CHI 2018

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The 2018 ACM CHI Conference on Human Factors in Computing Systems took place 21–27 April in Montreal, Canada, and attracted over 3,000 participants. This year's CHI marked the 50th anniversary of the "Mother of all Demos" and showcased many exciting new technologies and techniques that will help shape the future of pervasive computing.

The theme of CHI 2018 (https://chi2018.acm.org) was "Engage"—in the words of the conference organizers, "to engage with people, to engage with technology, to engage with newcomers, to engage with world-class research, to engage with your community of designers, researchers, and practitioners."

CHI 2018 also marked the 50th anniversary of the "Mother of all Demos," in which Douglas Engelbart presented the oN-Line System (NLS), the first to demonstrate use of a computer mouse, networked computers, linking files with hypertext, and early versions of a GUI. The CHI community celebrated this anniversary with a reception focusing on interacting with technology of the future. With 666 accepted papers and up to 21 simultaneous tracks, CHI 2018 covered a wide array of pervasive computing topics such as mobile, wearable, and ubiquitous technology in paper sessions, demos, and workshops, In this article, we highlight cutting-edge work on the interplay of the digital and analog worlds, input techniques, HCI in healthcare, smart environments, and ubiquitous technology for learning.

INTERPLAY OF THE DIGITAL AND ANALOG WORLDS

Despite advances in augmented reality (AR) and virtual reality (VR) hardware, there remain significant experiential tensions between physical and digital spaces or visual and haptic feedback modalities. An exciting thread of research at CHI 2018 explored the relationships between the analog and digital worlds.

Uniting or Separating Virtual and Physical Spaces

Researchers explored a variety of configurations for mixing digital and physical experiences. Augmenting physical spaces with projection, Dongdong Guan presented a work entitled "Two

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Kinds of Novel Multi-User Immersive Display Systems," in which projector arrays combined with specialized goggles enable multiple users to inhabit the same physical space but see different items projected into their respective spaces. In contrast, Thammathip Piumsomboon sought to bring users together in a shared AR and VR experience called "Mini-Me." Through redirected gaze and gestures, the digital avatar transfers nonverbal communication cues from the digital to the analogue world. Rather than bringing users who are physically apart together, Sebastian Marwecki presented VirtualSpace, a system that allows multiple users who physically share the same space to be digitally separated by offering different interactive applications. Although these applications run simultaneously in one physical space, the system ensures that users do not run into one another by offering interactivity in changing, nonoverlapping areas, driving users to certain parts of the space. These examples highlight the exciting possibilities when combining the analogue world with digital worlds.

Physical Objects in the Virtual World

Interaction with physical objects through a virtual world will make the aforementioned combination of analog and digital worlds even more compelling. Jan Gugenheimer presented FaceDisplay, a setup consisting of three small, outward-facing displays and a gesture recognition device attached to a VR headset. The setup allows interaction between the VR headset user (internal display) and any passer-by (external touch displays and gesture interaction). Lung-Pan Cheng also explored the concept of "human actuation" through the iTurk VR system, which lets users physically actuate their own experiences in VR by moving and arranging props in physical space that take on different appearances and functions at different points during a game. In an accessibility-minded take on this topic, Yuhang Zhao presented "Enabling People with Visual Impairments to Navigate Virtual Reality with a Haptic and Auditory Cane Simulation." This system allows visually impaired users to explore a virtual world with the use of a haptic controller that simulates cane interactions, transferring their knowledge and experience with real-world canes into the virtual world.

INPUT TECHNIQUES

As the capabilities of smart devices increase, so too are the ways in which users can input information into those devices. CHI 2018 featured a wide variety of novel input techniques for both mobile and wearable devices.

Smartwatch Input

Smartwatches in particular saw a large variety of presentations on different application areas. Robert Xiao introduced a device known as LumiWatch that projects interactive visuals onto the arm of the wearer and allows for interaction with these visuals. The author discussed the difficulties involved in calibrating the device across different lighting conditions and skin types. Daniel Buschek presented "Extending Keyboard Shortcuts with Arm and Wrist Rotation Gestures," which demonstrated how traditional keyboard shortcuts can be extended through interactive gestures performed during keypress. Pui Chung Wong's FingerT9 system allows users to input text on a smartwatch by moving their thumbs and fingers and utilizing the well-established T9 predictive text system.

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Wearables and Interactive Displays

A research direction that continued to be explored at CHI 2018 is the interaction between wearables and interactive displays. Tom Horak introduced a framework to support data analysis in a multi-device environment. His team's paper, aptly named "When David Meets Goliath," earned

an honorable mention. The presented framework allows users to preview and control what is shown on the large display using their smartwatch. Ville Mäkelä presented new interaction techniques in the Pocket Transfers application, allowing those passing a public display to "grab" content and transfer it to their device.

On-Skin Devices

Perhaps one of the most novel input techniques was presented by Aditya Shekhar Nittala under the title "Multi-Touch Skin: A Thin and Flexible Multi-Touch Sensor for On-Skin Input." This work showed how a flexible, on-skin device could be used for high-resolution multi-touch input anywhere on the body. On-skin devices are arguably the most "wearable" devices available—we therefore expect to see more use cases around this technology in the future.

