IoT supporting COVID-19 prevention, diagnosis and treatment

Desk Review, NGIoT, 3 August 2020

With around 15 million confirmed cases of COVID-19 worldwide, measures to control the epidemic in various regions have leveraged IoT to manage patients, identify and isolate those infected and prevent transmission. While some European countries and New Zealand have virtually stopped COVID-19 from spreading in their territories, other regions are far from that milestone. On 2 April, 2020 the World Health Organization hosted a high-level meeting between technology and health experts, signalling the urgent need for digital solutions to help tackle this global threat.

Cecilia Bonefeld-Dahl, Director General of DIGITALEUROPE, has highlighted the need to increase spending on infrastructure for on-line access, 5G rollout and to accelerate the implementation of a common European data space for health. Data essential for tracking and fighting diseases should be shared between the public sector, researchers and private companies while maintaining strong security and data protection safeguards, she urged. (Parliament Magazine EU). These actions are among those highlighted as innovation drivers by NGIoT's IoT scoping paper.
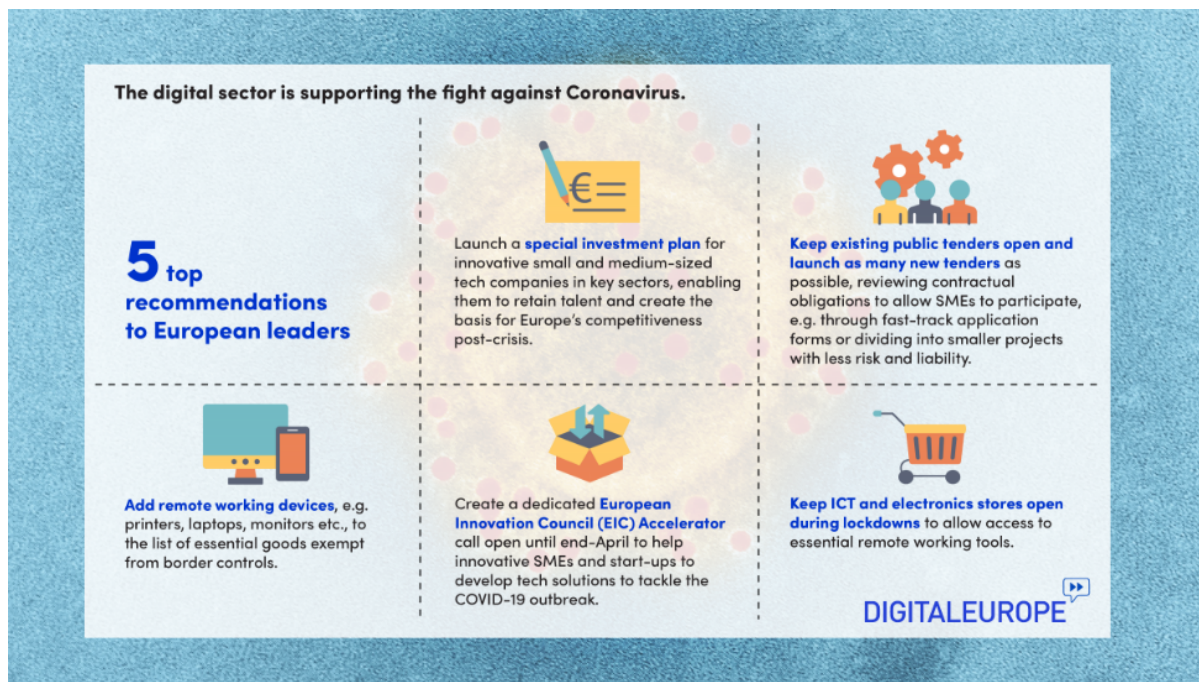

Fig. 1: The digital sector's support against Coronavirus, source DIGITALEUROPE

CONTACT TRACING

The scale of COVID-19 infections has outstripped governments' capacities to conduct manual contact tracing. Existing contact tracing practices are resource intensive, slow and often subject to recall bias. Therefore, contact tracing apps harnessing Bluetooth technology adopted by governments is one of the main ways IoT can support disease control.

