai created the COVID-19 Data Lake [26], in which a merged data model is made by uniquely assimilating multiple data sources. It is publicly available at no cost and unifies the data so that researchers can focus on analysis rather than data wrangling from across different platforms.

Robotics Technology is also seen as a helping hand to humans doing monotonous, repetitive, laborious tasks on behalf of humans. Robots can do a job for more extended periods efficiently. Robots can't get infected with viruses like

COVID-19, unlike humans, which makes them an essential part of the treatment and fighting the disease. Robots are helping frontline coronavirus workers like doctors, police, and cleaning staff in developed nations.

E. Web-based Disease Surveillance Tools

Different tools have been developed to track COVID-19 spread through various means. They are discussed below.

SORMAS

The Surveillance Outbreak Response Management and Analysis System (SORMAS) is a publicly available free mobile and web application that allows health workers to inform their departments about new cases, areas where there is a rapid increase in positive cases, and manage to slow down the patients [27]. This application is used by countries like Ghana, Nigeria, and Nepal. It is used for surveillance of new cases, contact tracing, and in managing lab data. Its new module allows the health workers to collect epidemiological data relating to the infected person and share it with health authorities.

DHIS2

Many countries, like Sri Lanka, are implementing DHIS2 surveillance in the fight against novel coronavirus. The DHIS2 framework is centered around the enlistment and following the visitors from zones with a severe danger of COVID-19 disease. Sri Lanka's health specialists distinguished a need to actualize sufficient precautionary measures to keep the virus from entering the nation because of the considerable number of vacationers from countries with high cases that routinely travel to Sri Lanka. They used several methods like screening at the entry points, tracing using surveillance tools until the incubation period was over.

Besides, DHIS2 Android Capture App is also used in surveillance, shifting more to Points of Entry, especially in landlocked countries where people depend on the trade routes for their livelihood. Due to COVID-19, these routes allowed only truck drivers ferrying essential products to enter the borders. Many countries are using such technologies to strengthen their surveillance and tracking system to avoid a rise in the number of cases. DHIS2 Android Capture App collects some personal information to use it for tracking the people with positive cases.

F. Patient Information

Different apps are capturing and providing patient-level information, which is helpful in COVID-19 management.

COVID-19 Sounds App & AI4COVID-19

Covid-19 Sounds [29], a volunteer App, ask the users to input their voice (short recordings) based on the questions provided in the App, which will be analyzed for their voice clarity, breathing patterns, and cough frequency of the patients, to develop algorithms for predicting COVID-19. Through this App, researchers are collecting data, and they are trying to create algorithms based mainly on the sounds of voice, coughing, and breathing. Researchers are trying to distinguish between the COVID-19 respiratory sound and the

sounds of illness related to respiratory. Apart from voice, the demographics and medical history of a patient is also captured in the App. To preserve the privacy of the users, this application's developers will work on options of "preprocessing" and "legal framework", they will also provide the dataset. AI4COVID-19 [29] is another such App that captures the coughing sound of patients and predicts the chances of a patient being Corona positive. This App is yet to be made publicly available.

Biosensors Patch

LifeSignals have come up with an innovative application of wireless biosensor patch for monitoring coronavirus symptoms. These patches are based on wireless biosensor technology and are made for managing two critical areas of the healthcare system, viz., Patient Seeking Information, and Lack of Information for urgent care. The two biosensor patches, 1AX & 2A, are attached to the chest area of the patient, which records temperature, respiration rate, ECG trace, heart rate, and movement in real-time. The data is then sent to the user's smartphone using an App. If there are signs of developing symptoms, then data captured from these patches are sent to the cloud platform so that healthcare authorities can do the needful. This biosensor technology can make a widespread difference in patient's treatment and for the healthcare workers. In these turbulent times, wearable biosensors have become the most searched application in managing the disease.[30]

APOLLO 247

The App is by the Apollo Hospitals Group, which is India's largest healthcare firm. It is a "mobile-first platform" developed to provide around-the-clock healthcare buddy. This App is coming very handy in the times of pandemic situation with its services in different areas like self-assessment for the patient, online consultation, booking a diagnostic test, and checking/recording the symptoms.

