Notes from the Community

Editors: Mary Baker ■ HP Labs ■ mary.baker@hp.com
Justin Manweiler ■ IBM T. J. Watson Research Center ■ jmanweiler@us.ibm.com

Improving Our Bodies, Our Meals, and Our Gadgets

Mary Baker, *HP Labs*
Justin Manweiler, *IBM T.J. Watson Research Center*

Thank you for reading this quarter's column. Our theme this quarter is the body—research focused on how to aid the body, replace parts of the body, use the body for security, virtualize the body, draw with virtualized parts of the body, tattoo the body, and feed the body with specially designed food. Readers also submitted links to other cool items, including innovations in flexible materials. Furthermore, we were happy to see readers submitting information about post-doc positions. Graduating students might want to keep an eye on the site (www.reddit.com/r/pervasivecomputing) for such listings.

IN AID OF THE BODY

The more we can sense, activate, and create at a scale for humans, the more we can provide needed assistance for our bodies. We are seeing rapid, wide-ranging innovation in this space.

Sensing for Independence

One of the most intriguing items submitted this quarter is Steve Saling's story. Saling is a landscape architect diagnosed a decade ago with amyotrophic lateral sclerosis (ALS), sometimes called Lou Gehrig's disease. The disease causes people to lose their ability to move and speak over time. Saling responded to this diagnosis by figuring out ways for ALS patients, and those with other disabling diseases, to retain more independence once they move into assisted living facilities.

Instead of needing to call for help to open a window, change the heating or cooling, use the elevator, open or close doors, or turn on and off lights, the systems Saling designed let ALS patients do these things for themselves using blinks or small facial movements, which are sensed and converted to commands. Saling worked with an architectural firm designing apartments for the Leonard Florence Center for Living outside of Boston to have these systems installed in the new apartments. The Center requires fewer staff members, because its tenants can do more for themselves. The elevator was the most challenging component, because it took a while to convince the elevator consultant to allow automation for the elevator. Read more about this exciting work and remarkable man at www.statnews.com/2016/07/06/als-design-residence.[1]

Printed Transportation

We see the capabilities of 3D printing highlighted in many ways these days, and the Go chair is one nice example. The Go chair is a 3D-printed consumer wheelchair, designed by Benjamin Hubert and his colleagues at his London studio, Layer (http://layerdesign.com). The seat and foot bay are made-to-measure for the particular user, as is a special pair of gloves.

Working with wheelchair users and the medical community, the Layer team determined that one of the principal problems for wheelchair users is the difficulty of self-propelling the chair over slippery or wet surfaces. They addressed this problem by making custom-fit gloves and designing carbon-fiber spokes for the wheels that can hook into the gloves. The 3D-printed seat is made of a semi-transparent resin and a thermoplastic polyurethane plastic and is light-weight, fits the body, and provides shock absorption. For more information, including sketches and photos, see www.dezeen.com/2016/05/18/benjamin-hubert-layer-3d-printed-wheelchair-launch-clerkenwell-design-week.[2]

Interactive Fist Bump

Research funding, medical progress, and politics all overlap, but regardless of your political persuasion, most readers will enjoy watching President Obama

JOIN OUR SUBREDDIT

This column offers a summary of interesting news and research in pervasive and mobile computing, with content drawn from submissions to a shared community on the social news site Reddit, at www.reddit.com/r/pervasivecomputing. We encourage you to join our subreddit and spread the news of this site to others, so that together we can build a sustainable online community for all aspects of pervasive and ubiquitous computing and the Internet of Things.

— Mary Baker and Justin Manweiler

NOTES FROM THE COMMUNITY

interact with Nathan Copeland, a paralyzed man in a wheelchair. Copeland uses a robotic arm developed by researchers at the University of Pittsburgh and their medical center. He controls the arm with his own brain signals via a "brain chip," which also interprets signals received in the other direction so he can feel when someone or something touches or interacts with his arm. The president clearly finds this technology fascinating and gives a very cogent explanation of how it works and why it will be even more exciting in the future. See www.nbcnews.com/video/watch-obama-fist-bump-a-robotic-arm-powered-by-a-brain-chip-785470531610 for the video.[3]

Impressive Arms

Speaking of robotic arms, another announcement comes from Mobius Bionics, one of several companies working on new, more advanced prosthetics. The LUKE arm is intended to provide more independence through flexibility, strength, and dexterity than previous arm prosthetics for people with forearm- through shoulder-level amputations. The shoulder is powered and can reach overhead or behind the back, while the elbow has enough strength to lift up a bag of groceries. The wrist is dexterous enough to hold a glass of liquid without spilling, and the hand can adjust its grip to hold heavy things or small fragile things without damaging them. For more information, see www.businesswire.com/news/home/20160708005511/en.[4] Our only concern is that the arm pictured in the press release appears to have its thumb at a very odd angle. That looks painful!

