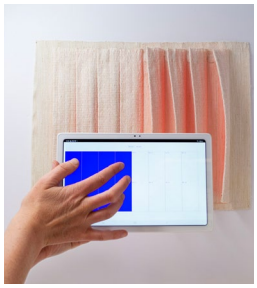
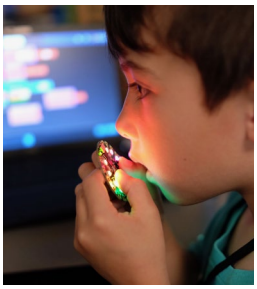
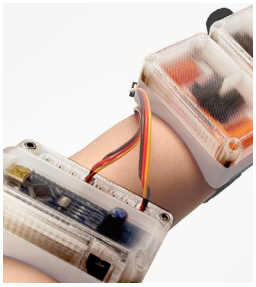
ATLAS

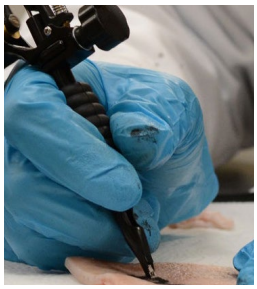
Research 2023

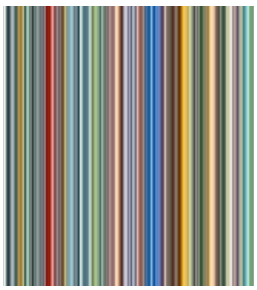


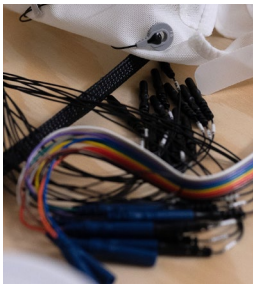


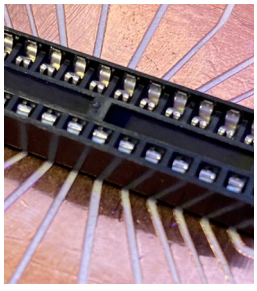
Radical Creativity and Invention











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From left to right, bottom to top:

Utility Research Lab
3D Printed Multi-Point Capacitive Touch Sensing

Brain Music Lab
Multimodal Brain and Body Music Interfaces

ACME Lab
Paper Play

Living Matter Lab
SCOBY Breastplate

TYPO Lab
BubbleSort

THING Lab
Emotitactor

Laboratory for Emergent Nanomaterials
Tech Tattoos

Creative Communities Group
Facilitating Computational Tinkering

Unstable Design Lab
Experimental Weaving Residency

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What is the ATLAS Institute?

With research labs and academic programs that inspire exploration and novel ideas, our vibrant community of technology visionaries and virtuosos reaches beyond convention and takes risks to invent the future.

Research Across Boundaries

One of 12 institutes at CU Boulder, ATLAS is home to researchers who transcend traditional disciplinary structures of engineering, design, science and art to inspire new realms of invention. We make tangible and digital tools and methods that shape how people interact with the world for a more inclusive, inspired and sustainable society.

Deep Design

Design is decision-making. And in the digital age, decisions have far-reaching implications. At ATLAS, we believe good design means understanding all the parameters, making responsible choices, reckoning with the consequences of our actions, and empowering real people with what we make. With this deep design approach, we address "wicked problems" that don't yield to conventional engineering approaches.

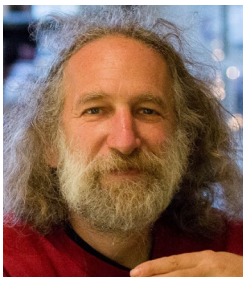
Engineering Degrees Remixed

ATLAS offers rigorous undergraduate, master's and PhD degrees in Creative Technology and Design granted by the College of Engineering and Applied Science. Our project-based teaching equips the next generation of strategic problem solvers, designers and makers with cross-functional expertise valued in leading industries.

Diverse Perspectives, Powerful Ideas

Diverse perspectives lead to better outcomes. We cultivate a community of unique individuals collaborating on creative endeavors and investigations. ATLAS champions the voracious polymaths and expansive thinkers committed to radical creativity and invention.

From ATLAS Institute Director Mark D Gross



We play in the margins, between and across conventional fields. We're committed to investigating beyond the boundaries. We're engineers, scientists, designers, artists – above all we are curious.

Research at the ATLAS Institute labs encompasses a diverse range of interests from e-textiles to nanomaterials to biohacking and more. The faculty members who direct these labs could each easily find a place in a conventional university department. Instead they choose to work with others whose particular expertise differs – sometimes dramatically – from their own.

To be sure, gathering such diverse research under one roof is an experiment. But it works: we attract outstanding students and faculty. Of the five ATLAS researchers currently eligible to receive the National Science Foundation's prestigious CAREER grant, three have received that award. One quarter of our PhD graduates now hold faculty jobs at peer institutions.

While the focus of each ATLAS laboratory is unique, common across them all is a culture of invention. We make stuff, whether software, hardware, molecules or music. We ask "What if?" and then set about making it real.

The projects we share in this catalog are but a small sample of research and creative work at the ATLAS Institute. There's a lot more. I invite you to visit and see for yourself, either in person or online.

Mark D Gross
ATLAS Institute Director and
Professor of Computer Science
mdgross@colorado.edu

ACME Lab

ACME Creativity Machine Environment (ACME) Lab investigates computational tools for design, creativity, cognition, tangible and embedded interaction, and computing for health and wellness. The lab holds that everyone can be creative because everyone can make things. To understand and explore the boundaries of human intelligence and creativity—how people design everything from meals to furniture, houses, and software—the lab builds physical, digital, and interactive models and machines that explain and simulate these concepts.

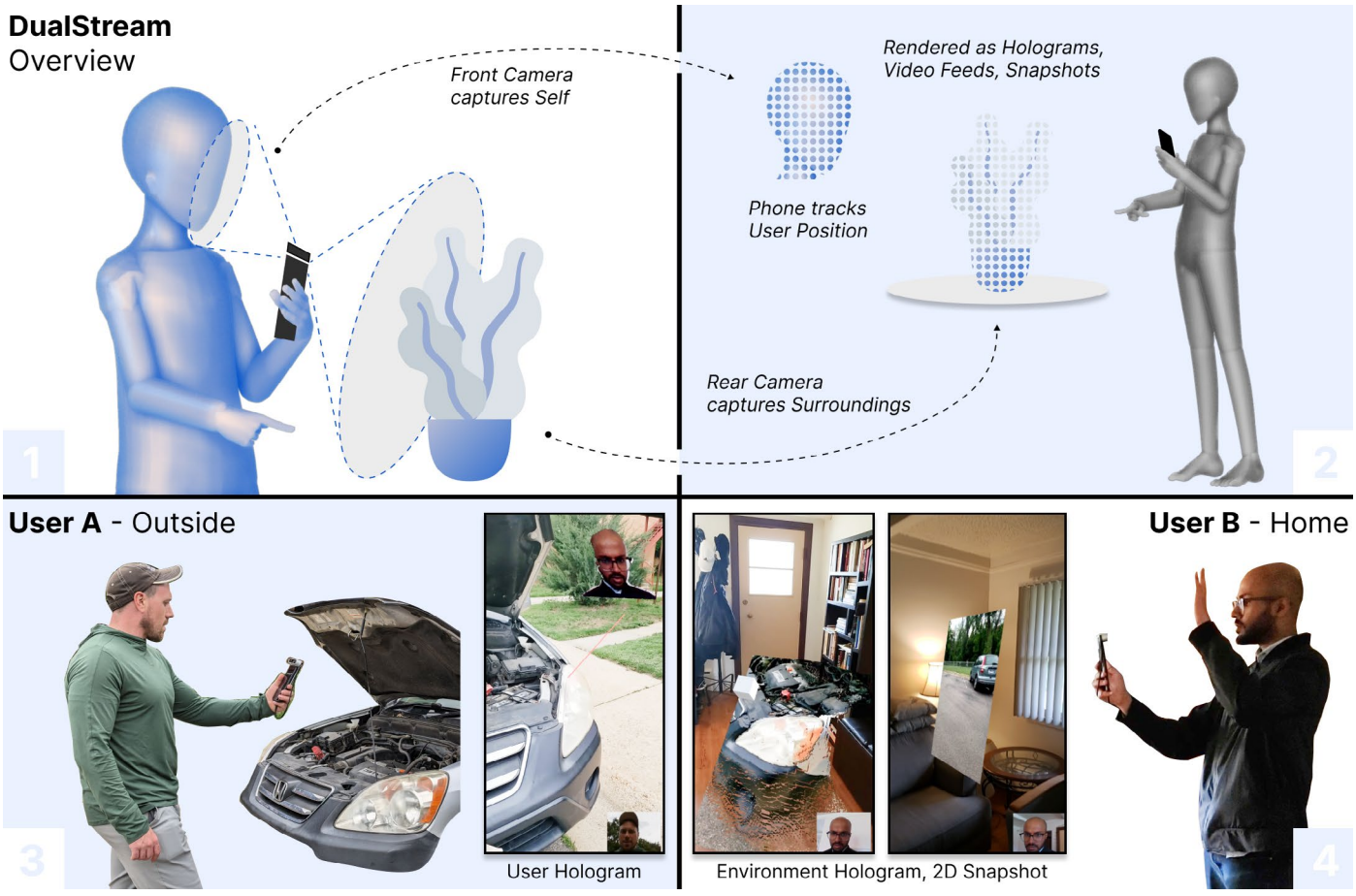
Lab Director
Ellen Yi-Luen Do

Ellen Yi-Luen Do, professor of computer science with the ATLAS Institute, invents at the intersections of people, design and technology. She works on computational tools for design, especially sketching, creativity and design cognition, including creativity support tools and design studies, tangible and embedded interaction and, most recently, computing for health and wellness.

Do holds a PhD in Design Computing from Georgia Institute of Technology, a Master of Design Studies from the Harvard Graduate School of Design and a bachelor's degree from National Cheng Kung University in Taiwan.

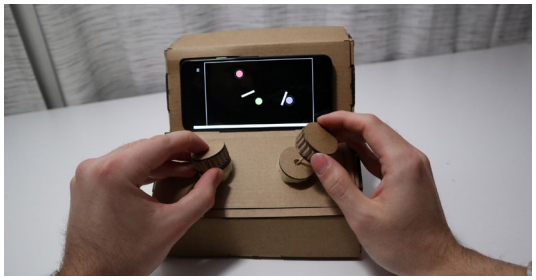
Shared Reality: DualStream

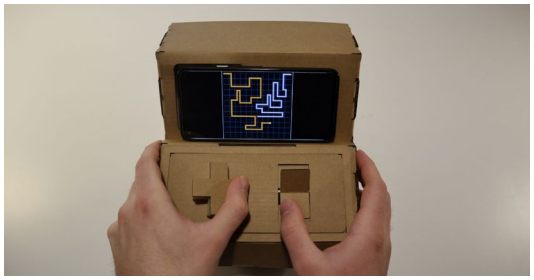
The Shared Reality Project investigates remote collaboration ecosystems that are spatial, immersive and widely accessible. The DualStream augmented reality prototype enables users to spatially share information about themselves and their surroundings in real time. Going beyond traditional audio and video conferencing tools, DualStream can convey three-dimensional information about facial expressions, creating avatars that look and move as we do in real life. Leveraging the mobility and ubiquity of phones, DualStream enables users to simultaneously feel they are “being there” in a remote location, and remote participants are “being here” in their local environment. DualStream envisions spatial computing that is more widely accessible than experiences reliant on expensive head-worn devices. By building cross-reality ecosystems with stronger connections across mobile devices, PCs and immersive setups, we can better support collaboration between people no matter where they are located or what tools they have access to.

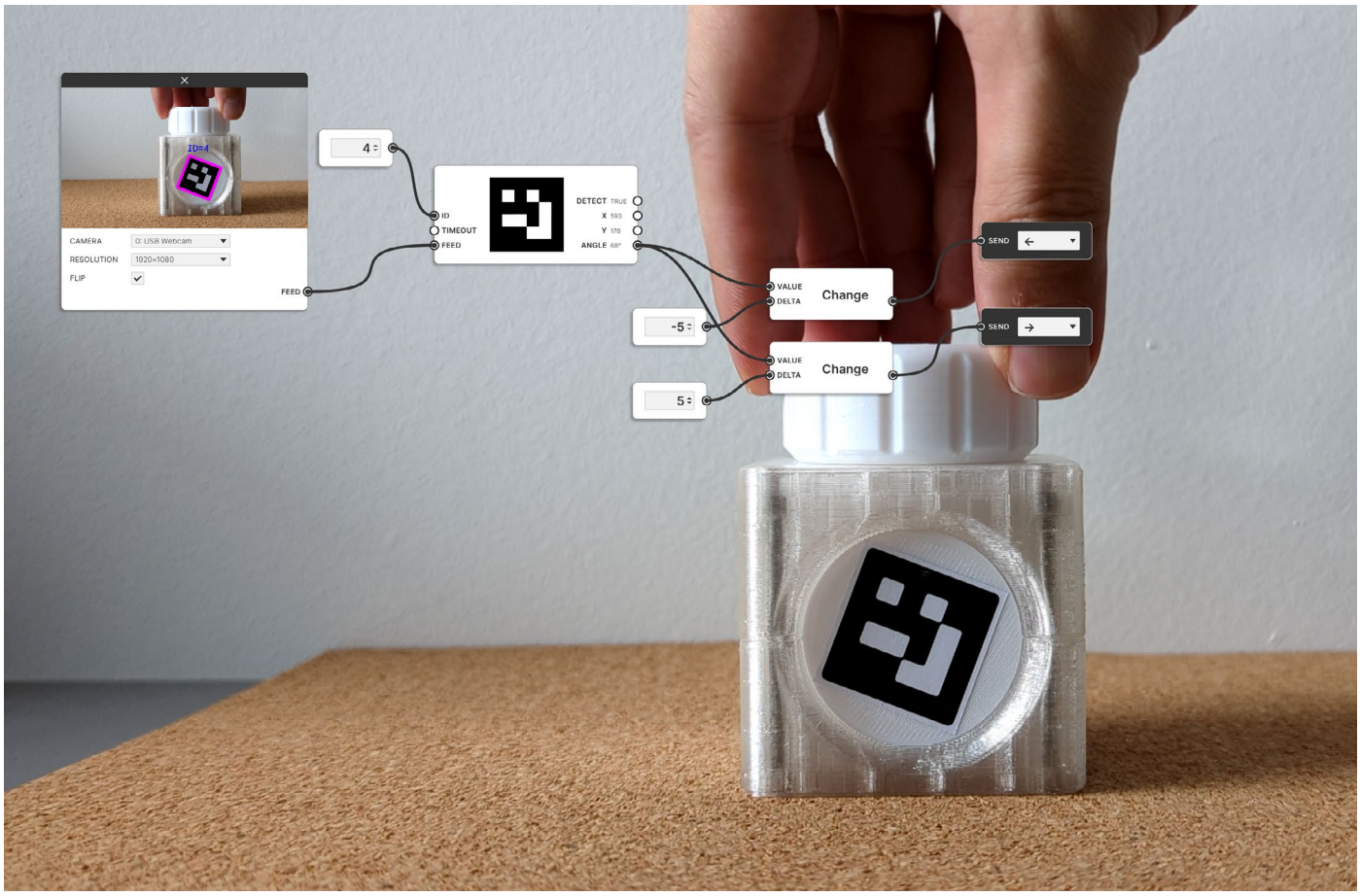


Beholder

The Beholder platform uses computer vision markers to detect and sense material interactions. This is an alternative to the dominant approach to physical computing that emphasizes circuitry and electronic components. Our computer vision system uses a camera, computer and printed fiducial markers to create functional tangible interfaces. Beholder applications include several interactive systems such as a desktop cardboard arcade game (Tinycade), data literacy for children (Data Is Yours), and material interactions for rhythm learning, shoulder exercise, and light and sound sculptures.