G. Doctor-Patient Interaction

There are different apps, discussed below, which help manage the interaction between health professionals and medical advice seekers.

Lyfas

Lyfas App [31] has been developed by Acculi Labs in India, which is a government-supported IT company. This App helps in the early detection of novel coronavirus cases, along with the evaluation of the infected population. It captures necessary health statistics via smartphone to decide one's inclination to Covid-19 infection. The way it manages the information of the individual data is, it creates a profile in the user's device, which is known as "Lyfas COVID Score," which provides a complete "medical screening test" and shares it with the health professionals. The App captures vital health information through the user's index finger via the rear camera. Then it performs tasks like charging the capillary pulse for sensing the change in blood volume and using exclusive algorithms, 95 biomarkers are being derived.

To seize body signals, Lyfas are combining the use of smartphone processor and smart sensors, based on the

principle of Photoplethysmography (PPG), Photo Chromatography (PCG), Arterial Photoplethysmography (APPG), mobile spirometry, and Pulse Rate Variability (PRV). It then provides parameters based on cardio-respiratory, cardio-vascular, hematology, hemorheology, and neurology, capable of tracking minute pathophysiological changes in the body. These changes are further profiled into organ system-wide response. The App can detect asymptomatic individuals with 92% Accuracy, 90% Specificity, and 92% Sensitivity. The application is beneficial in the surveillance of the community transmission as it can be used to screen the masses. Moreover, it found its use to invigilate the people kept under quarantine.

CovidDialog

Novel coronavirus has caused a situation of panic among the masses around the world. People have been experiencing psychological symptoms, thinking that they might have been exposed to the virus or come in close contact with some symptomatic person. Seasonal flu has comparable signs to the ones of COVID-19. Therefore, many people do not want to neglect their health and require the consultation of doctors. Due to the lockdown effect in many countries, people find it hard to come to the hospital and fear getting "cross-infection." For this purpose, a medical dialogue system has been developed, termed as CovidDialog [32], that can give doctor's consultation to the patients relating to novel coronavirus. On the two datasets (English & Chinese), it has generated several dialogues based on Neural Network Modeling Techniques. The datasets taken are of small size, which can suffer failure to fit the additional data or predict future observations. Therefore, to attenuate from failing of the model, on the "large-scale dialogue datasets," the pre-prepared loads of the models are taken, and small adjustments are made in values on CovidDialog. The response produced from the automatic and human assessment came with the result that gave a "doctor-like" environment, which is appropriate to the history of the patient and providing useful clinical information. CovidDialog model prepares the path for creating a novel coronavirus dialogue chatbot.

H. Informatory Chatbots

Many chatbots are available for resolving queries and seeking information related to COVID-19, which are based on Artificial Intelligence and Natural Language Processing (NLP). For Example, COVID-19 Preventable, Symptoma, COVID-19 Chatbot, WHO chatbot on Facebook Messenger, Rapid Response Virtual Agent, Microsoft Azure, LivePerson, Combat-19, and Directly. Some of them are discussed below.

COVID-19 Preventable Chatbot

COVID-19 Preventable chatbot [33] is the first official chatbot introduced in Thailand based on Artificial Intelligence through Dialogflow, which is very useful in supporting the hotline service. In this, data from dependable sources is changed into an inquiry and answer framework, which is then imported to normal language handling in the Dialogflow on Google. Prominent features for this chatbot include Reporting of a condition, Q&A on protection from COVID-19, Filter for fake news, Self-screening assistance, listing nearest hospitals,

providing hotline numbers to call in an emergency, and reporting notification. In the Dialogflow's mechanism, the extracted information is uploaded as intents that map the user's response. Then, possible statements and their synonyms are created to trigger related sense. This is one reason why a chatbot can mimic a human-like conversation. Regarding privacy and security, the chatbot does not ask for a user's personal information and has been developed on a global privacy protection and security policy [33].

