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Review Paper

Technology Role in COVID-19 Pandemic Confrontation: China Experience

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Abstract: The spreading outbreak of China's new coronavirus disease (COVID-19) is swiftly worldwide. In this time of unparalleled medical crises, attention has been paid to smart healthcare systems based on digital healthcare to provide possible health solutions to lessen the impact of the pandemic. The employment of modern digital technologies during the COVID-19 pandemic can substantially prevent the spread of the epidemic. This has been accomplished by adopting pandemic emergency control approaches and combining resources from numerous systems across the country, including business, the community, technology, education, and transportation. This paper focuses on the successful Chinese experience to fight the disease and how digital solutions can impact healthcare during this pandemic.

Keywords: COVID-19; IoT; Digital-healthcare; UVD; and Drones

1. Introduction

Coronavirus disease (COVID-19) is caused by the rapidly spreading extreme, acute respiratory syndrome coronavirus 2 (SARS-CoV-2) worldwide. It is a newly acknowledged disease that originally spread exponentially in Wuhan, China, and from there to other provinces in China and then worldwide. As of May 9th 2020, the number of COVID-19 patients worldwide exceeded 3 million, with more than 278,000 casualties. The clinical spectrum of SARS-CoV-2 pneumonia varies from mild to seriously ill cases and needs early diagnosis and monitoring for severe cases within a hospital setting and for mild cases remotely. The fear of contamination in clinical settings has contributed to a drastic decline in on-site routine treatment referrals [1].

There was also a perceived need to monitor non-severe COVID-19 patients continuously, either from their home quarantine site or from a dedicated quarantine site (e.g., hotels). Alternative routes for providing routine healthcare services to non-COVID-19 patients were also required while in quarantine [2]. Thus, the pandemic has created opportunities to develop and improve or build new routes for delivering remote healthcare services. This has created a dramatic impetus for finding new ways to track patient health status remotely and effectively. Remote health monitoring is about monitoring individuals outside the conventional hospital environment, typically at home. It allows monitoring patient well-being (e.g., quality of sleep) and condition (e.g., hypoxemia, atrial fibrillation) to track changes requiring medical care [3]. COVID-19 is driving a variety of groups to improve or create new approaches to coping with the novel Coronavirus, including researchers, entrepreneurs, governments, and industries worldwide. Perhaps the greatest benefit of the pandemic is the reinforcement of our modern, connected, and digital society's understanding of the significance of remote monitoring of health [4].

The massive effect of the COVID-19 pandemic on worldwide healthcare systems has pushed researchers to look for new ways to combat the disease [5]. With self-quarantine and social

distancing assuming importance in limiting community spread, digital and telehealth services can play a vital role in the COVID-19 pandemic. Virtual care can allow maintaining continuity of care to patients remotely. The successful Chinese fight against the disease has focused attention on digital health care. To limit the effects of this pandemic, emphasis has turned to smart health-caring systems, which take into account the digital health community in the quest for health solutions [6]. This manuscript focuses on the successful Chinese experience to fight the disease and how digital solutions can impact healthcare during this pandemic.

The Chinese government responded promptly to the emergency and implemented rigorous controls and timely deployment of resources to reduce loss and progressively control the pandemic. As illustrated in **Figure 1**, as of July 2020, the number of newly confirmed cases continues to reduce under the Chinese government's policy intervention with the modern technologies and its applications, although confirmed cases do not yet appear to be adequately managed in other regions of the world.

