HUMAN-ROBOT INTERACTION

The potential of socially assistive robots during infectious disease outbreaks

Brian Scassellati* and Marynel Vázquez

Robots have a role in addressing the secondary impacts of infectious disease outbreaks by helping us sustain social distancing, monitoring and improving mental health, supporting education, and aiding in economic recovery.

A recent Editorial in *Science Robotics* (*1*) highlighted some of the ways that robots are being used to help combat the COVID-19 pandemic, including vital contributions to clinical care, logistics, and surveillance. We believe that robots are poised to make important contributions in these areas where the pandemic has had a direct and immediate impact and that applying design principles from social robotics may aid in the adoption of these technologies, especially when in contact with people. Furthermore, we also believe that the secondary effects of the pandemic will benefit from work in robotics, specifically issues related to sustaining social distancing, mental health, education, and economic recovery.

SUSTAINING SOCIAL DISTANCING

Traditionally, telepresence robots have been viewed as an opportunity for robots to serve as surveillance and health monitoring tools in high-risk areas. We believe that telepresence can also affect day-to-day tasks to support appropriate social distancing. Robots can help replace direct person-to-person contact by allowing users to check on an elderly relative, share experiences with distant friends, or verify that an item is available in a store before visiting. Furthermore, there are physical, cognitive, and mental health issues associated with feelings of loneliness (*2*); the use of telepresence robots may reduce feelings of loneliness by providing much-needed social interactions during physical isolation. For instance, the possibility of physical play through telepresence robots could provide new means for children to engage creatively with each other (Fig. 1). Last, socially assistive robots can help people with the negative consequences of social distancing by motivating people to maintain physical activity (*3*) and proper nutrition (*4*). Applications in this area will require research into algorithms for personalization, policy learning and adaptation for multimodal behavioral data, and developing methods to motivate lasting behavioral change.

ADDRESSING MENTAL HEALTH CHALLENGES

The global pandemic is creating a wide variety of stressors that are certain to affect both current and future mental health care. Shelter-in-place orders are limiting current access that individuals have to mental health care services for preexisting conditions and preventing newly emerged cases from being diagnosed. The pandemic is also producing increased levels of anxiety and depression that are likely to persist long after shelter-in-place orders are lifted (*5*). Socially assistive robots have been proposed as a mechanism to support mental health activities ranging from screening and diagnosis to supporting on-demand therapy (*6*). Robots may be capable of playing a role in providing in-home methods for monitoring the mental and emotional state of users, identifying those who show depressive symptoms, and connecting those users with professional help. Furthermore, robots may be used to reinforce psychological strategies suggested by health experts for users to cope with negative mental states and stress. While many of these functions might have been previously supported by in-clinic visits, the additional demands that social isolation is likely to place on already strained health care systems may heighten the need for technology-based support. To be successful, these robots will need to perceive emotional states; calculate when it is appropriate to intercede; and develop long-term models of behavior, mood, and affect.

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SUPPLEMENTING DISTANCE EDUCATION

Robots have the potential to support in-home tutoring and remote instruction. A recent review (*7*) explains how robotic tutoring systems offer three notable advantages over virtual systems: (i) They can be used for curricula and populations that require engagement with physical learning, (ii) they are more engaging and foster more prosocial behavior, and (iii) users show increased learning gains when interacting with robots rather than virtual agents. During periods of social distancing, these advantages become even more vital for many populations. Robotic tutoring systems may offer a viable supplement to both curricular and noncurricular learning for children that struggle to engage with videotelephony or to work in front of a computer for a long time. Furthermore, such systems can support social and emotional learning, an essential part of early education, especially for children with autism (*8*). Parents struggling with additional challenges related to working at home, caring for sick family or neighbors, dealing with job loss, or providing additional childcare are also being asked to take a larger role in providing educational support. In-home tutoring robots may help alleviate some of these problems, but more research is required to generate content algorithmically, assess user competency, identify ways of teaching social and emotional skills, and leverage embodiment to facilitate learning.