WITH, FOR, AND ABOUT THE BODY

We can use technology to improve the health of our bodies, and we can use our bodies to improve the health of our technology.

Body Guard

Researchers at the University of Washington are working on new ways to transmit passwords by using the human body as the communication medium. They have found they can repurpose fingerprint sensors to send out information rather than just act as input devices.

Using a smartphone or other device with a fingerprint reader in one hand, the low-frequency (2 to 10 megahertz range) signals generated by the fingerprint sensors travel through the body to be received by a door lock or other device the user touches. The technique works in different positions, such as standing, sitting, or lying down, and it works for receivers anywhere on the body—legs, chest, hands, and so on. It even works when people are walking or otherwise moving around. The system can generate 25 bits per second using the fingerprint sensors, with scanning issuing 1-valued bits, and not scanning issuing 0-valued bits. 25 bits per second is sufficient to send simple passwords or numerical codes, which are more secure from eavesdropping when traveling through the body than they are when sent in the clear over wireless networks. This might be particularly useful for authenticating with on-body medical devices such as insulin pumps. See www.washington.edu/news/2016/09/27/secure-passwords-can-be-sent-through-your-body-instead-of-air for more details.[5]

Gaming for Your Health

Microsoft Research has confirmed what we really wanted to believe anyway: playing Pokémon Go actually is good for you! Compelling mobile games that combine game play with moving around the real world have measurable health benefits.

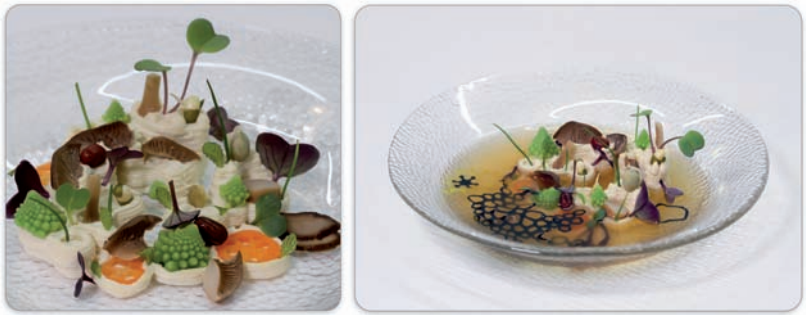
The researchers studied signals from large bodies of wearable sensor data and logs from search engines for 32,000 users over three months. They found that particularly enthusiastic players increased their daily step counts by more than 25 percent on average, or 1,473 steps. During the three months of their study, they believe the game has added around 144 billion steps to the activity of US participants. Read the article at https://arxiv.org/pdf/1610.02085v1.pdf for more details about whether this effect is lasting, whether it's true in general or only for particular groups of players, and how it stacks up against other attempts to use mobile applications to improve people's physical activity levels and therefore their health.[6]

Programmable Nosh

Our bodies need food, but when some of us hear the words "printed food," we envision horrid extruded cheese snack products and robots replacing human chefs. Instead, *digital gastronomy* is the hybrid cooking vision of researchers at the Hebrew University of Jerusalem, MIT Media Lab, and the Bezalel Academy of Arts and Design. It combines traditional cooking with digital fabrication enhancements that provide beautiful results, and sometimes even results carefully calculated to meet individual tastes.

Any readers who still struggle to achieve consistency with the outcome of their meringues will be delighted by the programmable heating pattern applied to the meringue surface in the video at https://vimeo.com/162494936. Heating changes the flavor of ingredients, and now you can control just how much of that surface you want changed (using a programmable laser) and to what degree. Or really, maybe you just want the pretty butterflies that appear on the meringues in the video! We are also particularly fond of the portion of the video showing a sweet potato in a 3D scanner—how could that not be a winner?

The chefs use 3D printers, laser cutters, 3D scanners, and milling machines to create amazing miniature landscapes of food, such as the coral reef soup in Figure 1. Have your lunch before checking out the video or the website (http://digitalgastronomy.co) so that you can eat it before you see how sad your lunch looks in contrast to these chefs' efforts.



(a) (b)

Figure 1. Coral reef soup: (a) the 3D-printed tofu coral base decorated with milled carrots, Romanesco broccoli, and other items; (b) the meal plated with broth and decorated with laser-cut nori seaweed. (Source: Amit Zoran; used with permission.)

