Massachusetts Institute of Technology

# Media Lab

## Projects | October 2014

MIT Media Lab
Buildings E14 / E15
75 Amherst Street
Cambridge, Massachusetts 02139-4307

communications@media.mit.edu
http://www.media.mit.edu
617 253-5960

Many of the MIT Media Lab research projects described in the following pages are conducted under the auspices of sponsor-supported, interdisciplinary Media Lab centers, consortia, joint research programs, and initiatives. They are:

**Autism & Communication Technology Initiative**
The Autism & Communication Technology Initiative utilizes the unique features of the Media Lab to foster the development of innovative technologies that can enhance and accelerate the pace of autism research and therapy. Researchers are especially invested in creating technologies that promote communication and independent living by enabling non-autistic people to understand the ways autistic people are trying to communicate; improving autistic people's ability to use receptive and expressive language along with other means of functional, non-verbal expression; and providing telemetric support that reduces reliance on caregivers' physical proximity, yet still enables enriching and natural connectivity as wanted and needed.

**Center for Civic Media**
Communities need information to make decisions and take action: to provide aid to neighbors in need, to purchase an environmentally sustainable product and shun a wasteful one, to choose leaders on local and global scales. Communities are also rich repositories of information and knowledge, and often develop their own innovative tools and practices for information sharing. Existing systems to inform communities are changing rapidly, and new ecosystems are emerging where old distinctions like writer/audience and journalist/amateur have collapsed. The Civic Media group is a partnership between the MIT Media Lab and Comparative Media Studies at MIT. Together, we work to understand these new ecosystems and to build tools and systems that help communities collect and share information and connect that information to action. We work closely with communities to understand their needs and strengths, and to develop useful tools together using collaborative design principles. We particularly focus on tools that can help amplify the voices of communities often excluded from the digital public sphere and connect them with new audiences, as well as on systems that help us understand media ecologies, augment civic participation, and foster digital inclusion.

**Center for Extreme Bionics**
Half the world s population currently suffers from some form of physical or neurological disability. At some point in our lives, it is all too likely that a family member or friend will be struck by a limiting or incapacitating condition, from dementia, to the loss of a limb, to a debilitating disease such as Parkinson s. Today we acknowledge and even "accept" serious physical and mental impairments as inherent to the human condition. But must these conditions be accepted as "normal"? What if, instead, through the invention and deployment of novel technologies, we could control biological processes within the body in order to repair or even eradicate them? What if there were no such thing as human disability? These questions drive the work of Media Lab faculty members Hugh Herr and Ed Boyden, and MIT Institute Professor Robert Langer, and what has led them and the MIT Media Lab to propose the establishment of a new Center for Extreme Bionics. This dynamic new interdisciplinary organization will draw on the existing strengths of research in synthetic neurobiology, biomechatronics, and biomaterials, combined with enhanced capabilities for design development and prototyping.

**Center for Mobile Learning**
The Center for Mobile Learning invents and studies new mobile technologies to promote learning anywhere anytime for anyone. The Center focuses on mobile tools that empower learners to think creatively, collaborate broadly, and develop applications that are useful to themselves and others around them. The Center's work covers location-aware learning applications, mobile sensing and data collection, augmented reality gaming, and other educational uses of mobile technologies. The Center s first major activity will focus on App Inventor, a programming system that makes it easy for learners to create mobile apps by fitting together puzzle piece-shaped blocks in a web browser.

**Communications Futures Program**
The Communications Futures Program conducts research on industry dynamics, technology opportunities, and regulatory issues that form the basis for communications endeavors of all kinds, from telephony to RFID tags. The program operates through a series of working groups led jointly by MIT researchers and industry collaborators. It is highly participatory, and its agenda reflects the interests of member companies that include both traditional stakeholders and innovators. It is jointly directed by Dave Clark (CSAIL), Charles Fine (Sloan School of Management), and Andrew Lippman (Media Lab).

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The most current information about our research is available on the MIT Media Lab Web site, at http://www.media.mit.edu/research/.

The Lab has also organized the following special interest groups (SIGs), which deal with particular subject areas.

**Advancing Wellness**
In contributing to the digital revolution, the Media Lab helped fuel a society where increasing numbers of people are obese, sedentary, and glued to screens. Our online culture has promoted meaningfulness in terms of online fame and numbers of viewers, and converted time previously spent building face-to-face relationships into interactions online with people who may not be who they say they are. What we have helped to create, willingly or not, often diminishes the social-emotional relationships and activities that promote physical, mental, and social health. Moreover, our workplace culture escalates stress, provides unlimited caffeine, distributes nutrition-free food, holds back-to-back sedentary meetings, and encourages overnight hackathons and unhealthy sleep behavior. Without being dystopian about technology, this effort aims to spawn a series of projects that leverage the many talents and strengths in the Media Lab in order to reshape technology and our workplace to enhance health and wellbeing.

**CE 2.0**
Most of us are awash in consumer electronics (CE) devices: from cellphones, to TVs, to dishwashers. They provide us with information, entertainment, and communications, and assist us in accomplishing our daily tasks. Unfortunately, most are not as helpful as they could and should be; for the most part, they are dumb, unaware of us or our situations, and often difficult to use. In addition, most CE devices cannot communicate with our other devices, even when such communication and collaboration would be of great help. The Consumer Electronics 2.0 initiative (CE 2.0) is a collaboration between the Media Lab and its sponsor companies to formulate the principles for a new generation of consumer electronics that are highly connected, seamlessly interoperable, situation-aware, and radically simpler to use. Our goal is to show that as computing and communication capability seep into more of our everyday devices, these devices do not have to become more confusing and complex, but rather can become more intelligent in a cooperative and user-friendly way.

**City Science**
The world is experiencing a period of extreme urbanization. In China alone, 300 million rural inhabitants will move to urban areas over the next 15 years. This will require building an infrastructure equivalent to the one housing the entire population of the United States in a matter of a few decades. In the future, cities will account for nearly 90 percent of global population growth, 80 percent of wealth creation, and 60 percent of total energy consumption. Developing better strategies for the creation of new cities, is therefore, a global imperative. Our need to improve our understanding of cities, however, is pressed not only by the social relevance of urban environments, but also by the availability of new strategies for city-scale interventions that are enabled by emerging technologies. Leveraging advances in data analysis, sensor technologies, and urban experiments, City Science will provide new insights into creating a data-driven approach to urban design and planning. To build the cities that the world needs, we need a scientific understanding of cities that considers our built environments and the people who inhabit them. Our future cities will desperately need such understanding.

**Connection Science**
As more of our personal and public lives become infused and shaped by data from sensors and computing devices, the lines between the digital and the physical have become increasingly blurred. New possibilities arise, some promising, others alarming, but both with an inexorable momentum that is supplanting time honored practices and institutions. MIT Connection Science is a cross-disciplinary effort drawing on the strengths of faculty, departments and researchers across the Institute, to decode the meaning of this dynamic, at times chaotic, new environment. The initiative will help business executives, investors, entrepreneurs and policymakers capitalize on the multitude of opportunities unlocked by the new hyperconnected world we live in.

**Future of News**
The Future of News is designing, testing, and making creative tools that help newsrooms adapt in a time of rapid change. As traditional news models erode, we need new models and techniques to reach a world hungry for news, but whose reading and viewing habits are increasingly splintered. Newsrooms need to create new storytelling techniques, recognizing that the way users consume news continues to change. Readers and viewers expect personalized content, deeper context, and information that enables them to influence and change their world. At the same time, newsrooms are seeking new ways to extend their influence, to amplify their message by navigating new paths for readers and viewers, and to find new methods of delivery. To tackle these problems, we will work with Media Lab students and the broader MIT community to identify promising projects and find newsrooms across the country interested in beta-testing those projects.

**Future Storytelling**
The Future Storytelling working group at the Media Lab is rethinking storytelling for the 21st century. The group takes a new and dynamic approach to how we tell our stories, creating new methods, technologies, and learning programs that recognize and respond to the changing communications landscape. The group builds on the Media Lab's more than 25 years of experience in developing society-changing technologies for human expression and interactivity. By applying leading-edge technologies to make stories more interactive, improvisational, and social, researchers are working to transform audiences into active participants in the storytelling process, bridging the real and virtual worlds, and allowing everyone to make and share their own unique stories. Research also explores ways to revolutionize imaging and display technologies, including developing next-generation cameras and programmable studios, making movie production more versatile and economic.

**Ultimate Media**
Visual media has irretrievably lost its lock on the audience but has gained unprecedented opportunity to evolve the platform by which it is communicated and to become integrated with the social and data worlds in which we live. Ultimate Media is creating a platform for the invention, creation, and realization of new ways to explore and participate in the media universe. We apply extremes of access, processing, and interaction to build new media experiences and explorations that permit instant video blogging, exploration of the universe of news and narrative entertainment, and physical interfaces that allow people to collaborate around media.

# V. Michael Bove Jr.: Object-Based Media

**Changing storytelling, communication, and everyday life through sensing, understanding, and new interface technologies.**

## 1. 3D Telepresence Chair

***V. Michael Bove Jr. and Daniel Novy***

An autostereoscopic (no glasses) 3D display engine is combined with a "Pepper's Ghost" setup to create an office chair that appears to contain a remote meeting participant. The system geometry is also suitable for other applications such as tabletop or automotive heads-up displays.

## 2. Awakened Apparel

***V. Michael Bove, Laura Perovich and Philippa Mothersill***

This project investigates soft mechanisms, origami, and fashion. We created a modified Miura fold skirt that changes shape through pneumatic actuation. In the future, our skirt could dynamically adapt to the climatic, functional, and emotional needs of the user for example, it might become shorter in warm weather.

Alumni Contributors: Jennifer Broutin and Kent Larson

## 3. BigBarChart

***V. Michael Bove and Laura Perovich***

BigBarChart is an immersive 3D bar chart that provides a new physical way for people to interact with data. It takes data beyond visualizations to map out a new area data experiences which are multisensory, embodied, and aesthetic interactions. BigBarChart is made up of a number of bars that extend up to 10 feet to create an immersive experience. Bars change height and color in response to interactions that are direct (a person entering the room), tangible (pushing down on a bar to get meta information), or digital (controlling bars and performing statistical analyses through a tablet). BigBarChart helps both scientists and the general public understand information from a new perspective. Early prototypes are available.

## 4. Bottles&Boxes: Packaging with Sensors

***Ermal Dreshaj and Daniel Novy***

We have added inexpensive, low-power, wireless sensors to product packages to detect user interactions with products. Thus, a bottle can register when and how often its contents are dispensed (and generate side effects like causing a music player to play music when the bottle is picked up, or generating an automatic refill order when near-emptiness is detected). A box can understand usage patterns of its contents. Consumers can vote for their favorites among several alternatives simply by handling them more often.

## 5. Calliope

***V. Michael Bove Jr., Edwina Portocarrero and Ye Wang***

Calliope is the follow-up to the NeverEnding Drawing Machine. A portable, paper-based platform for interactive story making, it allows physical editing of shared digital media at a distance. The system is composed of a network of creation stations that seamlessly blend analog and digital media. Calliope documents and displays the creative process with no need to interact directly with a computer. By using human-readable tags and allowing any object to be used as material for creation, it offers opportunities for cross-cultural and cross-generational collaboration among peers with expertise in different media.

## 6. Consumer Holo-Video

***V. Michael Bove Jr., Bianca Datta, Ermal Dreshaj and Sundeep Jolly***

The goal of this project, building upon work begun by Stephen Benton and the Spatial Imaging group, is to create an inexpensive desktop monitor for a PC or game console that displays holographic video images in real time, suitable for

entertainment, engineering, or medical imaging. To date, we have demonstrated the fast rendering of holo-video images (including stereographic images, which, unlike ordinary stereograms, have focusing consistent with depth information) from OpenGL databases on off-the-shelf PC graphics cards; current research addresses new optoelectronic architectures to reduce the size and manufacturing cost of the display system.

Alumni Contributors: James D. Barabas, Daniel Smalley and Quinn Y J Smithwick

## 7. Crystal Ball

***Amir Lazarovich, Dan Novy, Andy Lippman, Michael Bove***

A physical interface designed for simultaneous social interaction with visual material. We built a hemispherical, multi-person, interactive touch display that allows a small group of people in the same place or in equivalently equipped ones to jointly interact on the same surface. We created an application that runs on this platform and presents a selection of visual media and offers recommendations for common viewing.

## 8. Digital Synesthesia

***V. Michael Bove and Santiago Eloy Alfaro***

Digital Synesthesia looks to evolve the idea of Human-Computer Interfacing and give way for Human-World Interacting. It aims to find a way for users to experience the world by perceiving information outside of their sensory capabilities. Modern technology already offers the ability to detect information from the world that is beyond our natural sensory spectrum; however, there is still no real way for our brains and body to incorporate this new information as a part of our sensory toolkit, so that we can understand our surrounding world in new and undiscovered ways. The long-term vision of this work is to give users the ability to turn senses on and off depending on the desired experience. This project is part of the Ultimate Media initiative and will be applied to the navigation and discovery of media content.

## 9. Direct Fringe Writing of Computer-Generated Holograms

***V. Michael Bove Jr., Sundeep Jolly and University of Arizona College of Optical Sciences***

Photorefractive polymer has many attractive properties for dynamic holographic displays; however, the current display systems based around its use involve generating holograms by optical interference methods that complicate the optical and computational architectures of the systems, and limit the kinds of holograms that can be displayed. We are developing a system to write computer-generated diffraction fringes directly from spatial light modulators to photorefractive polymers, resulting in displays with reduced footprint and cost, and potentially higher perceptual quality.

## 10. Dressed in Data

***V. Michael Bove and Laura Perovich***

This project steps beyond data visualizations to create data experiences. It aims to engage not only the analytic mind, but also the artistic and emotional self. In this project, chemicals found in people s bodies and homes are turned into a series of fashions. Quantities, properties, and sources of chemicals are represented through various parameters of the fashion, such as fabric color, textures, and sizes. Wearing these outfits allows people to live the data to experience tangibly the findings from their homes and bodies. This is the first project in a series of works that seek to create aesthetic data experiences that prompt researchers and laypeople to engage with information in new ways.

## 11. Drift Bottle

***V. Michael Bove, Lingyun Sun and Zhejiang University***

How can emotions be conveyed, expressed, and felt? Drift Bottle is a project exploring interfaces that allow users to "feel" others  emotions to promote their communication. We have developed a voice message-exchange web service. Based on that, we design and develop several terminals with different interfaces

which convey emotions via media such as light, smell, and motion. One solution is to convey the emotions in voice messages via different colors of light. Our latest effort is conveying emotions via smells, with the intention of arousing the same emotions in the receivers.

## 12. Everything Tells a Story

***V. Michael Bove Jr., David Cranor and Edwina Portocarrero***

Following upon work begun in the Graspables project, we are exploring what happens when a wide range of everyday consumer products can sense, interpret into human terms (using pattern recognition methods), and retain memories, such that users can construct a narrative with the aid of the recollections of the "diaries" of their sporting equipment, luggage, furniture, toys, and other items with which they interact.

## 13. Guided-Wave Light Modulator

***V. Michael Bove Jr., Bianca Datta and Sunny Jolly***

We are developing inexpensive, efficient, high-bandwidth light modulators based on lithium niobate guided-wave technology. These modulators are suitable for demanding, specialized applications such as holographic video displays, as well as other light modulation uses such as compact video projectors.

Alumni Contributors: Daniel Smalley and Quinn Smithwick

## 14. Holoshop

***Paula Dawson, Masa Takatsuka, Hiroshi Yoshikawa, Brian Rogers, V. Michael Bove Jr.***

This project aims to make it easy to create 3D drawings that have the highly nuanced qualities of handmade drawings. Typically, 2D drawing relies on the conjunction of the friction and pressure of the medium (pencil and paper) to enable a sensitive registration of the gesture. However, when drawing in 3D there is not necessarily a support. Holoshop software uses forces and magnetism of open and closed fields to enable the user to locate fixed and semipermeable supports within the 3D environment. Holoshop is being developed for use in conjunction with a haptic device, the Phantom, enabling the user to navigate 3D space though both touch and vision. Also, the real-time modulation of lines from velocity and pressure enable responsive drawings which can be exported for holograms, 3D prints, and other 3D displays. This research is supported under Australian Research Council's Discovery Projects funding scheme (DP1094613).

## 15. Infinity-by-Nine

***V. Michael Bove Jr. and Daniel Novy***

We are expanding the home-video viewing experience by generating imagery to extend the TV screen and give the impression that the scene wraps completely around the viewer. Optical flow, color analysis, and heuristics extrapolate beyond the screen edge, where projectors provide the viewer's perceptual vision with low-detail dynamic patterns that are perceptually consistent with the video imagery and increase the sense of immersive presence and participation. We perform this processing in real time using standard microprocessors and GPUs.

## 16. ListenTree: Audio-Haptic Display in the Natural Environment

***V. Michael Bove, Joseph A. Paradiso, Gershon Dublon and Edwina Portocarrero***

ListenTree is an audio-haptic display embedded in the natural environment. Visitors to our installation notice a faint sound emerging from a tree. By resting their heads against the tree, they are able to hear sound through bone conduction. To create this effect, an audio exciter transducer is weatherproofed and attached to the tree's roots, transforming it into a living speaker, channeling audio through its branches, and providing vibrotactile feedback. In one deployment, we used ListenTree to display live sound from an outdoor ecological monitoring sensor network, bringing a faraway wetland into the urban landscape. Our intervention is motivated by a need for forms of display that fade into the background, inviting attention rather than

requiring it. We consume most digital information through devices that alienate us from our surroundings; ListenTree points to a future where digital information might become enmeshed in material.

## 17. Narratarium

***V. Michael Bove Jr., Fransheska Colon, Catherine Havasi, Katherine (Kasia) Hayden, Daniel Novy, Jie Qi and Robert H. Speer***

Narratarium augments printed and oral stories and creative play by projecting immersive images and sounds. We are using natural language processing to listen to and understand stories being told, and analysis tools to recognize activity among sensor-equipped objects such as toys, then thematically augmenting the environment using video and sound. New work addresses the creation and representation of audiovisual content for immersive story experiences and the association of such content with viewer context.

## 18. Networked Playscapes: Dig Deep

***V. Michael Bove and Edwina Portocarrero***

Networked Playscapes re-imagine outdoor play by merging the flexibility and fantastical of the digital world with the tangible, sensorial properties of physical play to create hybrid interactions for the urban environment. Dig Deep takes the classic sandbox found in children's playgrounds and merges it with the common fantasy of "digging your way to the other side of the world" to create a networked interaction in tune with child cosmogony.

## 19. Pillow-Talk

***V. Michael Bove Jr., Edwina Portocarrero and David Cranor***

Pillow-Talk is the first of a series of objects designed to aid creative endeavors through the unobtrusive acquisition of unconscious, self-generated content to permit reflexive self-knowledge. Composed of a seamless recording device embedded in a pillow, and a playback and visualization system in a jar, Pillow-Talk crystallizes that which we normally forget. This allows users to capture their dreams in a less mediated way, aiding recollection by priming the experience and providing no distraction for recall and capture through embodied interaction.

## 20. ProtoTouch: Multitouch Interfaces to Everyday Objects

***V. Michael Bove Jr. and David Cranor***

An assortment of everyday objects is given the ability to understand multitouch gestures of the sort used in mobile-device user interfaces, enabling people to use such increasingly familiar gestures to control a variety of objects, and to "copy" and "paste" configurations and other information among them.

## 21. ShAir: A Platform for Mobile Content Sharing

***Yosuke Bando, Daniel Dubois, Konosuke Watanabe, Arata Miyamoto, Henry Holtzman, and V. Michael Bove***

ShAir is a platform for instantly and easily creating local content-shareable spaces without requiring an Internet connection or location information. ShAir-enabled devices can opportunistically communicate with other mobile devices and optional pervasive storage devices such as WiFi SD cards whenever they enter the radio range of each other. Digital content can hop through devices in the background without user intervention. Applications that can be built on top of the platform include ad-hoc photo/video/music sharing and distribution, opportunistic social networking and games, digital business card exchange during meetings and conferences, and local news article sharing on trains and buses.

## 22. ShakeOnIt

***V. Michael Bove Jr. and David Cranor***

We are exploring ways to encode information exchange into preexisting natural interaction patterns, both between people and between a single user and objects with which he or she interacts on a regular basis. Two devices are presented to provoke thoughts regarding these information interchange modalities: a pair of gloves that requires two users to complete a "secret handshake" in order to gain

shared access to restricted information, and a doorknob that recognizes the grasp of a user and becomes operational only if the person attempting to use it is authorized to do so.

## 23. Slam Force Net

***V. Michael Bove Jr., Santiago Alfaro and Daniel Novy***

A basketball net incorporates segments of conductive fiber whose resistance changes with degree of stretch. By measuring this resistance over time, hardware associated with this net can calculate force and speed of a basketball traveling through the net. Applications include training, toys that indicate the force and speed on a display, dunk competitions, and augmented-reality effects on television broadcasts. This net is far less expensive and more robust than other approaches to measuring data about the ball (e.g., photosensors or ultrasonic sensors) and the only physical change required for the hoop or backboard is electrical connections to the net. Another application of the material is a flat net that can measure velocity of a ball hit or pitched into it (as in baseball or tennis); it can measure position as well (e.g., for determining whether a practice baseball pitch would have been a strike).

## 24. SurroundVision

***V. Michael Bove Jr. and Santiago Alfaro***

Adding augmented reality to the living-room TV, we are exploring the technical and creative implications of using a mobile phone or tablet (and possibly also dedicated devices like toys) as a controllable "second screen" for enhancing television viewing. Thus, a viewer could use the phone to look beyond the edges of the television to see the audience for a studio-based program, to pan around a sporting event, to take snapshots for a scavenger hunt, or to simulate binoculars to zoom in on a part of the scene. Recent developments include the creation of a mobile device app for Apple products and user studies involving several genres of broadcast television programming.

## 25. The "Bar of Soap": Grasp-Based Interfaces

***V. Michael Bove Jr. and Brandon Taylor***

We have built several handheld devices that combine grasp and orientation sensing with pattern recognition in order to provide highly intelligent user interfaces. The Bar of Soap is a handheld device that senses the pattern of touch and orientation when it is held, and reconfigures to become one of a variety of devices, such as phone, camera, remote control, PDA, or game machine. Pattern-recognition techniques allow the device to infer the user's intention based on grasp. Another example is a baseball that determines a user's pitching style as an input to a video game.

## 26. Ultra-High Tech Apparel

***V. Michael Bove, Philippa Mothersill, Laura Perovich, Christopher Bevans (CBAtelier), and Philipp Schmidt***

The classic lab coat has been a reliable fashion staple for scientists around the world. But Media Lab researchers are not only scientists we are also designers, tinkerers, philosophers, and artists. We need a different coat! Enter the Media Lab coat. Our lab coat is uniquely designed for, and with, the Media Lab community. It features reflective materials, new bonding techniques, and integrated electronics. Each Labber has different needs. Some require access to Arduinos, others need moulding materials, yet others carry around motors or smart tablets. The lab coat is a framework for customization. The coat is just the start. Together with some of the innovative member companies of the MIT Media Lab, we are exploring protective eyewear, footwear, and everything in between.

## 27. Vision-Based Interfaces for Mobile Devices

***V. Michael Bove Jr. and Santiago Alfaro***

Mobile devices with cameras have enough processing power to do simple machine-vision tasks, and we are exploring how this capability can enable new user interfaces to applications. Examples include dialing someone by pointing the camera at the person's photograph, or using the camera as an input to allow navigating virtual spaces larger than the device's screen.

## Ed Boyden: Synthetic Neurobiology

**Revealing insights into the human condition and repairing brain disorders via novel tools for mapping and fixing brain computations.**

### 28. Direct Engineering and Testing of Novel Therapeutic Platforms for Treatment of Brain Disorders

***Leah Acker, Bara Badwan, Changyang Linghu, Zixi Liu, Christian Wentz, Nir Grossman, Fumi Yoshida, Rin Yunis***

New technologies for controlling neural circuit dynamics, or entering information into the nervous system, may be capable of serving in therapeutic roles for improving the health of human patients enabling the restoration of lost senses, the control of aberrant or pathological neural dynamics, and the augmentation of neural circuit computation, through prosthetic means. We are assessing the translational possibilities opened up by our technologies, exploring the safety and efficacy of optogenetic neuromodulation in multiple animal models, and also pursuing, both in our group and in collaborations with others, proofs-of-principle of new kinds of neural control prosthetics. By combining observation of brain activity with real-time analysis and responsive optical neurostimulation, new kinds of "brain co-processors" may be possible which can work efficaciously with the brain to augment its computational abilities, e.g., in the context of cognitive, emotional, sensory, or motor disability.

### 29. Exploratory Technologies for Understanding Neural Circuits

***Adam Marblestone, Alexander Clifton, Asmamaw Wassie, Guangyu Xu, Jae-Byum Chang, Kate Adamala, Ishan Gupta, Fei Chen, Daniel Martin-Alarcon, Manos Karagiannis, Nikita Pak, Paul Tillberg***

We are continually exploring new strategies for understanding neural circuits, often in collaboration with other scientific, engineering, and biology research groups. If you would like to collaborate on such a project, please contact us.

### 30. Hardware and Systems for Control of Neural Circuits with Light

***Harbaljit Sohal, Anthony Zorzos***

The brain is a densely wired, heterogeneous circuit made out of thousands of different kinds of cells. Over the last several years, we have developed a set of fully genetically encoded "optogenetic" reagents that, when targeted to specific cells, enable their physiology to be controlled via light. To confront the 3D complexity of the living brain, enabling the analysis of the circuits that causally drive or support specific neural computations and behaviors, with our collaborators we have developed hardware for delivery of light into the brain, enabling control of complexly shaped neural circuits, as well as the ability to combinatorially activate and silence neural activity in distributed neural circuits. We anticipate that these tools will enable the systematic analysis of the brain circuits that mechanistically and causally contribute to specific behaviors and pathologies.

### 31. Molecular Reagents Enabling Control of Neurons and Biological Functions with Light

***Aimei Yang, Amy Chuong, Daniel Schmidt, Nathan Klapoetke***

Over the last several years our lab and our collaborators have pioneered a new area: the development of a number of fully genetically encoded reagents that, when targeted to specific cells, enable their physiology to be controlled via light. These reagents, known as optogenetic tools, enable temporally precise control of neural electrical activity, cellular signaling, and other high-speed natural as well as synthetic biology processes and pathways using light. Such tools are now in widespread use in neuroscience, for the study of the neuron types and activity patterns that mechanistically and causally contribute to processes ranging from cognition to emotion to movement, and to brain disorders. These tools are also being evaluated as components of prototype neural control devices for ultra-precise treatment of intractable brain disorders.

## 32. Recording and Data-Analysis Technologies for Observing and Analyzing Neural Circuit Dynamics

***Caroline Moore-Kochlacs, Deniz Aksel, Jake Bernstein, Jorg Scholvin, Jun Deguchi, Justin Kinney, Justine Cheng, Kiryl Piatkevich, Kris Payer, Mike Henninger, Moshe Ben-Ezra, Or Shemesh, Rebecca Luoh, Suhasa Kodandaramaiah, Young Gyu Yoon***

The brain is a 3D, densely wired circuit that computes via large sets of widely distributed neurons interacting at fast timescales. In order to understand the brain, ideally it would be possible to observe the activity of many neurons with as great a degree of precision as possible, so as to understand the neural codes and dynamics that are produced by the circuits of the brain. And, ideally, it would be possible to understand how those neural codes and dynamics emerge from the molecular, genetic, and structural properties of the cells making up the circuit. Along with our collaborators, we are developing a number of innovations to enable such analyses of neural circuit dynamics. These tools will hopefully enable pictures of how neurons work together to implement brain computations, and how these computations go awry in brain disorder states.

## 33. Understanding Neural Circuit Computations and Finding New TherapeuticTargets

***Annabelle Singer, Brian Allen, Denis Bozic, Eunice Wu, Giovanni Talei Franzesi, Melina Tsitsiklis, Rita Ainane, Sean Batir, Sunanda Sharma***

We are using our tools such as optogenetic neural control and brain circuit dynamics measurement both within our lab and in collaborations with others, to analyze how specific sets of circuit elements within neural circuits give rise to behaviors and functions such as cognition, emotion, movement, and sensation. We are also determining which neural circuit elements can initiate or sustain pathological brain states. Principles of controlling brain circuits may yield fundamental insights into how best to go about treating brain disorders. Finally, we are screening for neural circuit targets that, when altered, present potential therapeutic benefits, and which may serve as potential drug targets or electrical stimulation targets. In this way we hope to explore systematic, causal, temporally precise analyses of how neural circuits function, yielding both fundamental scientific insights and important clinically relevant principles.

# Cynthia Breazeal: Personal Robots

**Building socially engaging robots and interactive technologies to help people live healthier lives, connect with others, and learn better.**

## 34. AIDA: Affective Intelligent Driving Agent

***Cynthia Breazeal and Kenton Williams***

Drivers spend a significant amount of time multi-tasking while they are behind the wheel. These dangerous behaviors, particularly texting while driving, can lead to distractions and ultimately to accidents. Many in-car interfaces designed to address this issue still neither take a proactive role to assist the driver nor leverage aspects of the driver's daily life to make the driving experience more seamless. In collaboration with Volkswagen/Audi and the SENSEable City Lab, we are developing AIDA (Affective Intelligent Driving Agent), a robotic driver-vehicle interface that acts as a sociable partner. AIDA elicits facial expressions and strong non-verbal cues for engaging social interaction with the driver. AIDA also leverages the driver's mobile device as its face, which promotes safety, offers proactive driver support, and fosters deeper personalization to the driver.