People infected with COVID-19 are possibly infectious before they become symptomatic, with one estimate being that 50 percent of all new COVID-19 infections being transmitted from someone who is either pre-symptomatic or asymptomatic, (Science). Therefore, contact tracing is moving beyond tracking people with symptoms of the virus, to tracking health in general. UK researchers have developed a symptom tracking app that prompts users each day to record any symptoms and general wellbeing, the COVID-19 Symptom Tracker App 2020 (Mass General Cancer Center). Data from wearable smart devices, such as fitness apps could provide diagnostic support by detecting physiological changes (ABC News). The German Health Authority has already launched an application to collect wearable data voluntarily from citizens (The Star). Data could be incorporated into machine learning algorithms to try and provide diagnostic and surveillance support to health agencies.

Applications should enable users to control their data, collect only relevant data and have clear procedures for use by health authorities. Fear of loss of data security affects uptake. To maximise the uptake of case reporting there is a need for coordination and leadership. In Singapore, reports suggest around only 16 percent uptake of their contact tracing app (Radio NZ).

At the initiative of the European Commission and in line with the Toolbox for Tracing Apps published in April 2020, representatives of the NGI community set up a technical review facility that provides independent security and privacy analysis of COVID-19 related technology. The Emergency Tech Review Facility is a collaborative, community-focussed effort to quickly and transparently analyse COVID-19 tech solutions to improve trust in technology which could lead to wider uptake.

The Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT) makes it possible to interrupt new chains of SARS-CoV-2 transmission rapidly and effectively by informing potentially exposed people. The non-governmental organisation (NGO) provides standards, technology, and services to countries and developers, with an emphasis on preserving privacy. PEPP-PT builds on tested, fully implemented proximity measurement and scalable backend service, to enable tracing of infection chains across national borders.

The Australian federal government has sought to allay privacy concerns with its contact tracing app by proposing a jail term of up to five years for those that use COVIDSafe data for any purpose other than contact tracing. Australia's peak Internet of Things (IoT) industry body, IoT Alliance Australia (IoTAA), and Telstra, Optus and others have funded a COVID-19 discussion hub that examines the industry's response to the crisis. (IoT Hub).

AI, BIG DATA & SURVEILLANCE

Access to public information has led to the creation of national and regional dashboards that are continuously monitoring the virus, requiring the development of dashboards using Big Data and AI.

The European Commission will invest in the use of Artificial Intelligence to speed up the diagnosis of COVID-19 and improve future treatment of patients. A software developed to assist the work of medical staff by analysing images of pulmonary infections is introduced in 10 hospitals across Europe. The AI tool will allow the diagnosis of COVID-19 in less than one minute. The algorithm uses the images collected by a computerised tomography (CT) scanner (usually an integral part of a hospitals' infrastructure) to detect COVID-19 suspicious cases (European Commission).

An EU-funded consortium is using an EU-backed supercomputing platform, one of the world's most powerful, to check the potential impact of known molecules against the genomic structure of coronavirus. Exscalate4CoV has announced that an already registered generic drug used to treat osteoporosis, Raloxifene, could be an effective treatment for COVID-19 positive patients with mild or asymptomatic infection (European Commission).

China has created a massive surveillance system to fight the virus and is using Big Data and Machine Learning to analyse data. The Chinese government is gathering people's smartphone location data, body temperatures, travel history and other details in a centralised database. Thousands of facial recognition-powered CCTV cameras have also been installed at almost every quarantine center and only those who have been assigned the green colour code can drive on the roads. WeChat, the popular instant messaging app that also has a digital wallet, is being used to collect data. (Geospatial World). Chinese AI companies like SenseTime and Hanwang Technology have claimed to come up with a special facial recognition technology that can accurately recognize people even if they are masked. CCTV cameras have also been installed at most locations to ensure that those who are quarantined do not leave their homes. (Geospatial World). Baidu has also made tools to screen large populations and an AI-powered infrared system that can detect change in a person's body temperature. It was being used in Beijing's Qinghe Railway Station to identify passengers who were potentially infected. The system can examine up to 200 people in one minute without disrupting passenger flow. (Geospatial World).