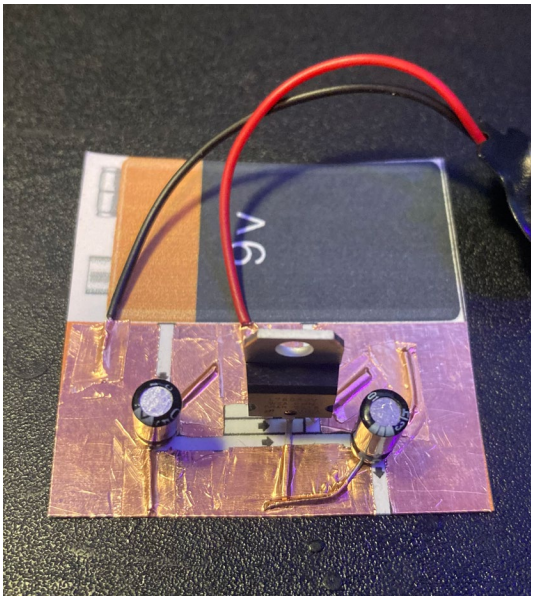


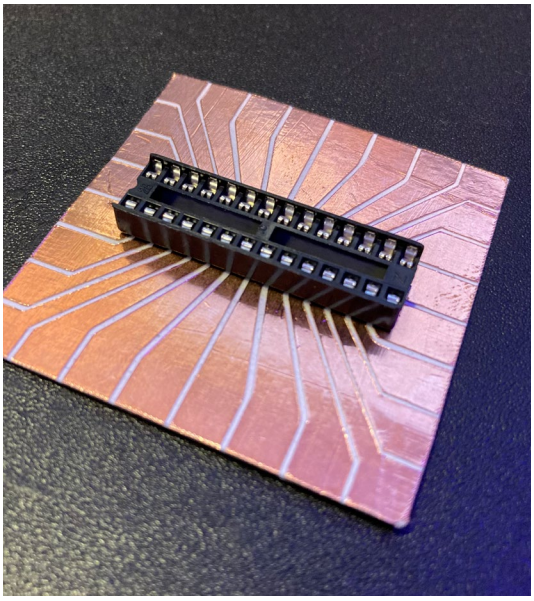


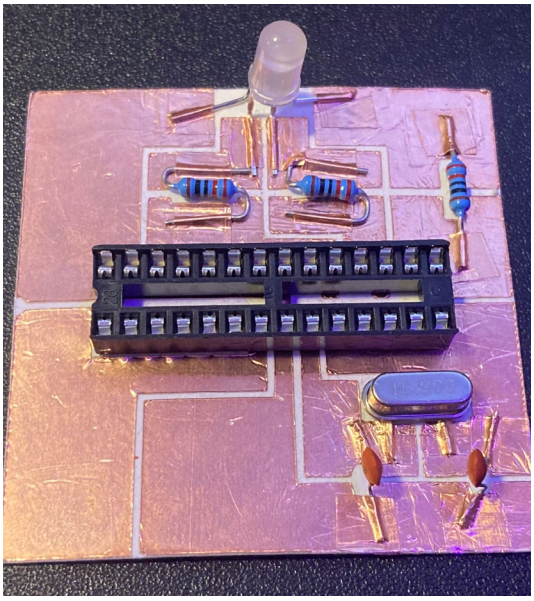

Targeting
100
Left
Right
Eyes closed
Behind the back
On your head

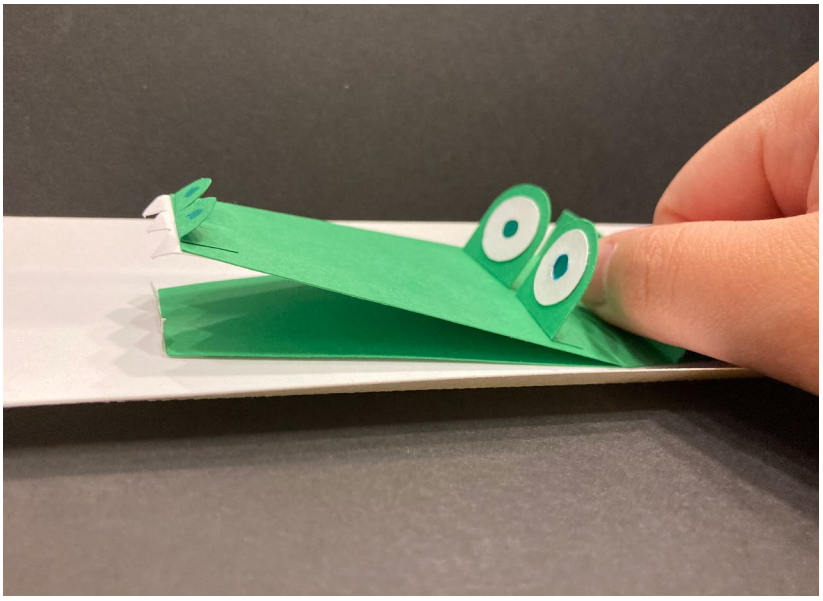
Paper Play

Paper Play explores new methods of paper circuit fabrication that increase flexibility in circuit design using circuit stickers, copper tape dispensers and magnets to make modular functional robotic construction kits. For example, conductive zones in paper circuits can be produced through subtractive processing. The PaperCAD software tool converts traditional circuit design to paper circuit design. Magnets enable mechanical movements to make prototyping and fabrication easier. This combination leverages both the flexibility of paper and the versatile movement provided by magnetism, integrating paper and magnets without special tools or materials.









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Making Material Interactions with Computer Vision. Peter Gyory, S. Sandra Bae, Ruhan Yang, Ellen Yi-Luen Do, Clement Zheng. *Proceedings of the CHI Conference on Human Factors in Computing Systems*, Hamburg, Germany. 2023

Cultivating Visualization Literacy for Children Through Curiosity and Play. S. Sandra Bae, Rishi Vanukuru, Ruhan Yang, Peter Gyory, Ran Zhou, Ellen Yi-Luen Do, Danielle Albers Szafir. *Proceedings of IEEE Visualization and Visual Analytics*, Oklahoma City, OK. 2022

AR Drum Circle: Real-Time Collaborative Drumming in AR. Torin Hopkins, Che Chuan "Suibi" Weng, Rishi Vanukuru, Emma A. Wenzel, Amy Banic, Mark D. Gross, Ellen Yi-Luen Do. *Frontiers in Virtual Reality*, Vol. 3. 2022

Build Your Own Arcade Machine with Tinycade. Peter Gyory, Perry Y Owens, Matthew Bethancourt, Amy Banic, Clement Zheng, Ellen Yi-Luen Do. *Proceedings of the 14th ACM conference on Creativity & Cognition*, Venice, Italy. 2022

Making Data Tangible: A Cross-disciplinary Design Space for Data Physicalization. S. Sandra Bae, Clement Zheng, Mary Etta West, Ellen Yi-Luen Do, Samuel Huron, Danielle Albers Szafir. *Proceedings of the CHI Conference on Human Factors in Computing System*, New Orleans. 2022

Sponsorship

Augmented Reality for Remote Assistance, AR Drum Circle, XR Jam (Mixed Reality Music Jamming), Shared-reality Collaboration. Ericsson Research

ARMAS – Augmented Reality Maintenance and Safety. Electric Power Research Institute

Home-based DIY Interactive Information Physicalization for Young Children and Their Parents. NSF EAGER IIS-2040489

Personal Pervasive Intelligence (PPI): Augmented Reality for the Internet of People and Things. NSF Industry-University Cooperative Research Center (IU/CRC) CNS-1941898

The Brain Music Lab conducts research and develops creative practices to promote health and well-being by combining new music technologies with EEG (brainwave data) and other physiological measurement techniques. In lab director Grace Leslie's performances, an algorithm imprints the spectrum of her sonified brain waves onto a bank of flute and vocal samples. This results in a transformed architecture of sound driven by her physiology.

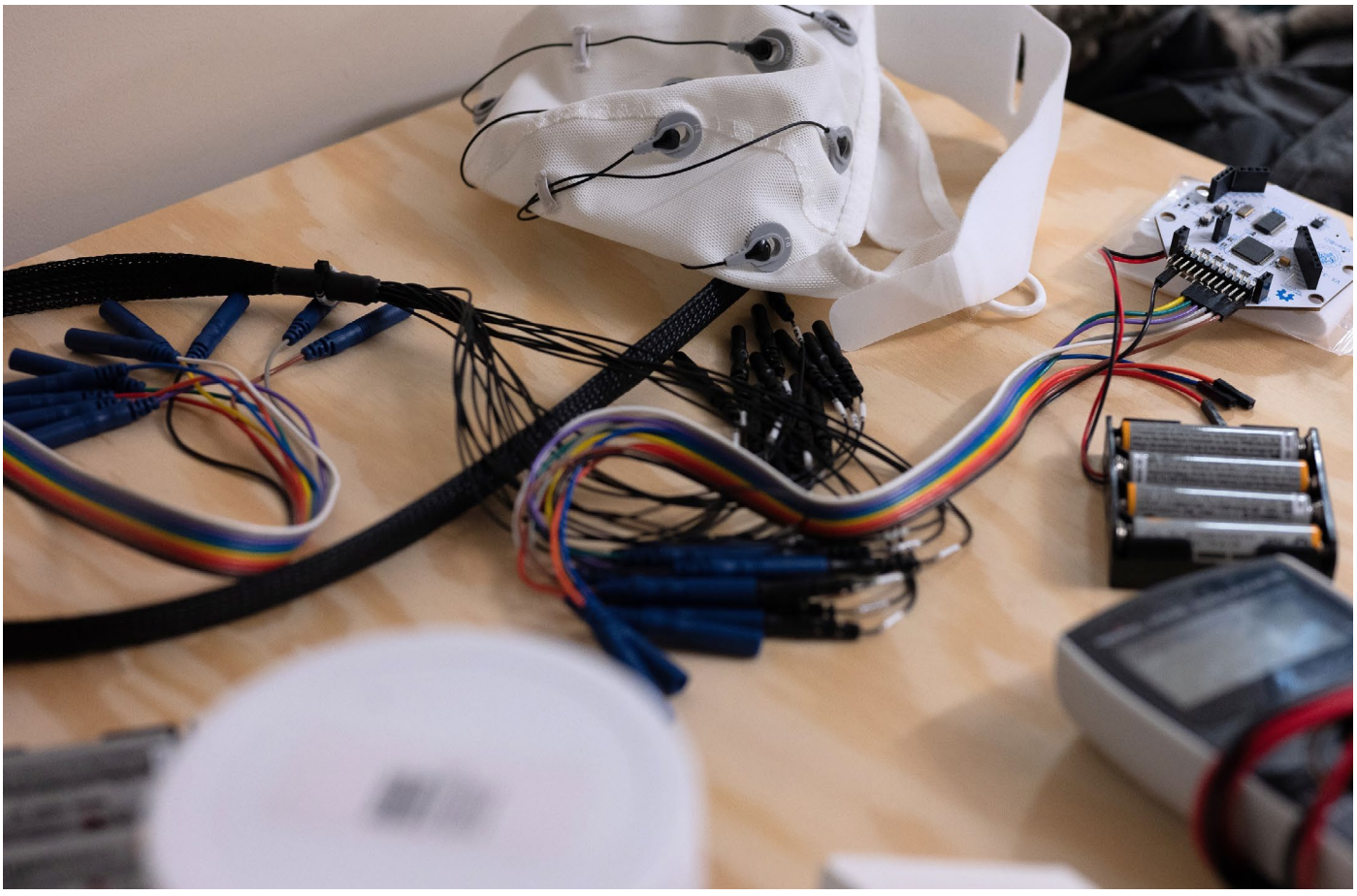
Lab Director
Grace Leslie

Grace Leslie, assistant professor of music with the ATLAS Institute, is a musician and scientist. Leslie integrates conventional musical expression with new forms available to electronic artists using technologies engineered at the Brain Music Lab. She develops brain-body music interfaces that reveal internal cognitive and affective states left unexpressed by sound or gesture.

Leslie completed undergraduate and master's work in music, science, and technology at CCRMA, Stanford University, the PhD in Music and Cognitive Science at the University of California San Diego, and postdoctoral fellowships at the MIT Media Lab and Dartmouth College. Prior to joining CU Boulder, Leslie was an assistant professor of Music Technology at Georgia Institute of Technology.