## 35. Animal-Robot Interaction

***Brad Knox, Patrick Mccabe and Cynthia Breazeal***

Like people, dogs and cats live among technologies that affect their lives. Yet little of this technology has been designed with pets in mind. We are developing systems that interact intelligently with animals to entertain, exercise, and empower them. Currently, we are developing a laser-chasing game, in which dogs or cats are tracked by a ceiling-mounted webcam, and a computer-controlled laser is moved with knowledge of the pet's position and movement. Machine learning will be applied to optimize the specific laser strategy. We envision enabling owners to initiate and view the interaction remotely through a web interface, providing stimulation and exercise to pets when the owners are at work or otherwise cannot be present.

## 36. Cloud-HRI

***Cynthia Breazeal, Nicholas DePalma, Adam Setapen and Sonia Chernova***

Imagine opening your eyes and being awake for only half an hour at a time. This is the life that robots traditionally live. This is due to a number of factors such as battery life and wear on prototype joints. Roboticists have typically muddled though this challenge by crafting handmade perception and planning models of the world, or by using machine learning with synthetic and real-world data, but cloud-based robotics aims to marry large distributed systems with machine learning techniques to understand how to build robots that interpret the world in a richer way. This movement aims to build large-scale machine learning algorithms that use experiences from large groups of people, whether sourced from a large number of tabletop robots or a large number of experiences with virtual agents. Large-scale robotics aims to change embodied AI as it changed non-embodied AI.

## 37. Command Not Found

***David Nunez, Tod Machover, Cynthia Breazeal***

A performance between a human and a robot tells the story of growing older and trying to maintain friendships with those we meet along the way. This project explores live-coding with a robot, in which the actor creates and executes software on a robot in real time; the audience can watch the program evolve on screen and the code, itself, is part of the narrative.

## 38. DragonBot: Android Phone Robots for Long-Term HRI

***Adam Setapen, Natalie Freed, and Cynthia Breazeal***

DragonBot is a new platform built to support long-term interactions between children and robots. The robot runs entirely on an Android cell phone, which displays an animated virtual face. Additionally, the phone provides sensory input (camera and microphone) and fully controls the actuation of the robot (motors and speakers). Most importantly, the phone always has an Internet connection, so a robot can harness cloud-computing paradigms to learn from the collective interactions of multiple robots. To support long-term interactions, DragonBot is a "blended-reality" character if you remove the phone from the robot, a virtual avatar appears on the screen and the user can still interact with the virtual character on the go. Costing less than $1,000, DragonBot was specifically designed to be a low-cost platform that can support longitudinal human-robot interactions "in the wild."

## 39. Global Literacy Tablets

***Cynthia Breazeal, David Nunez, Tinsley Galyean, Maryanne Wolf (Tufts), and Robin Morris (GSU)***

We are developing a system of early literacy apps, games, toys, and robots that will triage how children are learning, diagnose literacy deficits, and deploy dosages of content to encourage app play using a mentoring algorithm that recommends an appropriate activity given a child's progress. Currently, over 200 Android-based tablets have been sent to children around the world; these devices are instrumented to provide a very detailed picture of how kids are using these technologies. We are using this big data to discover usage and learning models that will inform future educational development.

## 40. Mind-Theoretic Planning for Robots

***Cynthia Breazeal and Sigurdur Orn Adalgeirsson***

Mind-Theoretic Planning (MTP) is a technique for robots to plan in social domains. This system takes into account probability distributions over the initial beliefs and goals of people in the environment that are relevant to the task, and creates a prediction of how they will rationally act on their beliefs to achieve their goals. The MTP system then proceeds to create an action plan for the robot that simultaneously takes advantage of the effects of anticipated actions of others and also avoids interfering with them.

## 41. Robot Learning from Human-Generated Rewards

***Brad Knox, Robert Radway, Tom Walsh, and Cynthia Breazeal***

To serve us well, robots and other agents must understand our needs and how to fulfill them. To that end, our research develops robots that empower humans by interactively learning from them. Interactive learning methods enable technically unskilled end-users to designate correct behavior and communicate their task knowledge to improve a robot's task performance. This research on interactive learning focuses on algorithms that facilitate teaching by signals of approval and disapproval from a live human trainer. We operationalize these feedback signals as numeric rewards within the machine-learning framework of reinforcement learning. In comparison to the complementary form of teaching by demonstration, this feedback-based teaching may require less task expertise and place less cognitive load on the trainer. Envisioned applications include human-robot collaboration and assistive robotic devices for handicapped users, such as myolectrically controlled prosthetics.

## 42. Robotic Language Learning Companions

***Cynthia Breazeal, Jacqueline Kory, Sooyeon Jeong, Paul Harris, Dave DeSteno, and Leah Dickens***

Young children learn language not through listening alone, but through active communication with a social actor. Cultural immersion and context are also key in long-term language development. We are developing robotic conversational partners and hybrid physical/digital environments for language learning. For example, the robot Sophie helped young children learn French through a food-sharing game. The game was situated on a digital tablet embedded in a café table. Sophie modeled how to order food and as the child practiced the new vocabulary, the food was delivered via digital assets onto the table's surface. Meanwhile, a teacher or parent can observe and shape the interaction remotely via a digital tablet interface to adjust the robot's conversation and behavior to support the learner. More recently, we have been examining how social nonverbal behaviors impact children's perceptions of the robot as an informant and social companion.

Alumni Contributors: Natalie Anne Freed and Adam Michael Setapen

## 43. Socially Assistive Robotics: An NSF Expedition in Computing

***Tufts University, University of Southern California, Kasia Hayden with Stanford University, Cynthia Breazeal, Edith Ackermann, Catherine Havasi, Sooyeon Jeong, Brad Knox, Jacqueline Kory, Jin Joo Lee, Samuel Spaulding, Willow Garage and Yale University***

Our mission is to develop the computational techniques that will enable the design, implementation, and evaluation of "relational" robots, in order to encourage social, emotional, and cognitive growth in children, including those with social or cognitive deficits. Funding for the project comes from the NSF Expeditions in Computing program. This Expedition has the potential to substantially impact the effectiveness of education and healthcare, and to enhance the lives of children and other groups that require specialized support and intervention. In particular, the MIT effort is focusing on developing second language learning companions for pre-school aged children, ultimately for ESL (English as a Second Language).

## 44. TinkRBook: Reinventing the Reading Primer

***Cynthia Breazeal, Angela Chang, and David Nunez***

TinkRBook is a storytelling system that introduces a new concept of reading, called textual tinkerability. Textual tinkerability uses storytelling gestures to expose the text-concept relationships within a scene. Tinkerability prompts readers to become more physically active and expressive as they explore concepts in reading together. TinkRBooks are interactive storybooks that prompt interactivity in a subtle way, enhancing communication between parents and children during shared picture-book reading. TinkRBooks encourage positive reading behaviors in emergent literacy: parents act out the story to control the words onscreen, demonstrating print referencing and dialogic questioning techniques. Young children actively explore the abstract relationship between printed words and their meanings, even before this relationship is properly understood. By making story elements alterable within a narrative, readers can learn to read by playing with how word choices impact the storytelling experience. Recently, this research has been applied in developing countries.

Alumni Contributor: Angela Chang

# Hugh Herr: Biomechatronics

**Enhancing human physical capability.**

## 45. Artificial Gastrocnemius

***Hugh Herr and Ken Endo***

Human walking neuromechanical models show how each muscle works during normal, level-ground walking. They are mainly modeled with clutches and linear springs, and are able to capture dominant normal walking behavior. This suggests to us to use a series-elastic clutch at the knee joint for below-knee amputees. We have developed the powered ankle prosthesis, which generates enough force to enable a user to walk "normally." However, amputees still have problems at the knee joint due to the lack of gastrocnemius, which works as an ankle-knee flexor and a plantar flexor. We hypothesize that metabolic cost and EMG patterns of an amputee with our powered ankle and virtual gastrocnemius will dramatically improve.

## 46. Biomimetic Active Prosthesis for Above-Knee Amputees

***Hugh Herr, Elliott Rouse and Luke Mooney***

Using biologically inspired design principles, a biomimetic robotic knee prosthesis is proposed that uses a clutchable series-elastic actuator. In this design, a clutch is placed in parallel to a combined motor and spring. This architecture permits the mechanism to provide biomimetic walking dynamics while requiring minimal electromechanical energy from the prosthesis. The overarching goal for this project is to design a new generation of robotic knee prostheses capable of generating significant energy during level-ground walking, that can be stored in a battery and used to power a robotic ankle prosthesis and other net-positive locomotion modes (i.e., stair ascent).

Alumni Contributor: Ernesto C. Martinez-Villalpando

## 47. Control of Muscle-Actuated Systems via Electrical Stimulation

***Hugh Herr***

Motivated by applications in rehabilitation and robotics, we are developing methodologies to control muscle-actuated systems via electrical stimulation. As a demonstration of such potential, we are developing centimeter-scale robotic systems that utilize muscle for actuation and glucose as a primary source of fuel. This is an interesting control problem because muscles: a) are mechanical state-dependent actuators; b) exhibit strong nonlinearities; and c) have slow time-varying properties due to fatigue-recuperation, growth-atrophy, and damage-healing cycles. We are investigating a variety of adaptive and robust control techniques to enable us to achieve trajectory tracking, as well as mechanical power-output control under sustained oscillatory conditions. To implement and test our algorithms, we developed an experimental capability that allows us to characterize and control muscle in real time, while imposing a wide variety of dynamical boundary conditions.

Alumni Contributor: Waleed A. Farahat

## 48. Dancing Control System for Bionic Ankle Prosthesis

***Hugh Herr, Bevin Lin, Elliott Rouse, Nathan Villagaray-Carski and Robert Emerson***

Professional ballroom dancer Adrianne Haslet-Davis lost her natural ability to dance when her left leg was amputated below the knee following the Boston Marathon bombings in April 2013. Hugh Herr was introduced to Adrianne while meeting with bombing survivors at Boston s Spaulding Rehabilitation Hospital. For Professor Herr, this meeting generated a research challenge: build Adrianne a bionic ankle prosthesis, and restore her ability to dance. The research team for this project spent some 200 days studying the biomechanics of dancing and designing the bionic technology based on their investigations. The control system for Adrianne was implemented on a customized BiOM bionic ankle prosthesis.

## 49. Effect of a Powered Ankle on Shock Absorption and Interfacial Pressure

***Hugh Herr and David Hill***

Lower-extremity amputees face a series of potentially serious post-operative complications. Among these are increased risk of further amputations, excessive stress on the unaffected and residual limbs, and discomfort at the human-prosthesis interface. Currently, conventional, passive prostheses have made strides towards alleviating the risk of experiencing complications, but we believe that the limit of "dumb" elastic prostheses has been reached; in order to make further strides we must integrate "smart" technology in the form of sensors and actuators into lower-limb prostheses. This project compares the elements of shock absorption and socket pressure between passive and active ankle-foot prostheses. It is an attempt to quantitatively evaluate the patient's comfort.

## 50. FitSocket: A Better Way to Make Sockets

***Arthur Petron, Hugh Herr, Roy Kornbluh (SRI), and Neri Oxman***

Sockets the cup-shaped devices that attach an amputated limb to a lower-limb prosthesis are made through unscientific, artisanal methods that do not have repeatable quality and comfort from one individual to the next. The FitSocket project aims to identify the correlation between leg tissue properties and the design of a comfortable socket. The FitSocket is a robotic socket measurement device that directly measures tissue properties. With this data, we can rapid-prototype test sockets and socket molds in order to make rigid, spatially variable stiffness, and spatially/temporally variable stiffness sockets.

Alumni Contributor: Elizabeth Tsai

## 51. FlexSEA: Flexible, Scalable Electronics Architecture for Prosthetic and Robotic Applications

***Hugh Herr and Jean-Francois Duval***

This project aims to enable fast prototyping of a multi-axis and multi-joint active prosthesis by developing a new modular electronics system. This system provides the required hardware and software to do precise motion control, data acquisition, and networking. Scalability is obtained by the use of a fast industrial communication protocol between the modules, and by a standardization of the peripherals interfaces: it is possible to add functionalities to the system simply by plugging additional cards. Hardware and software encapsulation is used to provide high-performance, real-time control of the actuators while keeping the high-level algorithmic development and prototyping simple, fast, and easy.

## 52. Human Walking Model Predicts Joint Mechanics, Electromyography, and Mechanical Economy

***Hugh Herr, Matthew Furtney and Stanford Research Institute***

We are studying the mechanical behavior of leg muscles and tendons during human walking in order to motivate the design of power-efficient robotic legs. The Endo-Herr walking model uses only three actuators (leg muscles) to power locomotion. It uses springs and clutches in place of other essential tendons and muscles to store energy and transfer energy from one joint to another during walking. Since mechanical clutches require much less energy than electric motors, this model can be used to design highly efficient robotic legs and exoskeletons. Current work includes analysis of the model at variable walking speeds and informing design specifications for a collaborative SuperFlex exosuit project.

Alumni Contributor: Ken Endo

## 53. Load-Bearing Exoskeleton for Augmentation of Human Running

***Hugh Herr, Grant Elliott and Andrew Marecki***

Augmentation of human locomotion has proved an elusive goal. Natural human walking is extremely efficient and the complex articulation of the human leg poses significant engineering difficulties. We present a wearable exoskeleton designed to reduce the metabolic cost of jogging. The exoskeleton places a stiff fiberglass spring in parallel with the complete leg during stance phase, then removes it so that the knee may bend during leg swing. The result is a bouncing gait with reduced reliance on the musculature of the knee and ankle.

## 54. Neural Interface Technology for Advanced Prosthetic Limbs

***Edward Boyden, Hugh Herr, Ron Riso and Katherine Song***

Recent advances in artificial limbs have resulted in the provision of powered ankle and knee function for lower extremity amputees and powered elbow, wrist, and finger joints for upper extremity prostheses. Researchers still struggle, however, with how to provide prosthesis users with full volitional and simultaneous control of the powered joints. This project seeks to develop means to allow amputees to control their powered prostheses by activating the peripheral nerves present in their residual limb. Such neural control can be more natural than currently used myoelectric control since the same functions previously served by particular motor fascicles can be directed to the corresponding prosthesis actuators for simultaneous joint control, as in normal limbs. Future plans include the capability to electrically activate the sensory components of residual limb nerves to provide amputees with tactile feedback and an awareness of joint position from their prostheses.

## 55. Powered Ankle-Foot Prosthesis

***Hugh Herr***

The human ankle provides a significant amount of net positive work during the stance period of walking, especially at moderate to fast walking speeds. Conversely, conventional ankle-foot prostheses are completely passive during stance, and consequently, cannot provide net positive work. Clinical studies indicate that transtibial amputees using conventional prostheses experience many problems during locomotion, including a high gait metabolism, a low gait speed, and gait asymmetry. Researchers believe the main cause for the observed locomotion is due to the inability of conventional prostheses to provide net positive work during

stance. The objective of this project is to develop a powered ankle-foot prosthesis that is capable of providing net positive work during the stance period of walking. To this end, we are investigating the mechanical design and control system architectures for the prosthesis. We are also conducting a clinical evaluation of the proposed prosthesis on different amputee participants.

Alumni Contributor: Samuel Au

## 56. Sensor-Fusions for an EMG Controlled Robotic Prosthesis

***Matthew Todd Farrell and Hugh Herr***

Current unmotorized prostheses do not provide adequate energy return during late stance to improve level-ground locomotion. Robotic prostheses can provide power during late-stance to improve metabolic economy in an amputee during level-ground walking. This project seeks to improve the types of terrain a robotic ankle can successfully navigate by using command signals taken from the intact and residual limbs of an amputee. By combining these commands signals with sensors attached to the robotic ankle, it might be possible to further understand the role of physiological signals in the terrain adaptation of robotic ankles.

## 57. Tethered Robotic System for Understanding Human Movements

***Hugh Herr and Jiun-Yih Kuan***

The goal of this project is to build a powerful system as a scientific tool for bridging the gap in the literature by determining the dynamic biomechanics of the lower-limb joints and metabolic effects of physical interventions during natural locomotion. This system is meant for use in applying forces to the human body and measuring the force, displacement, and other physiological properties simultaneously, helping investigate controllability and efficacy of mechanical devices physically interacting with a human subject.

## 58. Variable-Impedance Prosthetic (VIPr) Socket Design

***Hugh Herr, Arthur J Petron, Bryan Ranger and David Sengeh***

Today, 100 percent of amputees experience some form of prosthetic socket discomfort. This project involves the design and production of a comfortable, variable impedance prosthetic (VIPr) socket using digital anatomical data for a transtibial amputee using computer-aided design and manufacturing (CAD/CAM). The VIPr socket uses multiple materials to achieve compliance, thereby increasing socket comfort for amputees, while maintaining structural integrity. The compliant features are seamlessly integrated into the 3D-printed socket to achieve lower interface peak pressures over bony protuberances and other anatomical points in comparison to a conventional socket. This lower peak pressure is achieved through a design that uses anthropomorphic data acquired through surface scan and Magnetic Resonance Imaging techniques. A mathematical transformation maps the quantitative measurements of the human residual limb to the corresponding socket shape and impedance characteristics, spatially.

## 59. Volitional Control of a Powered Ankle-Foot Prosthesis

***Hugh Herr and Oliver Kannape***

This project focuses on giving transtibial amputees volitional control over their prostheses by combining electromyographic (EMG) activity from the amputees' residual limb muscles with intrinsic controllers on the prosthesis. The aim is to generalize biomimetic behavior of the prosthesis, making it independent of walking terrains and transitions.

## Cesar Hidalgo: Macro Connections

**Transforming data into knowledge.**

### 60. Data Visualization: The Pixel Factory

***Cesar A. Hidalgo and Macro Connections group***

**NEW LISTING**

The rise of computational methods has generated a new natural resource: data. While it's unclear if big data will open up trillion-dollar markets, it is clear that making sense of data isn't easy, and that data visualizations are essential to squeeze meaning out of data. But the capacity to create data visualizations is not widespread; to help develop it we introduce the Pixel Factory, a new initiative focusing on the creation of data-visualization resources and tools in collaboration with corporate members. Our goals are to create software resources for development of online data-visualization platforms that work with any type of data; and to create these resources as a means to learn. The most valuable outcome of this work will not be the software resources produced incredible as these could be but the generation of people with the capacity to make these resources.

### 61. DIVE

***Cesar A. Hidalgo, Manuel Aristaran and Kevin Zeng Hu***

**NEW LISTING**

The Data Integration and Visualization Engine (DIVE) is a platform for semi-automatically generating web-based, interactive visualizations of structured data sets. DIVE will allow users to quickly and efficiently create visualization engines like the Observatory of Economic Complexity, DataViva, and Pantheon. Three components lie at the core of DIVE: inferring the properties and models underlying arbitrary datasets, mapping these properties to visualizations, and programmatically creating scalable, customizable websites integrating these visualizations.

### 62. FOLD

***Alexis Hope, Kevin Hu***

**NEW LISTING**

Imagine reading about the 2008 housing crisis without knowing what a mortgage is. Jumping into complex news stories is difficult, particularly stories requiring historical or technical context. We hypothesize that the feeling of frustration and inadequacy that comes with not being able to understand the news causes readers to turn away from specific pieces or entire stories. FOLD is an authoring and publishing platform allowing storytellers to structure and contextualize their stories to make their work more accessible. Authors can provide curated tangents to readers by integrating contextual information from online sources or by reusing other authors context blocks. Readers can progress through a story vertically to read the narrative, and side-to-side to access these context blocks. We believe that FOLD can help readers of all ages and backgrounds confidently engage with complex stories.

### 63. GIFGIF

***Cesar A. Hidalgo, Andrew Lippman, Kevin Zeng Hu and Travis Rich***

An animated gif is a magical thing. It contains the power to compactly convey emotion, empathy, and context in a subtle way that text or emoticons often miss. GIFGIF is a project to combine that magic with quantitative methods. Our goal is to create a tool that lets people explore the world of gifs by the emotions they evoke, rather than by manually entered tags. A web site with 200,000 users maps the GIFs to an emotion space and lets you peruse them interactively.

### 64. Immersion

***Deepak Jagdish, Daniel Smilkov and Cesar Hidalgo***

Immersion is a visual data experiment that delivers a fresh perspective of your email inbox. Focusing on a people-centric approach rather than the content of the emails, Immersion brings into view an important personal insight the network of people you

are connected to via email, and how it evolves over the course of many years. Given that this experiment deals with data that is extremely private, it is worthwhile to note that when given secure access to your Gmail inbox (which you can revoke any time), Immersion only uses data from email headers and not a single word of any email's subject or body content.

## 65. Opus

***Cesar A. Hidalgo and Miguel Guevara***

Opus is an online tool exploring the work and trajectory of scholars. Through a suite of interactive visualizations, Opus help users explore the academic impact of a scholar's publications, discover her network of collaborators, and identify her peers.

## 66. Pantheon

***Ali Almossawi, Andrew Mao, Defne Gurel, Cesar A. Hidalgo, Kevin Zeng Hu, Deepak Jagdish, Amy Yu, Shahar Ronen and Tiffany Lu***

We were not born with the ability to fly, cure disease, or communicate at long distances, but we were born in a society that endows us with these capacities. These capacities are the result of information that has been generated by humans and that humans have been able to embed in tangible and digital objects. This information is all around us: it's the way in which the atoms in an airplane are arranged or the way in which our cellphones whisper dance instructions to electromagnetic waves. Pantheon is a project celebrating the cultural information that endows our species with these fantastic capacities. To celebrate our global cultural heritage, we are compiling, analyzing, and visualizing datasets that can help us understand the process of global cultural development.

## 67. Place Pulse

***Phil Salesses, Anthony DeVincenzi, and César A. Hidalgo***

Place Pulse is a website that allows anybody to quickly run a crowdsourced study and interactively visualize the results. It works by taking a complex question, such as  Which place in Boston looks the safest?  and breaking it down into easier-to-answer binary pairs. Internet participants are given two images and asked "Which place looks safer?" From the responses, directed graphs are generated and can be mined, allowing the experimenter to identify interesting patterns in the data and form new hypothesis based on their observations. It works with any city or question and is highly scalable. With an increased understanding of human perception, it should be possible for calculated policy decisions to have a disproportionate impact on public opinion.

## 68. StreetScore

***Nikhil Naik, Jade Philipoom, Ramesh Raskar, Cesar Hidalgo***

**NEW LISTING**

StreetScore is a machine learning algorithm that predicts the perceived safety of a streetscape. StreetScore was trained using 2,920 images of streetscapes from New York and Boston and their rankings for perceived safety obtained from a crowdsourced survey. To predict an image's score, StreetScore decomposes this image into features and assigns the image a score based on the associations between features and scores learned from the training dataset. We use StreetScore to create a collection of map visualizations of perceived safety of street views from cities in the United States. StreetScore allows us to scale up the evaluation of streetscapes by several orders of magnitude when compared to a crowdsourced survey. StreetScore can empower research groups working on connecting urban perception with social and economic outcomes by providing high resolution data on urban perception.

## 69. The Economic Complexity Observatory

***Alex Simoes and César A. Hidalgo***

With more than six billion people and 15 billion products, the world economy is anything but simple. The Economic Complexity Observatory is an online tool that helps people explore this complexity by providing tools that can allow decision makers to understand the connections that exist between countries and the myriad of products they produce and/or export. The Economic Complexity Observatory puts at everyone s fingertips the latest analytical tools developed to visualize and quantify the productive structure of countries and their evolution.

## 70. The Language Group Network

***Shahar Ronen, Kevin Hu, Michael Xu, and César A. Hidalgo***

Most interactions between cultures require overcoming a language barrier, which is why multilingual speakers play an important role in facilitating such interactions. In addition, certain languages not necessarily the most spoken ones are more likely than others to serve as intermediary languages. We present the Language Group Network, a new approach for studying global networks using data generated by tens of millions of speakers from all over the world: a billion tweets, Wikipedia edits in all languages, and translations of two million printed books. Our network spans over eighty languages, and can be used to identify the most connected languages and the potential paths through which information diffuses from one culture to another. Applications include promotion of cultural interactions, prediction of trends, and marketing.

## 71. The Network Impact in Success

***Cesar A. Hidalgo and Miguel Guevara***

Diverse teams of authors are known to generate higher-impact research papers, as measured by their number of citations. But is this because cognitively diverse teams produce higher quality work, which is more likely to get cited and adopted? Or is it because they possess a larger number of social connections through which to distribute their findings? In this project we are mapping the co-authorship networks and the academic diversity of the authors in a large volume of scientific publications to test whether the adoption of papers is explained by cognitive diversity or the size of the network associated with each of these authors. This project will help us understand whether the larger levels of adoption of work generated by diverse groups is the result of higher quality, or better connections.

## 72. The Privacy Bounds of Human Mobility

***Cesar A. Hidalgo and Yves-Alexandre DeMontjoye***

We used 15 months of data from 1.5 million people to show that four points approximate places and times are enough to identify 95 percent of individuals in a mobility database. Our work shows that human behavior puts fundamental natural constraints on the privacy of individuals, and these constraints hold even when the resolution of the dataset is low. These results demonstrate that even coarse datasets provide little anonymity. We further developed a formula to estimate the uniqueness of human mobility traces. These findings have important implications for the design of frameworks and institutions dedicated to protect the privacy of individuals.

## Hiroshi Ishii: Tangible Media

**Seamlessly coupling the worlds of bits and atoms by giving dynamic physical form to digital information and computation.**

### 73. Andante

***Xiao Xiao and Hiroshi Ishii***

Andante is a representation of music as animated characters walking along the piano keyboard that appear to play the physical keys with each step. Based on a view of music pedagogy that emphasizes expressive, full-body communication early in the learning process, Andante promotes an understanding of the music rooted in the body, taking advantage of walking as one of the most fundamental human rhythms.

### 74. inFORM

***Hiroshi Ishii, Alex Olwal, Daniel Leithinger and Sean Follmer***

Shape displays can be used to render both 3D physical content and user interface elements. We propose to use shape displays in three different ways to mediate interaction: facilitate, providing dynamic physical affordances through shape change; restrict, guiding users through dynamic physical constraints; and manipulate, actuating passive physical objects on the interface surface. We demonstrate this on a new, high-resolution shape display.

### 75. jamSheets: Interacting with Thin Stiffness-Changing Material

***Jifei Ou, Lining Yao, Daniel Tauber, Juergen Steimle, Ryuma Niiyama, Hiroshi Ishii***

This project introduces layer jamming as an enabling technology for designing deformable, stiffness-tunable, thin sheet interfaces. Interfaces that exhibit tunable stiffness properties can yield dynamic haptic feedback and shape deformation capabilities. In comparison to the particle jamming, layer jamming allows for constructing thin and lightweight form factors of an interface. We propose five layer structure designs and an approach which composites multiple materials to control the deformability of the interfaces. We also present methods to embed different types of sensing and pneumatic actuation layers on the layer-jamming unit. Through three application prototypes we demonstrate the benefits of using layer jamming in interface design. Finally, we provide a survey of materials that have proven successful for layer jamming.

### 76. MirrorFugue

***Xiao Xiao and Hiroshi Ishii***

MirrorFugue is an installation for a player piano that evokes the impression that the "reflection" of a disembodied pianist is playing the physically moving keys. Live music emanates from a grand piano, whose keys move under the supple touch of a pianist's hands reflected on the lacquered surface of the instrument. The pianist's face is displayed on the music stand, with subtle expressions projecting the emotions of the music. MirrorFugue recreates the feeling of a live performance, but no one is actually there. The pianist is an illusion of light and mirrors, a ghost both present and absent. Viewing MirrorFugue evokes the sense of walking into a memory, where the pianist plays without awareness of the viewer's presence; or, it is as if viewers were ghosts in another's dream, able to sit down in place of the performing pianist and play along.

## 77. Physical Telepresence

***Daniel Leithinger, Sean Follmer, Alex Olwal and Hiroshi Ishii***

We propose a new approach to physical telepresence, based on shared workspaces with the ability to capture and remotely render the shapes of people and objects. In this paper, we describe the concept of shape transmission, and propose interaction techniques to manipulate remote physical objects and physical renderings of shared digital content. We investigate, how the representation of user s body parts can be altered to amplify their capabilities for teleoperation. A preliminary evaluation found users were able to manipulate simple objects remotely, and found many different techniques for manipulation that highlight the expressive nature of our system.

Alumni Contributor: Alex Olwal

## 78. Pneumatic Shape-Changing Interfaces

***Hiroshi Ishii, Jifei Ou, Lining Yao, Ryuma Niiyama and Sean Follmer***

An enabling technology to build shape-changing interfaces through pneumatically driven soft composite materials. The composite materials integrate the capabilities of both input sensing and active shape output. We explore four applications: a multi-shape mobile device, table-top shape-changing tangibles, dynamically programmable texture for gaming, and shape-shifting lighting apparatus.

## 79. Radical Atoms

***Hiroshi Ishii***

Radical Atoms is our vision of interactions with future material. Radical Atoms takes a leap beyond Tangible Bits by assuming a hypothetical generation of materials that can change form and appearance dynamically, becoming as reconfigurable as pixels on a screen. Radical Atoms is a computationally transformable and reconfigurable material that is bidirectionally coupled with an underlying digital model (bits) so that dynamic changes of physical form can be reflected in digital states in real time, and vice versa.