To mitigate the epidemic and accurately scan people diagnosed with the virus, countries across the globe are tracking smartphone data. For instance, in Australia, it has become mandatory for all mobile connectivity companies to save at least two years of data of every person, including data regarding his whereabouts, or simply location data. This data would be critical in examining the travel history of the person who has tested positive. It would also become easier to spot any phone that has been in close range of the infected person's phone in the past few months. The owners of those phones can then be screened, irrespective of whether they have developed symptoms. (Geospatial World).

US, Singapore, Poland, Israel and South Korea are some of the other countries that are using smartphone tracking. It is believed that the British government is discussing the possibility of location data tracking with British Telecom, the country's biggest operator. A Washington Post report says that the White House is in talks with tech giants like Google and Facebook to effectively track user location data and gain insights from it. Further, reports suggest that most global telecom

companies are planning to develop a comprehensive framework that will enable sharing of data on an unparalleled scale. (Geospatial World).

Bio-surveillance could emerge as normal, recording the pulse rate, blood pressure and other biological parameters that drastically change when people feel happy, sad and angry. If a government knows what makes a particular person cheerful or gloomy, it can very easily devise strategies for manipulation. (Geospatial World).

The Chinese government joined hands with tech giants Alibaba and Tencent to develop a color-coded health rating system that is tracking millions of people daily. The smartphone app was first deployed in Hangzhou in collaboration with from Alibaba. It assigns three colours to people — green, yellow and red — on the basis of their travel and medical histories. In the industrial hub of Shenzhen, a similar software was created by Tencent.

Whether a person should be quarantined or allowed in public spaces was decided based on the colour code. Citizens had to log into the app using pay wallet services like Alibaba's Alipay, Ant's wallet, etc. Only those people who were assigned a green colour code could be allowed in public spheres after using the designated QR code at metro stations, offices and other public places. There were checkpoints at most public places where the code and a person's body temperature was checked. More than 200 Chinese cities were using this system. (Geospatial World).

BORDER CONTROL

Hong Kong and South Korea use GPS data for quarantining procedures. In Hong Kong, incoming passengers are provided with wristbands that link to a GPS-enabled smartphone to enforce self-isolation rules source (Straights Times).

In New Zealand, incoming passengers' address information is already routinely collected (The Conversation). A digital app that uses GPS data may enable passengers to update their self-isolation plan online to expedite screening procedures, help monitoring and enforcement of self-isolation rules and provide support to visitors during their self-isolation period. (Public Health Expert).

MEDICAL IoT

At present, there are no effective antiviral drugs against COVID-19, therefore case identification and monitoring are vital. The application of the IoT to medicine is referred to as the medical IoT (MIoT) which aims to establish a decision-oriented big data analysis model supported by information technology such as communication, electronics, biology, and medicine.

The current diagnosis of COVID-19 is mainly dependent on viral nucleic acid testing (NAT). The accuracy of current nucleic acid testing is approximately 30–50 percent (Clinical eHealth[1]). NATs differ from other tests in that they detect genetic materials (RNA or DNA) rather than antigens or antibodies. Detection of genetic materials allows an early diagnosis of a disease because the detection of antigens and/or antibodies requires time for them to start appearing in the bloodstream.

Computed Tomography' (CT) can precede the detection of nucleic acid tests in some patients. CT refers to a computerized x-ray imaging procedure in which a narrow beam of x-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed by the machine's computer to generate cross-sectional images of the body (Wikipedia).

The aforementioned software developed to assist the work of medical staff by analysing images of pulmonary infections (European Commission); as well as the EU-funded Exscalate4CoV consortium, which is using an EU-backed supercomputing platform, to identify a treatment for COVID-19 (European Commission) demonstrate development of MIoT in Europe.

Figure 2, IoT in Healthcare, source: IoT Magazine

With the help of data analytics and predictive models, medical professionals can understand more about diseases. Baidu, the Chinese Internet giant, has made its Lineatrfold algorithm available to teams that are fighting the outbreak, according to the MIT Technology Review. Unlike Ebola, HIV and Influenza, COVID-19 has only a single strand RNA, so it is able to rapidly mutate. The algorithm is a lot faster than other algorithms that help predict the structure of a virus. (Geospatial World).