Smartphone Input

Although smartphones have been more commoditized than smartwatches or wearables, their immense popularity ensures a continued interest in studying and improving the user experience of these devices. Daniel Trindade presented Hybrid-Brailler, a system that allows braille input on mobile devices through physical and gesture interaction with a custom-made case and a smartphone. Huy Viet Le demonstrated PalmTouch, which suggests that the palm of a user's hand can be used as a smartphone input modality. The authors envision that palm interaction can be used as a shortcut for navigation purposes, or for improving reachability.

HCI IN HEALTHCARE

With the rising prevalence of diseases like obesity, cancer, heart disease, and mental health disorders, researchers at CHI 2018 presented ways to better detect, monitor, and manage peoples' mental and physical health, as well as to improve communication and support between patients, caregivers, and clinicians. A clear commonality in these works is the unique role that human–computer interaction (HCI) continues to play in making our (technical) health solutions work for all stakeholders. Although much remains to be done, the research presented at CHI 2018 paints the picture of a better and more humane healthcare future.

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Device-Based Sensing

One line of research examines detection of medical symptoms by utilizing capabilities already available in the devices in the world around us. Edward Jay Wang presented Seismo, a method to monitor blood pressure using a smartphone's accelerometer to detect heartbeats and camera to measure pulse—this work received an honorable mention. Pablo Paredes presented "Fast & Furious: Detecting Stress with a Car Steering Wheel," an unobtrusive way to detect stress using the movements of a car's steering wheel. Ke Xu received an honorable mention for ECGLens, an interactive system to detect and analyze arrhythmia through convolutional neural networks and data mining techniques.

Supporting Clinical Practice

With the advent of electronic medical records and the deluge of online medical information, clinicians and patients face the challenge of integrating technology into clinical practice. Based on an investigation into the role and use of text in clinical practice, Nicole Sultanum presented Medstory, a text visualization web prototype resulting in six design recommendations for visualization design to support clinical text. Josephine Thomsen presented "Interactive Interior and

Proxemics Thresholds: Empowering Participants in Sensitive Conversations." This work showed an interactive table that supports consultation between healthcare personnel and cancer patients and their relatives, empowering the latter to control and structure conversations with doctors. Both aforementioned works received an honorable mention. Simo Hosio introduced Back Pain Workshop, a crowdsourced system to discover lower back pain treatments shared by professionals and nonprofessionals. Clinicians saw the system as a way to reflect on the public's feedback to certain treatments, and a potential tool to debrief incoming patients. These works stress the role of technology in supporting the human side of care.

Mobile Health Applications

Many presentations shared custom mobile applications or devices for diverse disease conditions. In this direction, Dmitri Katz presented "Designing for Diabetes Decision Support Systems with Fluid Contextual Reasoning," and showed that many diabetes applications fail to support self-care, a critical factor in the context of this disease. Katz and his coauthors received an honorable mention for their work. Pooja Desai described how focus groups faced challenges analyzing blood glucose forecast visualizations in "Pictures Worth a Thousand Words: Reflections on Visualizing Personal Blood Glucose Forecasts for Individuals with Type 2 Diabetes." In "Designing and Evaluating mHealth Interventions for Vulnerable Populations: A Systematic Review," which received an honorable mention, Elizabeth Stowell highlighted how vulnerable populations such as low-SES (socioeconomic status) and racial/ethnic minority groups are not being reflected in the literature on mobile health, and how most studies do not demonstrate improvements in health outcomes.

Health Tracking

Technologies that track health-related behaviors were prominent at CHI 2018. Blaine Price introduced Painpad, a tangible device that improved the frequency and compliance of pain self-reporting by hospitalized patients—highlighting the importance of personalization and the physicality of the device. Yuhan Luo introduced Time for Break, a desktop application that prompts information workers to move after prolonged periods of inactivity. Herman Saksono and colleagues' "Family Health Promotion in Low-SES Neighborhoods: A Two-Month Study of Wearable Activity Tracking" showed that adoption of tracking technologies by these populations is affected by internal and external factors, such as how the technology affects their emotions and concerns about safety in their neighborhoods.

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Mental Health

Mental health also represents an important category of tracking-related technology. In "How Information Sharing about Care Recipients by Family Caregivers Impacts Family Communication," Naomi Yamashita discussed information tracking and sharing among caregivers of depression sufferers. In "Identification of Imminent Suicide Risk among Young Adults Using Text Messages," Alicia Nobles used past text message and social media histories to predict suicidality risk. Jessica Schroeder presented Pocket Skills, a web-based mobile application that draws from dialectical behavioral therapy (DBT) to help patients self-track factors related to mental health and implement routine DBT skills in their lives. In "Quantifying the Changeable Self: The Role of Self-Tracking in Coming to Terms with and Managing Bipolar Disorder," Elizabeth Murnane highlighted how for the bipolar population, self-tracking should be designed to emphasize stability rather than optimizing human behavior to nearly "superhuman" levels.