Alumni Contributors: Keywon Chung, Adam Kumpf, Amanda Parkes, Hayes Raffle and Jamie B Zigelbaum

## 80. Tangible Bits

***Hiroshi Ishii, Sean Follmer, Jinha Lee, Daniel Leithinger and Xiao Xiao***

People have developed sophisticated skills for sensing and manipulating our physical environments, but traditional GUIs (Graphical User Interfaces) do not employ most of them. Tangible Bits builds upon these skills by giving physical form to digital information, seamlessly coupling the worlds of bits and atoms. We are designing "tangible user interfaces" that employ physical objects, surfaces, and spaces as tangible embodiments of digital information. These include foreground interactions with graspable objects and augmented surfaces, exploiting the human senses of touch and kinesthesia. We also explore background information displays that use "ambient media" light, sound, airflow, and water movement to communicate digitally mediated senses of activity and presence at the periphery of human awareness. We aim to change the "painted bits" of GUIs to "tangible bits," taking advantage of the richness of multimodal human senses and skills developed through our lifetimes of interaction with the physical world.

Alumni Contributors: Yao Wang, Mike Ananny, Scott Brave, Dan Chak, Angela Chang, Seung-Ho Choo, Keywon Chung, Andrew Dahley, Philipp Frei, Matthew G. Gorbet, Adam Kumpf, Jean-Baptiste Labrune, Vincent Leclerc, Jae-Chol Lee, Ali Mazalek, Gian Antonio Pangaro, Amanda Parkes, Ben Piper, Hayes Raffle, Sandia Ren, Kimiko Ryokai, Victor Su, Brygg Ullmer, Catherine Vaucelle, Craig Wisneski, Paul Yarin and Jamie B Zigelbaum

## 81. THAW

***Sang-won Leigh, Philipp Schoessler, Hiroshi Ishii, Pattie Maes***

We present a novel interaction system that allows collocated screen devices to work together. The system tracks the position of a smartphone placed on a host computer screen. As a result, the smartphone can interact directly with data displayed on the host computer, which opens up a novel interaction space. We believe that the space on and above the computer screen will open up huge possibilities for new types of interactions. What makes this technology especially interesting is today s ubiquity of smartphones and the fact that we can achieve the tracking solely through installing additional software on potentially any phone or computer.

## 82. TRANSFORM

***Hiroshi Ishii, Sean Follmer, Daniel Leithinger, Philipp Schoessler, Amit Zoran and LEXUS International***

**NEW LISTING**

TRANSFORM fuses technology and design to celebrate its transformation from still furniture to a dynamic machine driven by a stream of data and energy. TRANSFORM aims to inspire viewers with unexpected transformations and the aesthetics of the complex machine in motion. First exhibited at LEXUS DESIGN AMAZING MILAN (April 2014), the work comprises three dynamic shape displays that move over one thousand pins up and down in real time to transform the tabletop into a dynamic tangible display. The kinetic energy of the viewers, captured by a sensor, drives the wave motion represented by the dynamic pins. The motion design is inspired by dynamic interactions among wind, water, and sand in nature, Escher s representations of perpetual motion, and the attributes of sand castles built at the seashore. TRANSFORM tells of the conflict between nature and machine, and its reconciliation, through the ever-changing tabletop landscape.

# Joseph M. Jacobson: Molecular Machines

**Engineering at the limits of complexity with molecular-scale parts.**

## 83. Context-Aware Biology

***Joseph M. Jacobson and Charles Fracchia***

**NEW LISTING**

Current biological research workflows make use of disparate, poorly integrated systems that cause a large mental burden on the scientist, leading to mistakes on often long, complex, and costly experimental procedures. The lack of open tools to assist in the collection of distributed experimental conditions and data is largely responsible for making protocols difficult to debug and laboratory practice hard to learn. In this work, we describe an open Protocol Descriptor Language (PDL) and system to enable a context-rich, quantitative approach to biological research. We detail the development of a closed-loop pipetting technology and a wireless, sample temperature sensor that integrate with our Protocol Description platform, enabling novel, real-time experimental feedback to the researcher, thereby reducing mistakes and increasing overall scientific reproducibility.

## 84. GeneFab

***Bram Sterling, Kelly Chang, Joseph M. Jacobson, Peter Carr, Brian Chow, David Sun Kong, Michael Oh and Sam Hwang***

What would you like to "build with biology"? The goal of the GeneFab projects is to develop technology for the rapid fabrication of large DNA molecules, with composition specified directly by the user. Our intent is to facilitate the field of Synthetic Biology as it moves from a focus on single genes to designing complete biochemical pathways, genetic networks, and more complex systems. Sub-projects include: DNA error correction, microfluidics for high throughput gene synthesis, and genome-scale engineering (rE. coli).

Alumni Contributor: Chris Emig

## 85. NanoFab

***Kimin Jun, Jaebum Joo, and Joseph M. Jacobson***

We are developing techniques to use a focused ion beam to program the fabrication of nanowires-based nanostructures and logic devices.

## 86. Scaling Up DNA Logic and Structures

***Joseph M. Jacobson and Noah Jakimo***

Our goals include novel gene logic and data logging systems, as well as DNA scaffolds that can be produced on commercial scales. State of the art in the former is limited by finding analogous and orthogonal proteins for those used in current single-layer gates and two-layered circuits. State of the art in the latter is constrained in size and efficiency by kinetic limits on self-assembly. We have designed and plan to demonstrate cascaded logic on chromosomes and DNA scaffolds that exhibit exponential growth.

## 87. Synthetic Photosynthesis

***Joseph M. Jacobson and Kimin Jun***

We are using nanowires to build structures for synthetic photosynthesis for the solar generation of liquid fuels.

# Sepandar Kamvar: Social Computing

**Creating sociotechnical systems that shape our urban environments.**

## 88. Microculture

***Sep Kamvar, Yonatan Cohen, Lisa DePiano, Kathryn Grantham, and Josh Sarantitis***

**NEW LISTING**

Microculture gardens are a network of small-scale permaculture gardens that are aimed at reimagining our urban food systems, remediating our air supply, and making our streets more amenable to human-scale mobility. Microculture combines micro-gardening with the principles of permaculture, creatively occupying viable space throughout our communities with small-scale food forests. Micro-gardens have proven to be successful for the production of a broad range of species including leafy vegetables, fruit, root vegetables, herbs, and more. Traditionally, container-based micro-gardens occupy approximately one meter of space or less and are made from found, up-cycled materials. Our innovations involve the combining of permaculture and micro-gardening principles, developing a design and materials that allow for modularity, mobility, easy replicability, and placement in parking spots, and creating software that supports the placement, creation, and maintenance of these gardens.

## 89. Storyboards

***Sepandar Kamvar, Kevin Slavin, Jonathan Bobrow and Shantell Martin***

**NEW LISTING**

Giving opaque technology a glass house. Storyboards present the tinkerers or owners of electronic devices with stories of how their devices work. Just as the circuit board is a story of star-crossed lovers Anode and Cathode with its cast of characters (resistor, capacitor, transistor), Storyboards have their own characters driving a parallel visual narrative.

## 90. The Dog Programming Language

***Salman Ahmad and Sep Kamvar***

Dog is a new programming language that makes it easy and intuitive to create social applications. A key feature of Dog is built-in support for interacting with people. Dog provides a natural framework in which both people and computers can be sent requests and return results. It can perform a long-running computation while also displaying messages, requesting information, or sending operations to particular individuals or groups. By switching between machine and human computation, developers can create powerful workflows and model complex social processes without worrying about low-level technical details.

## 91. Wildflower Montessori

***Sep Kamvar, Katelyn Ryan, Mary Rockett, Yonatan Cohen, Kim Holleman, Kim Smith, Misse Carolan, Marcia Hubelbank, Angelina Hawley-Dolan, Castle O'Neill, Katie Tremblay, Catherine McTamaney***

Wildflower Montessori School is a pilot Lab School and the first in a new network of learning centers. Its aim is to be an experiment in a new learning environment, blurring the boundaries between coffee shops and schools, between home-schooling and institutional schooling, between tactile, multisensory methods and abstract thinking. Wildflower will serve as a research platform to test new ideas in advancing the Montessori Method in the context of modern fluencies, as well as to test how to direct the organic growth of a social system that fosters the growth and connection of such schools.

## 92. You Are Here

***Sep Kamvar, Yonatan Cohen, Wesam Manassra, Pranav Ramkrishnan, Stephen Rife, Jia Zhang, Edward Faulkner, Kim Smith, Asa Oines, and Jennifer Jang***

You Are Here is an experiment in microurbanism. In this project, we are creating 100 maps each of 100 different cities. Each map gives a collective portrait of one aspect of life in the city, and is designed to give communities meaningful micro-suggestions of what they might do to improve their city. The interplay between the visualizations and the community work they induce creates a collective, dynamic, urban-scale project.

# Kent Larson: Changing Places

**Enabling dynamic, evolving places that respond to the complexities of life.**

## 93. AEVITA

***Kent Larson, William Lark, Jr., Nicholas David Pennycooke and Praveen Subramani***

What happens when the driver the main conduit of information transaction between the vehicle and its surroundings is removed? The living EV system aims to fill this communication void by giving the autonomous vehicle the means to sense others around it, and react to various stimuli as intuitively as possible by taking design cues from the living world. The system comprises various types of sensors (computer vision, UWB beacon tracking, sonar) and actuators (light, sound, mechanical) in order to express recognition of others, announce intentions, and

portray the vehicle s general state. All systems are built on the second version of the half-scale CityCar concept vehicle, featuring advanced mixed-materials (CFRP + aluminum) and a significantly more modularized architecture.

## 94. CityFARM

***Camillee Richman, Elaine Kung, Emma Feshbach, Jordan Rogoff, Mathew Daiter, Kent Larson, Caleb Harper, Edward Platt, Preethi Vaidyanathan and Sophia Jaffee***

By 2030, nine billion people will populate the globe and six out of every 10 will live in cities. The future of global food production will mandate a paradigm shift to resource leveraged and environmentally sound urban food-growing solutions. The CityFARM project explores building-integrated agriculture and environmentally optimized growing. We are exploring what it means technologically, environmentally, and socially to design industrially scalable agricultural systems in the heart of urban areas. Through innovative research, and through development of hydroponic and aeroponic systems, diagnostic and networked sensing, building integration, and reductive energy design, CityFARM methodology reduces water consumption by 90%, eliminates chemical pesticides, and reduces embodied energy in produce by a factor of four. By fundamentally rethinking "grow it THERE and eat it HERE," we can eliminate environmental contaminants and increase access to nutrient-dense produce in our future cities.

## 95. CityHome

***Kent Larson and Hasier Larrea***

We demonstrate how the CityHome, which has a very small footprint (840 square feet), can function as an apartment two to three times that size. This is achieved through a transformable wall system which integrates furniture, storage, exercise equipment, lighting, office equipment, and entertainment systems. One potential scenario for the CityHome is where the bedroom transforms to a home gym, the living room to a dinner party space for 14 people, a suite for four guests, two separate office spaces plus a meeting space, or an a open loft space for a large party. Finally, the kitchen can either be open to the living space, or closed off to be used as a catering kitchen. Each occupant engages in a process to personalize the precise design of the wall units according to his or her unique activities and requirements.

Alumni Contributor: Daniel Smithwick

## 96. CityHOME: 200 SQ FT

***Kent Larson, Hasier Larrea, Daniel Goodman, Oier Ariño, Phillip Ewing***

Live large in 200 square feet! An all-in-one disentangled robotic furniture piece makes it possible to live large in a tiny footprint by not only magically reconfiguring the space but also by serving as a platform for technology integration and experience augmentation. 200 square feet was never so large.

## 97. CityScope

***Carson Smuts, Kent Larson, Mohammad Hadhrawi and J. Ira Winder***

CityScope is a project to develop simulation systems that can predict and quantify the potential impact of disruptive technologies within new and existing cities. We place a special emphasis on augmented reality decision support systems (ARDSS) that facilitate non-expert stakeholder collaboration within complex urban environments.

## 98. Context-Aware Dynamic Lighting

***Ronan Lonergan, Shaun Salzberg, Harrison Hall, and Kent Larson***

The robotic façade is conceived as a mass-customizable module that combines solar control, heating, cooling, ventilation, and other functions to serve an urban apartment. It attaches to the building chassis with standardized power, data, and mechanical attachments to simplify field installation and dramatically increase energy performance. The design makes use of an articulating mirror to direct shafts of sunlight to precise points in the apartment interior. Tiny, low-cost, easily installed

wireless sensors and activity recognition algorithms allow occupants to use a mobile phone interface to map activities of daily living to personalized sunlight positions. We are also developing strategies to control LED luminaires to turn off, dim, or tune the lighting to more energy-efficient spectra in response to the location, activities, and paths of the occupants.

## 99. FlickInk

***Sheng-Ying (Aithne) Pao and Kent Larson***

FlickInk is a gesture sensing pen to support collaborative work and to augment the environment. With a quick flick of the pen towards a desired destination, analog written content on paper instantly transfers onto the corresponding physical object in the environment. The FlickInk gesture sensing module allows for wireless communication and directional gesture sensing. If multiple surfaces are present, the direction of the pen swing determines which screen the information is transferred to. Furthermore, multiple users can flick their written content to multiple devices, creating a personalized collaborative environment.

## 100. LightByte: Animate the Sunlight

***Sheng-Ying (Aithne) Pao and Kent Larson***

Sunlight is one of the most fundamental elements in nature that we have free access to in urban environments. It is also at the core of how we experience the physical world. What if we could engage sunshine in the digital age, to tame, modify, and bend light to our will? LightByte, a massive interactive sun pixel façade, modifies the sun s rays at your whim into intricate shapes. It turns sunlight into an expressive medium to carry information, communicate ideas, and shape your own shadows.

## 101. MIT Commuter Common

***Kent Larson and J. Ira Winder***

The MIT Commuter Common develops a system for observing, visualizing, and understanding transportation behavior at the scale of MIT's entire population. As such, human transportation behavior is examined within the context of social institutional and urban tribal constructs. By recognizing such social institutional tribes as fundamental affecters of transportation behavior, we can develop new analytical units called commuter footprints. These footprints are derived from the digital breadcrumbs of user behavior within an institution. By bringing these footprints to light, it will give policymakers a new avenue to influence transportation behavior in urban areas by targeting these social institutional tribes as a whole.

## 102. Mobility on Demand Systems

***Kent Larson, Ryan C.C. Chin, Chih-Chao Chuang, William Lark, Jr., Brandon Phillip Martin-Anderson and SiZhi Zhou***

Mobility on Demand (MoD) systems are fleets of lightweight electric vehicles at strategically distributed electrical charging stations throughout a city. MoD systems solve the first and last mile problem of public transit, providing mobility between transit station and home/workplace. Users swipe a membership card at the MoD station to access vehicles, which can be driven to any other station (one-way rental). The Vélib' system of 20,000+ shared bicycles in Paris is the largest and most popular one-way rental system in the world. MoD systems incorporate intelligent fleet management through sensor networks, pattern recognition, and dynamic pricing, and the benefits of Smart Grid technologies include intelligent electrical charging (including rapid charging), vehicle-to-grid (V2G), and surplus energy storage for renewable power generation and peak sharing for the local utility. We have designed three MoD vehicles: CityCar, RoboScooter, and GreenWheel bicycle. (Continuing the vision of William J. Mitchell.)

## 103. OfficeLab: Desk

***Kent Larson, Oier Arino Zaldua, Jason P. Nawyn and James White***

How can office space be more efficient while still providing for the needs of its users? OfficeLab is a responsive and mobile workstation that encourages collaboration while reducing office space consumption. OfficeLab furniture provides

users the ability to adjust their privacy and comfort levels and the functionality to easily switch between private space, work space, team space, or conference space. All of this is done while increasing the personnel density within a specific work area. The workstation includes retractable privacy panels, peripheral light messaging, a height-adjustable desk, desktop induction charging, audio spotlights, and an RFID locking system. The furniture uses a chain network to provide electrical energy, allowing users to move freely throughout their work space.

## 104. Participatory Environmental Sensing for Communities

***Rich Fletcher and Kent Larson***

Air and water pollution are well-known concerns in cities throughout the world. However, communities often lack practical tools to measure and record pollution levels, and thus are often powerless to motivate policy change or government action. Current government-funded pollution monitors are sparsely located, and many large national and local governments fail to disclose this environmental data in areas where pollution is most prevalent. We have been developing very low-cost, ultra low-power environmental sensors for air, soil, and water, that enable communities to easily sample their environment and upload data to their mobile phone and an online map. This not only empowers communities to enact new policies, but also serves as a public resource for city health services, traffic control, and general urban design.

## 105. PlaceLab and BoxLab

***Jason Nawyn, Stephen Intille and Kent Larson***

The PlaceLab was a highly instrumented, apartment-scale, shared research facility where new technologies and design concepts were tested and evaluated in the context of everyday living. It was used by researchers until 2008 to collect fine-grained human behavior and environmental data, and to systematically test and evaluate strategies and technologies for the home in a natural setting with volunteer occupants. BoxLab is a portable version with many of the data collection capabilities of PlaceLab. BoxLab can be deployed in any home or workplace. (A House_n Research Consortium project funded by the National Science Foundation.)

Alumni Contributors: Jennifer Suzanne Beaudin, Manu Gupta, Pallavi Kaushik, Aydin Oztoprak, Randy Rockinson and Emmanuel Munguia Tapia

## 106. QuitoLab

***Kent Larson and Ramiro Almeida***

QuitoLab will incorporate both architectural and CityScope LEGO models of the historic core of Quito to engage local and visiting communities in experiencing and understanding the city in creative, multisensory ways. The goal of the QuitoLab project is to use multiscalar models as educational and community-building tools to present a multidimensional image of the city, its history, and its potential for future development. Quito will be one of the first case studies for CityScope, Changing Places platform for participatory urban design using LEGOs. CityScope uses 3D mapping technology to project urban data onto reconfigurable LEGO models. It creates a tangible, interactive platform that allows expert and non-expert stakeholders to understand and make informed decisions about the interaction of architecture, space use, mobility modes, energy and water networks, urban food production, movement of goods, data flows, and other urban systems.

## 107. Smart Customization of Men's Dress Shirts: A Study on Environmental Impact

***Ryan C. C. Chin, Daniel Smithwick, and Kent Larson***

Sanders Consulting s 2005 ground-breaking research, Why Mass Customization is the Ultimate Lean Manufacturing System, showed that the best standard mass-production practices, when framed from the point of view of the entire product lifecycle from raw material production to point of purchase was actually very inefficient and indeed wasteful in terms of energy, material use, and time. Our research examines the environmental impacts when applying mass customization methodologies to men's custom dress shirts. Our comparative study examines not only the energy and carbon emissions due production and distribution, but also customer acquisition and use, by using RFID tag technology to track shirt utilization of over 20 subjects over a three-month period.

## 108. Spike: Social Cycling

***Kent Larson and Sandra Richter***

Spike is a social cycling application developed for bike-sharing programs. The application persuades urban dwellers to bike together, increasing the perceived level of safety. Social deals and benefits that can only be redeemed together motivate the behavior change. Frequent Biker Miles sustain the behavior. An essential feature is real-time information on where the users of the social network are currently biking or when they are planning to bike, to facilitate bike dates.

# Andy Lippman: Viral Communications

**Creating scalable technologies that evolve with user inventiveness.**

## 109. Crystal Ball

***Amir Lazarovich, Dan Novy, Andy Lippman, Michael Bove***

A physical interface designed for simultaneous social interaction with visual material. We built a hemispherical, multi-person, interactive touch display that allows a small group of people in the same place or in equivalently equipped ones to jointly interact on the same surface. We created an application that runs on this platform and presents a selection of visual media and offers recommendations for common viewing.

## 110. Ethos

***Amir Lazarovich, Guy Zyskind, Oz Nathan, Alex 'Sandy' Pentland, Andy Lippman***

**NEW LISTING**

Ethos is a decentralized, Bitcoin-like network for storing and sharing valuable information. We provide transparency, control, and ownership over personal data and its distribution. Validation and maintenance is distributed throughout the data community and automatically maintained without needing a safe deposit box or a commercial site. What Bitcoin has done for currency and BitTorrent for media, Ethos does for personal data. Nodes in the network are incentivized by collecting transaction fees, coinbase transactions ("finding blocks"), and proof-of-storage fees to sustain the distribution of personal data. Fees are paid with the underlying crypto currency represented by the network, also known as "PrivacyCoin." The role of nodes besides the usual proof-of-work, which protects against "double spending," is to maintain shredded pieces of information and present them to the network on-demand.

## 111. GIFGIF

***Cesar A. Hidalgo, Andrew Lippman, Kevin Zeng Hu and Travis Rich***

An animated gif is a magical thing. It contains the power to compactly convey emotion, empathy, and context in a subtle way that text or emoticons often miss. GIFGIF is a project to combine that magic with quantitative methods. Our goal is to create a tool that lets people explore the world of gifs by the emotions they evoke, rather than by manually entered tags. A web site with 200,000 users maps the GIFs to an emotion space and lets you peruse them interactively.

## 112. Glance

***Andrew Lippman and Vivian Diep***

We address two critical elements of news: that it inform, and that it be trustworthy. Glance creates dynamic, real-time, semantic control over news presentation that reveals the inherent slant that underlies coverage of an event. The goal is to empower readers to understand their news intake through a visualization of metadata that empowers readers to choose their news source based computed metrics rather than sensationalized headlines. Relevant additional information, such as sentiment of text and public reaction, is gathered on each topic to further give readers a richer news-scape.

## 113. Glue

***Robert Hemsley, Jonathan Speiser, Dan Sawada, Savannah Niles, Eric Dahlseng, and Andrew Lippman***

Glue is a prototyping engine to support news and narrative analysis. The system works by coordinating the flow of media among an extensible set of asynchronous python processing modules. The growing set of existing modules analyzes web pages, video, and exogenous data such as tweets and creates fine-grained metadata, including frame-by-frame analysis for video. We use this to organize material for presentation, analysis, summarization. Currently, the system provides named-entity extraction, audio expression markers, face detectors, scene/edit point locators, excitement trackers, and thumbnail summarization. Glue includes a video recorder and processes 14 DirecTV feeds as well as video content crawled from the web. Video is retained dependent on storage capacity and the database is permanent. Glue is the metadata driver for most Ultimate Media projects-- a digestion system for mass media.

## 114. Helios

***Eric Dahlseng***

Helios provides an automatic way of socializing one's video interactions. It is a Chrome browser plug-in that records user's encounters with embedded videos on the web. This data is contributed to a group collection so that one can readily see what is trending among friends and where the outliers are. In addition the data is processed by Glue for metadata tagging.

Alumni Contributors: Dan Sawada and Jonathan Speiser and Robert Hemsley

## 115. Media Matrix

***Vivian Diep, Savannah L Niles, Andrew Lippman***

We present two scalable ways to explore and distribute media in all forms: video, text, and graphics; published and conversational. The first presentation has been demonstrated as an interactive, dynamic time/source array where one can see the pulse of publication and suggest media for friends. A revision organizes content as 3D stacks that correspond to people and topics. The Matrix dissolves media silos and types and assembles it in a data- and socially driven way. Glue is the engine that drives assembly.

## 116. NewsClouds

***Andrew Lippman and Thariq Shihipar***

**NEW LISTING**

NewsClouds explores how trending news topics are being discussed differently by various media sources, such as news broadcasts or Twitter. Instead of algorithmic comparisons, NewsClouds uses a Human-In-The-Loop model by emphasizing the

difference in vocabulary between the two sources. Users can select key words and phrases to see the context in which they are used by any source. NewsClouds can be a way of uncovering new aspects of a story or visualizing biases in rhetoric between sources.

## 117. QUANTIFY

***Cesar A. Hidalgo, Andrew Lippman, Kevin Zeng Hu and Travis Rich***

**NEW LISTING**

QUANTIFY is a generalized framework and javascript library to allow rapid multi-dimensional measurement of subjective qualities of media. The goal is to make qualitative metrics quantized. For everything from measuring emotional responses of content to the cultural importance of world landmarks, QUANTIFY helps to elicit the raw human subjectivity that fills much of our lives, and makes it programmatically actionable.

## 118. Recap

***Andrew Lippman, Eric Dahlseng and Savannah L Niles***

**NEW LISTING**

Recap uses Glue to automatically create video casts, allowing users to specify how much time they have available and then intelligently filling that chunk of time with the top trending stories of the day.

## 119. Recast

***Dan Sawada, Robert Hemsley, Andrew Lippman***

Recast is a media curation and distribution platform that enables anyone to create and distribute "news programs" that represent their views of the world from their own perspective. Recast provides a visual scripting interface similar to Scratch, where users can combine a series of logical blocks to query specific scene elements that presents their views from by drawing from arbitrary video contents, and constructing a story sequence. Recast uses the Constellation system as a backend for querying video content, and uses the Media Matrix as a content distribution platform.

Alumni Contributors: Robert Hemsley and Dan Sawada

## 120. Sphera

***Amir Lazarovich, Andrew Lippman***

One future of media experience lies within a socially connected virtual world. VR started almost 30 years ago and is now wearable, real time, integrated with sensing, and becoming transparent. Sphera realizes a socially driven 360-degree media space that includes ambient scenery, visual exploration, and integration with friends. By combining an Oculus Rift (VR heads-on display), Microsoft Kinect (depth sensor), and a natural voice command interface, we created a socially connected 360-degree immersive virtual world for media exploration and selection, and big-data manipulation and visualization.

## 121. Telecorrelator

***Andrew Lippman and Savannah L Niles***

The Telecorrelator allows people to view multiple perspectives of real-time news events aligned by content as well as time. It reveals emphasis and timing and allows participants to discover points of view and important events. Currently, the Telecorrelator aligns broadcast news from four broadcast sources to visually reveal the emphasis and time allocation they devote to a succession of events.

Alumni Contributors: Robert Hemsley and Dan Sawada

## 122. The Glass Infrastructure (GI)

***Andy Lippman, Jon Ferguson and Henry Holtzman***

This project builds a social, place-based information window into the Media Lab using 30 touch-sensitive screens strategically placed throughout the physical complex and at sponsor sites. The idea is get people to talk among themselves about the work that they jointly explore in a public place. We present Lab projects as dynamically connected sets of "charms" that visitors can save, trade, and

explore. The GI demonstrates a framework for an open, integrated IT system and shows new uses for it.

Alumni Contributors: Matt Blackshaw, Rick Borovoy, Greg Elliott, Catherine Havasi, Boris Grigory Kizelshteyn, Julia Ma, Daniel E Schultz and Polychronis Ypodimatopoulos

### 123. VR Codes

***Andy Lippman and Grace Woo***

VR Codes are dynamic data invisibly hidden in television and graphic displays. They allow the display to present simultaneously visual information in an unimpeded way, and real-time data to a camera. Our intention is to make social displays that many can use at once; using VR codes, users can draw data from a display and control its use on a mobile device. We think of VR Codes as analogous to QR codes for video, and envision a future where every display in the environment contains latent information embedded in VR codes.

### 124. WorldLens

***Jonathan Speiser, Robert Hemsley, Dan Sawada, and Andy Lippman***

World Lens informs users about newsworthy events that are both popular and obscure. It is a front page that is both navigable and scalable allowing one to discover as well as track ongoing events. We array in-depth news information across a large multitouch display organized by time, coverage, and geography. Elements are drawn from blogs, the web, newspapers, magazines, and television. Each is presented by a front page that tells the literal story. Readers can fly through the news space, mark items for interest, and activate each. News data is gathered and analyzed by Glue our system, which generates frame-by-frame metadata for video and page analysis for other online material.

Alumni Contributors: Robert Hemsley, Dan Sawada and Jonathan Speiser

## Tod Machover: Opera of the Future

**Extending expression, learning, and health through innovations in musical composition, performance, and participation.**

### 125. City Symphonies: Massive Musical Collaboration

***Tod Machover, Akito Van Troyer, Benjamin Bloomberg, Charles Holbrow, David Nunez, Simone Ovsey, Sarah Platte, Peter Alexander Torpey and Garrett Parrish***

Thus far, the impact of crowdsourced and interactive music projects has been limited: the public typically contributes only a small part of the final musical result, and is often disconnected from the artist leading the project. We believe that a new musical ecology is needed for true creative collaboration between experts and amateurs, benefiting both. Toward this goal, we have been creating city symphonies, each collaboratively composed with an entire city. We have designed the infrastructure needed to bring together an unprecedented number of people, including a variety of web-based music composition applications, a social media framework, and real-world community-building activities. This process establishes a new model for creating complex collaborations between experts and everyone else. Over the past two years, we premiered city symphonies in Toronto, Edinburgh, and Perth, and we are now developing a symphony with Lucerne, Switzerland.