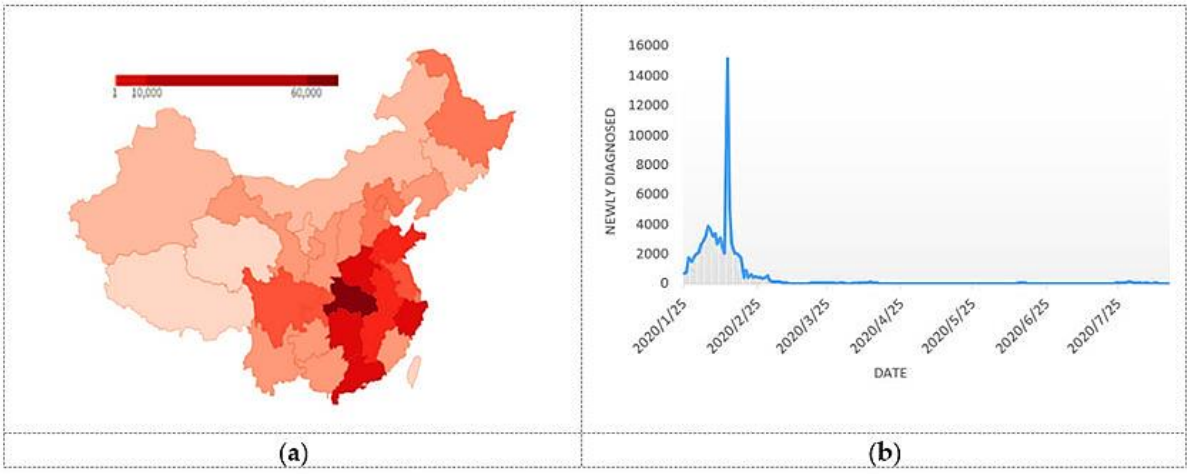


Figure 1. (a) Cumulative confirmed cases of COVID-19 pandemic in China [7]; (b) The development trend of COVID-19 pandemic in China: Newly diagnosed cases [7].

China's Health Information Technology Practice has contributed a vital role in China's response to the COVID-19 outbreak. Throughout the pandemic, information technology was utilized to predict epidemic trends, track close relationships, and diagnose patients remotely. We present specific health information technology practices for managing the COVID-19 outbreak in China and describe several health information technologies used to fight COVID-19 in detail, based on the health information technology framework for responding to the epidemic described in the following section.

2. Chinese experience while fighting the COVID-19 pandemic

As humankind celebrated the arrival of a new decade of development, Wuhan, China — a busy travel center with over 11 million residents – saw a virus steadily infecting its markets and streets. When COVID-19 (and commonly referred to as the Wuhan Virus or Coronavirus) was widely reported and acknowledged as a serious danger to people's lives and the global economy's health, it started to be referred to as the Wuhan Virus or Coronavirus. To respond to the upcoming Chinese New Year, the nation had to act. To limit travel, the Chinese authorities decided to institute the world's biggest quarantine ever in Wuhan [8]. The virus was held at bay as executives in the industry and their staff tried out new technology and methods to reduce the damage. In an effort to address the spread of COVID-19, authorities have partnered with the corporate sector to investigate new technologies to assist in combatting it. In the following section, we will illustrate the Digital Technologies used during the COVID19 pandemic in China.

2.1 Health sensors and Apps

China was the first country to encounter the COVID-19 disease, was also the first to develop innovative remote monitoring methods to assist clinical staff and public health experts. It's no surprise that the most basic kind of remote monitoring technology is a smartphone, enabling things like telemedicine consultations, symptom screening, and approximate heart rate monitoring using the camera and GPS location tracking. The Chinese government partnered with Tencent and Alibaba to establish color-coded health rating systems, which are added to WeChat, a Tencent-developed service, and AliPay, an Alibaba-developed service (Hangzhou, China). Citizens are instructed to download software that reports their whereabouts to the local police and other authorities. The software incorporates geo-tracking and meta-data such as trip reservations to identify residents as "red" or "green," according to **Figure 2**. Locations where high-risk persons may be restricted, include residential complexes, grocery shops, and workplaces [9]. The two services utilized for these purposes are WeChat and AliPay. China has launched an online consultation system in commonly used mobile apps, such as WeChat and Alipay, to provide technical support for the remote screening of COVID-19 infection risk. In addition, Universities and research institutions also contributed to the online consultation systems. An example is that the Second Affiliated Hospital of Xi'an Jiao tong University has developed a free online health consultation and COVID-19 risk screening platform [10].

Figure 2. Smartphone Color-Coded Health Rating Apps; green (low risk), yellow (moderate risk) to red (high risk)

2.2 Temperature Screening Checkpoints and Thermal Health Scans for Signs of Coronavirus Infection

In order to quickly identify suspected COVID-19 infections in high-density areas, such as train stations, bus stations, railway stations, airports, supermarkets, and residential area entrances, checkpoints for temperature screening have been erected [11]. Anyone entering a public area is temperature-screened using non-contact infrared thermometers for rapid body temperature measurement [12], as shown in **Figure 3a**. Since core temperature is particularly hard to assess without an invasive probe, far-infrared (FIR) thermal imaging is a hot contender for remote/non-contact monitoring Baidu (Beijing, China) has developed a system that can examine up to 200 people per minute and accurately determine the individual's off-range body temperature, without causing passenger delays. This is used at Beijing's Qinghe Railway Station. Megvii Technology Ltd [13]. (Beijing, China) fever-screening and face detection dual-sensing via infrared cameras and dual light fusion technology as given in **Figure 3b**.