In China, Alibaba has developed a Cloud-based Coronavirus diagnosis tool that the company claims is more than 96 percent accurate and takes less than 20 seconds to work. The tool uses AI to detect traces of the virus. Alibaba says that it has been used on more than 5,000 patients throughout China. (Geospatial World).

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[1] Chinese experts' consensus on the Internet of Things-aided diagnosis and treatment of coronavirus disease 2019 (COVID-19) Author: Li Bai,Dawei Yang,Xun Wang,Lin Tong,Xiaodan Zhu,Nanshan Zhong,Chunxue Bai,Charles A. Powell,Rongchang Chen,Jian Zhou,Yuanlin Song,Xin Zhou,Huili Zhu,Baohui Han,Qiang Li,Guochao Shi,Shengqing Li,Changhui Wang,Zhongmin Qiu,Yong Zhang,Yu Xu,Jie Liu et al., Publication: Clinical eHealth, Publisher: Elsevier, Date: 2020 https://www.sciencedirect.com/science/article/pii/S2588914120300046

MIoT is the basis of China's "COVID-19 Intelligent Diagnosis and Treatment Assistant Program (nCapp)". Considering the different levels of diagnosis and treatment among doctors in different regions and hospitals, some cases are still missed or misdiagnosed, especially when the nucleic acid test has a negative result (Clinical eHealth[2]).

The IoT nCapp cloud medical system platform contains the basic functions of IoT and has a core graphics processing unit (GPU). Cloud computing systems connected to existing electronic medical records, image archiving, and picture archiving and communication can better assist in deep mining and intelligent diagnosis. The functions of IoT are considered to be beneficial time assistance, supervision, and control of medical quality; as well as online monitoring, location tracking, alarm linkage, and follow-up scheduling; and finally systems management, remote maintenance, command management, and statistical decision-making functions, which can expand the massive information mining of COVID-19. It can also assist in asking questions; registering patients' details; coordinating with patients, community doctors, and experts; and providing safe diagnosis treatment programs and two-way referrals.

The three-linkage IoT cloud plus terminal nCapp COVID-19 diagnosis and treatment system uses 5G technology to meet the overall system's network requirements for network liquidity, efficiency, high load, and high capacity platform. Based on the WeChat, an nCapp smartphone app can coordinate the division of labour in the diagnosis and treatment of COVID-19 in one-, two-, and three-tier hospitals and perform three-level linkage among experts, primary doctors and service providers. nCapp can also be used by visualization techniques. The data visualization method of the system, with the cloud plus augmented reality, enable doctors and patients to communicate in an augmented reality way, to reduce cross infection.

China launched the "5G + Cloud + AI" pneumonia intelligent auxiliary analysis system that improves the accuracy of virus detection and shortens the time of CT scanning. Early data shows that the system can control the reading time within 1 minute through the AI algorithm, with detection accuracy greater than 90 percent which represents a significant improvement in the efficiency of epidemic diagnosis and treatment (China Telecom Americas).

HOME CARE & TELEHEALTH

In Japan, IoT and AI assist nursing care during the pandemic amid a labour shortage. Sensors monitor the lifestyle habits of the elderly while AI-initiated phone calls check on seniors daily, allowing caregivers to look after them remotely. The person's home is equipped with sensors installed in the bathroom, bedroom and refrigerator, as well as attached to doors, providing the care manager with data via the internet on how frequently he uses the bathroom, how long he sleeps and whether he has eaten. (Kyodo News)

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[2] Chinese experts' consensus on the Internet of Things-aided diagnosis and treatment of coronavirus disease 2019 (COVID-19) Author: Li Bai,Dawei Yang,Xun Wang,Lin Tong,Xiaodan Zhu,Nanshan Zhong,Chunxue Bai,Charles A. Powell,Rongchang Chen,Jian Zhou,Yuanlin Song,Xin Zhou,Huili Zhu,Baohui Han,Qiang Li,Guochao Shi,Shengqing Li,Changhui Wang,Zhongmin Qiu,Yong Zhang,Yu Xu,Jie Liu et al., Publication: Clinical eHealth, Publisher: Elsevier, Date: 2020 https://www.sciencedirect.com/science/article/pii/S2588914120300046