## 126. Death and the Powers: Global Interactive Simulcast

***Tod Machover, Peter Torpey, Ben Bloomberg, Elena Jessop, Charles Holbrow, Simone Ovsey, Garrett Parrish, Justin Martinez, and Kevin Nattinger.***

The live global interactive simulcast of the final February 2014 performance of "Death and the Powers" in Dallas made innovative use of satellite broadcast and Internet technologies to expand the boundaries of second-screen experience and interactivity during a live remote performance. In the opera, Simon Powers uploads his mind, memories, and emotions into The System, represented onstage through reactive robotic, visual, and sonic elements. Remote audiences, via simulcast, were treated as part of The System alongside Powers and the operabots. Audiences had an omniscient view of the action of the opera, as presented through the augmented, multi-camera video and surround sound. Multimedia content delivered to mobile devices, through the Powers Live app, privileged remote audiences with perspectives from within The System. Mobile devices also allowed audiences to influence The System by affecting the illumination of the Winspear Opera House s Moody Foundation Chandelier.

## 127. Death and the Powers: Redefining Opera

***Tod Machover, Ben Bloomberg, Peter Torpey, Elena Jessop, Bob Hsiung, Akito van Troyer***

"Death and the Powers" is a groundbreaking opera that brings a variety of technological, conceptual, and aesthetic innovations to the theatrical world. Created by Tod Machover (composer), Diane Paulus (director), and Alex McDowell (production designer), the opera uses the techniques of tomorrow to address age-old human concerns of life and legacy. The unique performance environment, including autonomous robots, expressive scenery, new Hyperinstruments, and human actors, blurs the line between animate and inanimate. The opera premiered in Monte Carlo in fall 2010, with additional performances in Boston and Chicago in 2011 and a new production with a global, interactive simulcast in Dallas in February 2014.

## 128. Disembodied Performance

***Tod Machover, Peter Torpey and Elena Jessop***

Early in the opera "Death and the Powers," the main character, Simon Powers, is subsumed into a technological environment of his own creation. The set comes alive through robotic, visual, and sonic elements that allow the actor to extend his range and influence across the stage in unique and dynamic ways. This environment assumes the behavior and expression of the absent Simon; to distill the essence of this character, we recover performance parameters in real time from physiological sensors, voice, and vision systems. Gesture and performance parameters are then mapped to a visual language that allows the off-stage actor to express emotion and interact with others on stage. To accomplish this, we developed a suite of innovative analysis, mapping, and rendering software systems.

## 129. Figments

***Peter Torpey***

Figments is a theatrical performance that tells a story inspired by a variety of source texts, including Dante Alighieri's prosimetrum La Vita Nuova. Framed by a woman's accidental discovery of the compelling journals of the Dante-archetype, three inner vignettes reveal the timeless tribulations of the memoir's author(s). Figments was created using Media Scores, a framework in development to facilitate the composition of Gesamtkunstwerk using parametric score-like visual notation. The Media Score for Figments is realized in this production through the performance of actors, light, visuals, and the generation of musical accompaniment in response to the expressive qualities represented in the score. The score served as a reference during the creation and design of the piece, a guide during rehearsals, and as show control for the final production.

## 130. Gestural Media Framework

***Tod Machover and Elena Jessop***

We are all equipped with two extremely expressive instruments for performance: the body and the voice. By using computer systems to sense and analyze human movement and voices, artists can take advantage of technology to augment the body's communicative powers. However, the sophistication, emotional content, and variety of expression possible through original physical channels is often not captured by the technologies used for analyzing them, and thus cannot be intuitively transferred from body to digital media. To address these issues, we are developing systems that use machine learning to map continuous input data, whether of gesture or voice, to a space of expressive, qualitative parameters. We are also developing a new framework for expressive performance augmentation, allowing users to create clear, intuitive, and comprehensible mappings by using high-level qualitative movement descriptions, rather than low-level descriptions of sensor data streams.

## 131. Hyperinstruments

***Tod Machover***

The Hyperinstruments project creates expanded musical instruments and uses technology to give extra power and finesse to virtuosic performers. They were designed to augment a wide range of traditional musical instruments and have been used by some of the world's foremost performers (Yo-Yo Ma, the Los Angeles Philharmonic, Peter Gabriel, and Penn & Teller). Research focuses on designing computer systems that measure and interpret human expression and feeling, exploring appropriate modalities and content of interactive art and entertainment environments, and building sophisticated interactive musical instruments for non-professional musicians, students, music lovers, and the general public. Recent projects involve both new hyperinstruments for children and amateurs, and high-end hyperinstruments capable of expanding and transforming a symphony orchestra or an entire opera stage.

Alumni Contributors: Roberto M. Aimi, Mary Farbood, Ed Hammond, Tristan Jehan, Margaret Orth, Dan Overholt, Egon Pasztor, Joshua Strickon, Gili Weinberg and Diana Young

## 132. Hyperproduction: Advanced Production Systems

***Tod Machover and Benjamin Bloomberg***

Hyperproduction is a conceptual framework and a software toolkit which allows producers to specify a descriptive computational model and consequently an abstract state for a live experience through traditional operating paradigms such as mixing audio or operation of lighting, sound, and video systems. The hyperproduction system is able to interpret this universal state and automatically utilize additional production systems, allowing for a small number of producers to cohesively guide the attention and perspective of an audience using many or very complex production systems simultaneously. We focus on exploring the relationship of conventional production systems and techniques to computational abstract models of live performance, with attention and perspective as the cornerstones of this exploration.

## 133. Hyperscore

***Tod Machover***

Hyperscore is an application to introduce children and non-musicians to musical composition and creativity in an intuitive and dynamic way. The "narrative" of a composition is expressed as a line-gesture, and the texture and shape of this line are analyzed to derive a pattern of tension-release, simplicity-complexity, and variable harmonization. The child creates or selects individual musical fragments in the form of chords or melodic motives, and layers them onto the narrative-line with expressive brushstokes. The Hyperscore system automatically realizes a full composition from a graphical representation. Currently, Hyperscore uses a mouse-based interface; the final version will support freehand drawing, and integration with the Music Shapers and Beatbugs to provide a rich array of tactile

tools for manipulation of the graphical score.

Alumni Contributors: Mary Farbood, Ed Hammond, Tristan Jehan, Margaret Orth, Dan Overholt, Egon Pasztor, Joshua Strickon, Gili Weinberg and Diana Young

## 134. Media Scores

***Tod Machover and Peter Torpey***

Media Scores extends the concept of a musical score to other modalities, facilitating the process of authoring and performing multimedia compositions and providing a medium through which to realize a modern-day Gesamtkunstwerk. The web-based Media Scores environment and related show control systems leverages research into multimodal representation and encoding of expressive intent. Using such a tool, the composer will be able to shape an artistic work that may be performed through a variety of media and modalities. Media Scores offer the potential for authoring content considering live performance data as well as audience participation and interaction. This paradigm bridges the extremes of the continuum from composition to performance, allowing for improvisation. The Media Score also provides a common point of reference in collaborative productions as well as the infrastructure for real-time control of technologies used during live performance.

## 135. Personal Opera

***Tod Machover and Peter Torpey***

Personal Opera is a radically innovative creative environment that enables anyone to create musical masterpieces sharing personal thoughts, feelings, and memories. Based on our design of, and experience with, such projects as Hyperscore and the Brain Opera, we are developing a totally new environment to allow the incorporation of personal stories, images, and both original and well-loved music and sounds. Personal Opera builds on our guiding principle that active music creation yields far more powerful benefits than passive listening. Using music as the through-line for assembling and conveying our own individual legacies, Personal Opera represents a new form of expressive archiving; easy to use and powerful to experience. In partnership with the Royal Opera House in London, we have begun conducting Personal Opera workshops specifically targeting seniors to help them tell their own meaningful stories through music, text, visuals, and acting.

## 136. Powers Sensor Chair

***Elena Jessop and Tod Machover***

The Powers Sensor Chair gives visitors a special glimpse into Tod Machover s robotic opera "Death and the Powers," by providing a new way to explore the sonic world of the opera. A solo participant sitting in a chair discovers that when she moves her hands and arms, the air in front of her becomes an instrument. With a small, delicate gesture, a sharp and energetic thrust of her hand, or a smooth caress of the space around her, she can use her expressive movement and gesture to play with and sculpt a rich sound environment drawn from the opera, including vocal outbursts and murmurs and the sounds of the show s special Hyperinstruments. This installation explores the body as a subtle and powerful instrument, providing continuous control of continuous expression, and incorporates Elena Jessop s high-level analysis frameworks for recognition and extension of expressive movement.

## 137. Remote Theatrical Immersion: Extending "Sleep No More"

***Tod Machover, Punchdrunk, Akito Van Troyer, Ben Bloomberg, Gershon Dublon, Jason Haas, Elena Jessop, Brian Mayton, Eyal Shahar, Jie Qi, Nicholas Joliat, and Peter Torpey***

We have collaborated with London-based theater group Punchdrunk to create an online platform connected to their NYC show, Sleep No More. In the live show, masked audience members explore and interact with a rich environment, discovering their own narrative pathways. We have developed an online companion world to this real-life experience, through which online participants partner with live audience members to explore the interactive, immersive show together. Pushing the current capabilities of web standards and wireless communications technologies,

the system delivers personalized multimedia content, allowing each online participant to have a unique experience co-created in real time by his own actions and those of his onsite partner. This project explores original ways of fostering meaningful relationships between online and onsite audience members, enhancing the experiences of both through the affordances that exist only at the intersection of the real and the virtual worlds.

### 138. Using the Voice As a Tool for Self-Reflection

***Tod Machover and Rebecca Kleinberger***

Our voice is an important part of our individuality. From the voices of others, we understand a wealth of non-linguistic information, such as identity, social-cultural clues, and emotional state. But the relationship we have with our own voice is less obvious. We don t hear it the way others do, and our brain treats it differently from any other sound. Yet its sonority is deeply connected with how we are perceived by society and how we see ourselves body and mind. This project is composed of software, devices, installations, and thoughts used to challenge us to gain new insights on our voices. To increase self-awareness we propose different ways to extend, project, and visualize the voice. We show how our voices sometimes escape our control, and we explore the consequences in terms of self-reflection, cognitive processes, therapy, affective features visualization, and communication improvement.

### 139. Vocal Vibrations: Expressive Performance for Body-Mind Wellbeing

***Tod Machover, Charles Holbrow, Elena Jessop, Rebecca Kleinberger, Le Laboratoire, and the Dalai Lama Center at MIT***

Vocal Vibrations explores the relationships between human physiology and the vibrations of the voice. The voice is an instrument everyone possesses it is incredibly individual, expressive, and intimately linked to the physical form. In collaboration with Le Laboratoire in Paris and the Dalai Lama Center at MIT, we are examining the hypothesis that the singing voice can influence mental and physical health through physicochemical phenomena. We are developing a series of multimedia experiences, from solo meditations to group singing circles, that explore possible emotional, cognitive, and physical transformations, all in a context of immersive music. In March 2014, we premiered a vocal art installation in Paris where a public Chapel space encourages careful and meditative listening, and a private "Cocoon environment guides an individual to explore his or her voice and its vibrations, augmented by tactile and acoustic stimuli.

Alumni Contributor: Eyal Shahar

## Pattie Maes: Fluid Interfaces

**Integrating digital interfaces more naturally into our physical lives, enabling insight, inspiration, and interpersonal connections.**

### 140. Augmented Airbrush

***Pattie Maes, Joseph A. Paradiso, Roy Shilkrot and Amit Zoran***

We present an augmented handheld airbrush that allows unskilled painters to experience the art of spray painting. Inspired by similar smart tools for fabrication, our handheld device uses 6DOF tracking, mechanical augmentation of the airbrush trigger, and a specialized algorithm to let the painter apply color only where indicated by a reference image. It acts both as a physical spraying device and as an intelligent digital guiding tool that provides manual and computerized control. Using an inverse rendering approach allows for a new augmented painting experience with unique results. We present our novel hardware design, control software, and a discussion of the implications of human-computer collaborative painting.

## 141. Enlight

***Pattie Maes, Yihui Saw, Tal Achituv, Natan Linder, and Rony Kubat***

In physics education, virtual simulations have given us the ability to show and explain phenomena that are otherwise invisible to the naked eye. However, experiments with analog devices still play an important role. They allow us to verify theories and discover ideas through experiments that are not constrained by software. What if we could combine the best of both worlds? We achieve that by building our applications on a projected augmented reality system. By projecting onto physical objects, we can paint the phenomena that are invisible. With our system, we have built "physical playgrounds" simulations that are projected onto the physical world and respond to detected objects in the space. Thus, we can draw virtual field lines on real magnets, track and provide history on the location of a pendulum, or even build circuits with both physical and virtual components.

## 142. EyeRing: A Compact, Intelligent Vision System on a Ring

***Roy Shilkrot and Suranga Nanayakkara***

EyeRing is a wearable, intuitive interface that allows a person to point at an object to see or hear more information about it. We came up with the idea of a micro-camera worn as a ring on the index finger with a button on the side, which can be pushed with the thumb to take a picture or a video that is then sent wirelessly to a mobile phone to be analyzed. The user uses voice to instruct the system on what information they are interested in and receives the answer in either auditory or visual form. The device also provides some simple haptic feedback. This finger-worn configuration of sensors and actuators opens up a myriad of possible applications for the visually impaired as well as for sighted people.

## 143. FingerReader

***Pattie Maes, Jochen Huber, Roy Shilkrot, Connie K. Liu and Suranga Nanayakkara***

FingerReader is a finger-worn device that helps the visually impaired to effectively and efficiently read paper-printed text. It works in a local-sequential manner for scanning text that enables reading of single lines or blocks of text, or skimming the text for important sections while providing auditory and haptic feedback.

## 144. GlassProv Improv Comedy System

***Pattie Maes, Scott Greenwald, Baratunde Thurston and Cultivated Wit***

As part of a Google-sponsored Glass developer event, we created a Glass-enabled improv comedy show together with noted comedians from ImprovBoston and Big Bang Improv. The actors, all wearing Glass, received cues in real time in the course of their improvisation. In contrast with the traditional model for improv comedy punctuated by freezing and audience members shouting suggestions using Glass allowed actors to seamlessly integrate audience suggestions. Actors and audience members agreed that this was a fresh take on improv comedy. This was a powerful demonstration that cues on Glass are suitable for performance actors could become aware of their presence without having their concentration or flow interrupted, and then view them at an appropriate time thereafter.

## 145. HandsOn: Collaborative 3D Augmented Reality System

**NEW LISTING**

***Pattie Maes and Kevin Wong***

2D screens, even stereoscopic ones, limit our capabilities to interact with 3D data. We believe that an augmented reality solution, where 3D data is seamlessly integrated in the real world, is promising. Therefore, we are exploring a collaborative augmented reality system for visualizing and manipulating 3D data using a head-mounted, see-through display where data manipulation can be done collaboratively using natural hand gestures.

## 146. JaJan!-Remote Language Learning in Shared Virtual Space

**NEW LISTING**

***Pattie Maes and Kevin Wong***

JaJan! is a virtual language learning application in a creative telepresence system where users can learn a language together in the same shared virtual space. JaJan! can support the following aspects of language learning: (i) learning in context; (ii) personalization of learning materials; (iii) learning with cultural information; (iv) enacting language learning scenarios; and (v) supporting creativity and collaboration. Although JaJan! is still in an early stage, we are confident that it will bring profound changes to the ways in which we experience language learning and can make a great contribution to the field of language education.

## 147. Limbo: Reprogramming Body-Control System

***Sang-won Leigh, Ermal Dreshaj, Pattie Maes, and Mike Bove***

This project aims to create technologies to support people who have lost the ability to control a certain part of their body, or who are attempting sophisticated tasks beyond their capabilities, using wearable sensing and actuating techniques. Our strategy is to mix a body gesture/signal detection system and a muscle actuating/limiting system, and to reprogram the way human body parts are controlled. For example, individuals with paralysis could regain the experience of grasping with their hands by actuating hand muscles based on gaze gestures. Individuals who have lost leg control could control their legs with finger movement and be able to drive a car without special assistance. Individuals handling very fragile objects could limit their grasping strength using voice commands (i.e., "not stronger," "weaker"). A person with a specific skill could help another complete a complicated task via another's body control system.

## 148. LuminAR

***Natan Linder, Pattie Maes, and Rony Kubat***

LuminAR reinvents the traditional incandescent bulb and desk lamp, evolving them into a new category of robotic, digital information devices. The LuminAR Bulb combines a Pico-projector, camera, and wireless computer in a compact form factor. This self-contained system enables users with just-in-time projected information and a gestural user interface, and it can be screwed into standard light fixtures everywhere. The LuminAR Lamp is an articulated robotic arm, designed to interface with the LuminAR Bulb. Both LuminAR form factors dynamically augment their environments with media and information, while seamlessly connecting with laptops, mobile phones, and other electronic devices. LuminAR transforms surfaces and objects into interactive spaces that blend digital media and information with the physical space. The project radically rethinks the design of traditional lighting objects, and explores how we can endow them with novel augmented-reality interfaces.

## 149. MARS: Manufacturing Augmented Reality System

***Rony Daniel Kubat, Natan Linder, Ben Weissmann, Niaja Farve, Yihui Saw and Pattie Maes***

Projected augmented reality in the manufacturing plant can increase worker productivity, reduce errors, gamify the workspace to increase worker satisfaction, and collect detailed metrics. We have built new LuminAR hardware customized for the needs of the manufacturing plant and software for a specific manufacturing use case.

## 150. Move Your Glass

***Pattie Maes and Niaja Farve***

Move Your Glass is an activity and behavior tracker that tries to increase wellness by enforcing positive behaviors.

## 151. Reality Editor: Programming Smarter Objects

***Valentin Heun, James Hobin, Pattie Maes***

The Reality Editor system supports editing the behavior and interfaces of so-called smart objects : objects or devices that have an embedded processor and communication capability. Using augmented reality techniques, the Reality Editor maps graphical elements directly on top of the tangible interfaces found on physical objects, such as push buttons or knobs. The Reality Editor allows flexible reprogramming of the interfaces and behavior of the objects as well as defining relationships between smart objects in order to easily create new functionalities.

## 152. ShowMe: Immersive Remote Collaboration System with 3D Hand Gestures

***Pattie Maes, Judith Amores Fernandez and Xavier Benavides Palos***

ShowMe is an immersive mobile collaboration system that allows remote users to communicate with peers using video, audio, and gestures. With this research, we explore the use of head-mounted displays and depth sensor cameras to create a system that (1) enables remote users to be immersed in another person s view, and (2) offer a new way of sending and receiving the guidance of an expert through 3D hand gestures. With our system, both users are surrounded in the same physical environment and can perceive real-time inputs from each other.

## 153. SmileCatcher

**NEW LISTING**

***Pattie Maes and Niaja Farve***

SmileCatcher is a game to be played solely or in groups that attempts to increase happiness. Previous research has shown that smiling correlates directly to happiness and can even produce happiness in a person. A user playing the game tries to collect as many smiles from people they interact with during a set period of time. In single player mode, the user compares their scores over subsequent days while multiple players compare their scores over a set period of time to other players. The objective of the tool is to encourage positive social interactions through gamification.

## 154. STEM Accessibility Tool for the Visually Impaired

**NEW LISTING**

***Pattie Maes and Rahul Namdev***

We are developing a very intuitive and interactive platform to make complex information (especially Science, Technology, Engineering, and Mathematical material) truly accessible to blind and visually impaired students by using the tactile device with no loss of information compared with printed materials. An important goal of this project is to develop tactile information-mapping protocols through which the tactile interface can best convey educational and other graphical materials.

## 155. TagMe

***Pattie Maes, Judith Amores Fernandez and Xavier Benavides Palos***

TagMe is an end-user toolkit for easy creation of responsive objects and environments. It consists of a wearable device that recognizes the object or surface the user is touching. The user can make everyday objects come to life through the use of RFID tag stickers, which are read by an RFID bracelet whenever the user touches the object. We present a novel approach to create simple and customizable rules based on emotional attachment to objects and social interactions of people. Using this simple technology, the user can extend their application interfaces to include physical objects and surfaces into their personal environment, allowing people to communicate through everyday objects in very low-effort ways.

## 156. THAW

***Sang-won Leigh, Philipp Schoessler, Hiroshi Ishii, Pattie Maes***

We present a novel interaction system that allows collocated screen devices to work together. The system tracks the position of a smartphone placed on a host computer screen. As a result, the smartphone can interact directly with data displayed on the host computer, which opens up a novel interaction space. We believe that the space on and above the computer screen will open up huge possibilities for new types of interactions. What makes this technology especially interesting is today s ubiquity of smartphones and the fact that we can achieve the tracking solely through installing additional software on potentially any phone or computer.

# Neri Oxman: Mediated Matter

**Designing for, with, and by Nature.**

## 157. 3D Printing of Functionally Graded Materials

***Neri Oxman and Steven Keating***

Functionally graded materials materials with spatially varying composition or microstructure are omnipresent in nature. From palm trees with radial density gradients, to the spongy trabeculae structure of bone, to the hardness gradient found in many types of beaks, graded materials offer material and structural efficiency. But in man-made structures such as concrete pillars, materials are typically volumetrically homogenous. While using homogenous materials allows for ease of production, improvements in strength, weight, and material usage can be obtained by designing with functionally graded materials. To achieve graded material objects, we are working to construct a 3D printer capable of dynamic mixing of composition material. Starting with concrete and UV-curable polymers, we aim to create structures, such as a bone-inspired beam, which have functionally graded materials. This research was sponsored by the NSF EAGER award: Bio-Beams: FGM Digital Design & Fabrication.

## 158. Additive Manufacturing in Glass: Electrosintering and Spark Gap Glass

***Neri Oxman, Steven Keating, John Klein***

Our initial experiments in spark electrosintering fabrication have demonstrated a capacity to solidify granular materials (35-88 micron soda ash glass powder) rapidly using high voltages and power in excess of 1 kW. The testbed high-voltage setup comprises a 220V 60A variable autotransformer and a 14,400V line transformer. There are two methods to form members using electrosintering: the one electrode drag (1ED) and the two electrode drag (2ED) techniques. The 1ED leaves the first electrode static while dragging the second through the granular mixture. This maintains a live current through the drag path and increases the thickness of the member due to the dissipation of heat. Large member elements have been produced with a tube diameter of around 0.75 . The 2ED method pulls both electrodes through the granular mixture together, sintering the material between the electrodes in a more controlled manner.

## 159. Anthozoa

***Neri Oxman***

A 3D-printed dress was debuted during Paris Fashion Week Spring 2013 as part of collaboration with fashion designer Iris Van Herpen for her show "Voltage." The 3D-printed skirt and cape were produced using Stratasys  unique Objet Connex multi-material 3D printing technology, which allows a variety of material properties to be printed in a single build. This allowed both hard and soft materials to be incorporated within the design, crucial to the movement and texture of the piece. Core contributers include: Iris Van Herpen, fashion designer (Amsterdam); Keren Oxman, artist and designer (NY); and W. Craig Carter (Department of Materials Science and Engineering, MIT). Fabricated by Stratasys.

## 160. Beast

***Neri Oxman***

Beast is an organic-like entity created synthetically by the incorporation of physical parameters into digital form-generation protocols. A single continuous surface, acting both as structure and as skin, is locally modulated for both structural support and corporeal aid. Beast combines structural, environmental, and corporeal performance by adapting its thickness, pattern density, stiffness, flexibility, and translucency to load, curvature, and skin-pressured areas respectively.

## 161. Bots of Babel

***Neri Oxman, Jorge Duro-Royo, Markus Kayser, Jared Laucks and Laia Mogas-Soldevila***

The Biblical story of the Tower of Babel involved a deliberate plan hatched by mankind to construct a platform from which man could fight God. The tower represented the first documented attempt at constructing a vertical city. The divine response to the master plan was to sever communication by instilling a different language in each builder. Tragically, the building s ultimate destruction came about through the breakdown of communications between its fabricators. In this installation we redeem the Tower of Babel by creating its antithesis. We will construct a virtuous, decentralized, yet highly communicative building environment of cable-suspended fabrication bots that together build structures bigger than themselves. We explore themes of asynchronous motion, multi-nodal fabrication, lightweight additive manufacturing, and the emergence of form through fabrication. (With contributions from Carlos Gonzalez Uribe and Dr. James Weaver (WYSS Institute and Harvard University))

## 162. Building-Scale 3D Printing

***Neri Oxman, Steven Keating and John Klein***

How can additive fabrication technologies be scaled to building-sized construction? We introduce a novel method of mobile swarm printing that allows small robotic agents to construct large structures. The robotic agents extrude a fast-curing material which doubles as both a concrete mold for structural walls and as a thermal insulation layer. This technique offers many benefits over traditional construction methods, such as speed, custom geometry, and cost. As well, direct integration of building utilities such as wiring and plumbing can be incorporated into the printing process. This research was sponsored by the NSF EAGER award: Bio-Beams: FGM Digital Design & Fabrication.

## 163. Carpal Skin

***Neri Oxman***

Carpal Skin is a prototype for a protective glove to protect against Carpal Tunnel Syndrome, a medical condition in which the median nerve is compressed at the wrist, leading to numbness, muscle atrophy, and weakness in the hand. Night-time wrist splinting is the recommended treatment for most patients before going into carpal tunnel release surgery. Carpal Skin is a process by which to map the pain-profile of a particular patient its intensity and duration and to distribute hard and soft materials to fit the patient s anatomical and physiological requirements, limiting movement in a customized fashion. The form-generation process is inspired by animal coating patterns in the control of stiffness variation.

## 164. CNSILK: Computer Numerically Controlled Silk Cocoon Construction

***Neri Oxman***

CNSILK explores the design and fabrication potential of silk fibers inspired by silkworm cocoons for the construction of woven habitats. It explores a novel approach to the design and fabrication of silk-based building skins by controlling the mechanical and physical properties of spatial structures inherent in their microstructures using multi-axis fabrication. The method offers construction without assembly such that material properties vary locally to accommodate for structural and environmental requirements. This approach stands in contrast to functional assemblies and kinetically actuated facades which require a great deal of energy to operate, and are typically maintained by global control. Such material architectures could simultaneously bear structural load, change their transparency so as to control light levels within a spatial compartment (building or vehicle), and open and close embedded pores so as to ventilate a space.

## 165. Digital Construction Platform

***Altec, BASF, Neri Oxman, Steven Keating, John Klein and Nathan Spielberg***

The DCP is an in-progress research project consisting of a compound robotic arm system. The system comprises a 5-axis Altec hydraulic mobile boom arm attached to a 6-axis KUKA robotic arm. Akin to the biological model of the human shoulder and hand, this compound system utilizes the large boom arm for gross positioning and the small robotic arm for fine positioning and oscillation correction, respectively. The platform is based on a fully mobile truck vehicle with a working reach diameter of over 80 feet. It can handle a 1,500lb. lift capacity and a 20lb. manipulation capacity. Potential applications include fabrication of non-standard architectural forms, integration of real-time on-site sensing data, improvements in construction efficiency, enhanced resolution, lower error rates, and increased safety.

## 166. Digitally Reconfigurable Surface

***Neri Oxman and Benjamin Peters***

The digitally reconfigurable surface is a pin matrix apparatus for directly creating rigid 3D surfaces from a computer-aided design (CAD) input. A digital design is uploaded into the device, and a grid of thousands of tiny pins much like the popular pin-art toy are actuated to form the desired surface. A rubber sheet is held by vacuum pressure onto the tops of the pins to smooth out the surface they form; this strong surface can then be used for industrial forming operations, simple resin casting, and many other applications. The novel phase-changing electronic clutch array allows the device to have independent position control over thousands of discrete pins with only a single motorized "push plate," lowering the complexity and manufacturing cost of this type of device. Research is ongoing into new actuation techniques to further lower the cost and increase the surface resolution of this technology.

## 167. FABRICOLOGY: Variable-Property 3D Printing as a Case for Sustainable Fabrication

***Neri Oxman***

Rapid prototyping technologies speed product design by facilitating visualization and testing of prototypes. However, such machines are limited to using one material at a time; even high-end 3D printers, which accommodate the deposition of multiple materials, must do so discretely and not in mixtures. This project aims to build a proof-of-concept of a 3D printer able to dynamically mix and vary the ratios of different materials in order to produce a continuous gradient of material properties with real-time correspondence to structural and environmental constraints.

Alumni Contributors: Mindy Eng, William J. Mitchell and Rachel Fong

## 168. FitSocket: A Better Way to Make Sockets

***Arthur Petron, Hugh Herr, Roy Kornbluh (SRI), and Neri Oxman***

Sockets the cup-shaped devices that attach an amputated limb to a lower-limb prosthesis are made through unscientific, artisanal methods that do not have repeatable quality and comfort from one individual to the next. The FitSocket project aims to identify the correlation between leg tissue properties and the design of a

comfortable socket. The FitSocket is a robotic socket measurement device that directly measures tissue properties. With this data, we can rapid-prototype test sockets and socket molds in order to make rigid, spatially variable stiffness, and spatially/temporally variable stiffness sockets.

Alumni Contributor: Elizabeth Tsai

## 169. Functionally Graded Filament-Wound Carbon-Fiber Prosthetic Sockets

***Neri Oxman, Carlos Gonzalez Uribe and Hugh Herr and the Biomechatronics group***

Prosthetic Sockets belong to a family of orthoic devices designed for amputee rehabilitation and performance augmentation. Although such products are fabricated out of lightweight composite materials and designed for optimal shape and size, they are limited in their capacity to offer local control of material properties for optimizing load distribution and ergonomic fit over surface and volume areas. Our research offers a novel workflow to enable the digital design and fabrication of customized prosthetic sockets with variable impedance informed by MRI data. We implement parametric environments to enable the controlled distribution of functional gradients of a filament-wound carbon fiber socket.