Figure 3. Temperature Screening and Thermal Health Scans Checkpoints

2.3 Robotics

Robots play an essential role in our fight against the COVID-19 pandemic, one of the biggest problems of our time. They are deployed in so many different ways and forms across the globe to prevent the spread of viruses and save lives. Some work as disinfecting robots. Some help monitor patient vital signs remotely without person-to-person contact. Some lend their helping hands to facilitate a conversation between infected patients and hospital staff, while others deliver medical supplies and goods [14].

This section will look at the vital roles that robots are currently playing across the globe to fight the COVID-19 pandemic.

2.3.1 UVD robots

UVD robots are movable platforms that use ultraviolet (UV) light to disinfect facilities. In Wuhan and other locations, China deployed around 2,000 UVD robots to eliminate viruses. Ultraviolet light (UV-C) kills hazardous germs, and the robot walks around the patient areas and operating theatres independently, applying the appropriate quantity of UV-C light to destroy certain viruses and bacteria. 99.99% of all viruses and bacteria are eliminated in 10 minutes with this treatment. if someone enters the room, the robot disengages as shown in **Figure 4a** [15].

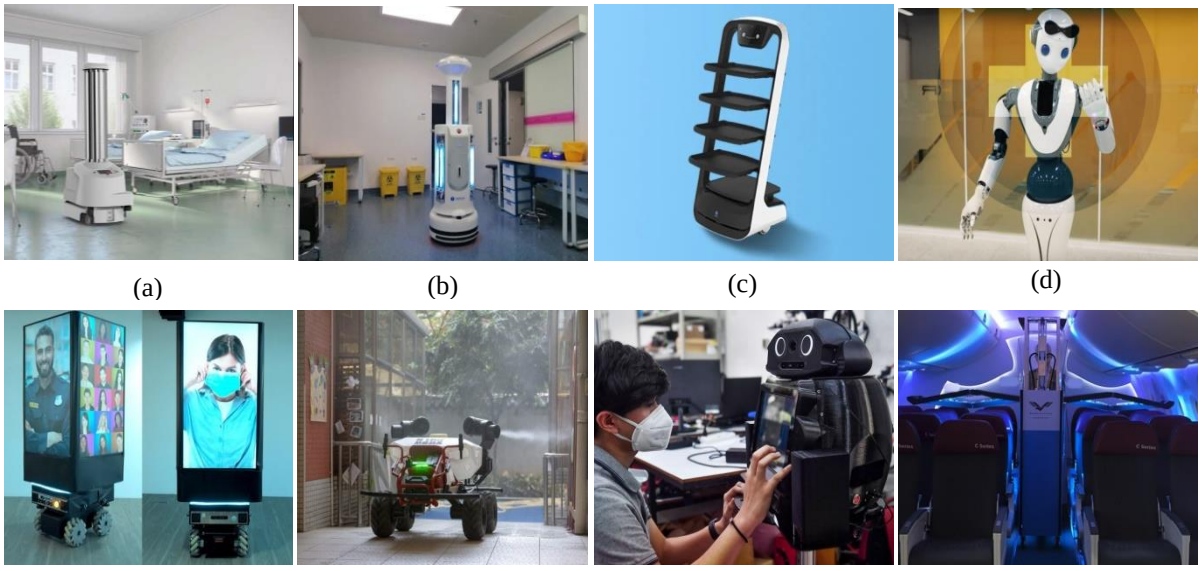


Figure 4. Different types of robotics fight the COVID-19 pandemic.: (a) UVD robot; (b) Disinfection robot; (c) Waiter robot; (d) Humanoid service robot; (e) Advertisement's robot; (f) Disinfectant robot for infected zones; (g) Fever's robot; (h) Robot for disinfection an aircraft's interior surfaces

2.3.2 Disinfection robots

After the coronavirus outbreak reached China, unprecedentedly enormous orders for disinfection robots have been made. To disinfect both medical staff and patients, this autonomous robot mixes chloric acid and plasma. Autonomous mobile disinfection robots can navigate on their own and execute human jobs like total disinfection in epidemic zones. A robot can carry 1,500 milliliters of disinfectant for 3 hours each time it is in use as shown in **Figure 4b** [16].

2.3.3 Waiter robot

This sort of robot, called PuduBot, is an autonomous service delivery robot. This little robot-on-wheels delivers prepared meals and medical supplies to patients who are confined in local hospitals. Robotic mapping may take two hours and the robot is ready for its maiden delivery. It utilizes sensor fusion navigation technology, including a vision sensor, to plot a course and avoid obstructions as shown in **Figure 4c** [17].