SMART ENVIRONMENTS

From individual devices to homes and even cities, our environments are increasingly smart and interconnected. Researchers have developed new methods and devices to interact with smart environments, yet they are also discerning how and why such systems ought to be designed.

Smart Things in Smart Spaces

In "Media of Things: Supporting the Production of Metadata Rich Media through IoT Sensing," which earned an honorable mention award, Gerard Wilkinson demonstrated how smart environments can generate metadata for object-based broadcasting. Metadata was generated by sensors attached to objects in a scene, and then used to reframe media, depending on the viewing device or number of displays. On the other hand, Ke Huo shared the Scenariot system, which allows users to localize and map IoT devices within AR scenes. Taesik Gong presented an application called Knocker that uses microphone, accelerator, and gyroscope input with a support vector machine classifier to identify everyday objects with near perfect accuracy. In this manner, smart devices can be activated simply by knocking on them. The work on novel interaction techniques also included work on larger environments. Yang Zhang presented Wall++, a low-cost method for adding interactivity to a wall. Wall++ uses mutual-capacitive sensing, commonly used in the touchscreen of smartphones, to detect a user's hand and body pose on a wall. Additionally, Zhang demonstrated that Wall++ can also be used for capturing airborne electromagnetic (EM) signals, which allows it to localize and detect active applications that emit EM radiance. These two input modalities on the wall can be used for novel room-scale interactive applications. The work was awarded with a best paper award.

Smart Design Principles

Various presenters at CHI 2018 explored how smart technologies can best be utilized in an everyday setting. In "Designing the Desirable Smart Home: A Study of Household Experiences and Energy Consumption Impacts," Rikke Hagensby Jensen categorized three smart home personas—helpers, optimizers, and hedonists—that mirror reason, ethics, and aesthetics in order to encourage sustainability in design. The work received an honorrable mention. In "Empowering End Users to Customize their Smart Environments: Model, Composition Paradigms, and Domain-Specific Tools," Giuseppe Desolda shared a prototype for expressing rules that lets end users synchronize the behavior of smart objects, amplifying their social and practical benefits. See the Smart Home department article in this issue for a more in-depth discussion of CHI 2018 papers related to smart homes.

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UBIQUITOUS TECHNOLOGY FOR LEARNING

Advances in technology bring more possibilities for incorporating technological systems into diverse educational settings. At CHI 2018, researchers presented work in understanding how to extend technologies to support different learning activities.

Public Learning

With digital media becoming increasingly common in museums, researchers examined the role of technology in the modern museum experience. In "Digital Exhibit Labels in Museums: Promoting Visitor Engagement with Cultural Artifacts," Jessica Roberts presented the design and in-depth evaluation of three types of interactive displays in museums that spark visitors' curiosity and help them learn about objects exhibited behind glass. The work received an honorable mention. By analyzing the different strategies that these interactive displays used to attract visi-

tors and initiate conversations among them, her evaluation provides inspiration for future designs of interactive displays in museums.

Youth Learning

Public learning for youth proves to be extra challenging as it aims to connect learning across schools, after school, at home, and in other settings. To address this challenge, June Ahn presented a sociotechnical system, Science Everywhere, that enables youth to share science learning and to interact with others on this content. The system includes a mobile component for individual sharing in addition to public displays placed in the neighborhood for community-wide sharing. Communities support youth learning by interacting with the shared content in the classroom, after school, and in other public settings. Additionally, a case study of Science Everywhere showed that the system bridged and encouraged youth learning opportunities and activities. New technologies also provide new opportunities in supporting youth learning in the classroom. Michelle Lui presented a simulation system, EvoRoom, and examined how students interact with one another, as well as how they interact with the system during a specific class activity. The system utilizes projected wall displays and tablets to support learning during the class. Lui and her colleagues found that increased student-to-student interactions were accompanied by improved interactions with the system. Their finding provides an example of how technology design could support in-class learning activities. Finally, wearables were also utilized to make learning for youth more engaging. Brittany Garcia presented a smartwatch app, ScienceStories, that is a tool for elementary school students to record reflections about science concepts. Her team designed and tested several versions of the application with different motivational structures. Since few researchers have investigated the use of smartwatches for educational purposes, their system and findings contribute to the knowledge of smartwatch application design for learning activities.

CONCLUSION

CHI 2018 was an engaging experience that marked not only the 50th anniversary of the Mother of all Demos but also showcased many exciting new technologies and techniques that will help to shape the future of pervasive computing. Pervasive technologies touch on many critical aspects of our daily life. In this article, we have highlighted ongoing research that spans and the digital and physical worlds and provides new means of input and interaction, in contexts ranging from homes and cities to hospitals and classrooms. This work emphasizes the importance of a human-centred perspective in technology design—putting the user's needs and wishes first.

Next year's CHI will take place in Glasgow on 4–9 May under the theme "Weaving the Threads of CHI" (https://chi2019.acm.org). We hope to see you there.

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