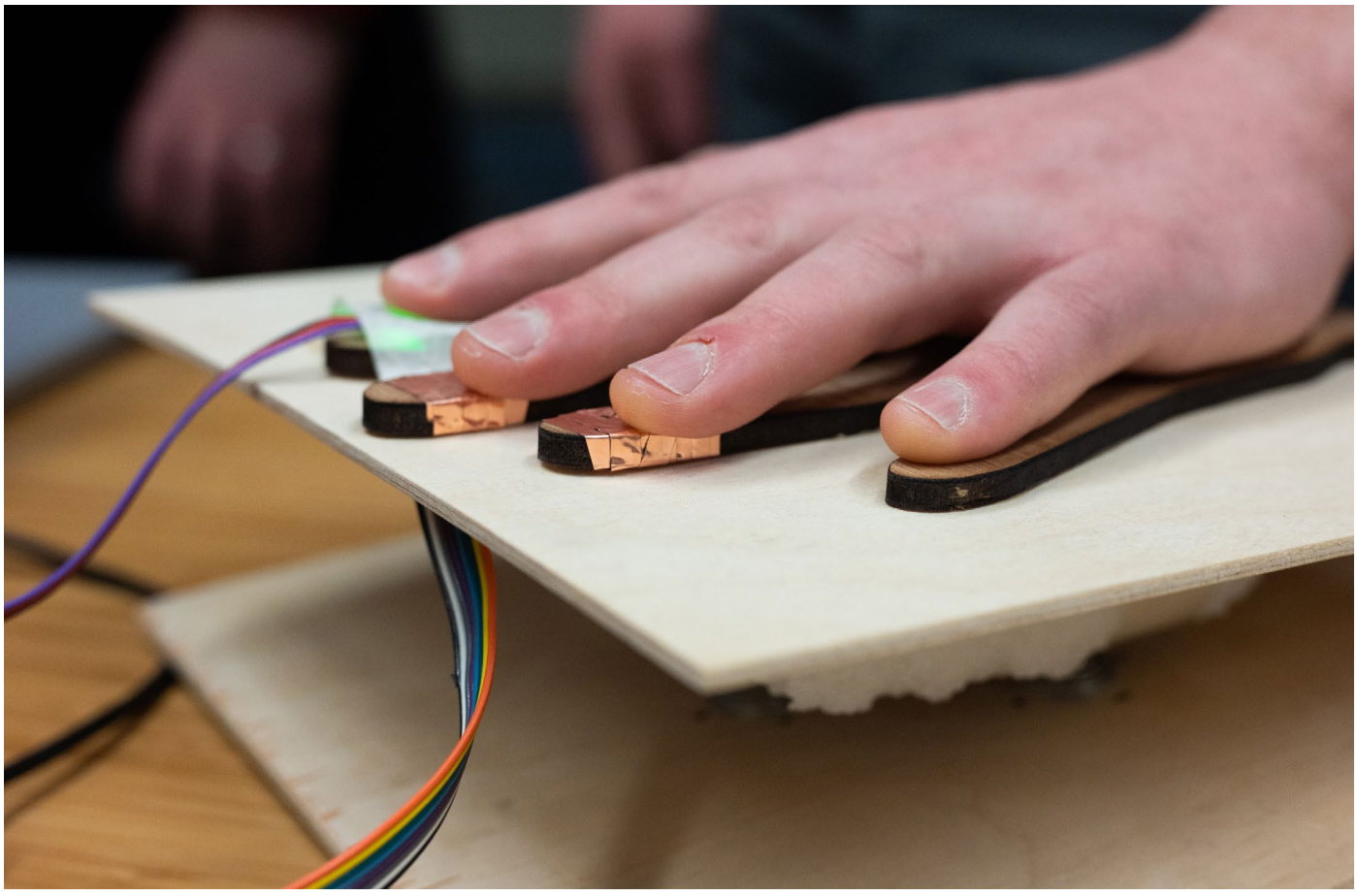
Multimodal Brain and Body Music Interfaces

People's natural brain and body rhythms can synchronize through stimuli such as music, which may create feelings of connection and well-being. This project builds multimodal signal-mapping interfaces that mediate interpersonal connections by deriving music from brain and body rhythms. The lab integrates sensors and signal processing software to stream live brain and body signals and extract key characteristics to drive sound synthesis. The lab is also building an open-source tool kit of accessible technologies and STEM learning modules for projects that further the understanding of brain and body signals. For researchers, doctors and caretakers, multimodal brain-music interfaces can expand our scientific understanding of music's beneficial effects on the brain and body, leading to new health and well-being interventions for adults, children and infants.



Syngeneia: An Environment for Sympathetic Music Making

Physiological signals express our inner rhythms. Syngeneia is an interactive sound installation that senses physiological signals and hand gestures from two performers and compares levels of relaxation or excitement. Participants collaborate to achieve a relaxed and harmonious melody or explore individually in an eerie and dissonant soundscape. Syngeneia uses two spring-mounted controllers, each with an embedded gyroscope/accelerometer to measure motion, a pulse sensor and three copper-tape electrodes to measure galvanic skin response (GSR). Signals from the electrodes reveal whether the two performers are in contact with each other. Sensor data is amplified and fed to an Arduino Nano microcontroller. The motion of each controller, individual heart rates, heart rate similarity, individual GSR and physical contact are all parameters to a MaxMSP patch that regulates both synthesizer parameters and generative algorithms for the notes played.



Vessels: Brain-Body Music Performance

Tthe Vessels brain-body performance combines flute and electronics improvisation with EEG (electroencephalogram) brainwave data sonification. It uses raw EEG, electrodermal activity (EDA) and electrocardiogram (ECG) signals to actuate sound samples recorded from lab director Grace Leslie's flute and voice. Slow impulse trains produce a series of finger snaps that reveal this static virtual space over time, while faster ones produce the sound of a wet finger running along the rim of a glass, activating a virtual resonant enclosure. Improvising on the flute while using this sonification system, Leslie learned to pare down her playing and limit overt physical expression as the muscle artifacts produced would flood the "vessels" with unwanted noise. The music that emerges from this practice, enabled by interactive electronics, allows slow breathing and long tones to bloom into massive sound structures. She has developed a paradoxical form of "introspective expression" enabled by training the body and perceptual mechanism with custom-engineered, musical biofeedback. In "Vessels," the sonic material is an almost static, digital and virtual space, and the musical narrative slowly emerges through an unfolding of cognitive and affective states.

Publications

SoniSpace: Expressive Movement Interaction to Encourage Taking Up Space with the Body. Ruojia Sun, Althea Vail Wallop, Grace Leslie, Ellen Yi-Luen Do. *Proceedings of the 2023 Designing Interactive Systems Conference*. Pittsburgh, PA. 2023

The Physiology of Musical Preference: A Secondary Analysis of the Study Forrest Dataset. Sophia Mehdizadeh, Grace Leslie. *Music Perception*. 2023

Composing at the Border of Experimental Music and Music Experiment. Grace Leslie. L. Margulis et al (eds.) *The Science-Music Borderlands: Reckoning with the Past and Imagining the Future*. 2023

Musical Components Important for the Mozart K448 Effect in Epilepsy. Robert Quon, Michael Casey, Edward Camp, Stephen Meisenhelter, Sarah Steimel, Yinchen Song, Markus Testorf, Grace Leslie, Krzysztof Bujarski, Alan Ettinger, Barbara Jobst. *Scientific Reports*. 2021

How Music Can Literally Heal the Heart. Elaine Chew, Psyche Loui, Grace Leslie, Caroline Palmer, Jonathan Berger, Edward W. Large, Nicolò F. Bernardi, Suzanne Hanser, Julian F. Thayer, Michael A. Casey, Pier D. Lambiase. *Scientific American*. 2021

Sponsorship

CAREER: Multimodal Brain and Body Music Interfaces to Promote Entrainment, Connection, and Creative Science Education. NSF IIS-2313518

Emergent Nanomaterials Lab

The Emergent Nanomaterials Lab manipulates matter on the smallest of scales to create materials with emergent properties, characterized by novel and sometimes surprising features arising from the interactions of multiple bodies. By synthesizing, assembling, combining and organizing nanoscale building blocks, the lab designs technologies that enhance the quality of human lives in the domains of health, energy, sensory augmentation and self-expression.

Emergent Nanomaterials Lab

colorado.edu/atlas/emergent-nanomaterials-lab

Lab Director **Carson Bruns**

Photo: Glenn Asakawa, University of Colorado Boulder

Carson Bruns, assistant professor of mechanical engineering with the ATLAS Institute, makest creative use of molecular nanotechnology to engineer materials for applications ranging from biohacking to energy transduction. His research involves the fabrication of tiny molecular and particulate building blocks that build themselves into more sophisticated structures by a process of self-assembly.

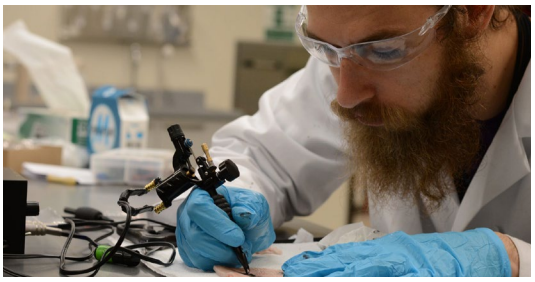
After receiving undergraduate degrees in chemistry and religion from Luther College and a PhD in organic chemistry from Northwestern University, Carson spent three years as a Miller Postdoctoral Fellow at University of California, Berkeley, before joining the CU Boulder faculty.

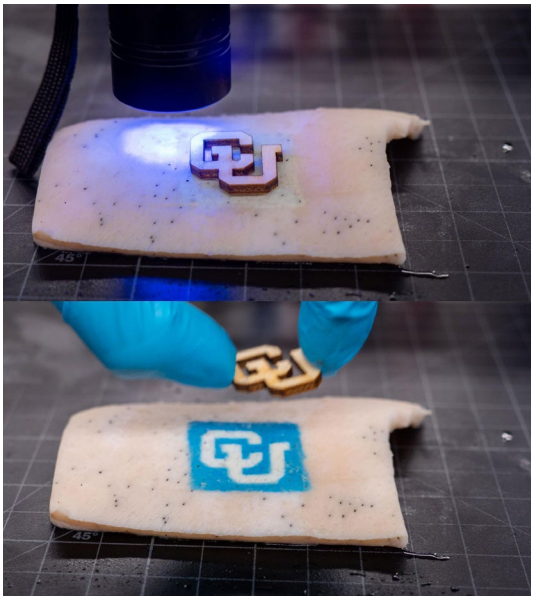
Emergent Nanomaterials Lab

colorado.edu/atlas/emergent-nanomaterials-lab

Tech Tattoos

Humans have been using the same tattooing technologies for thousands of years. It's time for an upgrade. The Tech Tattoos project rethinks the tattoo pigment as a way to permanently embed new technologies in the skin. The lab is formulating tattoo inks that conduct electricity and change color in response to different stimuli. These "tech tattoos" could power biomedical devices and wearable technologies, monitor and diagnose health issues, and augment human sensing and self-expression. The lab developed an ink made of photochromic microcapsules; a few seconds of tattooing this ink into skin leaves a color-changing mark that is activated by UV light. These tattoos turn blue in sunshine but disappear when sunscreen is applied, or in indoor lighting. This intradermal tattoo lasts for up to six months and offers a new way to monitor UV exposure to prevent skin cancer.



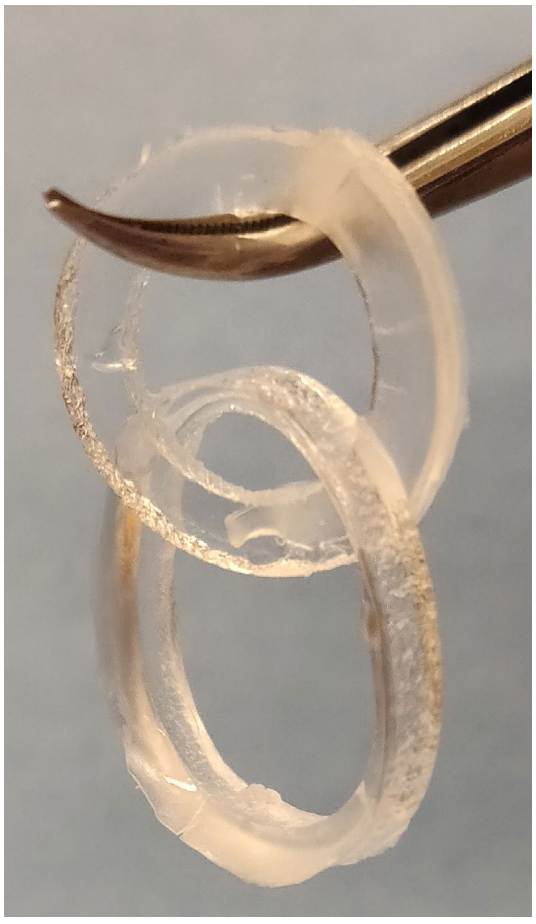


Emergent Nanomaterials Lab

colorado.edu/atlas/emergent-nanomaterials-lab

Slide-Ring Materials

While it is easy to thread a bead on a string in the macroscopic world, this is not always the case at molecular, nano- and microscopic scales. The lab is developing new nano- and microscale bead-on-a-string assemblies. Sliding the tiny beads along the strings offers a new mechanism for stress dissipation, mass transport and actuation. The lab aims to understand how to control and predict the properties of these “Slide-Ring Materials” to develop new applications such as eco-friendly plastics and rubbers as well as soft nanomachines.



Laboratory Automation

Many advances in medicine, energy production and space exploration depend on scientists and engineers inventing new molecules and materials. Unfortunately, we still synthesize molecules in a time-consuming and very manual fashion, creating a significant bottleneck to scientific progress. To address this, the team is building a laboratory automation robot for organic chemistry. Existing chemistry automation solutions suffer from a number of limitations, especially for one-off chemical “prototyping”. The team’s new chemical synthesis robot overcomes these limitations, with the goal of automating the most tedious and time-consuming chemistry lab operations: weighing solids, volumetrically dispensing liquids, running reactions and purification.