2.3.4 humanoid service robot

The humanoid service robot created by robotics startup CloudMinds is called XR-1 Cloud Ginger. This empathetic robot can interact with patients like a person. It simulates the ways that people move and speak (i.e., flexible fingers, eye contact, and arms that gesture). The robot's voice, pitch, tone, speaking cadence, and language were created to sound human. It can read and understand human emotions, and it even dances and exercises with patients to help them remain active and in good spirits as shown in **Figure 4d** [18].

2.3.5 Advertisement's robot

More ads featuring service robots are available. The robot is a mobile kiosk featuring four 55-inch 4K resolution displays, speakers, and microphones. Operators may launch teleconference video calls on several monitors. Two lidar scanners 360-degree obstacle avoidance while moving. Autonomous or teleoperated operation It can also show educational videos as shown in **Figure 4e** [19].

2.3.6 Disinfectant robot for infected zones

Originally designed as a field sprayer, the robot is now employed to spread disinfectant across the virus-infected regions, heavily inhabited regions, and vehicles that spread the infection. It features a 360° high-speed clever Jet Sprayer and an 80-liter container as shown in **Figure 4f** [20].

2.3.7 Fever's robots

It was created to observe stroke recovery patients. It is now being repurposed to battle the coronavirus epidemic. Hospitals utilize the robot to assess fevers and enable doctors and nurses to chat to patients through video connection. The doctors and nurses may speak with patients outside the room via the robot as shown in **Figure 4g** [21].

2.3.8 Robots for disinfection an aircraft's interior surfaces

This robot can clean an aircraft's interior surfaces in minutes between flights by using UV-C light technology. This sort of robot is known as Germ Falcon. UV lights are used to clean the passenger compartment, toilets, and galley. The machine is as little as an airline food and beverage trolley. With germicidal UVC lights, these retractable wings can clean up all the places where germ may spread as shown in **Figure 4h** [22].

2.4 Satellite monitoring

The hospitals were developed at an astounding rate, but GaoFen was used to keep tabs on their development. The Zhuhai-1 hyperspectral imaging satellite and ESA's Sentinel-1 satellites worked together to provide constant surveillance of hospital development as shown in **Figure 5**. The Wuhan

University studied many data sources to determine which location was optimal for the hospital. The Chinese second-generation AI satellite TFSTAR and its U.S. equivalent, ADA-Space, have processing and analytic capacity, which allows them to efficiently sort through data. In order to visualize COVID-19, the data processing and geocoding capabilities of TFSTAR were used to provide a depiction of COVID-19's global reach [13].

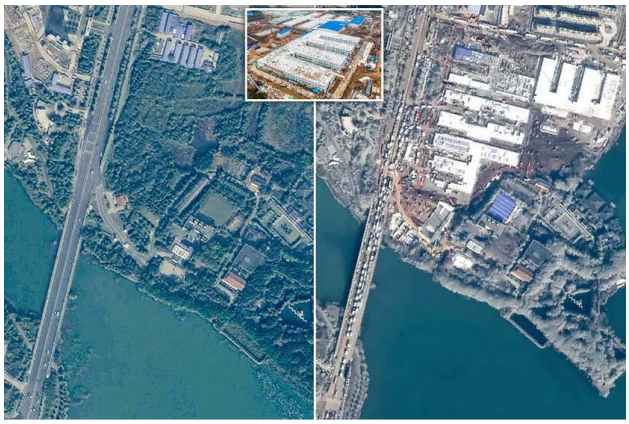


Figure 5. Zhuhai-1 hyperspectral imaging satellite [13].

2.5 Drones

Drones are considered a very useful tool during this epidemic. Many departments around China used drones for public safety and also found new uses for drones in combatting viruses. Drones are inherently efficient at reducing human contacts, and this is particularly important when police personnel might possibly become vectors for the virus to spread. For facilitating communication, disinfecting, and delivery, drones have been used. Some of these applications are brand-new, creative methods to employ drones to fight COVID-19. This figure displays the drones in the COVID-19 situation [23].