In the U.S., the Mayo Clinic is reportedly in talks with "makers of remote monitoring tools about ways to keep closer tabs on patients with COVID-19 who don't require intensive care." Similarly, to keep non-COVID patients healthy at home that other IoT devices measure "health metrics like temperature, blood pressure and blood sugar several times a day, and the results are automatically stored on the cloud, from which doctors get alerts if the readings are abnormal." (TIME)

Beyond collecting individual health stats, IoT devices are tracking community-level data, which in turn is used to better understand the evolution of the virus. Retail drugstores track inventory and sales of non-prescription fever reducers, for example, and any trends in those data might serve as an early, albeit crude, harbinger of growing spread of disease in a community (TIME).

The "U.S. health weather map" powered by Kinsa Insights provides a visualization of aggregated data on fevers and flu-like illnesses. Healthcare providers can then use the maps to identify areas where there are spikes in illness and gauge whether measures are successfully helping to slow the spread of COVID-19 in other areas.

The pace of IoT innovation in telehealth to fight a pandemic—that fundamentally requires a reduction in person-to-person contact—means that companies are launching innovation *before* security strategies…sometimes even before the technology is ready. History has shown that exactly these types of circumstances are when hackers are more likely to strike. (Security Boulevard)

ROBOTICS & DRONES

In order to scale critical ICU nursing resources during the outbreak in Wuhan, China, a field hospital was staffed primarily with IoT robots to clean, disinfect, deliver medicines and take patients' temperatures in the hospital. Hospital administrators indicated that the robots both better scaled nursing resources for critical care as well as lessened the transmission of the virus to hospital staff (NBC).

Robots in China are preparing meals at hospitals, providing waiter service in restaurants, spraying disinfectants, vending rice and dispensing hand sanitizers. In many hospitals, robots were also performing diagnoses and conducting thermal imaging. Shenzhen-based company Multicopter is using robots to transport medical samples. (Geospatial World). A hospital in Wuhan, the epicenter of the outbreak, was being staffed entirely by robots. Wuchang Hospital, China Mobile and Cloud Minds, a manufacturer of Cloud-based robotics systems, came together for this project aimed at making the hospital facility completely smart and digital. Most of the devices in the hospital are IoT enabled and services are carried out by robots. The initial screening of the patients is done by 5G-enabled thermometers that send instant updates. Also, there are rings and bracelets that are connected to the CloudMinds AI platform so that it can monitor all changes in the body. (Geospatial World).

As per a Reuters report, a small robot called Little Peanut was delivering food to passengers on a flight from Singapore to Hangzhou, China who were being held under quarantine in a hotel. (Geospatial World). CloudMinds alone has deployed 100 robots in the country's hospitals. A few

modified robots like Cloud Ginger (aka XR-1) and the Smart Transportation Robot carry food and medicine to patients from healthcare providers without any human contact. ([Geospatial World](#)). In some of the severely affected areas, where humans were at a risk of catching the virus, drones came to the rescue. Drones were transporting both medical equipment and patient samples, saving time and enhancing the speed of deliveries, while preventing contamination of medical samples. ([Geospatial World](#)).

Drones were also flying with QR code placards that could be scanned to register health information. Drones powered with facial recognition were also being used to broadcast warnings to the citizens to not step out of their homes and chide them for not wearing face masks. Antwork, a group company of Japanese dronemaker Terra Drone, carried medical samples and other essential materials in Xinchang when the city was grappling with the virus. ([Geospatial World](#)).

GLOBAL NAVIGATION SYSTEM OF SYSTEMS

Global Positioning technologies play a crucial role in epidemics. In China, BeiDou, the country's own GNSS constellation, helped track patients and affected places. With the help of reliable data and precise mapping and imagery, China could build thousands of new makeshift hospitals across the country ([Geospatial World](#)). According to reports, the Chinese government was able to hasten the construction of two new hospitals in Wuhan mainly due to BeiDou.