Publications

Slide-Ring Materials Based on Self-assembled Polyrotaxane Molecular Necklaces. Karan Dikshit, Carson J. Bruns. *Supramolecular Nanotechnology: Advanced Design of Self-Assembled Functional Materials 2*. 2023

Micromechanics and Damage in Slide-ring Networks. Samuel C. Lamont, Kyle Weishaar, Carson J. Bruns, Franck J. Vernerey. *Physical Review E*. 2023

Redox-switchable Host–guest Complexes of Metallocenes and [8]cycloparaphenylene. Hyejin Kwon, Brian S. Newell, Carson J. Bruns. *Nanoscale*. 2022

A Photochromic Intradermal Smart Tattoo Based on Diarylethene-Doped Polystyrene Nanoparticles for Personal y-Ray Dosimetry. Jesse Butterfield, Gregory Penoncello, Karan Dikshit, Carson J. Bruns. *ACS Applied Nano Materials*. 2022

Chemorheological Monitoring of Cross-Linking in Slide-Ring Gels Derived from a-Cyclodextrin Polyrotaxanes. Karan Dikshit, Carson J. Bruns. *Frontiers in Chemistry*. 2022

Sponsorship

Mechanics of Active Slide-Ring Networks: from Molecular Motors to Molecular Machines. NSF CMMI-2023179

Self-Assembly of Shape-Defined Micro-Hydrogels: Top-Down Meets Bottom-Up. NSF CBET-2106158

CAREER: Intradermal Biocompatibility of Nanoparticles as Minimally Invasive Implants for Human Health. NSF CBET-2235902

RoboChemistry: Human-Robot Collaboration for the Future of Organic Synthesis. NSF FW-HTF-R/ Collaborative Research DRL-2222952

Biomedical Tattoo Inks. Colorado Office of Economic Development and International Trade Lab Venture Challenge 2022 Advanced Industries Accelerator Proof-of-Concept Grant

The Living Matter Laboratory works at the intersection of biology, technology and art. The main theme is living organisms: the tiny beings around us and how we interact with them. The lab aims at a personal way of interacting with the microbiomes that are otherwise seen as something to be disinfected and removed from our bodies. On the technology side, the lab builds digital microfluidic biochips to help people do their own diagnostic tests. On the design and art side, the lab builds DIY bioreactors and bioplastics that people can grow at home for clothing, home objects or sustainable materials for other projects.

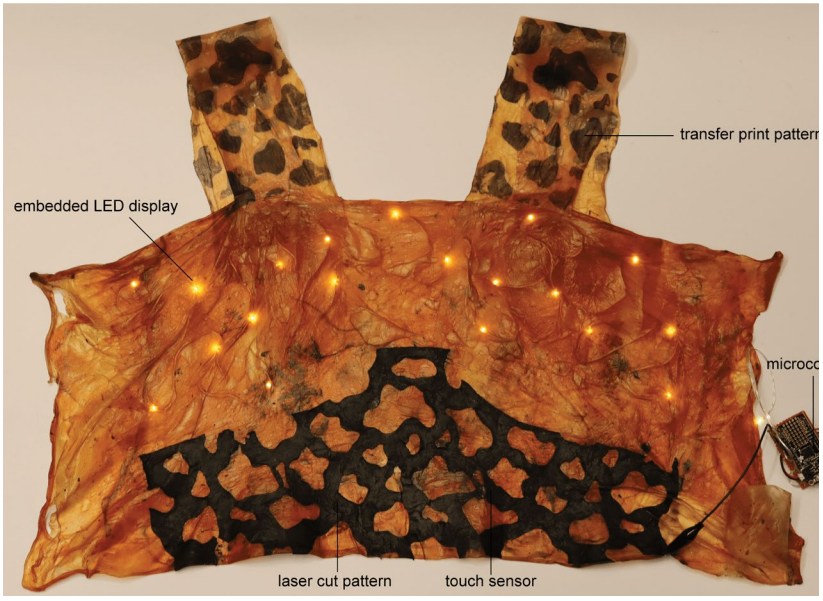
Lab Director
Mirela Alistar

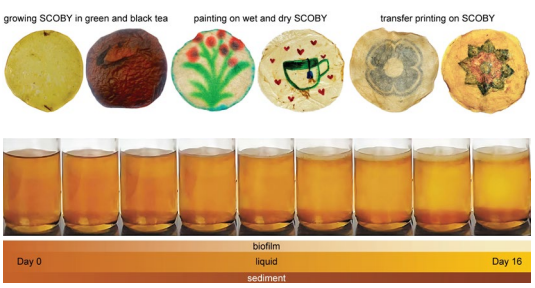
Mirela Alistar, assistant professor of computer science with the ATLAS Institute, investigates the extent to which we can change healthcare to make it a personal process. Her research focuses around microfluidic biochips, devices that enable direct interaction of humans with their microbiome for diagnosis purposes. Alistar has built systems based on biochips to serve as personal laboratories: small portable devices that people can own and use to develop customized bio-protocols (“bio-apps”). Alistar is an active contributor to the DIYBio movement, having led and co-founded community wetlabs. In this context, she organizes interactive performances, art installations and open workshops in order to engage the public in direct interaction with living materials (e.g., bacteria, viruses, fungi).

Alistar received her BSc in Computer Automation and Control at Politehnica Bucuresti, Romania, and her PhD from the Technical University of Denmark.

SCOBY Breastplate

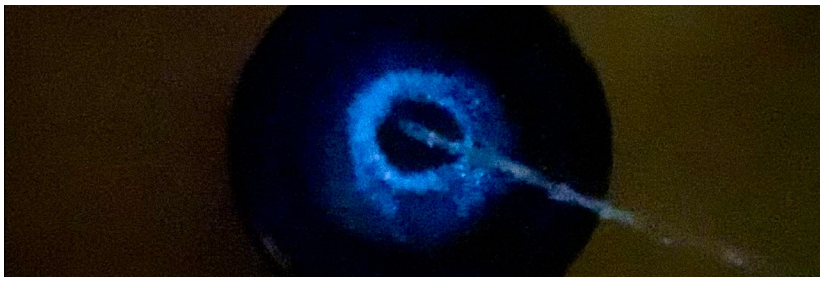
The SCOBY Breastplate is a sustainable, interactive wearable slowly grown and fabricated from kombucha SCOBY (Symbiotic Culture Of Bacteria and Yeast) biofilm over 13 weeks. LEDs embedded within the SCOBY breastplate produce different light patterns, responding to the wearer being hugged, tapped or brushed. This project challenges the fail-fast and rapid prototyping trends typical of creative technology research, and instead explores what it means to design at the pace of another living organism.

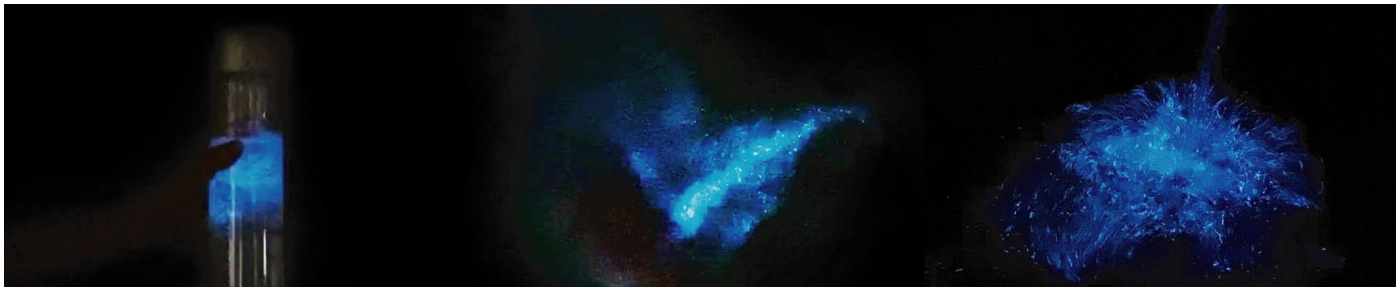


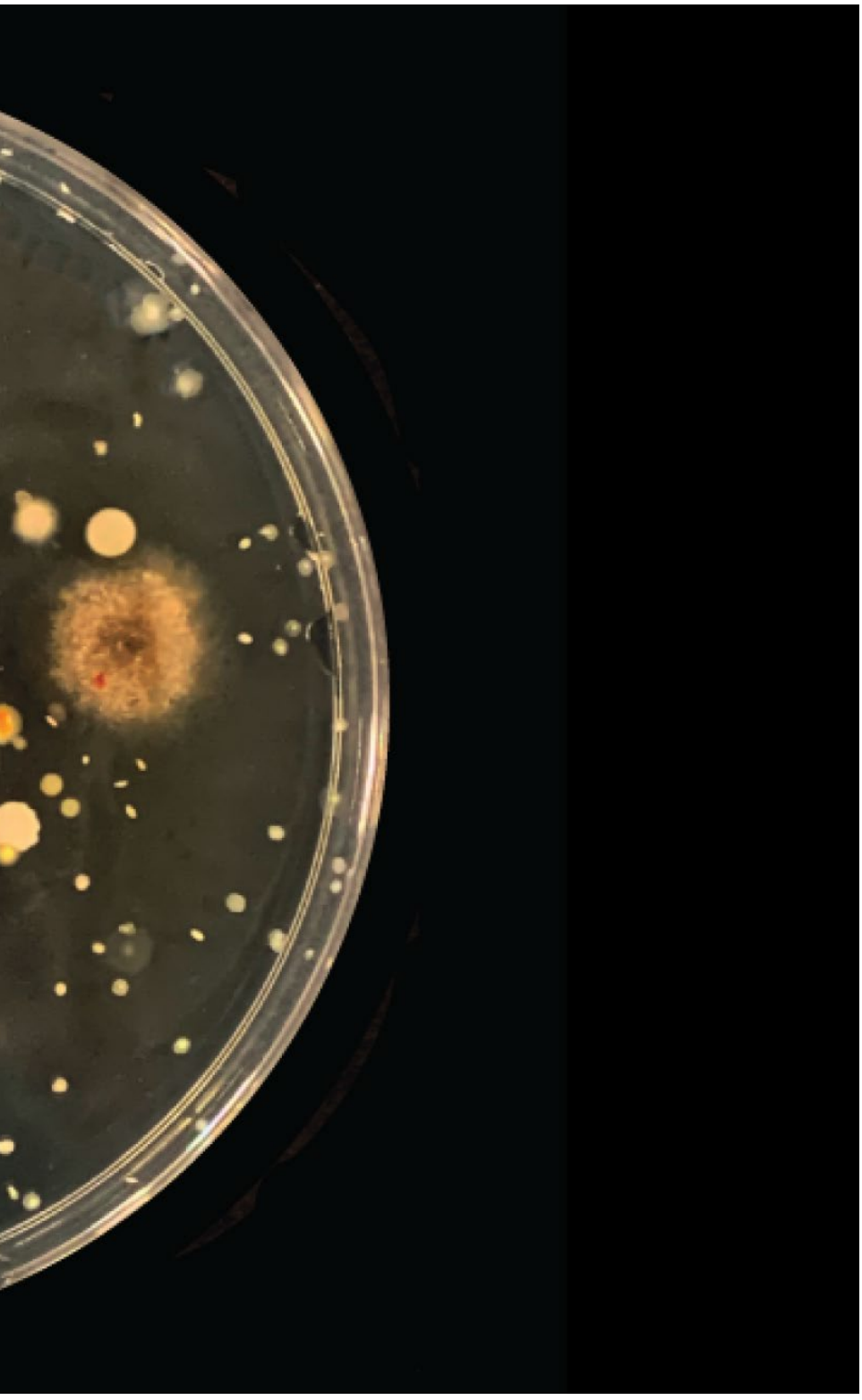


Designing with Bioluminescence

Designing with Bioluminescence explores the opportunity of interacting with dinoflagellates, bioluminescent algae that produce light when exposed to oxygen through physical stimulation. The project leverages the dinoflagellates' natural feedback mechanism to propose physical kinetic interactions, actively engaging the human user with the organism. An organism-centered design approach considers the well-being of the organism by focusing first on designing appropriate environments for the organism, then exploring the interactions available within these environments.

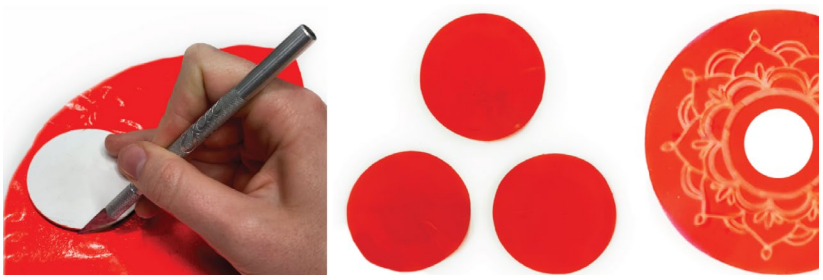


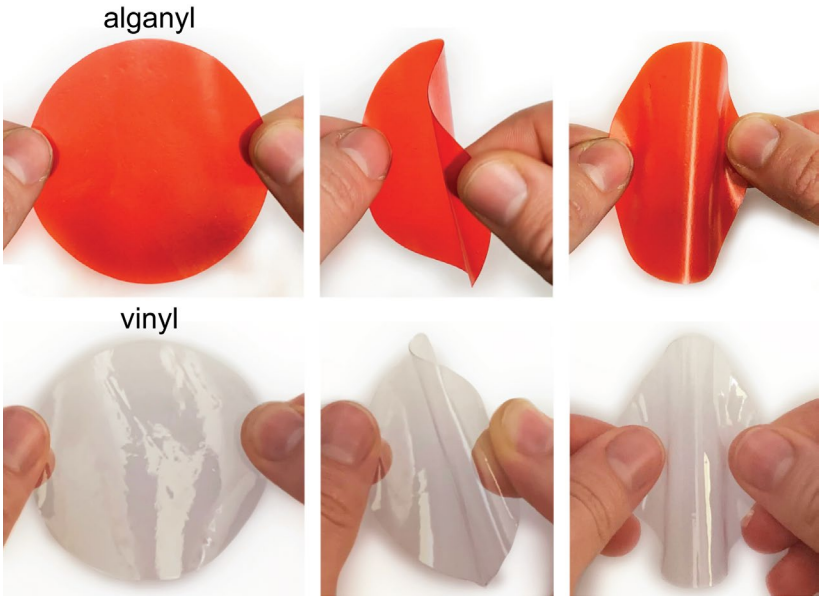


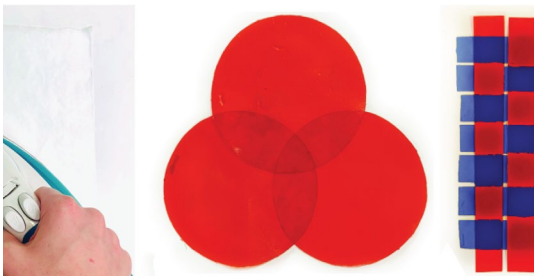


Alganyl: Biodegradable Plastic

Based on do-it-yourself (DIY) recipes for bioplastics, Alganyl is made from renewable resources, feels like vinyl and can be reused before ultimately being composted. Alganyl is a zero-waste material that can be recycled or biodegraded in 60 days. The lab's formula optimizes existing bioplastics for flexibility and strength, resulting in a biomaterial that acts and feels similar to vinyl fabric. Three principles guide designing with Alganyl: materiality, accessibility and sustainability. A replicable process involves cooking Alganyl followed by cutting and heat-sealing to create clothing. The lab has designed everyday objects made entirely of Alganyl including a sculpture, clothing, environment-sensing accessories and a recycled concert bag. Alganyl illustrates a future where designing with bioplastic is an autonomous form of self-expression that has minimal impact on the environment.