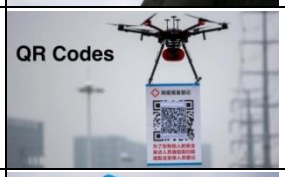
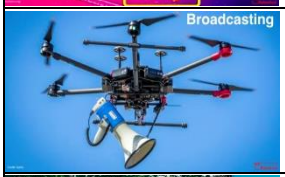
	**Usage:** Spraying streets with disinfectants or other substances to prevent the further spread of COVID-19 has an impact on reducing the transmission of the novel Coronavirus.		**Usage:** Surveillance to help enforce lockdowns, sanitary cordons, and curfews during the pandemic.
	**Usage:** Remote body temperature scanning. e.g., sensors can distinguish between a body temperature of 37.2C and 38.0C from 50 meters away.		**Usage:** Aerial QR Codes, carrying posters of QR codes which is used as a registration system for drivers to monitor population movement into the city.
	**Usage:** Loudspeakers on drones to encourage physical distancing and staying home.		**Usage:** flying cell phone towers to provide connectivity in Field hospitals and quarantine camps where traditional communication. Infrastructure is not yet in place.
	**Usage:** Cargo delivery, delivering essential medicines, and collecting patient samples for COVID-19 testing is being widely promoted.		**Usage:** providing maps overlaid with population data to plan the movement for delivery partners, placement of barricades, social boundaries, management of gates and roads.

Figure 6 Drones applications in the COVID-19 crisis

Drones are a microcosm of the whole IoT domain, whereby drones can adapt to their surroundings and interact with it. This means they can be used at multiple places, handle varied

loads, and gather data on almost anything. On-board a drone might incorporate electronics such as sensors, digital cameras, actuators, and communication technologies, such as Wi-Fi, 5G, LTE, or Ad-hoc networks, as depicted in **Figure 6**. The critical technical component in tiny device communication for things like healthcare monitoring equipment, environmental sensors, etc. is drones. IoT devices need to use plenty of energy to process and store data. Low-power, connected IoT devices are common in smart cities. This therefore rules out long-range signaling in these smart IoT devices. Reducing energy usage is a must, and data security is necessary to increase the overall quality of the user experience. Lightweight cryptography is used to solve IoT issues [24].

2.6 Mobile tracking/mass surveillance

The virus has established a large-scale surveillance system to counter it. China has a centralized database in which it collects everyone's location data, body temperatures, travel histories, and other facts. Every quarantine center is outfitted with thousands of face recognition-powered CCTV cameras, and only individuals given the green color code may drive on the highways. The popular instant messaging app WeChat is being exploited to harvest data. Using this data, the government may determine the number of persons that the infected individual came into touch with and then has them self-isolate. An example of this is that if a person in the previous ten days has used WeChat or AliPay to purchase biscuits, the employee who was in touch with them must be quarantined. **Figure 7** shows people's smartphone location data, body temperatures and persons were in close contact [13].

Figure 7. People's smartphone location, body temperatures and persons were in close contact [13].

2.7 Autonomous vehicles

Automated cars have proven useful in an emergency if the health-care workforce is strained, and the danger of human-to-human contact is an issue. Neolix and Baidu's autonomous vehicle platform, Apollo, teamed together to provide supplies and meals to a large hospital in Beijing. The Baidu Apollo micro-car kits and autonomous driving Cloud services are also free to enterprises combating the infection [25]. The I*driverplus* electric street cleaning trucks are also involved in the job. A business vehicle is being utilized to sterilize hospitals. **Figure 8** shows autonomous vehicle delivering essential goods like medicines and food items.

Figure 8. Autonomous vehicle delivering essential goods like medicines and food items.

2.8 Smart wearable bracelets

Patients, doctors, and nurses wear wristbands that are synchronized with CloudMinds' platform (Shenzhen, China), to monitor their vital indicators, including temperature, heart rate, and blood oxygen levels, to detect any early symptoms of infection or adverse events [26]. **Figure 9** shows different types of Smart wearable bracelets [4].

Figure 9. Different types of Smart wearable bracelets

2.9 Privacy implications

Such new, more-advanced technology have been helpful in saving millions of lives but come at a great cost when it comes to privacy. Chinese control of the Internet is already well-known, and it has been further enhanced with face recognition-powered CCTV cameras placed in all major cities to combat the Coronavirus. Removing the infection will save lives, and restoration to normality is of primary importance in these unique times. We now see the need to suppress the contentious privacy vs security discussion. But in a few months, we may end ourselves in a complicated scenario with respect to individual privacy. The question is, would governments retreat when the crisis is over, or will they further cement their hold on individual data? Nothing is settled.

3. Conclusion

The research discusses the successful Chinese experience in combating the disease and the usage of modern technologies that enhance the situation during these conditions. It presents how digital technologies can influence health care in the current epidemic.

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