In Ruichang, Jiangxi province, the police forces are using BeiDou-enabled drones for monitoring congested public areas. The Chinese Ministry of Transportation was able to swiftly send emergency messages to over 6 million connected vehicles using BeiDou. The Chinese e-commerce giant JD also delivered medical equipment in remote hospital areas in Wuhan with the help of robots based on BeiDou ([Geospatial World](#)).

While dozens of makeshift hospitals were being constructed their progress was continuously being monitored using GaoFen, a constellation of high-resolution Earth observation satellites. Zhuhai-1 hyperspectral imaging satellite and ESA's Sentinel-1 also helped in non-stop monitoring of hospital construction. The Wuhan University actively collected and analysed multiple data sources and identified which site would be best suitable for the hospital ([Geospatial World](#)).

TFSTAR, a second generation AI satellite designed by the Satellite Technology Research Center of University of Electronic Science and Technology of China (UESTC) and ADA-Space, is capable of powerful analytics and processing, which enables it to sift through the data. By combining TFSTAR's data processing capability with geocoding, a health visualization of COVID-19 was created on which people could see the geographical reach of the virus and could find out the distance between them and active infection ([Geospatial World](#)).

AUTONOMOUS VEHICLES

At a time of severe crunch of healthcare professionals and the risk of people-to-people contact, autonomous vehicles are proving to be useful delivering medicines and food items. Apollo, which is Baidu's autonomous vehicle platform, has joined hands with self-driving startup Neolix to deliver supplies and food to a big hospital in Beijing. Baidu Apollo has also made its micro-car kits and autonomous driving Cloud services available for free to companies fighting the virus. Idriverplus, a Chinese self-driving company that operates electric street cleaning vehicles, is also a part of the mission. The company's flagship vehicles are being used to disinfect hospitals. (Geospatial World).

One study looking at IoT applications to fight against the COVID-19 pandemic searched the databases of Google Scholar, PubMed, SCOPUS and ResearchGate using the keywords "Internet of Things" or "IoT" and "COVID-19". Further inputs are also taken from blogs and relevant reports. Results were found to support the view that IoT implementation impacts on reducing healthcare cost and improve treatment outcome of the infected patient. IoT is helpful for an infected patient of COVID-19 to identify symptoms and provides better treatment rapidly. It is useful for patient, physician, surgeon and hospital management system. (Elsevier Public Health Emergency Collection)

Beep, an autonomous shuttle service provider, said in early April that it was partnering with the Jacksonville Transportation Authority and shuttle maker Navya to transport COVID-19 tests at Mayo Clinic in Florida. (Reuters)

CONCLUSION

In Europe, IoT is part of the solution to COVID-19 prevention, diagnosis and treatment efforts. In terms of medical IoT, software developed to assist the work of medical staff by analysing images of pulmonary infections as well as use an EU-backed supercomputing platform, to identify a treatment for COVID-19 are prominent examples. The EC's COVID-19 technical review facility attempts to strike the balance between disease control and the protection and privacy of citizens' data.

Globally, the application of innovative IoT in smart health and care for COVID-19 disease transmission, monitoring, diagnosis and treatment is in evidence in a wide range of activities. Tech solutions were quickly identified and adapted for healthcare and both government agencies and medical authorities are relying on technology linked to IoT for contact tracing, Medical IoT, and Homecare and Telehealth. Prevention measures are in place harnessing big data and surveillance as well as border controls. Robotics, drones, GNSS and autonomous vehicles are increasingly being adopted to assist medical procedures while minimising the spread of the virus. ESA's Sentinel-1 also helped in non-stop monitoring of hospital construction in China.

Certain innovation drivers identified by NGIoT's IoT scoping paper (Edge computing, 5G, AI and analytics) are pre-requisites to the technologies listed above; while others (AR and tactile Internet, digital twins, distributing ledgers and nano electronics) are not yet in evidence in the fight against COVID-19, according to this current desk review, concluded 3 August, 2020.