Publications

µMe: Exploring the Human Microbiome as an Intimate Material for Living Interfaces. Fiona Bell, Michelle Ramsahoye, Joshua Coffie, Julia Tung, Mirela Alistar. *Proceedings of the Designing Interactive Systems Conference*, Pittsburgh, PA. 2023

Exploring Biofoam as a Material for Tangible Interaction. Eldy S. Lazaro Vasquez, Netta Ofer, Shanel Wu, Mary Etta West, Mirela Alistar, Laura Devendorf. *Proceedings of the 2022 Designing Interactive Systems Conference*, online. 2022

Biomaterial Playground: Engaging with Bio-based Materiality. Fiona Bell, Netta Ofer, Hyelin Choi, Ella McQuaid, Ethan Frier, Mirela Alistar. *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*, New Orleans, LA. 2022

ReClaym our Compost: Biodegradable Clay for Intimate Making. Fiona Bell, Netta Ofer, Mirela Alistar. *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, New Orleans, LA. 2022

Alganyl: Cooking Sustainable Clothing. Fiona Bell, Ella McQuaid, and Mirela Alistar. *Diseña*. 2022

THING
Lab

The Transformative Human Interfaces for the Next Generation (THING) Lab employs shape-changing materials, novel sensors and unique design methods to make digital information tangible, paving the way for a new generation of interactivity that goes beyond sight and sound.

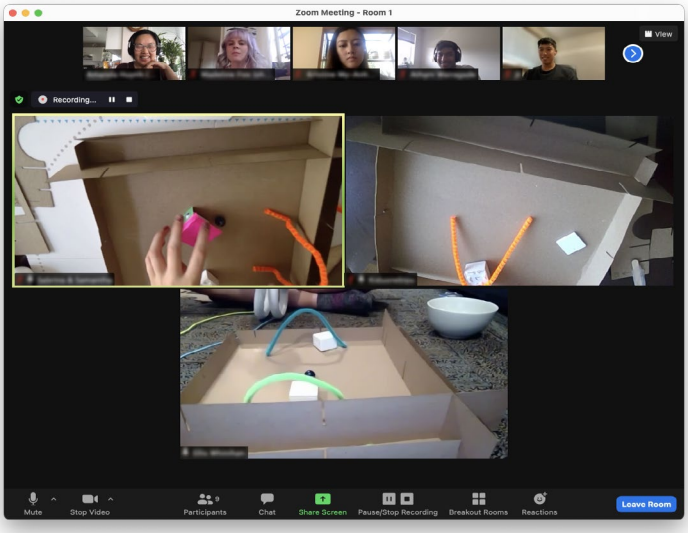
Lab Director
Daniel Leithinger

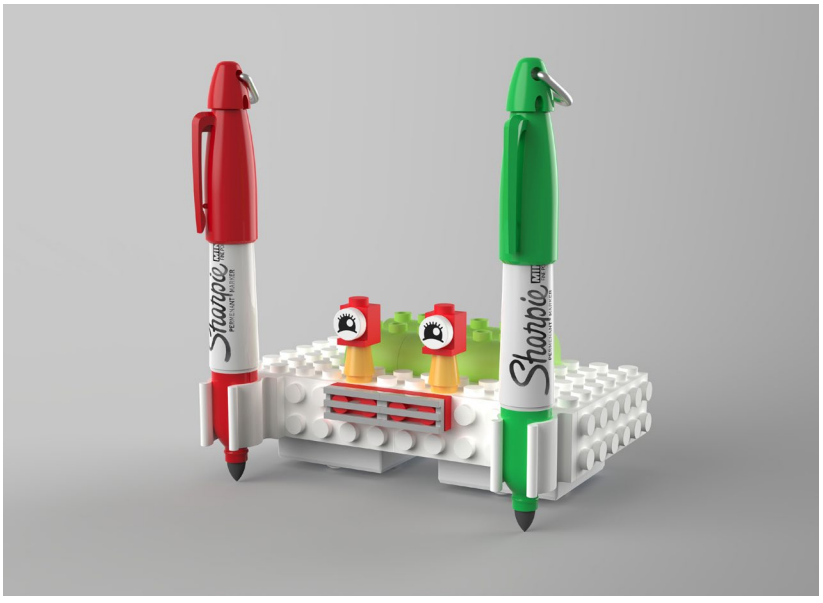
Daniel Leithinger, assistant professor of computer science with the ATLAS Institute, creates shape-changing human computer interfaces that push digital information past the boundaries of flat displays, and into the real world. Motivated by the belief that computers must embrace the dexterity and expressiveness of the human body, his interfaces allow users to touch, grasp and deform data physically.

Leithinger received master's and PhD degrees from the MIT Media Lab, and bachelor's and master's degrees from Upper Austria University of Applied Science.

Together Apart

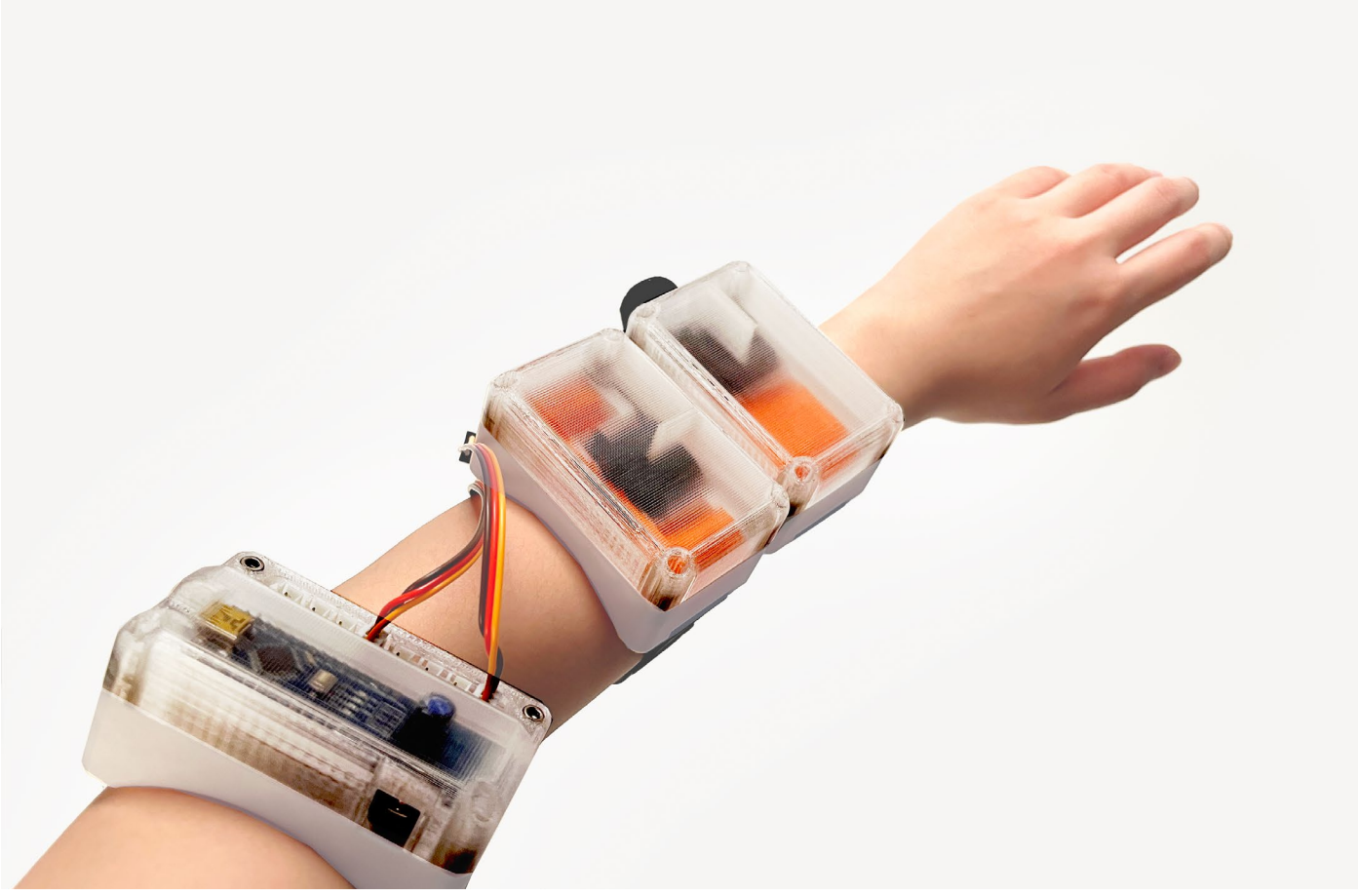
Together Apart is a multi-disciplinary, collaborative effort with researchers at the University of Washington Seattle to create a remote co-design platform for children. The group works with children co-designers from KidsTeam UW to explore how to improve collaboration via video conference. Together Apart is a robot tele-operation interface integrated with a multi-peer video calling application. It uses Sony toio tabletop robots and a tablet interface to add a tangible dimension to online co-design. Child designer partners interact with each other's designs and express themselves through the robots' movements. Children from KidsTeam UW use our system to make games, share robot expressions and dances, and create physical art together.