Symptoma

Symptoma is a widely used symptom checker and digital health assistant. It helps patients to receive the right diagnosis of over 20,000 diseases. During COVID-19, Symptoma has created a separate section for determining the risk of COVID-19 based on 18 simple questions available in 36 different languages, leading to a risk level for Covid-19. Based on the answers, the risk of novel coronavirus virus is determined. It also provides a solution to the number of calls at health authorities, where hotlines have struggled to keep up with increasing callers for pre-screening of the disease. This bot is accurate and efficient in its predictions. According to a report in the British Medical Journal [34], this chatbot has an Accuracy of 96.32%, a Sensitivity of 96.66%, and a Specificity of 96.31%.

COVID-19 Chatbot

This NLP-based chatbot, also referred to as "smart ubiquitous chatbot," assists the people who are treated for novel coronavirus [35]. It differs from other chatbots as it serves people kept under quarantine, which may be suffering from Groundhog Day Syndrome, mental stress, and depression. It consists of various modules like Information Understanding Module (IUM), Data Collection Module (DCM), Action Generator Module (AGM), and Depression Detector Module (DDM), which does not violate significant security concerns.

IV. DISCUSSION & CONCLUSION

COVID-19 pandemic has proved how vital technology has become in our life. With the help of technology, life continued, the office work changed to work from home, college students continued their studies from online classes at home, and other aspects of Decision Making was done efficiently under the current health emergency.

The most significant impact was seen in healthcare, where technology like Social distancing and contact tracing proved to be a game-changer in several countries, helping in preventing the disease from spreading, and AI-based robots helped medical personals from getting infected. With new patients rising every day, the workload on the frontline workers like doctors, non-medical workers, and police increased. But technology like drones and robots helped them in supplying essential items to the quarantined wards and in sanitizing/cleaning the hospitals & residences. New developments in the field of AI have led to a contactless diagnosis of patients with increased accuracy in less time, decreasing the risk of getting infected by a patient. Contact

tracing is an easy way to detect the infected person in your close contact.

Similarly, social distancing apps help in maintaining a healthy distance in public places. Also, it alerts us every time we come in contact with someone. Hygiene is the most critical tool in keeping the coronavirus in control by following simple health measures like wearing a mask in public, washing your hands, avoiding crowded places, and many more. Face Detection apps in factories and malls provide a check on someone who is not following the protocols. Most outbreaks like Black Plague, Spanish Flu, Asian Flu become so deadly due to unhygienic conditions, which are heavens for diseases to prosper. In the future also, hygiene is necessary to avoid outbreaks like these from taking over.

With increasing cases of infected people, the focus of hospitals and doctors are more on the COVID patients and are overlooking patients with other deadly diseases due to time shortage. The hospitals which are full of corona infected people are becoming extremely dangerous for non-COVID patients. In such cases, the Doctor-patient interaction apps come into play, which not only provides the guidance and necessary help required to the patients but also decreases the risk of getting in contact with another COVID-19 infected patient. These apps also help people who have mild symptoms of the virus and don't require a visit to the hospital. With apps like *Lyfas*, a person can be guided at their home to take necessary precautions without traveling anywhere, which has become nearly impossible in this situation.

Amid the emergency circumstances of the COVID-19 crisis, the development of various innovative applications using different technologies is trying its best to sustain the adversity of the pandemic. There are many applications from the findings that use Artificial Intelligence, which asks the user to check the status of their health and collects the information to predict if the user is healthy or unhealthy. As physicians and health care staff continue to monitor patients carefully despite the coronavirus outbreak, some applications help hospital staff in cost-effective testing and managing positive patients. As countries are moving to unlock the restrictions, national authorities have provided a specific set of Standard Operating Procedures (SOP) to its citizens. AI-driven applications have been used to keep a close watch on those who are violating SOP.

Unlike pandemics in the past (e.g., Spanish Flu, SARS, H1N1, Influenza, Swine flu), the current epidemic supports technology for decision making. There is no doubt that technology is the human's most trusted and advanced weapon in the fight against COVID-19. Applications discussed in this study can control and suppress spread, strengthen the health system and surveillance system, and keep an eye on the detection of active cases. Technology has come a long way, and a longer road is left to travel, but with today's technology, we can stand a chance of survival against these deadly pandemics.

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