## 170. Gemini

**NEW LISTING**

***Neri Oxman with Le Laboratoire (David Edwards, Founder), Stratasys, and SITU Fabrication***

Gemini is an acoustical  twin chaise" spanning multiple scales of human existence from the womb to the stretches of the Gemini zodiac. We are exploring interactions between pairs: sonic and solar environments, natural and synthetic materials, hard and soft sensations, and subtractive and additive fabrication. Made of two material elements a solid wood milled shell housing and an intricate cellular skin made of sound-absorbing material the chaise forms a semi-enclosed space surrounding the human with a stimulation-free environment, recapitulating the ultimate quiet of the womb. It is the first design to implement Stratasys' Connex3 technology using 44 materials with different pre-set mechanical combinations varying in rigidity, opacity, and color as a function of geometrical, structural, and acoustical constraints. This calming and still experience of being inside the chaise is an antidote to the stimuli-rich world in which we live.

## 171. Glass Printing

**NEW LISTING**

***Neri Oxman, Markus Kayser, John Klein***

Digital design and construction technologies for product and building scale are generally limited in their capacity to deliver multi-functional building skins. Recent advancements in additive manufacturing and digital fabrication at large are today enabling the fabrication of multiple materials with combinations of mechanical, electrical, and optical properties; however, most of these materials are non-structural and cannot scale to architectural applications. Operating at the intersection of additive manufacturing, biology, and architectural design, the Glass Printing project is an enabling technology for optical glass 3D printing at architectural scale designed to manufacture multi-functional glass structures and facade elements. The platform deposits molten glass in a layer-by-layer (FDM) fashion implementing numerical control of tool paths, and it allows for controlled optical variation across surface and volume areas.

## 172. Lichtenberg 3D Printing

***Neri Oxman and Steven Keating***

Using electricity to generate 3D Lichtenberg structures in sintered media (i.e. glass) offers a new approach to digital fabrication. By robotically controlling the electrodes, a digital form can be rapidly fabricated with the benefits of a fine fractal structure. There are numerous applications, ranging from chemical catalysts, to fractal antennas, to product design.

## 173. Meta-Mesh: Computational Model for Design and Fabrication of Biomimetic Scaled Body Armors

***Neri Oxman, Jorge Duro-Royo, and Laia Mogas-Soldevila***

A collaboration between Professor Christine Ortiz (project lead), Professor Mary C. Boyce, Katia Zolotovsky, and Swati Varshaney (MIT). Operating at the intersection of biomimetic design and additive manufacturing, this research proposes a computational approach for designing multifunctional scaled-armors that offer structural protection and flexibility in movement. Inspired by the segmented exoskeleton of Polypterus senegalus, an ancient fish, we have developed a hierarchical computational model that emulates structure-function relationships found in the biological exoskeleton. Our research provides a methodology for the generation of biomimetic protective surfaces using segmented, articulated components that maintain user mobility alongside full body coverage of doubly curved surfaces typical of the human body. The research is supported by the MIT Institute for Soldier Nanotechnologies, the Institute for Collaborative Biotechnologies, and the National Security Science and Engineering Faculty Fellowship Program.

## 174. Micro-Macro Fluidic Fabrication of a Mid-Sole Running Shoe

***Neri Oxman and Carlos Gonzalez Uribe***

Micro-macro Fluidic Fabrication (MMFF) enables the control of mechanical properties through the design of non-linear lattices embedded within multi-material matrices. At its core it is a hybrid technique that integrates molding, casting, and macro-fluidics. Its workflow allows for the fabrication of complex matrices with geometrical channels injected with polymers of different pre-set mechanical combinations. This novel fabrication technique is implemented in the design and fabrication of a midsole running shoe. The goal is to passively tune material stiffness across surface area in order to absorb the impact force of the user s body weight relative to the ground, and enhance the direction of the foot-strike impulse force relative to the center of body mass.

## 175. Monocoque

***Neri Oxman***

French for "single shell," Monocoque stands for a construction technique that supports structural load using an object's external skin. Contrary to the traditional design of building skins that distinguish between internal structural frameworks and non-bearing skin elements, this approach promotes heterogeneity and differentiation of material properties. The project demonstrates the notion of a structural skin using a Voronoi pattern, the density of which corresponds to multi-scalar loading conditions. The distribution of shear-stress lines and surface pressure is embodied in the allocation and relative thickness of the vein-like elements built into the skin. Its innovative 3D printing technology provides for the ability to print parts and assemblies made of multiple materials within a single build, as well as to create composite materials that present preset combinations of mechanical properties.

## 176. PCB Origami

***Neri Oxman and Yoav Sterman***

The PCB Origami project is an innovative concept for printing digital materials and creating 3D objects with Rigid-flex PCBs and pick and place machines. These machines allow printing of digital electronic materials, while controlling the location and property of each of the components printed. By combining this technology with Rigid-flex PCB and computational origami, it is possible to create from a single sheet of PCB almost any 3D shape that is already embedded with electronics, to produce a finished product with that will be both structural and functional.

## 177. Printing Living Materials

***Neri Oxman, Will Patrick, Sunanda Sharma, Steven Keating, Steph Hays, Eléonore Tham, Professor Pam Silver, and Professor Tim Lu***

How can biological organisms be incorporated into product, fashion, and architectural design to enable the generation of multi-functional, responsive, and highly adaptable objects? This research pursues the intersection of synthetic

biology, digital fabrication, and design. Our goal is to incorporate engineered biological organisms into inorganic and organic materials to vary material properties in space and time. We aim to use synthetic biology to engineer organisms with varied output functionalities and digital fabrication tools to pattern these organisms and induce their specific capabilities with spatiotemporal precision.

## 178. Printing Multi-Material 3D Microfluidics

***Neri Oxman, Steven Keating, Will Patrick and David Sun Kong (MIT Lincoln Laboratory)***

Computation and fabrication in biology occur in aqueous environments. Through on-chip mixing, analysis, and fabrication, microfluidic chips have introduced new possibilities in biology for over two decades. Existing construction processes for microfluidics use complex, cumbersome, and expensive lithography methods that produce single-material, multi-layered 2D chips. Multi-material 3D printing presents a promising alternative to existing methods that would allow microfluidics to be fabricated in a single step with functionally graded material properties. We aim to create multi-material microfluidic devices using additive manufacturing to replicate current devices, such as valves and ring mixers, and to explore new possibilities enabled by 3D geometries and functionally graded materials. Applications range from medicine to genetic engineering to product design.

## 179. Rapid Craft

***Neri Oxman***

The values endorsed by vernacular architecture have traditionally promoted designs constructed and informed by and for the environment while using local knowledge and indigenous materials. Under the imperatives and growing recognition of sustainable design, Rapid Craft seeks integration between local construction techniques and globally available digital design technologies to preserve, revive, and reshape these cultural traditions.

## 180. Raycounting

***Neri Oxman***

Raycounting is a method for generating customized light-shading constructions by registering the intensity and orientation of light rays within a given environment. 3D surfaces of double curvature are the result of assigning light parameters to flat planes. The algorithm calculates the intensity, position, and direction of one or multiple light sources placed in a given environment and assigns local curvature values to each point in space corresponding to the reference plane and the light dimension. Light performance analysis tools are reconstructed programmatically to allow for morphological synthesis based on intensity, frequency, and polarization of light parameters as defined by the user.

## 181. Silk Pavilion

***Neri Oxman, Jorge Duro-Royo, Carlos Gonzalez, Markus Kayser, and Jared Laucks, with James Weaver (Wyss Institute, Harvard University) and Fiorenzo Omenetto (Tufts University)***

The Silk Pavilion explores the relationship between digital and biological fabrication. The primary structure was created from 26 polygonal panels made of silk threads laid down by a CNC (Computer-Numerically Controlled) machine. Inspired by the silkworm s ability to generate a 3D cocoon out of a single multi-property silk thread, the pavilion's overall geometry was created using an algorithm that assigns a single continuous thread across patches, providing various degrees of density. Overall density variation was informed by deploying the silkworm as a biological "printer" in the creation of a secondary structure. Positioned at the bottom rim of the scaffold, 6,500 silkworms spun flat, non-woven silk patches as they locally reinforced the gaps across CNC-deposited silk fibers. Affected by spatial and environmental conditions (geometrical density, variation in natural light and heat), the silkworms were found to migrate to darker and denser areas.

## 182. SpiderBot

***Neri Oxman and Benjamin Peters***

The SpiderBot is a suspended robotic gantry system that provides an easily deployable platform from which to print large structures. The body is composed of a deposition nozzle, a reservoir of material, and parallel linear actuators. The robot is connected to stable points high in the environment, such as large trees or buildings. This arrangement is capable of moving large distances without the need for more conventional linear guides, much like a spider does. The system is easy to set up for mobile projects, and will afford sufficient printing resolution and build volume. Expanding foam can be deposited to create a building-scale printed object rapidly. Another material type of interest is the extrusion or spinning of tension elements, like rope or cable. With tension elements, unique structures such as bridges or webs can be wrapped, woven, or strung around environmental features or previously printed materials.

## 183. Swarm Construction

***Neri Oxman and Markus Kayser***

**NEW LISTING**

The robotic swarm construction project aims to build architectural structures autonomously. In nature swarm behavior can be found in many species, swarm construction most notably in termite mounts, termites utilize highly sophisticated hierarchical behaviors to construct their habitat in a global coordinated fashion with only local communication. The aim of this robotic swarm of individual robots is to build a self-supporting architectural structure collaboratively from fibers. The use of fibers as a construction material can achieve high degrees of variation in terms of structural performance as well as the ability to imbed various functionalities through the use of different fibers such as fluidic channels for heating and cooling of the structure, light guides for illumination as well as data transfer and conductive fibers for electrical applications as well as the potential for embedding a network of sensors. Here the building material becomes a fabric of various materials and functionalities in a single construction process. The robots are building and climbing tubular structures which become single threads within the larger construction network of the emerging architecture. Communication of the individual robots within the swarm is key for the construction of a large-scale structure, embedding hierarchies in the communication protocols and algorithmic decision-making informed by onboard sensors. The robots are energy independent using photovoltaic and curing of resin shall be provided by UV spectrum of solar radiation (direct and scattered light). These robots shall become organism-like entities, 'living' in accordance to the circadian rhythm.

# Sputniko!: Design Fiction

**Sparking imagination and discussion about the social, cultural, and ethical implications of new technologies through design and storytelling.**

## 184. CremateBot: Transform, Reborn, Free

***Hiromi Ozaki and Dan Chen***

**NEW LISTING**

CremateBot is an apparatus that takes in human-body clippings such as fingernails, hair, or dead skin and turns them into ashes through the cremation process. The process of converting human remains to ashes becomes a critical experience for observers, causing witnesses to question their sense of existence and physical self through the conversion process. CremateBot transforms our physical self and celebrates our rebirth through self-regeneration. The transformation and rebirth open our imagination to go beyond our physical self and cross the span of time.

Similar to Theseus  paradox, the dead human cells which at one point were considered part of our physical selves and helped to define our sense of existence are continually replaced with newly generated cells. With the recent advancement in implants, biomechatronics, and bioengineered organs, how we define ourselves is increasingly blurred.

### 185. Crowbot Jenny

***Sputniko! (Hiromi Ozaki)***

Crowbot Jenny, inspired by Donna Haraway s philosophical memoir When Species Meet (2007), is a solitary girl who, despite her generation s tendency toward communication overload, has trouble relating to her peers. In fact, Crowbot Jenny prefers to talk with animals and develops the Crowbot, an instrument that replicates a range of crow calls, to commune with her army of birds. Sputniko! talked with various crow specialists from University of Cambridge (UK), University of Utsunomiya (Japan), and University of Tokyo (Japan) who also provided her with sample crow calls such as "Hello," "I'm in danger," "I love you!" or "Where is my Child!?" which she installed inside Crowbot.

### 186. I(')mpossible baby

***Ai Hasegawa***

**NEW LISTING**

Delivering a baby from same-sex parents is not a sci-fi dream anymore the recent developments in genetics and stem cell research have made this dream much closer to reality. Is creating a baby from same-sex parents the right thing to do? Who has the right to decide this, and how? This project explores the bioethics of producing babies for same-sex couples. In the first phase, DNA data will be simulated to visualise the "potential" baby. The project will then explore creating partial organs of the "potential baby" over the next few years. You have the right to know, think, and raise your voice about whether this dream becomes a reality not just the authorities and researchers.

### 187. Menstruation Machine Takashi's Take

***Sputniko! (Hiromi Ozaki)***

What does menstruation mean, biologically, culturally, and historically, to humans? Who might choose to have it, and how might they have it? The Menstruation Machine fitted with a blood dispensing mechanism and electrodes simulating the lower abdomen simulates the pain and bleeding of a five-day menstruation process. The project video features a transvestite male Takashi, who one day chooses to wear 'Menstruation' in an attempt to biologically dress up as a female, being unsatisfied by just aesthetically appearing female. He builds and wears the machine to fulfill his desire to understand what the period feels like for his female friends.

## Joseph Paradiso: Responsive Environments

**Augmenting and mediating human experience, interaction, and perception with sensor networks.**

### 188. Chain API

***Joseph A. Paradiso, Gershon Dublon, Brian Mayton and Spencer Russell***

RESTful services and the Web provide a framework and structure for content delivery that is scalable not only in size but more importantly in use cases. As we in Responsive Environments build systems to collect, process, and deliver sensor data, this project serves as a research platform that can be shared between a variety of projects both inside and outside the group. By leveraging hyperlinks between sensor data clients can browse, explore and discover their relationships and interactions in ways that can grow over time.

## 189. Circuit Stickers

***Joseph A. Paradiso, Jie Qi, Nan-wei Gong and Leah Buechley***

Circuit Stickers is a toolkit for crafting electronics using flexible and sticky electronic pieces. These stickers are created by printing traces on flexible substrates and adding conductive adhesive. These lightweight, flexible, and sticky circuit boards allow us to begin sticking interactivity onto new spaces and interfaces such as clothing, instruments, buildings, and even our bodies.

## 190. Circuit Stickers Activity Book

***Leah Buechley and Jie Qi***

The Circuit Sticker Activity Book is a primer for using circuit stickers to create expressive electronics. Inside are explanations of the stickers, and circuits and templates for building functional electronics directly on the pages of the book. The book covers five topics, from simple LED circuits to crafting switches and sensors. As users complete the circuits, they are also prompted with craft and drawing activities to ensure an expressive and artistic approach to learning and building circuits. Once completed, the book serves as an encyclopedia of techniques to apply to future projects.

## 191. Data-Driven Elevator Music

***Joe Paradiso, Gershon Dublon, Brian Dean Mayton and Spencer Russell***

Our glass building lets us see across spaces through the walls that enclose us and beyond. Yet invisibly, networks of sensors inside and out capture the often imperceivable dimensions of the built and natural environment. Our project uses multi-channel spatial sound to bring that data into the utilitarian experience of riding the glass elevator. In the past, we've mixed live sound from microphones throughout the building with sonification of sensor data, using a pressure sensor to provide fine-grained altitude for control. In its present form, the elevator is displaying data from the Living Observatory, a wetland restoration site 60 miles away. Each string pluck represents a new data point streaming in; its pitch corresponds to the temperature at the sensor and its timbre reflects the humidity. Live and recorded sound reflect the real ambience of the remote wetland.

Alumni Contributor: Nicholas Joliat

## 192. DoppelLab: Experiencing Multimodal Sensor Data

***Joe Paradiso, Gershon Dublon and Brian Dean Mayton***

Homes and offices are being filled with sensor networks to answer specific queries and solve pre-determined problems, but no comprehensive visualization tools exist for fusing these disparate data to examine relationships across spaces and sensing modalities. DoppelLab is a cross-reality virtual environment that represents the multimodal sensor data produced by a building and its inhabitants. Our system encompasses a set of tools for parsing, databasing, visualizing, and sonifying these data; by organizing data by the space from which they originate, DoppelLab provides a platform to make both broad and specific queries about the activities, systems, and relationships in a complex, sensor-rich environment.

## 193. Experiential Lighting: New User-Interfaces for Lighting Control

***Joseph A. Paradiso, Matthew Aldrich and Nan Zhao***

We are evaluating new methods of interacting and controlling solid-state lighting based on our findings of how participants experience and perceive architectural lighting in our new lighting laboratory (E14-548S). This work, aptly named "Experiential Lighting," reduces the complexity of modern lighting controls (intensity/color/space) into a simple mapping, aided by both human input and sensor measurement. We believe our approach extends beyond general lighting control and is applicable in situations where human-based rankings and preference are critical requirements for control and actuation. We expect our foundational studies to guide future camera-based systems that will inevitably incorporate context in their operation (e.g., Google Glass).

## 194. FingerSynth: Wearable Transducers for Exploring the Environment through Sound

***Joseph A. Paradiso and Gershon Dublon***

The FingerSynth is a wearable musical instrument made up of a bracelet and set of rings that enables its players to produce sound by touching nearly any surface in their environments. Each ring contains a small, independently controlled audio exciter transducer. The rings sound loudly when they touch a hard object, and are silent otherwise. When a wearer touches their own (or someone else's) head, the contacted person hears sound through bone conduction, inaudible to others. A microcontroller generates a separate audio signal for each ring, and can take user input through an accelerometer in the form of taps, flicks, and other gestures. The player controls the envelope and timbre of the sound by varying the physical pressure and the angle of their finger on the surface, or by touching differently resonant surfaces. The FingerSynth encourages players to experiment with the materials around them and with one another.

## 195. Hacking the Sketchbook

***Joseph A. Paradiso and Jie Qi***

In this project we investigate how the process of building a circuit can be made more organic, like sketching in a sketchbook. We integrate a rechargeable power supply into the spine of a traditional sketchbook, so that each page of the sketchbook has power connections. This enables users to begin creating functioning circuits directly onto the pages of the book and to annotate as they would in a regular notebook. The sequential nature of the sketchbook allows creators to document their process for circuit design. The book also serves as a single physical archive of various hardware designs. Finally, the portable and rechargeable nature of the book allows users to take their electronic prototypes off of the lab bench and share their creations with people outside of the lab environment.

## 196. ListenTree: Audio-Haptic Display in the Natural Environment

***V. Michael Bove, Joseph A. Paradiso, Gershon Dublon and Edwina Portocarrero***

ListenTree is an audio-haptic display embedded in the natural environment. Visitors to our installation notice a faint sound emerging from a tree. By resting their heads against the tree, they are able to hear sound through bone conduction. To create this effect, an audio exciter transducer is weatherproofed and attached to the tree's roots, transforming it into a living speaker, channeling audio through its branches, and providing vibrotactile feedback. In one deployment, we used ListenTree to display live sound from an outdoor ecological monitoring sensor network, bringing a faraway wetland into the urban landscape. Our intervention is motivated by a need for forms of display that fade into the background, inviting attention rather than requiring it. We consume most digital information through devices that alienate us from our surroundings; ListenTree points to a future where digital information might become enmeshed in material.

## 197. Living Observatory: Sensor Networks for Documenting and Experiencing Ecology

***Glorianna Davenport, Joe Paradiso, Gershon Dublon, Pragun Goyal and Brian Dean Mayton***

Living Observatory is an initiative for documenting and interpreting ecological change that will allow people, individually and collectively, to better understand relationships between ecological processes, human lifestyle choices, and climate change adaptation. As part of this initiative, we are developing sensor networks that document ecological processes and allow people to experience the data at different spatial and temporal scales. Low-power sensor nodes capture climate and other data at a high spatiotemporal resolution, while others stream audio. Sensors on trees measure transpiration and other cycles, while fiber-optic cables in streams capture high-resolution temperature data. At the same time, we are developing tools that allow people to explore this data, both remotely and onsite. The remote interface allows for immersive 3D exploration of the terrain, while visitors to the site will be able to access data from the network around them directly from wearable devices.

## 198. Mobile, Wearable Sensor Data Visualization

**NEW LISTING**

***Joseph A. Paradiso, Gershon Dublon, Donald Haddad, Brian Mayton and Spencer Russell***

As part of the Living Observatory ecological sensing initiative, we've been developing new approaches to mobile, wearable sensor data visualization. The Tidmarsh app for Google Glass visualizes real-time sensor network data based on the wearer's location and gaze. A user can approach a sensor node to see 2D plots of its real-time data stream, and look across an expanse to see 3D plots encompassing multiple devices. On the back-end, the app showcases our Chain API, crawling linked data resources to build a dynamic picture of the sensor network. Besides development of new visualizations, we are building in support for voice queries, and exploring ways to encourage distributed data collection by users.

## 199. Prosthetic Sensor Networks: Factoring Attention, Proprioception, and Sensory Coding

***Joseph A. Paradiso and Gershon Dublon***

Sensor networks permeate our built and natural environments, but our means for interfacing to the resultant data streams have not evolved much beyond HCI and information visualization. Researchers have long experimented with wearable sensors and actuators on the body as assistive devices. A user s neuroplasticity can, under certain conditions, transcend sensory substitution to enable perceptual-level cognition of extrasensory stimuli delivered through existing sensory channels. But there remains a huge gap between data and human sensory experience. We are exploring the space between sensor networks and human augmentation, in which distributed sensors become sensory prostheses. In contrast, user interfaces are substantially unincorporated by the body our relationship to them never fully pre-attentive. Attention and proprioception are key, not only to moderate and direct stimuli, but also to enable users to move through the world naturally, attending to the sensory modalities relevant to their specific contexts.

## 200. Sambaza Watts

***Joe Paradiso, Ethan Zuckerman, Rahul Bhargava, Pragun Goyal, Alexis Hope and Nathan Matias***

We want to help people in nations where electric power is scarce to sell power to their neighbors. We re designing a piece of prototype hardware that plugs into a diesel generator or other power source, distributes the power to multiple outlets, monitors how much power is used, and uses mobile payments to charge the customer for the power consumed.

## 201. techNailogy

**NEW LISTING**

***Cindy Hsin-Liu Kao, Artem Dementyev, Chris Schmandt***

techNailogy is a nail-mounted gestural input surface. Using capacitive sensing on printed electrodes, the interface can distinguish on-nail finger swipe gestures with high accuracy. techNailogy works in real time: we miniaturized the system to fit on the fingernail, while wirelessly transmitting the sensor data to a mobile phone or PC. techNailogy allows for one-handed and always-available input, while being unobtrusive and discreet. Inspired by commercial nail stickers, the device blends into the user s body, is customizable, fashionable, and even removable. We show example applications of using the device as a remote controller when hands are busy and using the system to increase the input space of mobile phones.

## 202. Ubiquitous Sonic Overlay

**NEW LISTING**

***Joseph A. Paradiso and Spencer Russell***

With our Ubiquitous Sonic Overlay, we are working to place virtual sounds in the user's environment, fixing them in space even as the user moves. We are working toward creating a seamless auditory display indistinguishable from the user's actual surroundings. Between bone-conduction headphones, small and cheap orientation sensors, and ubiquitous GPS, a confluence of fundamental technologies is in place. However, existing head-tracking systems either limit the motion space to a small area (e.g., Occulus Rift), or sacrifice precision for scale using technologies like GPS. We are seeking to bridge the gap to create large outdoor spaces of sonic objects.

## Alex 'Sandy' Pentland: Human Dynamics

**Exploring how social networks can influence our lives in business, health, governance, and technology adoption and diffusion.**

### 203. Ethos

***Amir Lazarovich, Guy Zyskind, Oz Nathan, Alex 'Sandy' Pentland, Andy Lippman***

**NEW LISTING**

Ethos is a decentralized, Bitcoin-like network for storing and sharing valuable information. We provide transparency, control, and ownership over personal data and its distribution. Validation and maintenance is distributed throughout the data community and automatically maintained without needing a safe deposit box or a commercial site. What Bitcoin has done for currency and BitTorrent for media, Ethos does for personal data. Nodes in the network are incentivized by collecting transaction fees, coinbase transactions ("finding blocks"), and proof-of-storage fees to sustain the distribution of personal data. Fees are paid with the underlying crypto currency represented by the network, also known as "PrivacyCoin." The role of nodes besides the usual proof-of-work, which protects against "double spending," is to maintain shredded pieces of information and present them to the network on-demand.

### 204. Inducing Peer Pressure to Promote Cooperation

***Ankur Mani, Iyad Rahwan, and Alex 'Sandy' Pentland***

Cooperation in a large society of self-interested individuals is notoriously difficult to achieve when the externality of one individual s action is spread thin and wide. This leads to the tragedy of the commons, with rational action ultimately making everyone worse off. Traditional policies to promote cooperation involve Pigouvian taxation or subsidies that make individuals internalize the externality they incur. We introduce a new approach to achieving global cooperation by localizing externalities to one s peers in a social network, thus leveraging the power of peer-pressure to regulate behavior. The mechanism relies on a joint model of externalities and peer-pressure. Surprisingly, this mechanism can require a lower budget to operate than the Pigouvian mechanism, even when accounting for the social cost of peer pressure. Even when the available budget is very low, the social mechanisms achieve greater improvement in the outcome.

### 205. Mobile Territorial Lab

***Alex 'Sandy' Pentland and Bruno Lepri***

The Mobile Territorial Lab (MTL) aims at creating a living laboratory integrated in the real life of the Trento territory in Italy, open to manifold kinds of experimentations. In particular, the MTL is focused on exploiting the sensing capabilities of mobile phones to track and understand human behaviors (e.g., families' spending behaviors, lifestyles, mood and stress patterns); on designing and testing social strategies aimed at empowering individual and collective lifestyles through attitude and behavior change; and on investigating new paradigms in personal data management and sharing. This project is a collaboration with Telecom Italia SKIL Lab, Foundation Bruno Kessler, and Telefonica I+D.

### 206. openPDS/SaferAnswers: Protecting the Privacy of Metadata

***Alex 'Sandy' Pentland, Brian Sweatt, Erez Shmueli, and Yves-Alexandre de Montjoye***

In a world where sensors, data storage, and processing power are too cheap to meter, how do you ensure that users can realize the full value of their data while protecting their privacy? openPDS is a field-tested, personal metadata management framework which allows individuals to collect, store, and give fine-grained access to their metadata to third parties. SafeAnswers is a new and practical way of protecting the privacy of metadata at an individual level. SafeAnswers turns a hard

anonymization problem into a more tractable security one. It allows services to ask questions whose answers are calculated against the metadata instead of trying to anonymize individuals' metadata. Together, openPDS and SafeAnswers provide a new way of dynamically protecting personal metadata.

## 207. Sensible Organizations

***Alex 'Sandy' Pentland, Benjamin Waber and Daniel Olguin Olguin***

Data mining of email has provided important insights into how organizations function and what management practices lead to greater productivity. But important communications are almost always face-to-face, so we are missing the greater part of the picture. Today, however, people carry cell phones and wear RFID badges. These body-worn sensor networks mean that we can potentially know who talks to whom, and even how they talk to each other. Sensible Organizations investigates how these new technologies for sensing human interaction can be used to reinvent organizations and management.

## 208. The Privacy Bounds of Human Mobility

***Cesar A. Hidalgo and Yves-Alexandre DeMontjoye***

We used 15 months of data from 1.5 million people to show that four points approximate places and times are enough to identify 95 percent of individuals in a mobility database. Our work shows that human behavior puts fundamental natural constraints on the privacy of individuals, and these constraints hold even when the resolution of the dataset is low. These results demonstrate that even coarse datasets provide little anonymity. We further developed a formula to estimate the uniqueness of human mobility traces. These findings have important implications for the design of frameworks and institutions dedicated to protect the privacy of individuals.

## 209. Using Big Data for Effective Marketing

**NEW LISTING**

***Pål Sundsøy, Johannes Bjelland, Asif Iqbal, Sandy Pentland, and Yves-Alexandre de Montjoye***

Using big data for effective marketing is hard. As a consequence, 80% of marketing decisions are still based on gut feeling. This work shows how a principled approach to big data can improve customer segmentation. We run a large-scale text-based experiment in an Asian country, comparing our data-driven approach to the company marketer's best practice. Our approach outperforms marketing's 13 times in click-through rate for a data plan. It also shows significantly better retention rate.

## 210. What Can Your Phone Metadata Tell about You?

***Yves-Alexandre de Montjoye, Jordi Quoidbach, Florent Robic, and Sandy Pentland***

How much can others learn about your personality just by looking at the way you use your phone? We provide the first evidence that personality types (for example, neurotism, extraversion, openness) can be predicted from standard mobile phone metadata. We have developed a set of novel psychology-informed indicators that can be computed from any set of mobile phone metadata. These fall into five categories, and range from the time it took you to answer a text, the entropy of your contacts, your daily distance traveled, or the percentage of text conversations you started. Using these 36 indicators, we were able to predict people's personalities correctely up to 63%, 1.7 times better than random using only metadata.

## Rosalind W. Picard: Affective Computing

**Advancing wellbeing using new ways to communicate, understand, and respond to emotion.**

### 211. Auditory Desensitization Games

***Rosalind W. Picard, Matthew Goodwin and Rob Morris***

Persons on the autism spectrum often report hypersensitivity to sound. Efforts have been made to manage this condition, but there is wide room for improvement. One approach exposure therapy has promise, and a recent study showed that it helped several individuals diagnosed with autism overcome their sound sensitivities. In this project, we borrow principles from exposure therapy, and use fun, engaging games to help individuals gradually get used to sounds that they might ordinarily find frightening or painful.