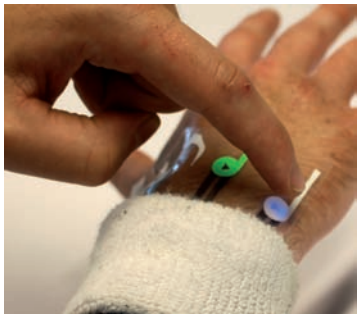


Figure 2. A Stretchi interactive tattoo used to control a music player. (Source: Michael Wessely; used with permission.)

MIXED AND VIRTUAL BODIES

Two appealing uses of virtualization bring remote people to our local space or our local selves into a product design space.

Wait, Where Are You Really?

Researchers at Microsoft have been working on "holoportation" with the goal of making communication and interaction with remote people as natural as face-to-face interaction. They use high-quality 3D capture technology to create 3D models of people that can then be sent over the network. The real people at the other end, using HoloLens or other such displays, can then see the remote people mixed into their own current physical space and interact with them in real time. Check out www.microsoft.com/en-us/research/project/holoportation-3, including the YouTube video, to see a demonstration of this technology.

The video is fun to watch but can be a little tricky to analyze, because it presents the remote picture and the local picture with the remote one blended in, from a particular viewpoint. One of the delightful results of this work is the ability to record and replay the holoportation experience, reduced in scale, so you can see a miniature "memory" of your interaction with the remote person, as if you were both filmed in the same space at the same time.

Hands-on Design

SketchingWithHands is a captivatingly different project from KAIST that aims to make it easier for people to design handheld products. It's a 3D sketching system with an integrated hand-tracking system. As you can see in the video at www.youtube.com/watch?v=g9lFiAZVX_w, the artist poses his hand in the air, and the sketching system presents a sketch of the hand in that posture. The artist can move his hand around, and the sketched hand does likewise. The artist can apply the usual tools to sketch the proposed product, and then can use more unusual tools, such as one that lets you check the intersections of sketch planes with the virtual hand. Drawing hands is time consuming and sometimes tricky, so this system seems like it could spare product designers a lot of time and grief. Check out the video for a more detailed walk through the system and its capabilities.

MATERIALLY COOL STUFF

We've entered a time of tremendous innovation and excitement in material science. The results include new materials for various kinds of printing—whether 3D, stretchable, or both—as well as our increasing ability to deploy carbon nanotubes in new ways. Metamaterials let us fabricate functional items with no need for assembly, while

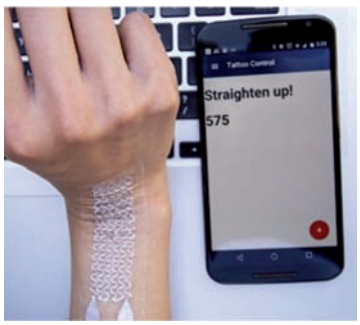


Figure 3. Skintillates are temporary tattoos that can do things. Pictured is a strain gauge warning the wearer to straighten her wrist. (Source: Joanne Lo; used with permission.)

flexible, stretchable, and printable electronics free us from a rigid design space.

It's a Bit of Stretch

Last column we looked at flexible holographic telephony, and this quarter we stretch that flexibility further to look at new user interfaces, functional tattoos, and how to put touchscreens anywhere.

Stretchis are user interfaces that include sensors and displays but are very stretchable and can conform to the shape of the objects they cover. Thin, customizable, and transparent where you want them to be, you can design them digitally and then print them yourself using low-cost silk-screening processes. Stretchis

NOTES FROM THE COMMUNITY

remain functional even when stretched to twice their length.

To make all this possible, the inventors use a multilayer fabrication approach with four basic kinds of layers. The first layer is the substrate of pure polydimethylsiloxane, which even lets you embed the interfaces into porous materials such as fabrics. The second layer is a sensing layer (currently supporting touch and proximity sensing) made from conductive ink laid down in the pattern and shape you've designed. The third layer is the electroluminescent display, itself made from five layers of inks including conductive, binding, and phosphorescent layers. The fourth layer is an "aesthetics layer" of colored inks in whatever shapes you want. The layers can be stacked in different ways and can contain several layers of the same kind—for example, if you want two different kinds of sensing, you would include two sensing layers. In demos at www.youtube.com/watch?v=gPVdvxfeE50, you can see Stretchis used to add notification functionality to container covers and applied as tattoos, such as the music-controlling tattoo in Figure 2. Read more about Stretchis at www.lri.fr/~fanis/docs/stretchis.pdf.[7]

For more fun with tattoos, or "epidermal interactions," we have Skintillates. These are thin electronics and electrical traces fabricated onto temporary tattoo paper.[8] Joanne Lo, Jung-Lin Lee, and Eric Paulos, from UC Berkeley, demonstrate using Skintillates as capacitive buttons, sliders, and wheels to control applications on a mobile phone via a low-power Bluetooth module, or as resistive sensors compatible with Makey Makey for controlling an online game. They also show a strain gauge pictured in Figure 3 that can be applied to wrists, necks, or wherever a user needs to sense posture issues. See https://vimeo.com/165809373 for a demonstration.