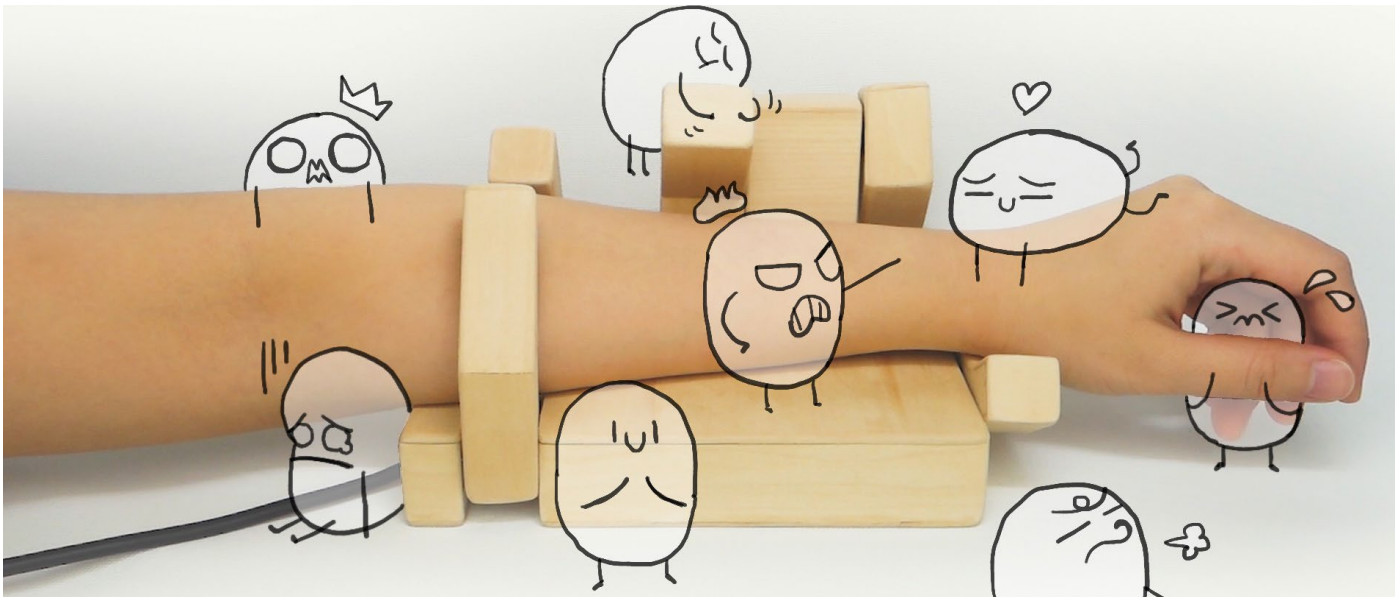


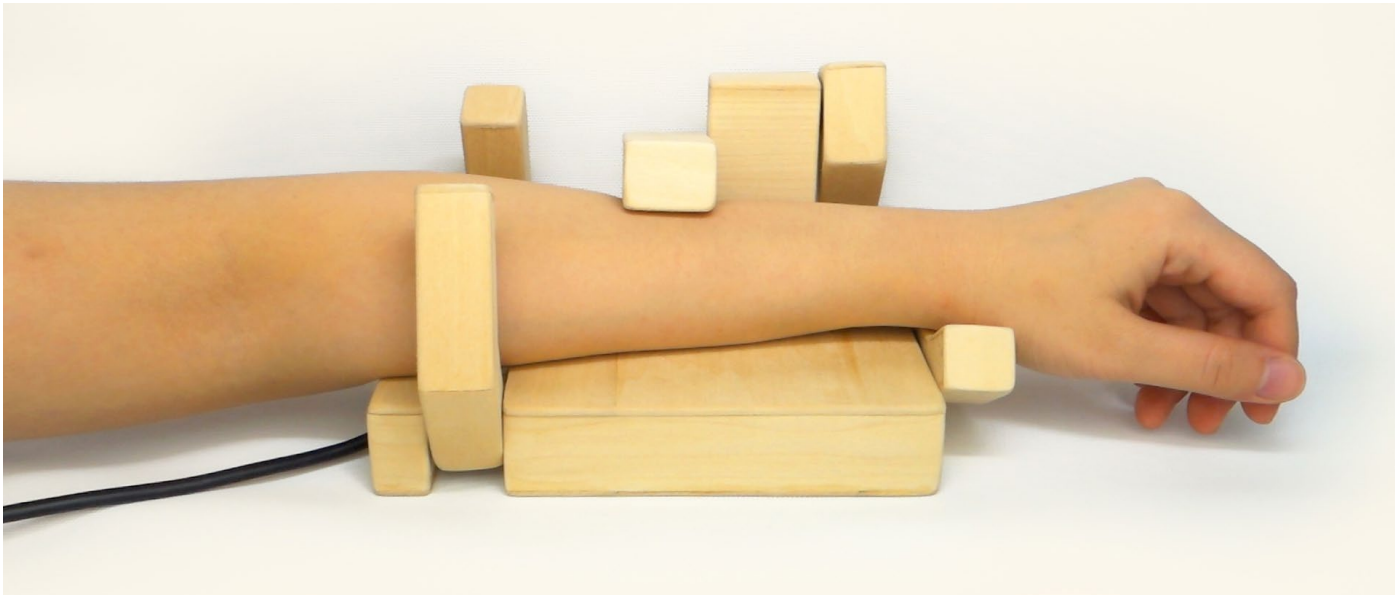


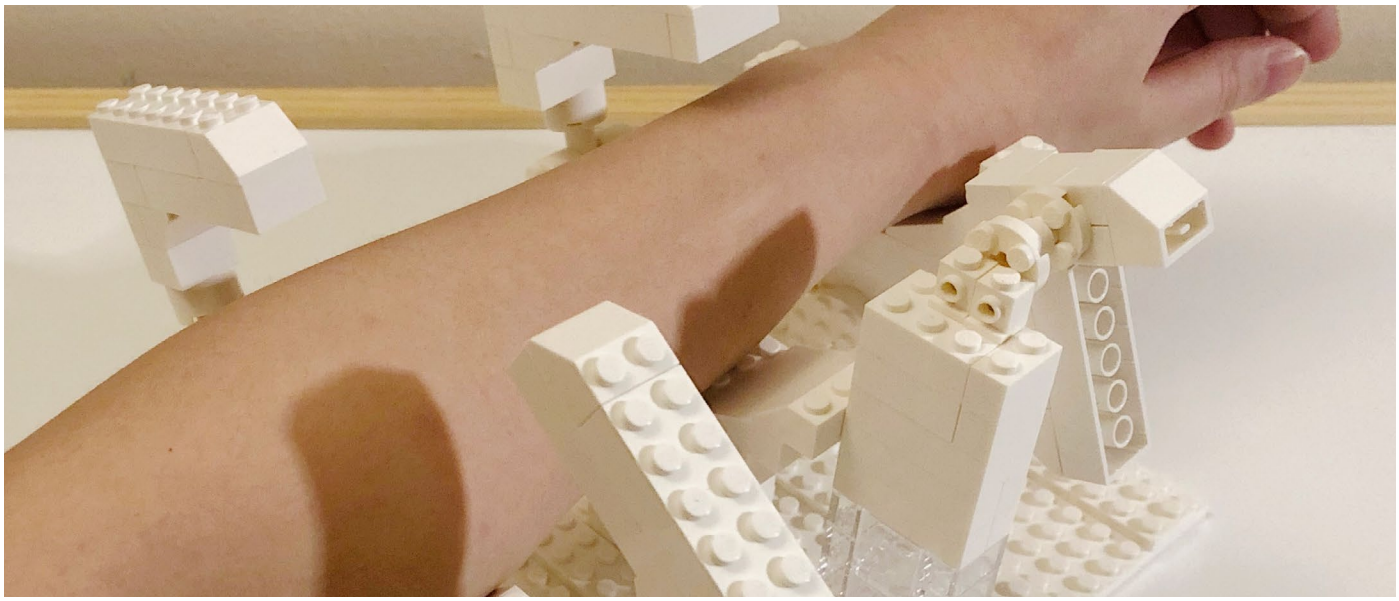
Emotitactor

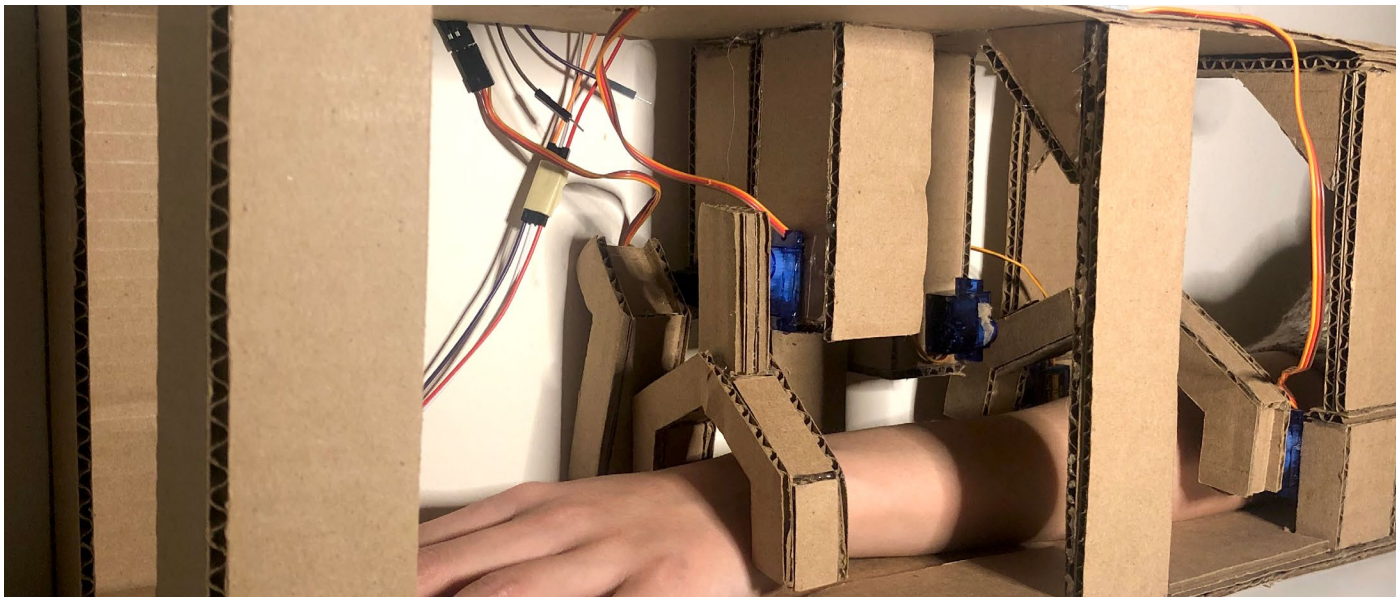
Emotitactor explores emotional robotic touch. People can communicate distinct emotions solely through touch – might this also apply to robotic touch? To enable designers to experiment with various types of affective touch for conveying emotions such as anger and happiness, the Emotitactor platform comprises a robotic tactor interface and a software design tool. A study with 11 interaction designers revealed common patterns in the tactile sensations they proposed for each emotion. The “otherness” of robotic touch broadens the possibilities of emotional communication beyond mimicking interpersonal touch.











HECTARE—Immersive Training Simulation for Astronauts

Hyper-realistic Elastically Computed Topologies in Adaptive Reality Environments (HECTARE) simulates detailed terrains at planetary-scale by prioritizing the storage, cache, and retrieval of underlying large-scale land-form data and generating realistic and interactive surface detail in real-time. To navigate large-scale terrain while immersed in a conference-room-scale physical environment, the project explores redirected walking techniques with algorithms that solve for people in a physical space who are not in aligned virtual spaces. The simulation environment is a testbed for assessing the impact of redirected walking techniques, investigating low-gravity physics, precision of tracking, the realism of avatars and interactivity of detailed models. The project also investigates mixed-reality interfaces that support tool handling, interaction with habitat and dynamic walkable terrain through a combination of swarm robotics, props and haptic gloves.

Publications

TactorBots: A Haptic Design Toolkit for Out-of-lab Exploration of Emotional Robotic Touch. Ran Zhou, Zachary Schwemler, Akshay Baweja, Harpreet Sareen, Casey Lee Hunt, Daniel Leithinger. *Proceedings of the CHI Conference on Human Factors in Computing Systems*, Hamburg, Germany. 2023

EmotiTactor: Exploring How Designers Approach Emotional Robotic Touch. Ran Zhou, Harpreet Sareen, Yufei Zhang, Daniel Leithinger. *Proceedings of the 2022 Designing Interactive Systems Conference,* online. 2022

Designing Together, Miles Apart: A Longitudinal Tabletop Telepresence Adventure in Online Co-design with Children. Casey Hunt, Kaiwen Sun, Zahra Dhuliawala, Fumi Tsukiyama, Iva Matkovic, Zachary Schwemier, Anastasia Wolf, Zihao Zhang, Alison Druin, Amanda Huynh, Daniel Leithinger, Jason Yip. *Proceedings of the 2023 ACM Conference on Interaction Design and Children*, Chicago, IL. 2023

Sponsorship

Hyper-realistic Elastically Computed Topologies in Adaptive Reality Environments (HECTARE). Diamond Age Technologies and NASA STTR 22-1-T11.06-1681

TYPO
Lab

TYPO Lab is an experimental studio for creative work and research related to the technologies of language. The lab investigates a wide range of text-based technologies, from manual typewriters to software for natural language processing and explores the various media and methods of words.

Lab Director
Joel Swanson

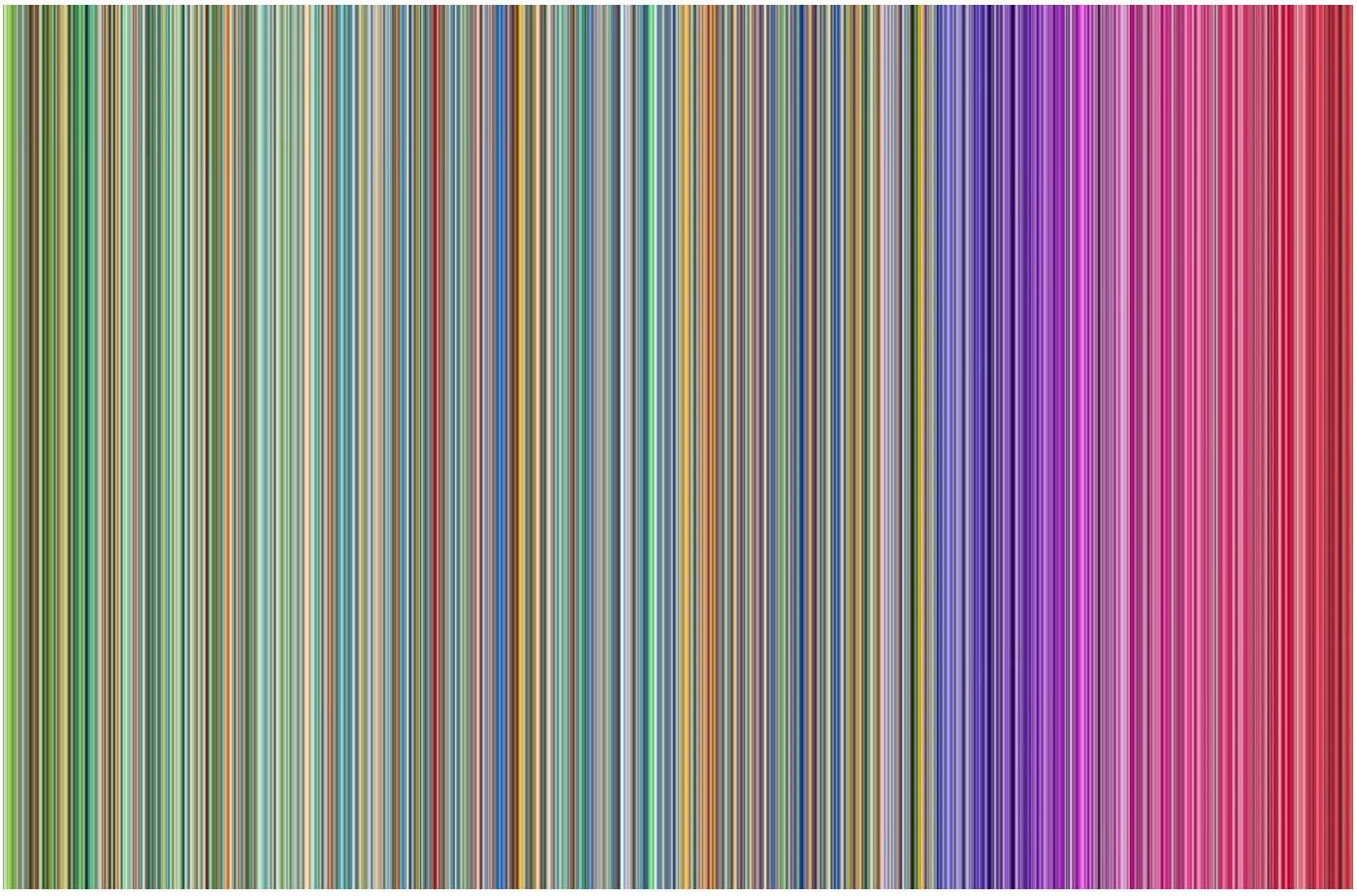
Photo credit: David Schmidt / 211 Photography

Joel Swanson is an associate professor in the Herbst Program for Engineering, Ethics & Society and the ATLAS Institute. He is a practicing artist exploring the intersection of language and technology, illuminating the subtle but powerful ways that language shapes perception. Swanson explores how language structures our world through standards such as spelling and grammar, digital character encoding, and even alphabetization. As tools of language, he is interested in erasers, highlighters and correctional fluid but also typography, spell-check algorithms and machine learning. He intends his artwork to make people perceive words from new and unconventional perspectives.