### 212. Automatic Stress Recognition in Real-Life Settings

***Rosalind W. Picard, Robert Randall Morris and Javier Hernandez Rivera***

Technologies to automatically recognize stress are extremely important to prevent chronic psychological stress and pathophysiological risks associated with it. The introduction of comfortable and wearable biosensors has created new opportunities to measure stress in real-life environments, but there is often great variability in how people experience stress and how they express it physiologically. In this project, we modify the loss function of Support Vector Machines to encode a person's tendency to feel more or less stressed, and give more importance to the training samples of the most similar subjects. These changes are validated in a case study where skin conductance was monitored in nine call center employees during one week of their regular work. Employees working in this type of setting usually handle high volumes of calls every day, and they frequently interact with angry and frustrated customers that lead to high stress levels.

### 213. Autonomic Nervous System Activity in Epilepsy

***Rosalind W. Picard and Ming-Zher Poh***

We are performing long-term measurements of autonomic nervous system (ANS) activity on patients with epilepsy. In certain cases, autonomic symptoms are known to precede seizures. Usually in our data, the autonomic changes start when the seizure shows in the EEG, and can be measured with a wristband (much easier to wear every day than wearing an EEG). We found that the larger the signal we measure on the wrist, the longer the duration of cortical brain-wave suppression following the seizure. The duration of the latter is a strong candidate for a biomarker for SUDEP (Sudden Unexpected Death in Epilepsy), and we are working with scientists and doctors to better understand this. In addition, bilateral changes in ANS activity may provide valuable information regarding seizure focus localization and semiology.

### 214. BioGlass: Physiological Parameter Estimation Using a Head-mounted Wearable Device

***Rosalind W. Picard, Javier Hernandez Rivera, James M. Rehg (Georgia Tech) and Yin Li (Georgia Tech)***

What if you could see what calms you down or increases your stress as you go through your day? What if you could see clearly what is causing these changes for your child or another loved one? People could become better at accurately interpreting and communicating their feelings, and better at understanding the needs of those they love. This work explores the possibility of using sensors embedded in Google Glass, a head-mounted-wearable device, to robustly measure physiological signals of the wearer.

## 215. Building the Just-Right-Challenge in Games and Toys

***Rosalind W. Picard and Elliott Hedman***

Working with the LEGO Group and Hasbro, we looked at the emotional experience of playing with games and LEGO bricks. We measured participants skin conductance as they learned to play with these new toys. By marking the stressful moments we were able to see what moments in learning should be redesigned. Our findings suggest that framing is key how can we help children recognize their achievements? We also saw how children are excited to take on new responsibilities but are then quickly discouraged when they aren t given the resources to succeed. Our hope for this work is that by using skin conductance sensors, we can help companies better understand the unique perspective of children and build experiences fit for them.

## 216. Cardiocam

***Ming-Zher Poh, Daniel McDuff and Rosalind W. Picard***

Cardiocam is a low-cost, non-contact technology for measurement of physiological signals such as heart rate and breathing rate using a basic digital imaging device such as a webcam. The ability to perform remote measurements of vital signs is promising for enhancing the delivery of primary healthcare.

## 217. College Sleep

***Akane Sano, Amy Yu, Sara Taylor, Cesar Hidalgo and Rosalind Picard***

Sleep is critical to a wide range of biological functions; inadequate sleep results in impaired cognitive performance and mood, and adverse health outcomes including obesity, diabetes, and cardiovascular disease. Recent studies have shown that healthy and unhealthy sleep behaviors can be transmitted by social interactions between individuals within social networks. We investigate how social connectivity and light exposure influence sleep patterns and their health and performance. Using multimodal data collected from closely connected MIT/Harvard undergraduates with wearable sensors and mobile phones, we are developing statistical and multiscale mathematical models of sleep dynamics within social networks based on sleep and circadian physiology. These models will provide insights into the emergent dynamics of sleep behaviors within social networks, and allow us to test the effects of candidate strategies for intervening in populations with unhealthy sleep behaviors.

## 218. Digging into Brand Perception with Psychophysiology

***Rosalind W. Picard and Elliott Hedman***

What do customers really think about your company or brand? Using skin conductance sensors, we measure what excites and frustrates customers when discussing topics relevant to your brand. For example, with the National Campaign to Prevent Teenage Pregnancy, we saw conversations about empowerment and abortion upset conservative families. However, talking about the importance of strong families excited and engaged them. Rather than rely on self-reports, physiological measurements allow us to pinpoint what words and concepts affect your customers. We hope work like this will help companies better reflect on how their actions and messaging affect their customer s opinion in more detailed and accurate ways.

## 219. Emotion Prototyping: Redesigning the Customer Experience

***Rosalind W. Picard and Elliott Hedman***

You can test whether a website is usable by making wire frames, but how do you know if that site, product, or store is emotionally engaging? We build quick, iterative, environments where emotions can be tested and improved. Emphasis is on setting up the right motivation (users always have to buy what they pick), pressures (can you buy the laptop in 10 minutes?), and environment (competitors products better be on the shelf too). Once we see where customers are stressed or miss the fun part, we change the space on a daily, iterative cycle. Within two to three weeks, we can tell how to structure a new offering for a great experience. Seldom do the emotions we hope to create happen on the first try; emotion prototyping delivers the experience we want. We hope to better understand the benefits of emotion prototyping, especially while using the skin conductance sensor.

## 220. Exploring Temporal Patterns of Smile

***Rosalind W. Picard and Mohammed Ehasanul Hoque***

A smile is a multi-purpose expression. We smile to express rapport, polite disagreement, delight, sarcasm, and often, even frustration. Is it possible to develop computational models to distinguish among smiling instances when delighted, frustrated, or just being polite? In our ongoing work, we demonstrate that it is useful to explore how the patterns of smile evolve through time, and that while a smile may occur in positive and in negative situations, its dynamics may help to disambiguate the underlying state.

## 221. Facial Expression Analysis Over the Web

***Rosalind W. Picard, Daniel Jonathan McDuff, and formerly: Affectiva and Forbes***

This work builds on our earlier work with FaceSense, created to help automate the understanding of facial expressions, both cognitive and affective. The FaceSense system has now been made available commercially by Media Lab spinoff Affectiva as Affdex. In this work we present the first project analyzing facial expressions at scale over the Internet. The interface analyzes the participants' smile intensity as they watch popular commercials. They can compare their responses to an aggregate from the larger population. The system also allows us to crowd-source data for training expression recognition systems and to gain better understanding of facial expressions under natural at-home viewing conditions instead of in traditional lab settings.

Alumni Contributor: Rana El Kaliouby

## 222. Fathom: Probabilistic Graphical Models to Help Mental Health Counselors

***Karthik Dinakar, Jackie Chen, Henry A. Lieberman, and Rosalind W. Picard***

We explore advanced machine learning and reflective user interfaces to scale the national Crisis Text Line. We are using state-of-the-art probabilistic graphical topic models and visualizations to help a mental health counselor, extract patterns of mental health issues experienced by participants, and bring large scale data science to understanding the distribution of mental health issues in the United States.

## 223. FEEL: A Cloud System for Frequent Event and Biophysiological Signal Labeling

***Yadid Ayzenberg and Rosalind W. Picard***

The wide availability of low-cost, wearable, biophysiological sensors enables us to measure how the environment and our experiences impact our physiology. This creates a new challenge: in order to interpret the collected longitudinal data, we require the matching contextual information as well. Collecting weeks, months, and years of continuous biophysiological data makes it unfeasible to rely solely on our memory for providing the contextual information. Many view maintaining journals as burdensome, which may result in low compliance levels and unusable data. We present an architecture and implementation of a system for the acquisition, processing, and visualization of biophysiological signals and contextual information.

## 224. Gesture Guitar

***Rosalind W. Picard, Rob Morris and Tod Machover***

Emotions are often conveyed through gesture. Instruments that respond to gestures offer musicians new, exciting modes of musical expression. This project gives musicians wireless, gestural-based control over guitar effects parameters.

## 225. Got Sleep?

***Akane Sano, Rosalind W. Picard***

Got Sleep? is an android application to help people to be aware of their sleep-related behavioral patterns and tips about how they should change their behaviors to improve their sleep. The application evaluates people s sleep habits before they start using the app, tracks day and night behaviors, and provides feedback about what kinds of behavior changes they should make and whether the improvement is achieved or not.

## 226. IDA: Inexpensive Networked Digital Stethoscope

***Yadid Ayzenberg***

Complex and expensive medical devices are mainly used in medical facilities by health professionals. IDA is an attempt to disrupt this paradigm and introduce a new type of device: easy to use, low cost, and open source. It is a digital stethoscope that can be connected to the Internet for streaming physiological data to remote clinicians. Designed to be fabricated anywhere in the world with minimal equipment, it can be operated by individuals without medical training.

## 227. Lensing

***Catherine Kreatsoulas (Harvard), Rosalind W. Picard, Karthik Dinakar, David Blei (Columbia) and Matthew Nock (Harvard)***

**NEW LISTING**

Conversations between two individuals whether between doctor and patient, mental health therapist and client, or between two people romantically involved with each other are complex. Each participant contributes to the conversation using her or his own 'lens'. This project involves advanced probabilistic graphical models to statistically extract and model these dual lenses across large datasets of real-world conversations, with applications that can improve crisis and psychotherapy counseling and patient-cardiologist consultations. We're working with top psychologists, cardiologists, and crisis counseling centers in the United States.

## 228. MACH: My Automated Conversation coacH

***M. Ehsan Hoque, Rosalind Picard***

MACH, My Automated Conversation coacH, is a system for people to practice social interactions in face-to-face scenarios. MACH consists of a 3D character that can see, hear, and make its own decisions in real time. The system was validated in the context of job interviews with 90 MIT undergraduate students. Students who interacted with MACH demonstrated significant performance improvement compared to the students in the control group. We are currently expanding this technology to open up new possibilities in behavioral health (e.g., treating people with Asperger syndrome, social phobia, PTSD) as well as designing new interaction paradigms in human-computer interaction and robotics.

## 229. Making Engaging Concerts

***Rosalind W. Picard and Elliott Hedman***

Working with the New World Symphony, we measured participant skin conductance as they attended a classical concert for the first time. With the sensor technology, we noted times when the audience reacted or engaged with the music and other times when they became bored and drifted away. Our overall findings suggest that transitions, familiarity, and visual supplements can make concerts accessible and exciting for new concert goers. We hope this work can help entertainment industries better connect with their customers and refine the presentation of their work so that it can best be received by a more diverse audience.

## 230. Mapping the Stress of Medical Visits

***Rosalind W. Picard and Elliott Hedman***

Receiving a shot or discussing health problems can be stressful, but does not always have to be. We measure participants' skin conductance as they use medical devices or visit hospitals and note times when stress occurs. We then prototype possible solutions and record how the emotional experience changes. We hope work like this helps bring the medical community closer to their customers.

## 231. Measuring Arousal During Therapy for Children with Autism and ADHD

***Rosalind W. Picard and Elliott Hedman***

Physiological arousal is an important part of occupational therapy for children with autism and ADHD, but therapists do not have a way to objectively measure how therapy affects arousal. We hypothesize that when children participate in guided activities within an occupational therapy setting, informative changes in electrodermal activity (EDA) can be detected using iCalm. iCalm is a small, wireless sensor that measures EDA and motion, worn on the wrist or above the ankle. Statistical analysis describing how equipment affects EDA was inconclusive, suggesting that many factors play a role in how a child s EDA changes. Case studies provided examples of how occupational therapy affected children s EDA. This is the first study of the effects of occupational therapy s in situ activities using continuous physiologic measures. The results suggest that careful case study analyses of the relation between therapeutic activities and physiological arousal may inform clinical practice.

## 232. Mobile Health Interventions for Drug Addiction and PTSD

***Rich Fletcher and Rosalind W. Picard***

We are developing a mobile phone-based platform to assist people with chronic diseases, panic-anxiety disorders, or addictions. Making use of wearable, wireless biosensors, the mobile phone uses pattern analysis and machine learning algorithms to detect specific physiological states and perform automatic interventions in the form of text/images plus sound files and social networking elements. We are currently working with the Veterans Administration drug rehabilitation program involving veterans with PTSD.

## 233. Mobisensus: Predicting Your Stress/Mood from Mobile Sensor Data

***Akane Sano and Rosalind Picard***

Can we recognize stress, mood, and health conditions from wearable sensors and mobile-phone usage data? We analyze long-term, multi-modal physiological, behavioral, and social data (electrodermal activity, skin temperature, accelerometer, phone usage, social network patterns) in daily lives with wearable sensors and mobile phones to extract bio-markers related to health conditions, interpret inter-individual differences, and develop systems to keep people healthy.

## 234. Multimodal Computational Behavior Analysis

***David Forsyth (UIUC), Gregory Abowd (GA Tech), Jim Rehg (GA Tech), Shri Narayanan (USC), Matthew Goodwin (NEU), Rosalind W. Picard, Javier Hernandez Rivera, Micah Eckhardt, Stan Scarloff (BU) and Takeo Kanade (CMU)***

This project will define and explore a new research area we call Computational Behavior Science integrated technologies for multimodal computational sensing and modeling to capture, measure, analyze, and understand human behaviors. Our motivating goal is to revolutionize diagnosis and treatment of behavioral and developmental disorders. Our thesis is that emerging sensing and interpretation capabilities in vision, audition, and wearable computing technologies, when further developed and properly integrated, will transform this vision into reality. More specifically, we hope to: (1) enable widespread autism screening by allowing non-experts to easily collect high-quality behavioral data and perform initial assessment of risk status; (2) improve behavioral therapy through increased availability and improved quality, by making it easier to track the progress of an intervention and follow guidelines for maximizing learning progress; and (3) enable longitudinal analysis of a child's development based on quantitative behavioral data, using new tools for visualization.

Alumni Contributor: Rana El Kaliouby

## 235. Objective Asessment of Depression and Its Improvement

**NEW LISTING**

***Rosalind W. Picard, Szymon Fedor, Brigham and Women's Hospital and Massachusetts General Hospital***

Current methods to assess depression and then ultimately select appropriate treatment have many limitations. They are usually based on having a clinician rate scales, which were developed in the 1960s. Their main drawbacks are lack of objectivity, being symptom-based and not preventative, and requiring accurate communication. This work explores new technology to assess depression, including its increase or decrease, in an automatic, more objective, presymptomatic and cost-effective way using wearable sensors and smart phones for monitoring 24/7 different personal parameters (physiological data, voice characteristics, sleep, social interaction, etc.). We aim to enable early diagnosis of depression, prevention of depression, assessment of depression for people who cannot communicate, better assignment of a treatment, early detection of treatment remission and response, and anticipation of post-treatment relapse or recovery.

## 236. Panoply

***Rosalind W. Picard and Robert Morris***

Panoply is a crowdsourcing application for mental health and emotional well-being. The platform offers a novel approach to computer-based psychotherapy, one that is optimized for accessibility, engagement and therapeutic efficacy. A three-week randomized controlled trial with 166 participants compared Panoply to an active control task (online expressive writing). Panoply conferred greater or equal benefits for nearly every therapeutic outcome measure. Panoply also significantly outperformed the control task on all measures of engagement.

## 237. Reinventing the Retail Experience

***Elliott Hedman and Rosalind W. Picard***

With skin conductance sensors, we map out what frustrates and excites customers as they shop from layout to wanting to touch the product. Our work has helped a variety of large retailers innovate on what it means to shop. Findings have focused on reducing the stress of choices and learning while surprising customers in new ways. With the sensor technology we can pinpoint moments when customers are overwhelmed and then build out new ways to make retail engaging again.

### 238. SenseGlass: Using Google Glass to Sense Daily Emotions

**NEW LISTING**

***Rosalind W. Picard and Javier Hernandez Rivera***

For over a century, scientists have studied human emotions in laboratory settings. However, these emotions have been largely contrived elicited by movies or fake lab stimuli, which tend not to matter to the participants in the studies, at least not compared with events in their real lives. This work explores the utility of Google Glass, a head-mounted wearable device, to enable fundamental advances in the creation of affect-based user interfaces in natural settings.

### 239. StoryScape

***Rosalind W. Picard and Micah Eckhardt***

Stories, language, and art are at the heart StoryScape. While StoryScape began as a tool to meet the challenging language learning needs of children diagnosed with autism, it has become much more. StoryScape was created to be the first truly open and customizable platform for creating animated, interactive storybooks that can interact with the physical world. Download the android app: https://play.google.com/store/apps/details?id=edu.mit.media.storyscape and make your own amazing stories at https://storyscape.io/.

### 240. Valinor

**NEW LISTING**

***Rosalind W. Picard, Karthik Dinakar, Eric Horvitz (Microsoft Research) and Matthew Nock (Harvard)***

We are developing statistical tools for understanding, modeling and predicting self-harm by using advanced probabilistic graphical models and fail-soft machine learning in collaboration with Harvard and Microsoft Research

## Ramesh Raskar: Camera Culture

**Making the invisible visible inside our bodies, around us, and beyond for health, work, and connection.**

### 241. 6D Display

***Ramesh Raskar, Martin Fuchs, Hans-Peter Seidel, and Hendrik P. A. Lensch***

Is it possible to create passive displays that respond to changes in viewpoint and incident light conditions? Holograms and 4D displays respond to changes in viewpoint. 6D displays respond to changes in viewpoint as well as surrounding light. We encode the 6D reflectance field into an ordinary 2D film. These displays are completely passive and do not require any power. Applications include novel instruction manuals and mood lights.

### 242. A Switchable Light Field Camera

***Matthew Hirsch, Sriram, Sivaramakrishnan, Suren Jayasuriya, Albert Wang, Aloysha Molnar, Ramesh Raskar, and Gordon Wetzstein***

We propose a flexible light field camera architecture that represents a convergence of optics, sensor electronics, and applied mathematics. Through the co-design of a sensor that comprises tailored, Angle Sensitive Pixels and advanced reconstruction algorithms, we show that contrary to light field cameras today our system can use the same measurements captured in a single sensor image to recover either a high-resolution 2D image, a low-resolution 4D light field using fast, linear processing, or a high-resolution light field using sparsity-constrained optimization.

## 243. Bokode: Imperceptible Visual Tags for Camera-Based Interaction from a Distance

***Ramesh Raskar, Ankit Mohan, Grace Woo, Shinsaku Hiura and Quinn Smithwick***

With over a billion people carrying camera-phones worldwide, we have a new opportunity to upgrade the classic bar code to encourage a flexible interface between the machine world and the human world. Current bar codes must be read within a short range and the codes occupy valuable space on products. We present a new, low-cost, passive optical design so that bar codes can be shrunk to fewer than 3mm and can be read by unmodified ordinary cameras several meters away.

## 244. CATRA: Mapping of Cataract Opacities Through an Interactive Approach

***Ramesh Raskar, Vitor Pamplona, Erick Passos, Jan Zizka, Jason Boggess, David Schafran, Manuel M. Oliveira, Everett Lawson, and Estebam Clua***

We introduce a novel interactive method to assess cataracts in the human eye by crafting an optical solution that measures the perceptual impact of forward scattering on the foveal region. Current solutions rely on highly trained clinicians to check the back scattering in the crystallin lens and test their predictions on visual acuity tests. Close-range parallax barriers create collimated beams of light to scan through sub-apertures scattering light as it strikes a cataract. User feedback generates maps for opacity, attenuation, contrast, and local point-spread functions. The goal is to allow a general audience to operate a portable, high-contrast, light-field display to gain a meaningful understanding of their own visual conditions. The compiled maps are used to reconstruct the cataract-affected view of an individual, offering a unique approach for capturing information for screening, diagnostic, and clinical analysis.

## 245. Coded Computational Photography

***Jaewon Kim, Ahmed Kirmani, Ankit Mohan and Ramesh Raskar***

Computational photography is an emerging multi-disciplinary field at the intersection of optics, signal processing, computer graphics and vision, electronics, art, and online sharing in social networks. The first phase of computational photography was about building a super-camera that has enhanced performance in terms of the traditional parameters, such as dynamic range, field of view, or depth of field. We call this Epsilon Photography. The next phase of computational photography is building tools that go beyond the capabilities of this super-camera. We call this Coded Photography. We can code exposure, aperture, motion, wavelength, and illumination. By blocking light over time or space, we can preserve more details about the scene in the recorded single photograph.

## 246. Coded Focal Stack Photography

***Ramesh Raskar, Gordon Wetzstein, Xing Lin and Tsinghua University***

We present coded focal stack photography as a computational photography paradigm that combines a focal sweep and a coded sensor readout with novel computational algorithms. We demonstrate various applications of coded focal stacks, including photography with programmable non-planar focal surfaces and multiplexed focal stack acquisition. By leveraging sparse coding techniques, coded focal stacks can also be used to recover a full-resolution depth and all-in-focus (AIF) image from a single photograph. Coded focal stack photography is a significant step towards a computational camera architecture that facilitates high-resolution post-capture refocusing, flexible depth of field, and 3D imaging.

## 247. Compressive Light Field Camera: Next Generation in 3D Photography

***Kshitij Marwah, Gordon Wetzstein, Yosuke Bando and Ramesh Raskar***

Consumer photography is undergoing a paradigm shift with the development of light field cameras. Commercial products such as those by Lytro and Raytrix have begun to appear in the marketplace with features such as post-capture refocus, 3D capture, and viewpoint changes. These cameras suffer from two major drawbacks: major drop in resolution (converting a 20 MP sensor to a 1 MP image) and large form factor. We have developed a new light field camera that circumvents traditional resolution losses (a 20 MP sensor turns into a full sensor resolution refocused image) in a thin form factor that can fit into traditional DSLRs and mobile phones.

## 248. Eyeglasses-Free Displays

**NEW LISTING**

***Ramesh Raskar and Gordon Wetzstein***

Millions of people worldwide need glasses or contact lenses to see or read properly. We introduce a computational display technology that predistorts the presented content for an observer, so that the target image is perceived without the need for eyewear. We demonstrate a low-cost prototype that can correct myopia, hyperopia, astigmatism, and even higher-order aberrations that are difficult to correct with glasses.

## 249. Imaging through Scattering Media Using Femtophotography

***Ramesh Raskar, Christopher Barsi and Nikhil Naik***

We use time-resolved information in an iterative optimization algorithm to recover reflectance of a three-dimensional scene hidden behind a diffuser. We demonstrate reconstruction of large images without relying on knowledge of diffuser properties.

## 250. Inverse Problems in Time-of-Flight Imaging

***Ayush Bhandari and Ramesh Raskar***

We are exploring mathematical modeling of Time-of-Flight imaging problems and solutions.

## 251. Layered 3D: Glasses-Free 3D Printing

***Gordon Wetzstein, Douglas Lanman, Matthew Hirsch, Wolfgang Heidrich, and Ramesh Raskar***

We are developing tomographic techniques for image synthesis on displays composed of compact volumes of light-attenuating material. Such volumetric attenuators recreate a 4D light field or high-contrast 2D image when illuminated by a uniform backlight. Since arbitrary views may be inconsistent with any single attenuator, iterative tomographic reconstruction minimizes the difference between the emitted and target light fields, subject to physical constraints on attenuation. For 3D displays, spatial resolution, depth of field, and brightness are increased, compared to parallax barriers. We conclude by demonstrating the benefits and limitations of attenuation-based light field displays using an inexpensive fabrication method: separating multiple printed transparencies with acrylic sheets.

## 252. LensChat: Sharing Photos with Strangers

***Ramesh Raskar, Rob Gens and Wei-Chao Chen***

With networked cameras in everyone's pockets, we are exploring the practical and creative possibilities of public imaging. LensChat allows cameras to communicate with each other using trusted optical communications, allowing users to share photos with a friend by taking pictures of each other, or borrow the perspective and abilities of many cameras.

## 253. Looking Around Corners

***Andreas Velten, Di Wu, Christopher Barsi, Ayush Bhandari, Achuta Kadambi, Nikhil Naik, Micha Feigin, Daniel Raviv, Thomas Willwacher, Otkrist Gupta, Ashok Veeraraghavan, Moungi G. Bawendi, and Ramesh Raskar***

Using a femtosecond laser and a camera with a time resolution of about one trillion frames per second, we recover objects hidden out of sight. We measure speed-of-light timing information of light scattered by the hidden objects via diffuse surfaces in the scene. The object data are mixed up and are difficult to decode using traditional cameras. We combine this "time-resolved" information with novel reconstruction algorithms to untangle image information and demonstrate the ability to look around corners.

Alumni Contributors: Andreas Velten, Otkrist Gupta and Di Wu

## 254. NETRA: Smartphone Add-On for Eye Tests

***Vitor Pamplona, Manuel Oliveira, Erick Passos, Ankit Mohan, David Schafran, Jason Boggess and Ramesh Raskar***

Can a person look at a portable display, click on a few buttons, and recover his refractive condition? Our optometry solution combines inexpensive optical elements and interactive software components to create a new optometry device suitable for developing countries. The technology allows for early, extremely low-cost, mobile, fast, and automated diagnosis of the most common refractive eye disorders: myopia (nearsightedness), hypermetropia (farsightedness), astigmatism, and presbyopia (age-related visual impairment). The patient overlaps lines in up to eight meridians and the Android app computes the prescription. The average accuracy is comparable to the prior art and in some cases, even better. We propose the use of our technology as a self-evaluation tool for use in homes, schools, and at health centers in developing countries, and in places where an optometrist is not available or is too expensive.

## 255. New Methods in Time-of-Flight Imaging

***Ramesh Raskar, Christopher Barsi, Ayush Bhandari, Anshuman Das, Micha Feigin-Almon and Achuta Kadambi***

Time-of-flight (ToF) cameras are commercialized consumer cameras that provide a depth map of a scene, with many applications in computer vision and quality assurance. Currently, we are exploring novel ways of integrating the camera illumination and detection circuits with computational methods to handle challenging environments, including multiple scattering and fluorescence emission.

Alumni Contributor: Refael Whyte

## 256. PhotoCloud: Personal to Shared Moments with Angled Graphs of Pictures

***Ramesh Raskar, Aydin Arpa, Otkrist Gupta and Gabriel Taubin***

We present a near real-time system for interactively exploring a collectively captured moment without explicit 3D reconstruction. Our system favors immediacy and local coherency to global consistency. It is common to represent photos as vertices of a weighted graph. The weighted angled graphs of photos used in this work can be regarded as the result of discretizing the Riemannian geometry of the high dimensional manifold of all possible photos. Ultimately, our system enables everyday people to take advantage of each others' perspectives in order to create on-the-spot spatiotemporal visual experiences similar to the popular bullet-time sequence. We believe that this type of application will greatly enhance shared human experiences spanning from events as personal as parents watching their children's football game to highly publicized red-carpet galas.

## 257. Polarization Fields: Glasses-Free 3DTV

***Douglas Lanman, Gordon Wetzstein, Matthew Hirsch, Wolfgang Heidrich, and Ramesh Raskar***

We introduce polarization field displays as an optically efficient design for dynamic light field display using multi-layered LCDs. Such displays consist of a stacked set of liquid crystal panels with a single pair of crossed linear polarizers. Each layer is modeled as a spatially controllable polarization rotator, as opposed to a conventional spatial light modulator that directly attenuates light. We demonstrate that such displays can be controlled, at interactive refresh rates, by adopting the SART algorithm to tomographically solve for the optimal spatially varying polarization state rotations applied by each layer. We validate our design by constructing a prototype using modified off-the-shelf panels. We demonstrate interactive display using a GPU-based SART implementation supporting both polarization-based and attenuation-based architectures.

## 258. Portable Retinal Imaging

***Everett Lawson, Jason Boggess, Alex Olwal, Gordon Wetzstein, and Siddharth Khullar***

The major challenge in preventing blindness is identifying patients and bringing them to specialty care. Diseases that affect the retina, the image sensor in the human eye, are particularly challenging to address, because they require highly trained eye specialists (ophthalmologists) who use expensive equipment to visualize the inner parts of the eye. Diabetic retinopathy, HIV/AIDS related retinitis, and age-related macular degeneration are three conditions that can be screened and diagnosed to prevent blindness caused by damage to retina. We exploit a combination of two novel ideas which simplify the constraints of traditional devices, with simplified optics and cleaver illumination in order to capture and visualize images of the retina in a standalone device easily operated by the user. Prototypes are conveniently embedded in either a mobile hand-held retinal camera, or wearable eyeglasses.

## 259. Reflectance Acquisition Using Ultrafast Imaging

***Ramesh Raskar and Nikhil Naik***

We demonstrate a new technique that allows a camera to rapidly acquire reflectance properties of objects "in the wild" from a single viewpoint, over relatively long distances and without encircling equipment. This project has a wide variety of applications in computer graphics including image relighting, material identification, and image editing.

Alumni Contributor: Andreas Velten

## 260. Second Skin: Motion Capture with Actuated Feedback for Motor Learning

***Ramesh Raskar, Kenichiro Fukushi, Christopher Schonauer and Jan Zizka***

We have created a 3D motion-tracking system with automatic, real-time vibrotactile feedback and an assembly of photo-sensors, infrared projector pairs, vibration motors, and wearable suit. This system allows us to enhance and quicken the motor learning process in a variety of fields such as healthcare (physiotherapy), entertainment (dance), and sports (martial arts).

Alumni Contributor: Dennis Ryan Miaw

## 261. Shield Field Imaging

***Jaewon Kim***

We present a new method for scanning 3D objects in a single shot, shadow-based method. We decouple 3D occluders from 4D illumination using shield fields: the 4D attenuation function which acts on any light field incident on an occluder. We then analyze occluder reconstruction from cast shadows, leading to a single-shot light field camera for visual hull reconstruction.