In addition to tattoos for the human body, we now have a flexible layer to apply to any surface that we'd like to turn into a touchscreen. The NBC Flex exploits carbon nanotubes with their shape changed to "nanobuds" in a film that can bend or stretch up to 120 percent of its size without losing conductivity. The film is supposed to make for a better touchscreen surface, because it reduces reflections and can conform to many shapes. The inventors, from startup Canatu in Finland, also envision using it in smart clothes, medical applications, automobile dashboards, and many other places. Learn more at www.technocrazed.com/stretchable-film-can-make-touchscreen-any-surface.

Flex Time

Another interesting area in material science is the move "to engineer not only the outer shape of objects, but also their internal microstructure" in such a way as to create materials with controlled movement.[9] Researchers at the Hasso-Plattner Institute have designed materials made of grids of silicone cells with different patterns that allow for different levels of rigidity. With flexible cells touching rigid ones, the shearing of the flexible parts can make the rigid parts move too. The inventors demonstrate 3D-printable objects such as functional door latches and pliers that are one piece—they require no assembly. In the case of the door latch, rotating its handle causes the touching cells to shear, which retracts the latch. To see a demonstration of these mechanisms in action, go to www.dezeen.com/2016/09/27/metamaterials-mechanisms-design-3d-printed-plastic-door-handle-hasso-plattner-institute-technology.[10]

REFERENCES

1. L. Samuel, "Architect with ALS Designs a Residence He Can Control with Just Blinks," *STAT*, 6 July 2016; www.statnews.com/2016/07/06/als-design-residence.
2. A. Morby, "Benjamin Hubert's 3D-Printed Wheelchair to Launch during Clerkenwell Design Week," *Dezeen*, 18 May 2016; www.dezeen.com/2016/05/18/benjamin-hubert-layer-3d-printed-wheelchair-launch-clerkenwell-design-week.
3. "Watch Obama Fist Bump a Robotic Arm Powered by a Brain Chip," *NBC News*, 13 Oct. 2016; www.nbcnews.com/video/watch-obama-fist-bump-a-robotic-arm-powered-by-a-brain-chip-785470531610.
4. "Mobius Bionics to Bring DEKA's LUKE Prosthetic Arm to Market," *Businesswire*, 8 July 2016; www.businesswire.com/news/home/20160708005511/en.
5. J. Langston, "Secure Passwords Can Be Sent through Your Body, Instead of Air," *UW Today*, 27 Sept. 2016; www.washington.edu/news/2016/09/27/secure-passwords-can-be-sent-through-your-body-instead-of-air.
6. T. Althoff, R.W. White, and E. Horvitz, "Influence of Pokémon Go on Physical Activity: Study and Implications," 6 Oct. 2016; https://arxiv.org/pdf/1610.02085v1.pdf.
7. M. Wessely, T. Tsandilas, and W.E. Mackay, "Stretchis: Fabricating Highly Stretchable User Interfaces," *Proc. 29th Ann. Symp. User Interface Software and Technology* (UIST), 2016, pp. 697–704; doi: 10.1145/2984511.2984521.
8. J. Lo, J.-L. Lee, and E. Paulos, "Skintillates: Towards Epidermal Electronic Interactions," *Proc. 2016 ACM Conf. Designing Interactive Systems* (DIS), 2016, pp. 853–864; doi: 10.1145/2901790.2901885.
9. A. Ion et al., "Metamaterial Mechanisms," *Proc. 29th Ann. Symp. User Interface Software and Technology* (UIST), 2016, pp. 529–539; https://hpi.de/fileadmin/user_upload/fachgebiete/baudisch/projects/metamaterial/metamaterial-mechanisms/2016UIST_Metamaterial_Mechanisms__authors_copy_.pdf.
10. R.S. Aouf, "Metamaterials Make It Possible to Create Mechanisms from a Single Piece of Plastic," *Dezeen*, 27 Sept. 2016; www.dezeen.com/2016/09/27/metamaterials-mechanisms-design-3d-printed-plastic-door-handle-hasso-plattner-institute-technology.

Mary Baker is a senior research scientist at HP Labs. Contact her at mgbaker@hp.com.

Justin Manweiler is a researcher at the IBM T.J. Watson Research Center. Contact him at jmanweiler@us.ibm.com.