Swanson received a Master of Fine Arts from the University of California San Diego with a focus on computing and the arts and a Bachelor of Fine Arts in digital art from CU Boulder.

BubbleSort

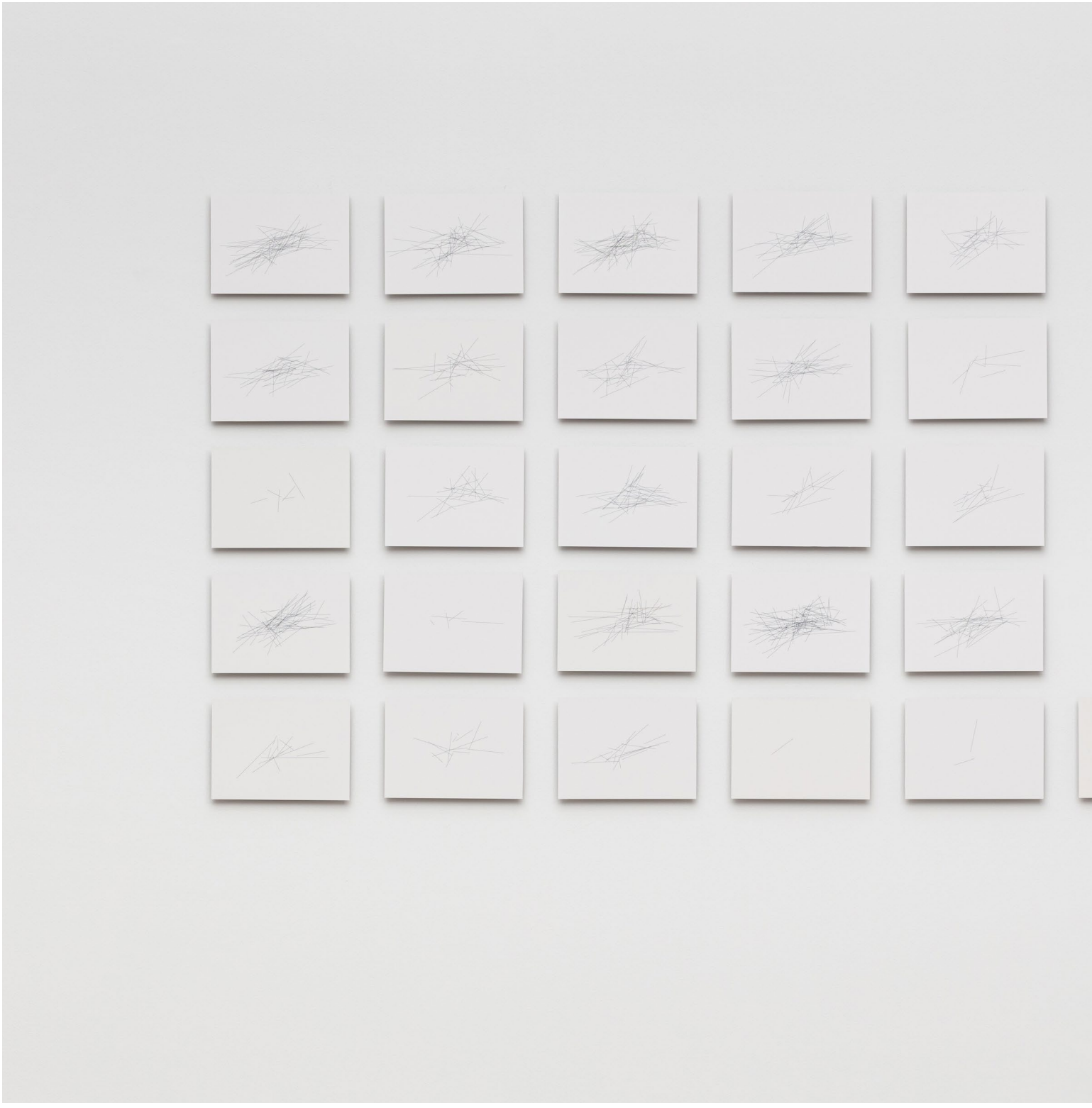
This computational animation takes a set of 2,331 name colors as defined by the World Wide Web Consortium (W3C) and, using a bubble sort algorithm, re-sorts them from alphabetical order by name to a hue-based ordering. Once the sorting is complete, the algorithm re-sorts the colors back into alphabetical order. Bubble sorting is an inefficient way to sort information as it compares each element to every other. However inefficient, bubble sorting reveals the comparison of information in real time, creating an aesthetically engaging visual experience. This work examines Internet-based protocols and the various methods of sorting and translating between organizational systems.

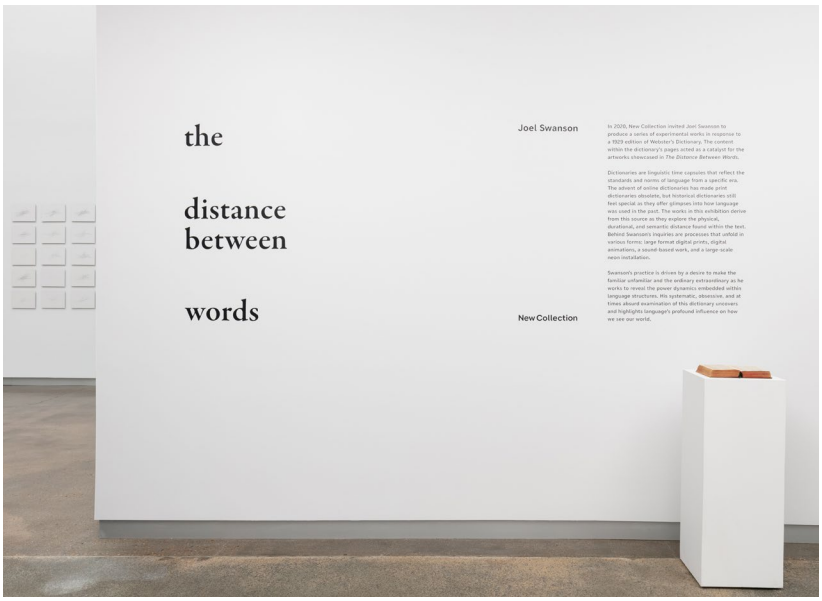


The Distance Between Words

In 2020, New Collection invited lab director Joel Swanson to produce a series of experimental works in response to a 1929 edition of Webster's Dictionary. The content within the dictionary's pages catalyzed the artworks showcased in The Distance Between Words. Dictionaries are linguistic time capsules that reflect the standards and norms of language from a specific year. Online dictionaries have made print dictionaries obsolete, but historical dictionaries still feel special, offering glimpses into how language was used in the past. The words in this exhibition derive from this source as they explore the physical, durational and semantic distance found within text. The work is driven by a desire to make the familiar unfamiliar and the ordinary extraordinary as Swanson works to reveal the power dynamics embedded within the structures of language. The systematic, obsessive and at times absurd examination of this dictionary uncovers and highlights language's profound influence on how we see our world.

Photo: Wes Magyar





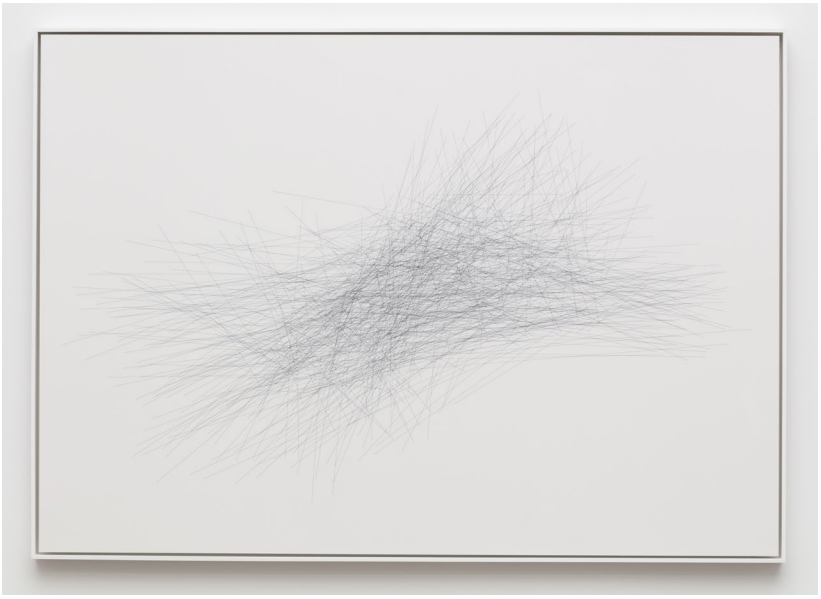


Photo: Wes Magyar

TYPO
Lab

Love,

"Love," is a 4-story illuminated public sculpture designed from handwriting samples of Nobel Laureates. Located across from the University of California Berkeley campus, the work humanizes some of the brightest minds of our time.

Photo credit: Minoosh Zomorodinia

Exhibitions

Bubble Sort. FILE Electronic Language International Festival. São Paulo, Brazil. 2023

Prismatic. Dairy Center for the Arts. Boulder, CO. 2023

The Distance Between Words. New Collection. Denver, CO. 2022

Love,. Public artwork installation. Berkeley, CA. 2022

Sponsorship

A Speculative Design Lab Exploring the Intersections of Language and Technology. University of Colorado Boulder Research & Innovation 2023 Seed Grant

The United States of America, Reconfigured. University of Colorado Boulder Research & Innovation Office 2023 Arts & Humanities Grant

The Unstable Design Lab investigates designing and making textiles (some with integrated circuitry), builds community and advocates for the arts within engineering practice. The lab creates open-source tools and programs that support collaboration across arts and engineering, using them to make interactive objects that help people experience the everyday in new ways.

Unstable Design Lab

colorado.edu/atlas/unstable-design-lab

Lab Director **Laura Devendorf**

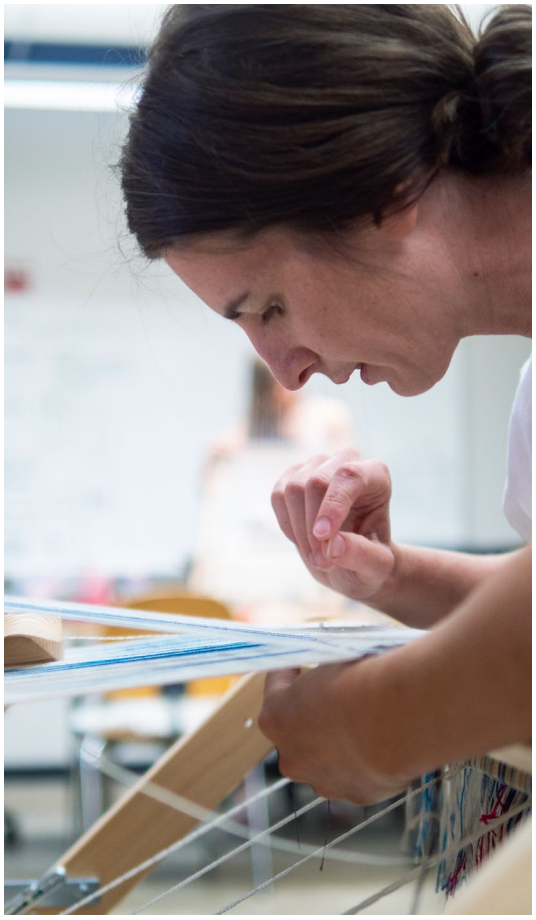


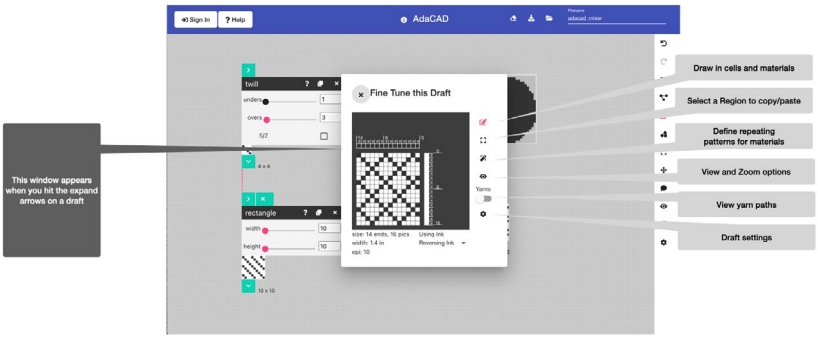
Photo: Glenn Asakawa, University of Colorado Boulder

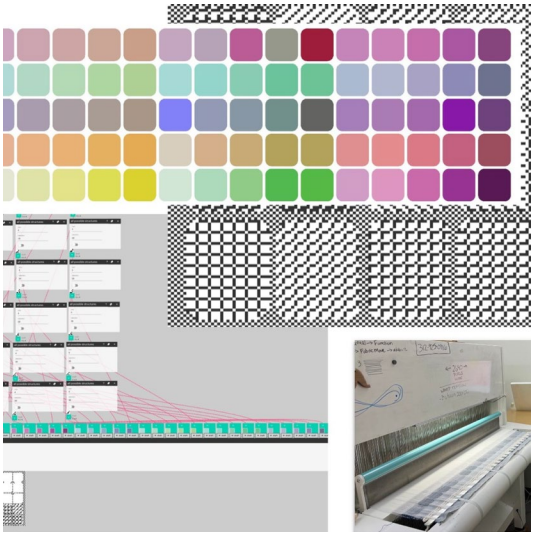
Laura Devendorf, assistant professor of information science with the ATLAS Institute, is an artist and technologist working predominantly in human-computer interaction and design research. She designs and develops systems that embody alternative visions for human-machine relations within creative practice. Her work focuses on smart textiles – a project that interweaves the production of computational design tools with cultural reflections on gendered forms of labor and visions for how wearable technology could shape how we perceive lived environments.