## 262. Single Lens Off-Chip Cellphone Microscopy

***Ramesh Raskar and Aydin Arpa***

Within the last few years, cellphone subscriptions have widely spread and now cover even the remotest parts of the planet. Adequate access to healthcare, however, is not widely available, especially in developing countries. We propose a new approach to converting cellphones into low-cost scientific devices for microscopy. Cellphone microscopes have the potential to revolutionize health-related screening and analysis for a variety of applications, including blood and water tests. Our optical system is more flexible than previously proposed mobile microscopes, and allows for wide field of view panoramic imaging, the acquisition of parallax, and coded background illumination, which optically enhances the contrast of transparent and refractive specimens.

## 263. Skin Perfusion Photography

***Ramesh Raskar, Christopher Barsi and Guy Satat***

Skin and tissue perfusion measurements are important parameters for estimating wounds and burns, and for monitoring plastic and reconstructive surgeries. In this project, we use a standard camera and a laser in order to image blood flow in skin tissue. We show results of blood flow maps of hands, arms, and fingers. We combine the complex scattering of laser light from blood with computational techniques found in computer science.

## 264. Slow Display

***Daniel Saakes, Kevin Chiu, Tyler Hutchison, Biyeun Buczyk, Naoya Koizumi and Masahiko Inami***

How can we show our 16-megapixel photos from our latest trip on a digital display? How can we create screens that are visible in direct sunlight as well as complete darkness? How can we create large displays that consume less than 2W of power? How can we create design tools for digital decal application and intuitive-computer aided modeling? We introduce a display that is high resolution but updates at a low frame rate, a slow display. We use lasers and monostable light-reactive materials to provide programmable space-time resolution. This refreshable, high resolution display exploits the time decay of monostable materials, making it attractive in terms of cost and power requirements. Our effort to repurpose these materials involves solving underlying problems in color reproduction, day-night visibility, and optimal time sequences for updating content.

## 265. SpeckleSense

***Alex Olwal, Andrew Bardagjy, Jan Zizka and Ramesh Raskar***

Motion sensing is of fundamental importance for user interfaces and input devices. In applications where optical sensing is preferred, traditional camera-based approaches can be prohibitive due to limited resolution, low frame rates, and the required computational power for image processing. We introduce a novel set of motion-sensing configurations based on laser speckle sensing that are particularly suitable for human-computer interaction. The underlying principles allow these configurations to be fast, precise, extremely compact, and low cost.

## 266. StreetScore

***Nikhil Naik, Jade Philipoom, Ramesh Raskar, Cesar Hidalgo***

**NEW LISTING**

StreetScore is a machine learning algorithm that predicts the perceived safety of a streetscape. StreetScore was trained using 2,920 images of streetscapes from New York and Boston and their rankings for perceived safety obtained from a crowdsourced survey. To predict an image's score, StreetScore decomposes this image into features and assigns the image a score based on the associations between features and scores learned from the training dataset. We use StreetScore to create a collection of map visualizations of perceived safety of street views from cities in the United States. StreetScore allows us to scale up the evaluation of streetscapes by several orders of magnitude when compared to a crowdsourced survey. StreetScore can empower research groups working on connecting urban perception with social and economic outcomes by providing high resolution data on urban perception.

## 267. Tensor Displays: High-Quality Glasses-Free 3D TV

***Gordon Wetzstein, Douglas Lanman, Matthew Hirsch and Ramesh Raskar***

We introduce tensor displays: a family of glasses-free 3D displays comprising all architectures employing (a stack of) time-multiplexed LCDs illuminated by uniform or directional backlighting. We introduce a unified optimization framework that encompasses all tensor display architectures and allows for optimal glasses-free 3D display. We demonstrate the benefits of tensor displays by constructing a reconfigurable prototype using modified LCD panels and a custom integral imaging backlight. Our efficient, GPU-based NTF implementation enables interactive applications. In our experiments we show that tensor displays reveal practical architectures with greater depths of field, wider fields of view, and thinner form factors, compared to prior automultiscopic displays.

## 268. Theory Unifying Ray and Wavefront Lightfield Propagation

***George Barbastathis, Ramesh Raskar, Belen Masia, Se Baek Oh and Tom Cuypers***

This work focuses on bringing powerful concepts from wave optics to the creation of new algorithms and applications for computer vision and graphics. Specifically, ray-based, 4D lightfield representation, based on simple 3D geometric principles, has led to a range of new applications that include digital refocusing, depth estimation, synthetic aperture, and glare reduction within a camera or using an array of cameras. The lightfield representation, however, is inadequate to describe interactions with diffractive or phase-sensitive optical elements. Therefore we use Fourier optics principles to represent wavefronts with additional phase information. We introduce a key modification to the ray-based model to support modeling of wave phenomena. The two key ideas are "negative radiance" and a "virtual light projector." This involves exploiting higher dimensional representation of light transport.

## 269. Trillion Frames Per Second Camera

***Andreas Velten, Di Wu, Adrián Jarabo, Belen Masia, Christopher Barsi, Chinmaya Joshi, Everett Lawson, Moungi Bawendi, Diego Gutierrez, and Ramesh Raskar***

We have developed a camera system that captures movies at an effective rate of approximately one trillion frames per second. In one frame of our movie, light moves only about 0.6 mm. We can observe pulses of light as they propagate through a scene. We use this information to understand how light propagation affects image formation and to learn things about a scene that are invisible to a regular camera.

## 270. Ultrasound tomography

**NEW LISTING**

***Ramesh Raskar, Micha Feigin-Almon and Brian Anthony***

Traditional medical ultrasound assumes that we are imaging ideal liquids. We interested at imaging muscle and bone as well as measuring elastic properties of tissues, all of which are places where this assumption fails quite miserably. Interested in cancer detections, Duchenne muscular dystrophy and prostethic fitting, we use tomographic techniques as well as ideas from seismic imaging to deal with these issues.

## 271. Vision on Tap

***Ramesh Raskar***

Computer vision is a class of technologies that lets computers use cameras to automatically stitch together panoramas, reconstruct 3D geometry from multiple photographs, and even tell you when the water's boiling. For decades, this technology has been advancing mostly within the confines of academic institutions and research labs. Vision on Tap is our attempt to bring computer vision to the masses.

Alumni Contributor: Kevin Chiu

## 272. VisionBlocks

***Chunglin Wen and Ramesh Raskar***

VisionBlocks is an on-demand, in-browser, customizable, computer-vision application-building platform for the masses. Even without any prior programming experience, users can create and share computer vision applications. End-users drag and drop computer vision processing blocks to create their apps. The input feed could be either from a user's webcam or a video from the Internet. VisionBlocks is a community effort where researchers obtain fast feedback, developers monetize their vision applications, and consumers can use state-of-the-art computer vision techniques. We envision a Vision-as-a-Service (VaaS) over-the-web model, with easy-to-use interfaces for application creation for everyone.

Alumni Contributors: Abhijit Bendale, Kshitij Marwah and Jason Boggess and Kevin Chiu

## 273. Visual Lifelogging

***Hyowon Lee, Nikhil Naik, Lubos Omelina, Daniel Tokunaga, Tiago Lucena and Ramesh Raskar***

We are creating a novel visual lifelogging framework for applications in personal life and workplaces.

# Mitchel Resnick: Lifelong Kindergarten

**Engaging people in creative learning experiences.**

## 274. App Inventor

***Hal Abelson, Eric Klopfer, Mitchel Resnick, Andrew McKinney, CSAIL and Scheller Teacher Education Program***

App Inventor is an open-source tool that democratizes app creation. By combining LEGO-like blocks onscreen, even users with no prior programming experience can use App Inventor to create their own mobile applications. Currently, App Inventor has over 2,000,000 users and is being taught by universities, schools, and community centers worldwide. In those initiatives, students not only acquire important technology skills such as computer programming, but also have the opportunity to apply computational thinking concepts to many fields including science, health, education, business, social action, entertainment, and the arts. Work on App Inventor was initiated in Google Research by Hal Abelson and is continuing at the MIT Media Lab as part of its Center for Mobile Learning, a collaboration with the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) and the Scheller Teacher Education Program (STEP).

## 275. Build-in-Progress

***Tiffany Tseng and Mitchel Resnick***

Build-in-Progress is a platform for sharing the story of your design process. With Build-in-Progress, makers document as they develop their design process, incorporating iterations and failures along the way and getting feedback as they develop their projects.

## 276. Computer Clubhouse

***Mitchel Resnick, Natalie Rusk, Chris Garrity, Alisha Panjwani***

At Computer Clubhouse after-school centers, young people (ages 10-18) from low-income communities learn to express themselves creatively with new technologies. Clubhouse members work on projects based on their own interests, with support from adult mentors. By creating their own animations, interactive stories, music videos, and robotic constructions, Clubhouse members become more capable, confident, and creative learners. The first Computer Clubhouse was established in 1993, as a collaboration between the Lifelong Kindergarten group and The Computer Museum (now part of the Boston Museum of Science). With financial support from Intel Corporation, the network has expanded to more than 100 centers in 20 countries, serving more than 20,000 young people. The Lifelong Kindergarten group continues to develop new technologies, introduce new educational approaches, and lead professional-development workshops for Clubhouses around the world.

Alumni Contributors: rberg, Leo Burd, Robbin Chapman, Rachel Garber, Tim Gorton, Michelle Hlubinka, Elisabeth Sylvan and Claudia Urrea

## 277. Computer Clubhouse Village

***Chris Garrity, Natalie Rusk, and Mitchel Resnick***

The Computer Clubhouse Village is an online community that connects people at Computer Clubhouse after-school centers around the world. Through the Village, Clubhouse members and staff at more than 100 Clubhouses in 20 countries can share ideas with one another, get feedback and advice on their projects, and work together on collaborative design activities.

Alumni Contributors: Robbin Chapman, Rachel Garber and Elisabeth Sylvan

## 278. DIY Cellphone

***David A. Mellis and Leah Buechley***

An exploration into the possibilities for individual construction and customization of the most ubiquitous of electronic devices, the cellphone. By creating and sharing open-source designs for the phone's circuit board and case, we hope to encourage a proliferation of personalized and diverse mobile phones. Freed from the constraints of mass production, we plan to explore diverse materials, shapes, and functions. We hope that the project will help us explore and expand the limits of do-it-yourself (DIY) practice. How close can a homemade project come to the design of a cutting-edge device? What are the economics of building a high-tech device in small quantities? Which parts are even available to individual consumers? What's required for people to customize and build their own devices?

## 279. DressCode

***Jennifer Jacobs, Leah Buechley, and Mitchel Resnick***

DressCode is a computer-aided design and fabrication tool that combines programming with graphic drawing and manipulation, allowing novice programmers to create computationally-generated, physical artifacts. The software consists of a programming environment and a graphic-user interface design tool, as well as a custom programming language. The GUI tools allow for a unique combination of graphic drawing and computational manipulation, because the software automatically generates editable code in the programming environment that reflects the designer s drawing actions. DressCode exports designs that are compatible with digital fabrication machines, allowing for the creation of physical artifacts. We have introduced DressCode to amateur programmers with a series of craft activities that allow them to produce functional, beautiful, and unique objects including t-shirts, jewelry, and personal accessories.

## 280. Family Creative Learning

***Ricarose Roque, Natalie Rusk, and Mitchel Resnick***

In Family Creative Learning, we engage parents and children in workshops to design and learn together with creative technologies, like the Scratch programming language and the MaKey MaKey invention kit. Just as children's literacy can be supported by parents reading with them, children's creativity can be supported by parents creating with them. In these workshops, we especially target families with limited access to resources and social support around technology. By promoting participation across generations, these workshops engage parents in supporting their children in becoming creators and full participants in today s digital society.

## 281. Learning Creative Learning

***Mitchel Resnick, Philipp Schmidt, Natalie Rusk, Grif Peterson, Katherine McConachie, Srishti Sethi, Alisha Panjwani***

Learning Creative Learning (http://learn.media.mit.edu/lcl) is an online course that introduces ideas and strategies for supporting creative learning. The course engages educators, designers, and technologists from around the world in applying creative learning tools and approaches from the MIT Media Lab. We view the course as an experimental alternative to traditional Massive Open Online Courses (MOOCs), putting greater emphasis on peer-to-peer learning, hands-on projects, and sustainable communities.

## 282. Learning with Data

***Sayamindu Dasgupta and Mitchel Resnick***

More and more computational activities revolve around collecting, accessing, and manipulating large sets of data, but introductory approaches for learning programming typically are centered around algorithmic concepts and flow of control, not around data. Computational exploration of data, especially data-sets, has been usually restricted to predefined operations in spreadsheet software like Microsoft Excel. This project builds on the Scratch programming language and environment to allow children to explore data and datasets. With the extensions provided by this project, children can build Scratch programs to not only manipulate and analyze data from online sources, but also to collect data through various means such as surveys and crowd-sourcing. This toolkit will support many different types of projects like online polls, turn-based multiplayer games, crowd-sourced stories, visualizations, information widgets, and quiz-type games.

## 283. MaKey MaKey

***Eric Rosenbaum, Jay Silver, and Mitchel Resnick***

MaKey MaKey lets you transform everyday objects into computer interfaces. Make a game pad out of Play-Doh, a musical instrument out of bananas, or any other invention you can imagine. It's a little USB device you plug into your computer, and you use it to make your own switches that act like keys on the keyboard: Make + Key = MaKey MaKey! It s plug and play. No need for any electronics or programming skills. Since MaKey MaKey looks to your computer like a regular mouse and keyboard, it s automatically compatible with any piece of software you can think of. It s great for beginners tinkering and exploring, for experts prototyping and inventing, and for everybody who wants to playfully transform their world.

## 284. Making Learning Work

***J. Philipp Schmidt, Juliana Nazare, Srishti Sethi***

Improving adult learning, especially for adults who are unemployed or unable to financially support their families, is a challenge that affects the future well-being of millions of individuals in the US. We are working with the Joyce Foundation, employers, learning researchers, and the Media Lab community to prototype three to five new models for adult learning that involve technology innovation and behavioral insights.

## 285. Making with Stories

***Alisha Panjwani, Natalie Rusk, Mitchel Resnick***

We are developing a set of participatory maker activities to engage youth in creating tangible projects that depict stories about themselves and their worlds. These activities introduce electronics and computational tools as a medium to create, connect, express, and derive meaning from personal narratives. For example, we are offering workshops where participants design sewable circuits and bring them together to create a collaborative Story Quilt. Through the Making with Stories project we are exploring how story-based pedagogy can inspire youth participation in arts and engineering within formal and informal learning environments.

## 286. Map Scratch

***Sayamindu Dasgupta, Brian Silverman, and Mitchel Resnick***

Map Scratch is an extension of Scratch that enables kids to program with maps within their Scratch projects. With Map Scratch, kids can create interactive tours, games, and data visualizations with real-world geographical data and maps.

## 287. Media Lab Virtual Visit

***Srishti Sethi and J. Philipp Schmidt***

**NEW LISTING**

Media Lab Virtual Visit is intended to open up the doors of the Media Lab to people from all around the world. The visit is hosted on the Unhangout platform, a new way of running large-scale unconferences on the web that was developed at the Media Lab. It is an opportunity for students or potential collaborators to talk with current researchers at the Lab, learn about their work and share ideas.

## 288. MelodyMorph

***Eric Rosenbaum and Mitchel Resnick***

MelodyMorph is an interface for constructing melodies and making improvised music. It removes a constraint of traditional musical instruments: a fixed mapping between space and pitch. What if you blew up the piano so you could put the keys anywhere you want? With MelodyMorph you can create a customized musical instrument, unique to the piece of music, the player, or the moment.

## 289. Novice Design of Interactive Products

**NEW LISTING**

***David A. Mellis and Mitchel Resnick***

Despite recent widespread interest in hobbyist electronics and the maker movement, the design of printed circuit boards (PCBs) remains an obscure and often intimidating activity. This project attempts to introduce PCB design and production to new audiences by creating examples, activities, and other resources that provide context and motivation for those practices. I've developed a series of interactive lights that demonstrate the creation of useable products with simple circuits. These examples introduce novices to the space of possibilities and provide them with a starting point for creating their own designs. In workshops, novices design, produce, assemble, and program their own electronic circuits. These workshops provide an entry point to understanding the way that electronic products are made and an opportunity for discussion and reflection about how more people might get involved in their production.

## 290. Open Learning

***Philipp Schmidt and Mitchel Resnick***

Learning for everyone, by everyone. The Open Learning project builds online learning communities that work like the web: peer-to-peer, loosely joined, open. And it works with Media Lab faculty and students to open up the magic of the Lab through online learning. Our first experiment was Learning Creative Learning, a course taught at the Media Lab, which attracted 24,000 participants. We are currently developing ideas for massive citizen science projects, engineering competitions for kids, and new physical infrastructures for learning that reclaim the library.

## 291. Para

**NEW LISTING**

***Jennifer Jacobs, Mitchel Resnick, Joel Brandt, and Radomir Mech***

Procedural representations, enabled through programming, are a powerful tool for digital illustration but writing code conflicts with the intuitiveness and immediacy of direct manipulation. Para is a digital illustration tool that uses direct manipulation to define and edit procedural artwork. Through creating and altering vector paths, artists can define iterative distributions, parametric constraints, and conditional behaviors. Para makes it easier for people to create generative artwork, and creates a intuitive workflow between manual and procedural drawing methods.

## 292. Scratch

***Mitchel Resnick, Natalie Rusk, Eric Schilling, Amos Blanton, Champika Fernando, Sayamindu Dasgupta, Ricarose Roque, Kasia Chmielinski, Shane Clements, Carl Bowman, Matt Taylor, Ray Schamp, Chris Willis-Ford, Brian Silverman, Paula Bonta***

Scratch is a programming language and online community (http://scratch.mit.edu) that makes it easy to create your own interactive stories, games, animations, and simulations and share your creations online. As young people create and share Scratch projects, they learn to think creatively, reason systematically, and work collaboratively, while also learning important mathematical and computational ideas. Young people around the world have shared more than six million projects on the Scratch website, with thousands of new projects every day.

Alumni Contributors: Karen Brennan, Gaia Carini, Michelle Chung, Margarita Dekoli, Evelyn Eastmond, John H. Maloney, Amon Millner, Andres Monroy-Hernandez, Eric Rosenbaum, Jay Saul Silver and Tamara Stern

## 293. Scratch Data Blocks

***Sayamindu Dasgupta, Mitchel Resnick, Natalie Rusk, and Benjamin Mako Hill***

**NEW LISTING**

Scratch Data Blocks is an NSF-funded project that extends the Scratch programming language to enable youth to analyze and visualize their own learning and participation in the Scratch online community. With Scratch Data Blocks, youth in the Scratch community can easily access, analyze, and represent data about the ways they program, share, and discuss Scratch projects.

## 294. Scratch Day

***Lisa O'Brien, Kasia Chmielinski, Carl Bowman, and Mitchel Resnick***

Scratch Day (day.scratch.mit.edu) is a network of face-to-face local gatherings, on the same day in all parts of the world, where people can meet, share, and learn more about Scratch, a programming environment that enables people to create their own interactive stories, games, animations, and simulations. We believe that these types of face-to-face interactions remain essential for ensuring the accessibility and sustainability of initiatives such as Scratch. In-person interactions enable richer forms of communication among individuals, more rapid iteration of ideas, and a deeper sense of belonging and participation in a community. The first Scratch Day took place in 2009. In 2014, there were 260 events in 56 countries.

Alumni Contributor: Karen Brennan

## 295. Scratch Extensions

***Shane Clements, Chris Willis-Ford, Sayamindu Dasgupta, Amos Blanton, Mitchel Resnick***

The Scratch extension system enables anyone to extend the Scratch programming language through custom programming blocks written in JavaScript. The extension system is designed to enable innovating on the Scratch programming language itself, in addition to innovating with it through projects. With the extension system, anyone can write custom Scratch blocks that enable others to use Scratch to program hardware devices such as the LEGO WeDo, get data from online web-services such as weather.com, and use advanced web-browser capabilities such as speech recognition.

Alumni Contributors: Abdulrahman Y. idlbi and John H. Maloney

## 296. ScratchJr

***Mitchel Resnick, Champika Fernando, Tim Mickel, Sayamindu Dasgupta, Marina Bers, Paula Bonta, and Brian Silverman***

The ScratchJr project brings the ideas and spirit of Scratch programming activities to younger children, enabling children ages five to seven to program their own interactive stories, games, and animations. To make ScratchJr developmentally appropriate for younger children, we are revising the interface and providing new structures to help young children learn core math concepts and problem-solving strategies. ScratchJr is now available as a free app for iPads (and will be available for Android soon).

## 297. Singing Fingers

***Eric Rosenbaum, Jay Silver, and Mitchel Resnick***

Singing Fingers allows children to fingerpaint with sound. Users paint by touching a screen with a finger, but color only emerges if a sound is made at the same time. By touching the painting again, users can play back the sound. This creates a new level of accessibility for recording, playback, and remixing of sound.

## 298. Start Making!

***Alisha Panjwani, Jennifer Jacobs, Tiffany Tseng, Jie Qi, David Mellis, Chris Garrity, Ricarose Roque, Natalie Rusk, Mitchel Resnick***

The Lifelong Kindergarten group is collaborating with the Museum of Science in Boston to develop materials and workshops that engage young people in "maker" activities in Computer Clubhouses around the world, with support from Intel. The activities introduce youth to the basics of circuitry, coding, crafting, and engineering.

In addition, graduate students are testing new maker technologies and workshops for Clubhouse staff and youth. The goal of the initiative is to help young people from under-served communities gain experience and confidence in their ability to design, create, and invent with new technologies.

### 299. Unhangout

***Philipp Schmidt, Drew Harry, Charlie DeTar, and Srishti Sethi***

Unhangout is an open-source platform for running large-scale unconferences online. We use Google Hangouts to create as many small sessions as needed, and help users find others with shared interests. Think of it as a classroom with an infinite number of breakout sessions. Each event has a landing page, which we call the lobby. When participants arrive, they can see who else is there and chat with each other. The hosts can do a video welcome and introduction that gets streamed into the lobby. Participants then break out into smaller sessions (up to 10 people per session) for in-depth conversations, peer-to-peer learning, and collaboration on projects. UnHangouts are community-based learning instead of top-down information transfer.

## Deb Roy: Social Machines

**Designing media technologies for social engagement and change.**

### 300. Media Ecosystem Analysis: Lessons from the Boston Marathon Bombings

***Soroush Vosoughi and Deb Roy***

In this project we examine the social media and traditional media's response to the Boston Marathon bombings from the moment of the explosion to two weeks after the events, including the search, hunt, and capture of the suspects. We use big data analytics, natural language processing, and complex system and network analysis techniques. We focus specifically on information flow, engagement and attention of the audience, emergence of broadcasters, source and spread of rumors, and interplay of various media. We hope to develop a better understanding of the nature of information generation and flow from broadcasters and audiences across different media. Using this event as a case study, we can find out what went wrong or right, and come up with recommendations for different actors (news sources, social media participants, police departments) to better facilitate information flow and minimize misunderstanding and the spread of false information.

### 301. Predicting the Veracity of Rumors in Social Networks

***Soroush Vosoughi and Deb Roy***

The spread of malicious or accidental misinformation in social media, especially in time-sensitive situations such as real-world emergencies, can have harmful effects on individuals and society. Motivated by this, we are creating computational models of false and true information on Twitter and Reddit to investigate the nature of rumors surrounding real-world events, using the April 2013 Boston Marathon bombings as a case study. When fully trained, our models will be evaluated on the rumors surrounding the August 2014 Ferguson unrest. Once fully evaluated, the models will be used to build a real-time rumor verification system for Twitter and Reddit that can be used during real-world emergencies. This system will have immediate real-world applications for consumers of news, journalists, and emergency services and can help minimize and dampen the impact of misinformation.

## Chris Schmandt: Speech + Mobility

**Enhancing mobile life through improved user interactions.**

### 302. Activ8

***Misha Sra and Chris Schmandt***

Activ8 is a system of three short games: See-Saw, a balancing game for Glass; Jump Beat, a music beat matching game for Glass; and Learning to Fly, a Kinect game where users keep a virtual bird in the air by flapping their arms. Recent epidemiological evidence points at sitting as being the most common contributor to an inactive lifestyle. We aim to offer a starting point towards designing and building an understanding about how "physical casual games" can contribute to helping address the perils of sitting.

### 303. Back to the Desktop

***Andrea Colaco, Hye Soo Yang, Chris Schmandt***

In this project, we construct a virtual desktop centered around the smartphone display with the surface around the display opportunistically used for input. We use a 3-pixel optical time-of-flight sensor, Mime, to capture hand motion. The sensor on the phone allows the table surface next to the phone to be mapped to conventional desktop windows, and the phone's display is a small viewport onto this desktop. Moving the hand is like moving the mouse, and as the user shifts into another part of the desktop, the phone viewport display moves with it. We demonstrate that instead of writing new applications to use smart surfaces, existing applications can be readily controlled with the hands.

### 304. Glass Ear

***Dhruv Jain and Chris Schmandt***

**NEW LISTING**

Persons with hearing loss use visual signals such as gestures and lip movement to interpret speech. While hearing aids and cochlear implants can improve sound recognition, they generally do not help the wearer localize sound necessary to leverage these visual cues. We design and evaluate visualizations for spatially locating sound on a head-mounted display (HMD). After a large-scale formative study and gathering preferences for specific design options, we implemented a real-time proof-of-concept HMD prototype on Google Glass and solicited feedback from deaf and hard of hearing individuals. Current developments are aiming towards creating a wearable prototype for field deployments.

### 305. iReality

***Chris Schmandt and Hye Soo Yang***

**NEW LISTING**

iReality is a spatial data retrieval system in Augmented Reality application for full-display head-mounted displays. It is geared towards restoring a larger operational space for spatially oriented digital information by associating it with physical objects and spaces. The system is built around a physical notebook and a bookshelf and the user is able to augment any desired contents onto these objects. Different levels of augmentation is used to supplement the situational lack of object or space affordances for mobile use cases. Natural hand gestures integrated with the system further facilitate more intuitive and easier user interactions.

### 306. Live Trace

***Hye Soo Yang, Andrea Colaco and Chris Schmandt***

In this interactive experience we are interested in enabling quick input actions to Google Glass. The application allows users to trace an object or region of interest in their live view. We use the trace as the foundation for allowing the user to indicate interest in a visual region. Once selected, the user can choose to apply filters to the region, annotate the selection through speech input, or capture text through optical character recognition. These selection and processing tools could naturally

integrate with quick note-taking applications where limited touchpad input precludes such input. The Live Trace app demonstrates the effectiveness of gestural control for head-mounted displays.

## 307. MugShots

***Cindy Hsin-Liu Kao and Chris Schmandt***

MugShots enables visual communication though everyday objects. We embed a small display into a coffee mug an object with frequent daily use. Targeted for the workplace, the mug transitions between different communication modes in public and private spaces. In the private office space, the mug is an object for intimate communication between remote friends; users receive emoticon stickers via the display. When brought to a public area, the mug switches to a pre-selected image of the user's choice, serving as a social catalyst to trigger conversations in public spaces.

## 308. OnTheGo

***Misha Sra, Chris Schmandt***

**NEW LISTING**

As mobile device screens continue to get smaller (smartwatches, head-mounted devices like Google Glass), touch-based interactions with them become harder. With OnTheGo, our goal is to complement touch- and voice-based input on these devices by adding interactions through in-air gestures around the devices. Gestural interactions are not only intuitive for certain situations where touch may be cumbersome like running, skiing, or cooking, but are also convenient for things like quick application and task management, certain types of navigation and interaction, and simple inputs to applications.

## 309. Pintail

***Chris Schmandt and Sujoy Kumar Chowdhury***

Pintail is a travel companion app for guided storytelling. It will start by capturing your travel plan so that it can nudge you with personalized story-creation triggers at the right context. Pintail would act as a work-in-progress scrapbook from the moment a trip is planned. It will provide users the structure and tools for storytelling while taking into account the short attention span of today's audience. Pintail would use priming as a technique by showing the user what others feel or have drawn about the places he or she is visiting. Some of the content of Pintail prompts would be automatically collected from travel review sites. Users can then use the Pintail story-creation tools to reflect and create their own stories. Pintail would also attempt to balance between the story creation activity and the actual trip experience.

## 310. Spellbound

***Misha Sra and Chris Schmandt***

Spellbound is a mobile game that gets you outdoors. It explores the space between physical sports and the fantastical worlds of video games as a place to create new game dynamics around real-time mobile, social, and physically active digital play.

## 311. Spotz

***Chris Schmandt and Misha Sra***

Exploring your city is a great way to make friends, discover new places, find new interests, and invent yourself. Spotz is an Android app where everyone collectively defines the places they visit and the places in turn define them. Spotz allows you to discover yourself by discovering places. You tag a spot and create some buzz for it; if everyone agrees the spot is fun this bolsters your "fun" quotient. If everyone agrees the spot is geeky it pushes up your "geeky" score. Thus emerges your personal tag cloud. Follow tags to chance upon new places. Find people with similar tag clouds as your own and experience new places together. Create buzz for your favorite spots and track other buzz to find who has the #bestchocolatecake in town!