ECONOMIC RECOVERY EFFORTS

The global pandemic has already caused a deep and wide-spread impacts to our economy, and the long-term impacts on careers and employment will be substantial (*9*). Many will find their current work roles altered, many new careers are likely to emerge, and many more will simply search for work of any form. There are numerous technology-based attempts to provide vocational training and to support job searches, including

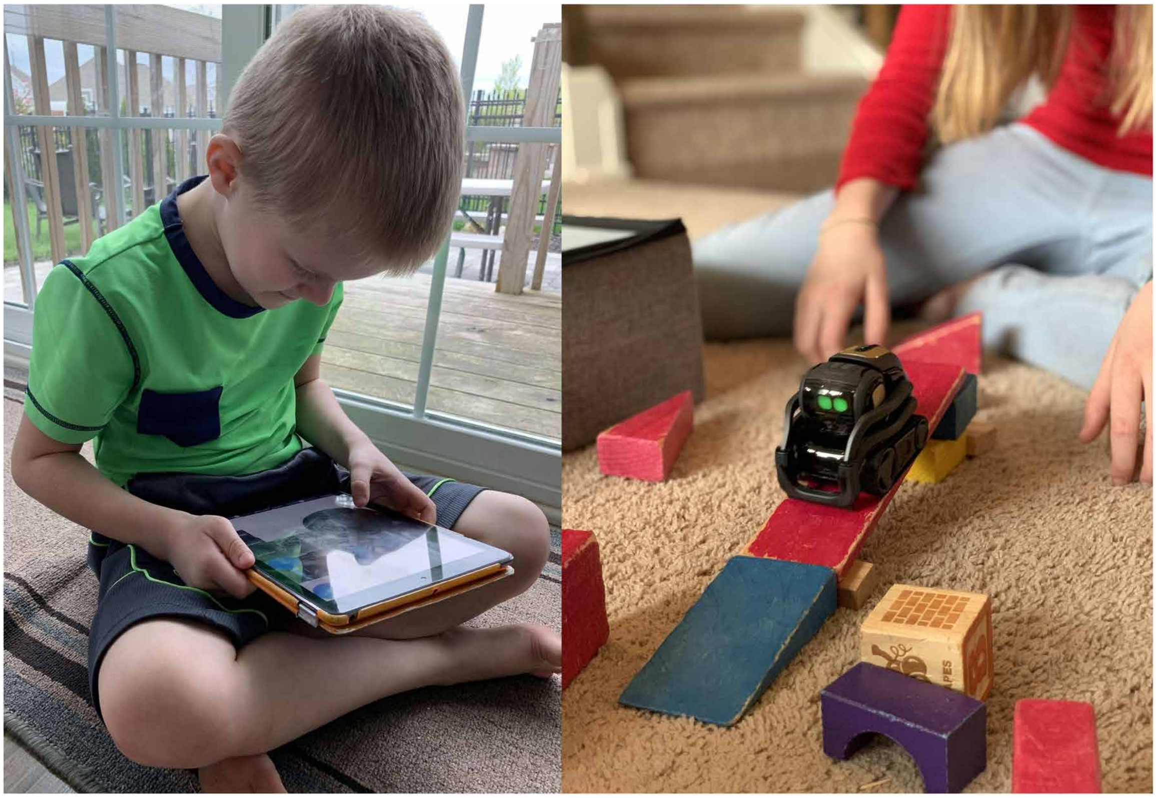

Fig. 1. Reducing social isolation for children with robotics. Robots can be used to enable remote physical play for kids during social isolation. The child in the left image controls the remote robot in the right image to engage in remote play.

intelligent systems that screen job candidates, match candidates to positions, help with training new employees, or support training individuals on interviewing skills [e.g., (*10*)]. The role of robotics in this area is less clear. Would employers find value in screening remote candidates using an embodied interface, allowing them to have a more realistic sense of how the applicant would respond to their customers? Could robots provide a certification of how well a job-seeker can handle interruptions, manage customer complaints, or solve critical scheduling problems? Would job seekers benefit from a robotic coach that helped them learn successful interviewing techniques? Developments in this area will hinge on our ability to simulate realistic human behavior, to quantify social or "soft" skills, and to guide skill development toward long-term goals.

Interdisciplinary robotics research has established the foundation for combating some of the secondary effects of COVID-19, with a few efforts becoming commercially viable especially in the education domain. However, the use of robots in managing public health, supporting education, and pushing forward economic recovery efforts remains limited at a global scale. Substantial investments in robotics and human-robot interaction research are needed to understand how to best design and implement robotic systems to help people combat the consequences of infectious diseases. The challenge is not only understanding how we can best engineer robots for sustained operation in dynamic human environments but also understanding how to best introduce the technology into societies to maximize positive social impact.

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10.1126/scirobotics.abc9014

Citation: B. Scassellati, M. Vázquez, The potential of socially assistive robots during infectious disease outbreaks. *Sci. Robot.* **5**, eabc9014 (2020).

Science Robotics

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Sci. Robotics **5**, eabc9014.
DOI: 10.1126/scirobotics.abc9014

Science Robotics (ISSN 2470-9476) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science Robotics* is a registered trademark of AAAS.