ROBOTS AND SOCIETY

Combating COVID-19—The role of robotics in managing public health and infectious diseases

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COVID-19 may drive sustained research in robotics to address risks of infectious diseases.

The outbreak of COVID-19 has now become a pandemic. The new coronavirus has affected nearly all continents; at the time of writing, South Korea, Iran, Italy, and other European countries have experienced sharp increases in diagnosed cases. Globalization and increasingly interconnected economies mean most countries will be affected by COVID-19. Global effort is therefore required to break the chains of virus transmission.

Could robots be effective resources in combating COVID-19? Robots have the potential to be deployed for disinfection, delivering medications and food, measuring vital signs, and assisting border controls. As epidemics escalate, the potential roles of robotics are becoming increasingly clear. During the 2015 Ebola outbreak, workshops organized by the White House Office of Science and Technology Policy and the National Science Foundation identified three broad areas where robotics can make a difference: clinical care (e.g., telemedicine and decontamination), logistics (e.g., delivery and handling of contaminated waste), and reconnaissance (e.g., monitoring compliance with voluntary quarantines). Many of these applications are being actively explored in China, although in limited areas and many as proofs of concept. Frontline health care practitioners are still exposed to the pathogen with direct patient contact, albeit with protective gear. The COVID-19 outbreak has introduced a fourth area: continuity of work and maintenance of socioeconomic functions. COVID-19 has affected manufacturing and the economy throughout the world. This highlights the need for more research into remote operation for a broad array of applications requiring dexterous manipulation—from manufacturing to remotely operating power or waste treatment plants.

For each of these areas, there are extensive developments, as well as opportunities, to be explored in robotics. In the case of clinical care, areas of specific importance include disease prevention, diagnosis and screening, and patient care and disease management.

For disease prevention, robot-controlled noncontact ultraviolet (UV) surface disinfection is being used because COVID-19 spreads not only from person to person via close contact respiratory droplet transfer but also via contaminated surfaces. Coronaviruses can persist on inanimate surfaces—including metal, glass, or plastic—for days, and UV light devices (such as PX-UV) have been shown to be effective in reducing contamination on high-touch surfaces in hospitals. Instead of manual disinfection, which requires workforce mobilization and increases exposure risk to cleaning personnel, autonomous or remote-controlled disinfection robots could lead to cost-effective, fast, and effective disinfection (*1*). Opportunities lie in intelligent navigation and detection of high-risk, high-touch areas, combined with other preventative measures. New generations of robots, from macro- to microscale, could be developed to navigate high-risk areas and continually work to sterilize all high-touch surfaces.

For diagnosis and screening, mobile robots for temperature measurement in public areas and ports of entry represent a practical use of mature technologies. Automated camera systems are commonly used to screen multiple people simultaneously in large areas. Incorporating these thermal sensors and vision algorithms onto autonomous or remotely operated robots could increase the efficiency and coverage of screening. These mobile robots could also be used to repeatedly monitor temperatures of in-/outpatients in various areas of the hospitals with data linked to hospital information systems. By networking existing security systems with facial recognition software, it is possible to retrace contacts of infected individuals to alert others who might be at risk of infection. It is important, however, to introduce appropriate rules to respect privacy.

For initial diagnostic testing for COVID-19, most countries recommend collecting and testing nasopharyngeal and oropharyngeal swabs (*2*). This involves sample collection, handling, transfer, and testing. During a major outbreak, a key challenge is a lack of qualified staff to swab patients and process test samples. Automated or robot-assisted nasopharyngeal and oropharyngeal swabbing

Medical personnel work inside one of the emergency structures that were set up to ease procedures outside the hospital of Brescia, Northern Italy, Tuesday, 10 March 2020.

may speed up the process, reduce the risk of infection, and free up staff for other tasks. Some people do not develop symptoms of the virus or harbor the virus at the moment of testing. In these cases, a blood test to check for antibody appearance could be crucial and used to identify silent infections. Automating the process of drawing blood for laboratory tests could also relieve medical staff from a task with a high risk of exposure. Researchers are studying robotic systems based on ultrasound imaging identification of peripheral forearm veins for automated venepuncture (*3*). Automated multiplex real-time assays would allow rapid in vitro qualitative detection and discrimination of pathogens. Autonomous drones or ground vehicles may be used for sample transfer as well as delivery of medicines to infected patients when movement is inadvisable.

COVID-19 could be a catalyst for developing robotic systems that can be rapidly deployed with remote access by experts and essential service providers without the need of traveling to front lines. Widespread quarantine of patients may also mean prolonged isolation of individuals from social interaction, which may have a negative impact on mental health. To address this issue, social robots could be deployed to provide continued social interactions and adherence to treatment regimes without fear of spreading disease. However, this is a challenging area of development because social interactions require building and maintaining complex models of people, including their knowledge, beliefs, emotions, as well as the context and environment of the interaction.

Teleoperation is also a mature technology that can be used for both telemedicine and telecommuting. In recent weeks, schools, universities, and companies in China have adopted online courses and interactions. As 5G bandwidth and 4-8K video become widely available, COVID-19 may mark the tipping point of how future organizations operate. Rather than cancelling large international exhibitions and conferences, new forms of gathering—online rather than in-person attendance—may increase. Remote attendees may become accustomed to using robotic avatars and controls. Eventually, many conferences may be available via high-definition low-latency virtual reality, with the attendees' virtual robot avatars fully mobile and immersed in the conference context. All of these modalities would reduce disease infection rates and carbon footprint simultaneously.

Historically, robots have been developed to take on dull, dirty, and dangerous jobs. Their first wide-spread deployment was in industrial applications, similarly combating infectious diseases involves an environment that is unsuitable for human workers but is suitable to robots. The experiences with the Ebola outbreak identified a broad spectrum of use cases, but funding for multidisciplinary research, in partnership with agencies and industry, to meet these use cases remains limited. Now, the impact of COVID-19 may drive further research in robotics to address risks of infectious diseases. But without sustained research efforts robots will, once again, not be ready for the next incident. By fostering a fusion of engineering and infectious disease professionals with dedicated funding we can be ready when (not if) the next pandemic arrives.

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