## 312. techNailogy

***Cindy Hsin-Liu Kao, Artem Dementyev, Chris Schmandt***

**NEW LISTING**

techNailogy is a nail-mounted gestural input surface. Using capacitive sensing on printed electrodes, the interface can distinguish on-nail finger swipe gestures with high accuracy. techNailogy works in real time: we miniaturized the system to fit on the fingernail, while wirelessly transmitting the sensor data to a mobile phone or PC. techNailogy allows for one-handed and always-available input, while being unobtrusive and discreet. Inspired by commercial nail stickers, the device blends into the user s body, is customizable, fashionable, and even removable. We show example applications of using the device as a remote controller when hands are busy and using the system to increase the input space of mobile phones.

# Kevin Slavin: Playful Systems

**Designing systems that become experiences to transcend utility and usability.**

## 313. Tools for Super-Human Time Perception

***Kevin Slavin and Che-Wei Wang***

**NEW LISTING**

Time perception is a fundamental component in our ability to build mental models of our world. Without accurate and precise time perception, we might have trouble understanding speech, fumble social interactions, have poor motor control, hallucinate, or remember events incorrectly. Slight distortions in time perception are commonplace and may lead to slight dyslexia, memory shifts, poor eye-hand coordination and other relatively benign symptoms, but could a diminishing sense of time signal the onset of a serious brain disorder? Could time perception training help prevent or reverse brain disorders? This project is a series of experimental tools built to assist and increase human time perception. By approaching time-perception training from various perspectives, we hope to find a tool or collection of tools to increase time perception, and in turn discover what an increase in time perception might afford us.

## 314. 20 Day Stranger

***Kevin Slavin, Julie Legault, Taylor Levy, Che-Wei Wang, Dalai Lama Center for Ethics and Transformative Values and Tinsley Galyean***

20 Day Stranger is a mobile app that creates an intimate and anonymous connection between you and another person. For 20 days, you get continuous updates about where they are, what they are doing, and eventually even how they are feeling, and them likewise about you. But you will never know who this person is. Does this change the way you think about other people you see through out your day, anyone of which could be your stranger?

## 315. 32,768 Times Per Second

***Kevin Slavin and Taylor Levy***

The crystal oscillator inside a quartz wristwatch vibrates at 32,768 times per second. This is too fast for a human to perceive, and even more difficult to imagine its interaction with the mechanical circulation of a clock. 32,768 Times Per Second is a diagrammatic, procedural, and fully functional sculpture of the electro-mechanical landscape inside a common wristwatch. Through a series of electronic transformations, the signal from a crystal is broken down over and over, and then built back up to the human sense of time.

## 316. beneath the chip

***Kevin Slavin and Taylor Levy***

**NEW LISTING**

Sculptural artifacts that model and reveal the embedded history of human thought and scientific principles hidden inside banal digital technologies. These artifacts provide alternative ways to engage and understand the deepest interior of our everyday devices, below the circuit, below the chip. They build a sense of the machines within the machine, the material, the grit of computation.

## 317. Case and Molly

***Gregory Borenstein***

Case and Molly is a prototype for a game inspired by (and in homage to) William Gibson's novel Neuromancer. It's about the coordination between virtual and physical, "cyberspace" and "meat." We navigate the tension between our physical surroundings and our digital networks in a state of continuous partial attention; Case and Molly uses the mechanics and aesthetics of Neuromancer to explore this quintessential contemporary dynamic. The game is played by two people mediated by smartphones and an Oculus Rift VR headset. Together, and under time pressure, they must navigate Molly through physical space using information that is only available to Case. In the game, Case sees Molly's point of view in immersive 3D, but he can only communicate a single bit of information to her. Meanwhile, Molly traverses physical obstacles hoping Case can solve abstract puzzles in order to gain access to the information she needs.

## 318. Cordon Sanitaire

***Kevin Slavin***

Named for, and inspired by, the medieval practice of erecting barriers to prevent the spread of disease, Cordon Sanitaire is a collaborative, location-based mobile game in which players seek to isolate an infectious "patient zero" from the larger population. Every day, the game starts abruptly synchronizing all players at once and lasts for two minutes. In 60 seconds, players must choose either to help form the front line of a quarantine, or remain passive. Under pressure, the uninfected attempt to collaborate without communication, seeking to find the best solution for the group. When those 60 seconds end, a certain number of players are trapped inside with patient zero, and the score reflects the group s ability to cooperate under duress.

## 319. DeepView: Computational Tools for Chess Spectatorship

***Gregory Borenstein, Kevin Slavin, and Maurice Ashley***

Competitive chess is an exciting spectator sport. It is fast-paced, dynamic, and deeply psychological. Unfortunately, most of the game's drama is only visible to spectators who are themselves expert chess players. DeepView seeks to use computational tools to make the drama of high-level chess accessible to novice viewers. There is a long tradition of software trying to beat human players at chess; DeepView takes advantage of algorithmic tools created in the development of advanced chess engines such as Deep Blue, but instead uses them to understand and explain the styles of individual players and the dynamics of a given match. It puts into the hands of chess commentators powerful data science tools that can calculate player position preferences and likely game outcomes, helping commentators to better explain the exciting human story inside every match.

## 320. Designing Immersive Multi-Sensory Eating Experiences

***Kevin Slavin and Janice Wang***

Food offers a rich multi-modal experience that can deeply affect emotion and memory. We're interested in exploring the artistic and expressive potential of food beyond mere nourishment, as a means of creating memorable experiences that involve multiple senses. For instance, music can change our eating experience by altering our emotions during the meal, or by evoking a specific time and place. Similarly, sight, smell, and temperature can all be manipulated to combine with food for expressive effect. In addition, by drawing upon people's physiology and upbringing, we seek to create individual, meaningful sensory experiences. Specifically, we are exploring the connection between music and flavor perception.

## 321. Dice++

***Kevin Slavin and Jonathan Bobrow***

**NEW LISTING**

Today, algorithms drive our cars, our economy, what we read, and how we play. Modern-day computer games utilize weighted probabilities to make games more competitive, fun, and addicting. In casinos, slot machines once a product of simple probability employ similar algorithms to keep players playing. Dice++ takes the seemingly straight probability of rolling a die and determines an outcome with algorithms of its own.

## 322. EyeWire

***Sebastian Seung, Kevin Slavin, Gregory Borenstein, Taylor Levy, David Robert, Che-Wei Wang and Seung Lab (MIT BCS)***

The Seung Lab at MIT's Brain + Cognitive Sciences Department has developed EyeWire, a game to map the brain. To date, it has attracted an online community of over 50,000 "citizen neuroscientists" who are mapping the 3D structure of neurons and discovering neural connections. Playful Systems is collaborating with the Seung Lab to reconsider EyeWire as a large scale mass-appeal mobile game to attract 1MM players or more. We are currently developing mobile, collaborative game mechanics, and shifting the focus to short-burst gameplay.

## 323. Homeostasis

***Kevin Slavin, Kamal Farah, Julie Legault and Denis Bozic***

**NEW LISTING**

A large-scale art installation that investigates the biological systems that represent and embody human life, and their relationship to the built environment. This synthetic organism built from interconnected microbiological systems will be sustained in part through its own feedback and feedforward loops, but also through interactions with the architectural systems (like HVAC). As the different systems react and exchange material inputs and outputs, they move towards homeostasis. In the process, Homeostasis creates a new landscape of the human body, in which we can experience the wonder and vulnerability of its interconnected systems.

## 324. MicroPsi: An Architecture for Motivated Cognition

***Joscha Bach***

**NEW LISTING**

The MicroPsi project explores broad models of cognition, built on a motivational system that gives rise to autonomous social and cognitive behaviors. MicroPsi agents are grounded AI agents, with neuro-symbolic representations, affect, top-down/bottom-up perception, and autonomous decision making. We are interested in finding out how motivation informs social interaction (cooperation and competition, communication and deception), learning. and playing; shapes personality; and influences perception and creative problem solving.

## 325. radiO_o

***Kevin Slavin, Mark Feldmeier, Taylor Levy, Daniel Novy and Che-Wei Wang***

radiO_o is a battery-powered speaker worn by hundreds of party guests, turning each person into a local mobile sound system. The radiO_o broadcast system allows the DJ to transmit sounds over several pirate radio channels to mix sounds between hundreds of speakers roaming around the space and the venue s existing sound system.

## 326. Soft Exchange: Interaction Design with Biological Interfaces

***Kevin Slavin and Kamal Farah***

**NEW LISTING**

The boundaries and fabric of human experience are continuously redefined by microorganisms, interacting at an imperceptible scale. Though hidden, these systems condition our bodies, environment, and even sensibilities and desires. The proposed works introduce a model of interaction in which the microbiome is an extension of the human sensory system, accessed through a series of biological interfaces that enable exchange. Biological Interfaces transfer discrete behaviors of microbes into information across scales, where it may be manipulated, even if unseen. In the same way the field of HCI has articulated our exchanges with electronic signals, Soft Exchange opens up the question of how to design for this other invisible, though present, and vital material.

## 327. Storyboards

***Sepandar Kamvar, Kevin Slavin, Jonathan Bobrow and Shantell Martin***

**NEW LISTING**

Giving opaque technology a glass house. Storyboards present the tinkerers or owners of electronic devices with stories of how their devices work. Just as the circuit board is a story of star-crossed lovers Anode and Cathode with its cast of characters (resistor, capacitor, transistor), Storyboards have their own characters driving a parallel visual narrative.

## 328. Valise: Microbial Object of Desire

***Kevin Slavin and Julie Legault***

**NEW LISTING**

Reimagined biology is exploring the limits of the known world with scientists and researchers taking biotechnology and genetic engineering further, discovering unimagined possibilities. Through this synthetic biology is a promise of advancements in all fields, and the offer of new materials for designers, technologists, and artists to explore. Due to our complex social and medical history with microorganisms, acceptance for live-culture consumer products requires a shift in public opinion. Valise, an object that allows direct interaction with microorganisms to experiment with biology as material, will be produced to explore engineering acceptance of biological systems as produced through reimagined biology. In Valise, various inputs can be manipulated and created to yield tangible effects on a live culture, resulting in experiential sensorial and visualised data in scenic and graphical format for the user. As these slow interactions take place, the object can exist as an evolving, living ornament.

# Ethan Zuckerman: Civic Media

**Creating, deploying, and evaluating tools and practices that foster civic participation and the flow of information within and between communities.**

## 329. "Make the Breast Pump Not Suck!" Hackathon

***Tal Achituv, Catherine D'Ignazio, Alexis Hope, Taylor Levy, Alexandra Metral, Che-Wei Wang***

**NEW LISTING**

In September 2014, 150 parents, engineers, designers, and healthcare practitioners gathered at the MIT Media Lab for the "Make the Breast Pump Not Suck" Hackathon. As one of the midwives at our first hackathon said, "Maternal health lags behind other sectors for innovation." We are bringing together people from diverse fields, sectors, and backgrounds to take a crack at making life better for moms, babies, and new families.

## 330. Action Path

***Erhardt Graeff and Ethan Zuckerman***

Action Path is location-based survey platform for Android smartphones that crowdsources feedback from citizens in a way that fosters civic learning through reflective political practice.  Existing platforms for civic engagement, whether online or offline, are inconvenient and disconnected from the source of issues they are meant to address. They require that citizens leave the places they normally inhabit physically or virtually and commit to a separate space and set of processes. Action Path is designed to answer the challenge: How do you address barriers to effective engagement in community projects, and ensure all citizens can have their voice heard on how to improve their local communities? It does so by converting individual actions into collective action and by providing context and a sense of efficacy, which may help citizens become more effective through regular practice and feedback.

## 331. Call to Action

***Sasha Costanza-Chock, Rodrigo Davies, Alex Goncalves, Tami Forrester and Erica Deahl***

Call to Action is an open-source web platform for creating telephone-based services such as hotlines, voice petitions, and phone blogging. The platform, currently under development, provides an easy-to-use graphical interface that enables the user to plan the flow of calls, record custom audio, and make use of all the input and output features offered by a regular telephone. The service requires no software programming experience, and users can build a service in under half an hour.

## 332. Civic Crowdfunding Research Project

***Ethan Zuckerman and Rodrigo Davies***

The Civic Crowdfunding project is an initiative to collect data and advance social research into the emerging field of civic crowdfunding the use of online crowdfunding platforms to provide services to communities. The project aims to bring together folks from across disciplines and professions from research and government to the tech sector and community organizations to talk about civic crowdfunding and its benefits, challenges, and opportunities. It combines qualitative and quantitative research methods, from analysis of the theory and history of crowdfunding to fieldwork-based case studies and geographic analysis of the field.

## 333. Codesign Toolkit

***Sasha Costanza-Chock and Becky Hurwitz***

Involving communities in the design process results in products that are more responsive to a community's needs, more suited to accessibility and usability concerns, and easier to adopt. Civic media tools, platforms, and research work best when practitioners involve target communities at all stages of the process iterative ideation, prototyping, testing, and evaluation. In the codesign process, communities act as codesigners and participants, rather than mere consumers, end-users, test subjects, or objects of study. In the Codesign Studio, students practice these methods in a service learning project-based studio, focusing on collaborative design of civic media with local partners. The Toolkit will enable more designers and researchers to utilize the co-design process in their work by presenting current theory and practices in a comprehensive, accessible manner.

Alumni Contributor: Molly Sauter

## 334. Controversy Mapper

***Hal Roberts, Ethan Zuckerman, Rahul Bhargava, Erhardt Graeff, Matthew Stempeck, Harvard's Berkman Center for Internet & Society and Yochai Benkler***

How does a media controversy become the only thing any of us talk about? Using the Media Cloud platform, we're reverse-engineering major news stories to visualize how ideas spread and media frames change over time, and whose voices dominate a discussion. We've started with a case study of Trayvon Martin, a teenager shot and killed in Florida. His story became major national news several weeks after his death. We looked at attention paid through multiple media sources talking about Trayvon: news and blog articles, broadcast television, tweets, Google search trends, and petition signatures calling for his killer's arrest. Then, we dove into the networks of interlinked articles, tracing how the framing of Trayvon's story changed and identifying the most influential sources according to network structure. Analyses of stories like Trayvon's provide a revealing portrait of today's complicated media ecosystems.

## 335. Data Crowdsourcing

***Ethan Zuckerman, Rahul Bhargava, Nathan Matias and Sophie Diehl***

Passing On uses data from twenty years of New York Times stories about society's heroes, leaders, and visionaries to crowdsource improvements to Wikipedia. Obituaries reflect society's values for men's and women's achievements, aspirations, and families. Passing On creates compelling stories about notable women to inspire the public to contribute to Wikipedia.

## 336. Data Therapy

***Ethan Zuckerman and Rahul Bhargava***

As part of our larger effort to build out a suite of tools for community organizers, we are helping to build their capacity to do their own creative data visualization and presentation. New computer-based tools are lowering the barriers of entry for making engaging and creative presentations of data. Rather than encouraging partnerships with epidemiologists, statisticians, or programmers, we see an opportunity to build capacity within small community organizations by using these new tools. This work involves workshops, webinars, and writing about how to pick more creative ways to present their data stories.

## 337. Digital Humanitarian Marketplace

***Matthew Stempeck***

The Internet has disrupted the aid sector like so many other industries before it. In times of crisis, donors are increasingly connecting directly with affected populations to provide participatory aid. The Digital Humanitarian Marketplace aggregates these digital volunteering projects, organizing them by crisis and skills required to help coordinate this promising new space.

## 338. Erase the Border

***Catherine D'Ignazio***

Erase the Border is a web campaign and voice petition platform. It tells the story of the Tohono O'odham people, whose community has been divided along 75 miles of the US-Mexico border by a fence. The border fence divides the community, prevents tribe members from receiving critical health services, and subjects O'odham to racism and discrimination. This platform is a pilot that we are using to research the potential of voice and media petitions for civic discourse.

## 339. FOLD

***Alexis Hope, Kevin Hu***

**NEW LISTING**

Imagine reading about the 2008 housing crisis without knowing what a mortgage is. Jumping into complex news stories is difficult, particularly stories requiring historical or technical context. We hypothesize that the feeling of frustration and inadequacy that comes with not being able to understand the news causes readers to turn away from specific pieces or entire stories. FOLD is an authoring and publishing platform allowing storytellers to structure and contextualize their stories to make their work more accessible. Authors can provide curated tangents to readers by integrating contextual information from online sources or by reusing other authors context blocks. Readers can progress through a story vertically to read the narrative, and side-to-side to access these context blocks. We believe that FOLD can help readers of all ages and backgrounds confidently engage with complex stories.

## 340. Framework for Consent Policies

***Willow Brugh***

**NEW LISTING**

This checklist is designed to help projects that include an element of data collection to develop appropriate consent policies and practices. The checklist can be especially useful for projects using digital or mobile tools to collect, store, or publish data, yet understand the importance of seeking the informed consent of individuals involved (the data subjects). This checklist does not address the additional considerations necessary when obtaining the consent of groups or communities, nor how to approach consent in situations where there is no connection to the data subject. This checklist is intended for use by project coordinators, and can ground conversations with management and project staff in order to identify risks and mitigation strategies during project design or implementation. It should ideally be used with the input of data subjects.

## 341. HackathonFAQ

***Ethan Zuckerman, Willow Brugh and J Nathan Matias***

Discourse on hackathons tends to emphasize projects and project creators rather than the events as a social practice within existing communities. Hackathons have a history as a community building method for education and creation. More recently,

institutions have used hackathons to invite conversation and design with groups affected by those institutions. This step towards broader participation is obfuscated by stories that focus on the creation of products and the lucky geniuses whose work is appropriated by institutions. Critiques of hackathons often accept the same assumptions, focusing on high profile events, critiquing the small number of sustained projects, and questioning hackathons as a form of entrepreneurial free labor.

## 342. Mapping the Globe

***Catherine D'Ignazio, Ethan Zuckerman and Ali Hashmi***

Mapping the Globe is an interactive tool and map that helps us understand where the Boston Globe directs its attention. Media attention matters in quantity and quality. It helps determine what we talk about as a public and how we talk about it. Mapping the Globe tracks where the paper's attention goes and what that attention looks like across different regional geographies in combination with diverse data sets like population and income. Produced in partnership with the Boston Globe.

## 343. Media Cloud

***Hal Roberts, Ethan Zuckerman and David LaRochelle***

Media Cloud is a platform for studying media ecosystems the relationships between professional and citizen media, between online and offline sources. By tracking millions of stories published online or broadcast via television, the system allows researchers to track the spread of memes, media framings, and the tone of coverage of different stories. The platform is open source and open data, designed to be a substrate for a wide range of communications research efforts. Media Cloud is a collaboration between Civic Media and the Berkman Center for Internet and Society at Harvard Law School.

## 344. Media Cloud Brazil

***Ethan Zuckerman, Alexandre Gonçalves, Ronaldo Lemos, Carlos Affonso Pereira de Souza, Hal Roberts, David Larochelle, Renato Souza, and Flavio Coelho***

Media Cloud is a system that facilitates massive content analysis of news on the Web. Developed by the Berkman Center for Internet and Society at Harvard University, Media Cloud already analyzes content in English and Russian. During the last months, we have been working on support for Portuguese content. We intend to analyze the online debate on the most controversial and politically hot topics of the Brazilian Civil Rights Framework for the Internet, namely network neutrality and copyright reform. At the same time, we are writing a step-by-step guide to Media Cloud localization. In the near future, we will be able to compare different media ecosystems around the world.

## 345. Media Meter

***Ethan Zuckerman, J. Nathan Matias, Matt Stempeck, Rahul Bhargava and Dan Schultz***

What have you seen in the news this week? And what did you miss? Are you getting the blend of local, international, political, and sports stories you desire? We re building a media-tracking platform to empower you, the individual, and news providers themselves, to see what you re getting and what you re missing in your daily consumption and production of media. The first round of modules developed for the platform allow you to compare the breakdown of news topics and byline gender across multiple news sources.

## 346. Media Meter Focus

***Muhammad Ali Hashmi***

**NEW LISTING**

MediaMeter Focus shows global media attention focus mapping. What was covered in the news this week? Did the issues you care about get the attention you think they deserved? Did the media talk about these topics in the way you want them to? The tool-set also shows news topics mapped against country locations.

Alumni Contributor: Catherine D'Ignazio

## 347. NetStories

***Ethan Zuckerman, Heather Craig, Adrienne Debigare and Dalia Othman***

**NEW LISTING**

Recent years have witnessed a surge in online digital storytelling tools, enabling users to more easily create engaging multimedia narratives. Increasing internet access and powerful in-browser functionality have laid the foundation for the proliferation of new online storytelling technologies, ranging from tools for creating interactive online videos to tools for data visualization. While these tools may contribute to diversification of online storytelling capacity, sifting through tools and understanding their respective limitations and affordances poses a challenge to storytellers. The NetStories research initiative explores emergent online storytelling tools and strategies through a combination of analyzing tools, facilitating story-hack days, and creating an online database of storytelling tools.

## 348. NewsPad

***J. Nathan Matias, Andrés Monroy-Hernández***

NewsPad is a collaborative article editor that empowers small communities to write articles collaboratively through community sourcing, structured stories, and distributed syndication.

## 349. NGO2.0

***Jing Wang, Wang Yu, Sun Huan***

NGO2.0 is a project grown out of the work of MIT's New Media Action Lab. The goal of NGO2.0 is to strengthen the digital and social media literacy of Chinese grassroots NGOs. Since 2009, the project has established collaborative relationships with IT corporations, universities, and city based software developers communities to advocate the development of a new brand of public interest sector that utilizes new media and nonprofit technology to build a better society. NGO2.0 addresses three major need categories of grassroots NGOs: communication, resources, and technology. Within each category, NGO2.0 developed and implemented online and offline projects. These include: Web 2.0 training workshops, a crowdsourced philanthropy map, news stories and videos for NGOs, NGO-CSR Partnership Forum, online NGO self-evaluation and on-site NGO participatory evaluation, database of Chinese NGOs, and online survey of Chinese NGOs' internet usage.

## 350. Open Gender Tracker

***Irene Ros, Adam Hyland, J. Nathan Matias and Ethan Zuckerman***

Open Gender Tracker is a suite of open source tools and APIs that make it easy for newsrooms and media monitors to collect metrics and gain a better understanding of gender diversity in their publications and audiences. This project has been created in partnership with Irene Ros of Bocoup, with funding from the Knight Foundation.

## 351. Open Water Project

***Adrienne Debigare, Ethan Zuckerman, Heather Craig, Catherine D'Ignazio, Don Blair and Public Lab Community***

**NEW LISTING**

The Open Water Project aims to develop and curate a set of low-cost, open source tools enabling communities everywhere to collect, interpret, and share their water quality data. Traditional water monitoring uses expensive, proprietary technology, severely limiting the scope and accessibility of water quality data. Homeowners interested in testing well water, watershed managers concerned about fish migration and health, and other groups could benefit from an open source, inexpensive, accessible approach to water quality monitoring. We're developing low-cost, open source hardware devices that will measure some of the most common water quality parameters, using designs that makes it possible for anyone to build, modify, and deploy water quality sensors in their own neighborhood.

## 352. Out for Change: Transformative Media Organizing Project

***Sasha Costanza-Chock, Becky Hurwitz, Heather Craig, Royal Morris, with support from Rahul Bhargava, Ed Platt, Yu Wang***

The Out for Change Transformative Media Organizing Project (OCTOP) links LGBTQ, Two-Spirit, and allied media makers, online organizers, and tech-activists across the United States. In 2013-2014, we are conducting a strengths/needs assessment of the media and organizing capacity of the movement, as well as offering a series of workshops and skillshares around transmedia organizing. The project is guided by a core group of project partners and advisers who work with LGBTQ and Two-Spirit folks. The project is supported by faculty and staff at the MIT Center for Civic Media, Research Action Design and by the Ford Foundation s Advancing LGBT Rights Initiative.

## 353. PageOneX

***Ethan Zuckerman, Edward Platt, Rahul Bhargava and Pablo Rey Mazon***

Newspaper front pages are a key source of data about our media ecology. Newsrooms spend massive time and effort deciding what stories make it to the front page. PageOneX makes coding and visualizing newspaper front page content much easier, democratizing access to newspaper attention data. Communication researchers have analyzed newspaper front pages for decades, using slow, laborious methods. PageOneX simplifies, digitizes, and distributes the process across the net and makes it available for researchers, citizens, and activists.

## 354. Promise Tracker

***Ethan Zuckerman, Rahul Bhargava, Alexis Hope, Jude Mwenda Ntabathia, Chelsea Barabas, Heather Craig and Yu Wang***

After an election, how can citizens hold leaders accountable for promises made during the campaign season? We are exploring the role citizen monitoring can play in holding elected leaders accountable for promises they make about infrastructure. We are designing and piloting a tool called Promise Tracker in both the United States and Brazil. Promise Tracker will allow citizens to see evidence documenting the origin of a promise, collect data about the status of a promise for example, going to the location of a proposed health clinic and taking a photo of the site and then take action if the promise is not fulfilled. Actions can take many forms: citizens can notify civic leaders of their concerns, approve of progress being made, join a recall effort, or amplify a story about unfulfilled promises to journalists.

## 355. Sambaza Watts

***Joe Paradiso, Ethan Zuckerman, Rahul Bhargava, Pragun Goyal, Alexis Hope and Nathan Matias***

We want to help people in nations where electric power is scarce to sell power to their neighbors. We re designing a piece of prototype hardware that plugs into a diesel generator or other power source, distributes the power to multiple outlets, monitors how much power is used, and uses mobile payments to charge the customer for the power consumed.

## 356. Student Legal Services for Innovation

***Ethan Zuckerman and J Nathan Matias***

Should students be prosecuted for innovative projects at hackathons? In December, four undergraduates associated with the Media Lab were subpoenaed by the New Jersey Attorney General after winning a programming competition with a bitcoin-related proof of concept. We're working with MIT administration and the Electronic Frontier Foundation to support the students and establish legal support for informal innovation and hackathons.

## 357. Terra Incognita: 1000 Cities of the World

***Catherine D'Ignazio, Ethan Zuckerman and Rahul Bhargava***

Terra Incognita is a global news game and recommendation system. Terra Incognita helps you discover interesting news and personal connections to cities that you haven't read about. Whereas many recommendation systems connect you on the basis of "similarity", Terra Incognita connects you to information on the basis

of "serendipity". Each time you open the application, Terra Incognita shows you a city that you have not yet read about and gives you options for reading about it. Chelyabinsk (Russia), Hiroshima (Japan), Hagåtña (Guam) and Dhaka (Bangladesh) are a few of the places where you might end up.

## 358. thanks.fm

***J. Nathan Matias and Mitchel Resnick***

Thanks.fm is a web platform for thanking and acknowledging your creative collaborators. Add a project, acknowledge individuals, and embed acknowledgments throughout the social web.

## 359. The Babbling Brook

***Catherine D'Ignazio and Ethan Zuckerman***

The Babbling Brook is an unnamed neighborhood creek in Waltham, MA, that winds its way to the Charles River. With the help of networked sensors and real-time processing, the brook constantly tweets about the status of its water quality, including thoughts and bad jokes about its own environmental and ontological condition. Currently, the Babbling Brook senses temperature and depth and cross-references that information with real-time weather data to come up with extremely bad comedy. Thanks to Brian Mayton, the Responsive Environments group and Tidmarsh Farms' Living Observatory for their support.

## 360. The People's Bot

***Ethan Zuckerman, J. Nathan Matias, Chelsea Barabas***

Telepresent robots are often pitched as a technology to extend the influence of those who already have money and power. We want to use robotic telepresence for the public good broadening access, supporting public interest reporting, and funding access initiatives.

## 361. VoIP Drupal

***Leo Burd***

VoIP Drupal is an innovative framework that brings the power of voice and Internet-telephony to Drupal sites. It can be used to build hybrid applications that combine regular touchtone phones, web, SMS, Twitter, IM and other communication tools in a variety of ways, facilitating community outreach and providing an online presence to those who are illiterate or do not have regular access to computers. VoIP Drupal will change the way you interact with Drupal, your phone, and the web.

## 362. Vojo.co

***Alex Goncalves, Denise Cheng, Ethan Zuckerman, Rahul Bhargava, Sasha Costanza-Chock, Rebecca Hurwitz, Edward Platt, Rodrigo Davies and Rogelio Lopez***

Vojo.co is a hosted mobile blogging platform that makes it easy for people to share content to the web from mobile phones via voice calls, SMS, or MMS. Our goal is to make it easier for people in low-income communities to participate in the digital public sphere. You don't need a smart phone or an app to post blog entries or digital stories to Vojo any phone will do. You don't even need Internet access: Vojo lets you create an account via SMS and start posting right away. Vojo is powered by the VozMob Drupal Distribution, a customized version of the popular free and open source content management system that is being developed through an ongoing codesign process by day laborers, household workers, and a diverse team from the Institute of Popular Education of Southern California (IDEPSCA).

## 363. What We Watch

***Ethan Zuckerman, Rahul Bhargava and Edward Platt***

More than a billion people a month visit YouTube to watch videos. Sometimes, those billion people watch the same video. What We Watch is a browser for trending YouTube videos. Some videos trend in a single country, and some find regional audiences. Others spread across borders of language, culture, and nation to reach a global audience. What We We watch lets us visualize and explore the connections between countries based on their video viewing habits.

## 364. Whose Voices? Twitter Citation in the Media

***Ethan Zuckerman, Nathan Matias, Diyang Tang***

Mainstream media increasingly quote social media sources for breaking news. "Whose Voices" tracks who's getting quoted across topics, showing just how citizen media sources are influencing international news reporting.