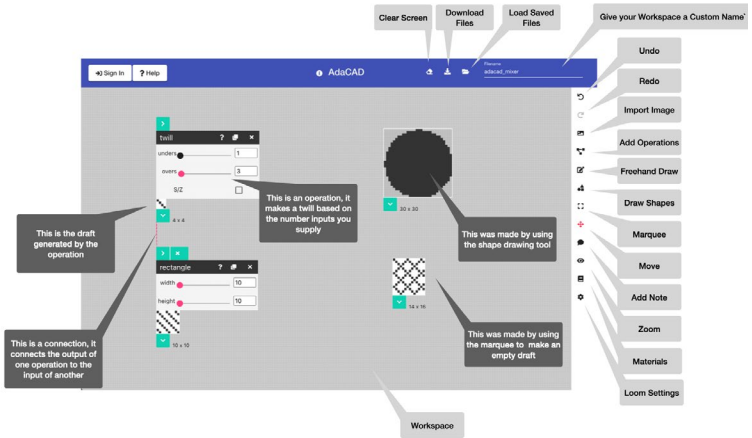
Devendorf earned bachelor's degrees in studio art and computer science from the University of California Santa Barbara before earning her PhD at UC Berkeley School of Information.

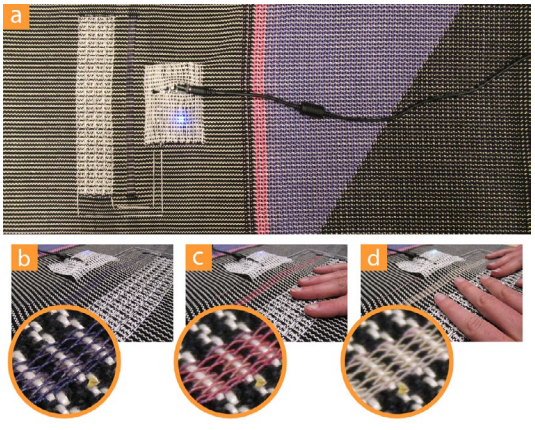
AdaCAD

AdaCAD is a parametric design tool for woven textile structures. Designing smart textiles presents constraints that differ from traditional weaving processes. However, tools that address these needs do not exist, so designers of smart textiles adapt their use of traditional weaving methods to accomplish their goals. The lab is creating a computational design tool for smart textile weaving that blends features from traditional weaving software with circuit layout tools. The software presents new representations and processes for designing smart weaves.



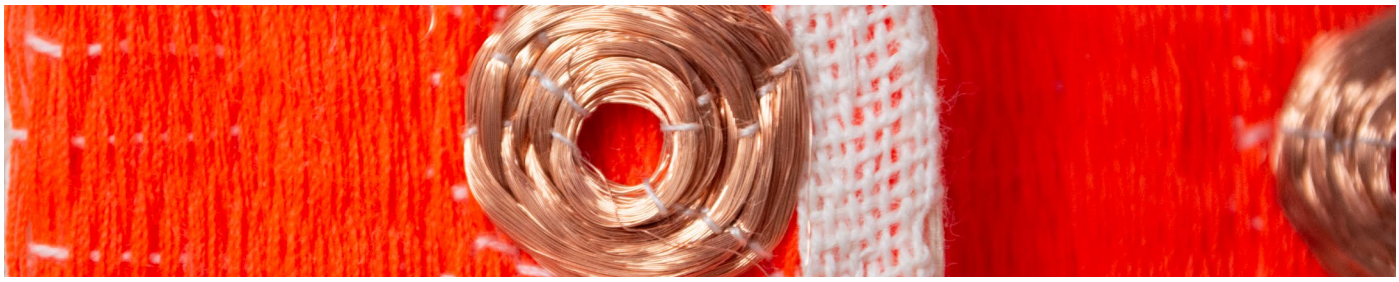






Experimental Weaving Residency

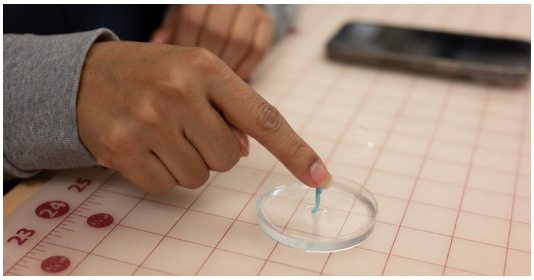
Each year, the Unstable Design Lab hosts a weaver-in-residence. The 2023 Experimental Weaving Residency explored fabrics that can oscillate between two states. We used our knowledge of weaving, electronics and programming woven drafts to generate samples that fold, flap and collapse. The result: an e-textile woven in a single piece that, when removed from the loom, can be cut apart into distinct flaps. When connected to a controller via a custom interface to control its motion, the cloth performs gestures like rustling, flickering and slow rhythmic opening and closing, suggesting a passage of wind or sunlight across the piece, bringing it to life. Two electromagnetic coils control each flap. When a coil is powered and attracted to a magnet, the flap closes and the cloth appears white. When opened, light bounces from the flap's bright orange interior onto the base cloth, creating a warm neon glow – changing the color of the fabric in a large-scale, structural manner. We developed weaving strategies in which disparate elements – neutral base, neon flaps, copper coils – are fully integrated into a single-piece fabric on the loom.

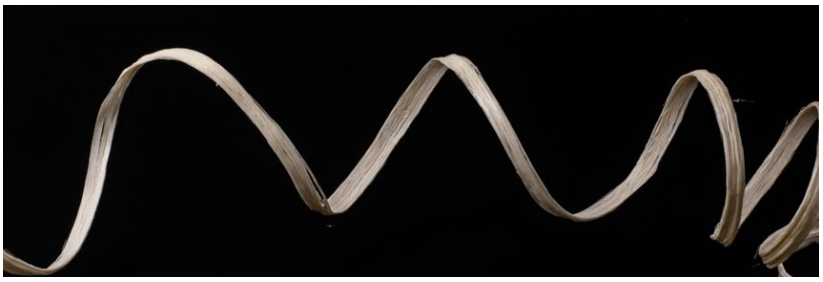


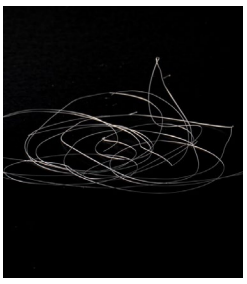
Spinning Biofibers

Collaboration with the Living Matter and Utility Research Labs

Smart textiles integrate electronic materials into knitted or woven structures. They are widely used in soft and conformal electronic systems for applications in fashion, robotics and medicine. However, smart textiles pose significant environmental risks because they combine two highly toxic waste streams: textile and electronics waste. This work explores creating and using sustainable bio-based fibers that support disassembly and electronics recyclability.







Publications

Wear: An Exoskeleton for Caring. Laura Devendorf. *Feminist Designer*. 2023

Towards Mutual Benefit: Reflecting on Artist Residencies as a Method for Collaboration in DIS. Laura Devendorf, Leah Buechley, Noura Howell, Jennifer Jacobs, Hsin-Liu (Cindy) Kao, Martin Murer, Daniela Rosner, Nica Ross, Robert Soden, Jared Tso, Clement Zheng. *Proceedings of the 2023 Conference on Designing Interactive Systems Conference*, Pittsburgh, PA. 2023

AdaCAD: Parametric Design as a New Form of Notation for Complex Weaving. Laura Devendorf, Kathryn Walters, Marianne Fairbanks, Etta Sandry, Emma R. Goodwill. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, Hamburg, Germany. 2023

Crafting Interactive Circuits on Glazed Ceramic Ware. Clement Zheng, Bo Han, Xin Liu, Laura Devendorf, Hans Tan, Ching Chiuan Yen. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, Hamburg, Germany. 2023

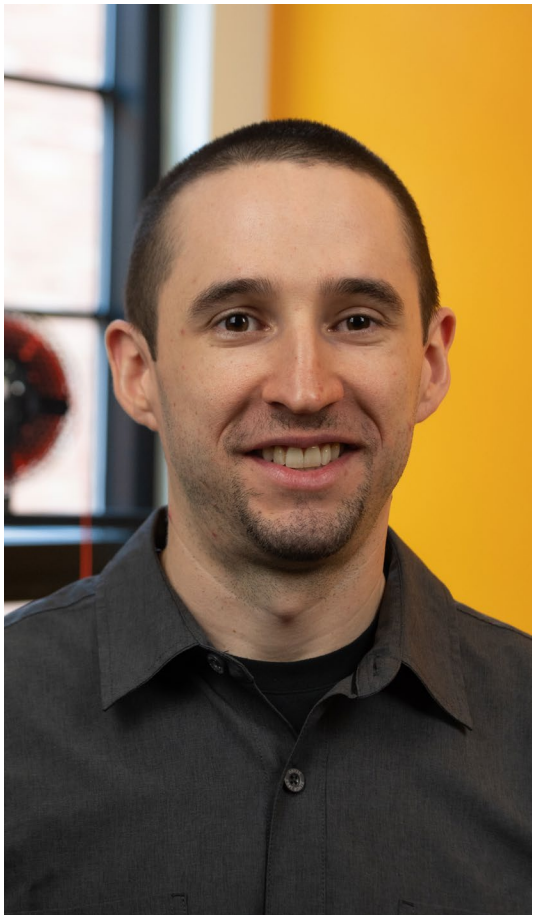
Sketching Across the Senses: Exploring Sensory Translation as a Generative Practice for Designing Data Representations. Jordan Wirfs-Brock, Maxene Graze, Laura Devendorf, Audrey Desjardins, Visda Goudarzi, Mikhaila Friske, Brian C. Keegan. *CHI Conference on Human Factors in Computing Systems Extended Abstracts*, Hamburg, Germany. 2023

Sponsorship

CAREER: Investigating Novel Tools and Collaborative Programs for Smart Textiles Innovation at the Intersection of Engineering and Craft. NSF IIS-1943109

The Utility Research Lab invents and investigates digital fabrication technology, tools and techniques to advance science and engineering while positively impacting people, society and the environment. Through developing hardware, software and materials, the lab aims to empower people to create with purpose.

Lab Director
Michael Rivera



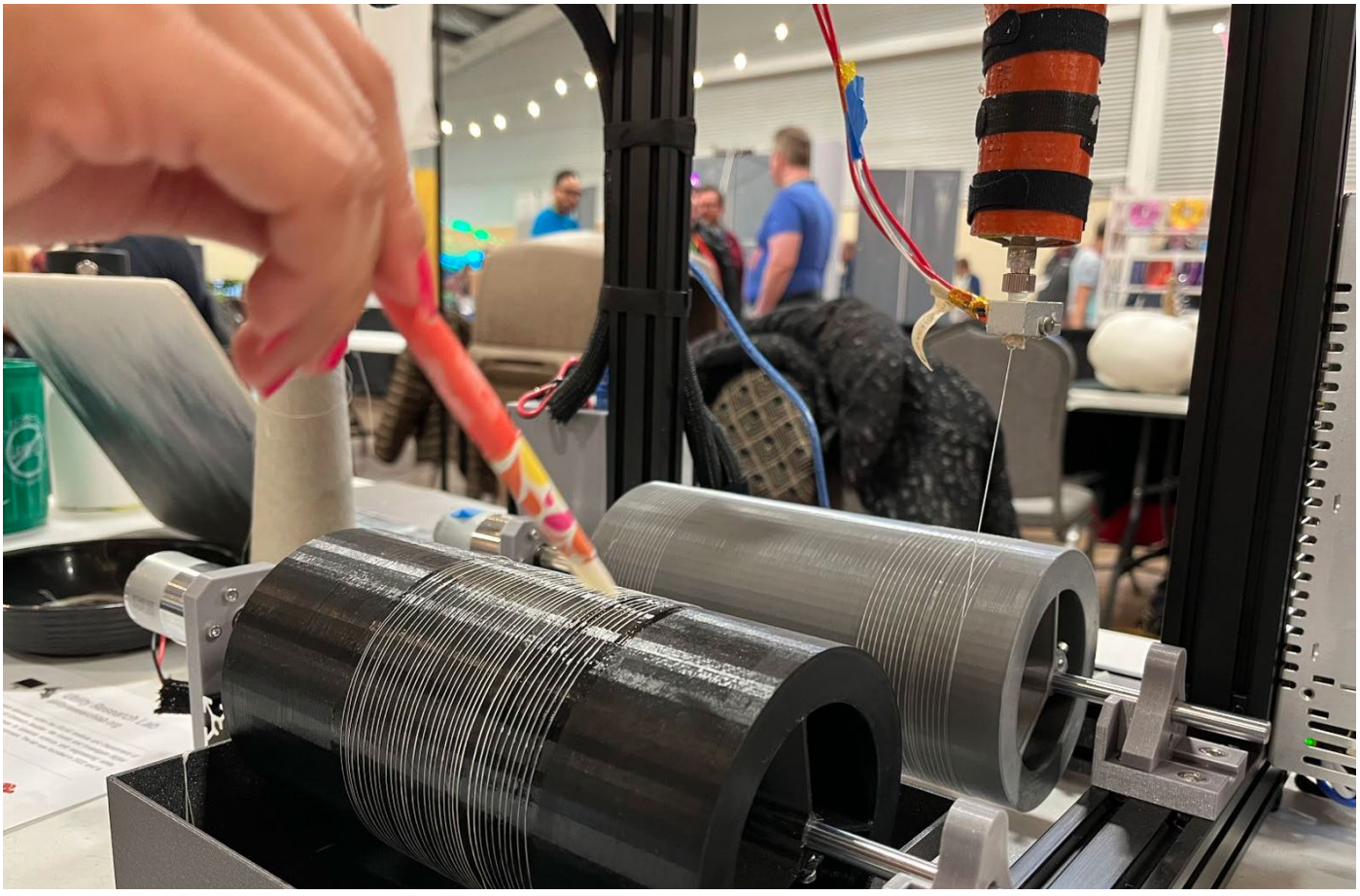
Michael Rivera, assistant professor of computer science with the ATLAS Institute, researches digital fabrication, inventing and investigating hardware and software systems that enable people to create useful and usable technologies. He believes technology should be purposeful and those who create it should pay careful attention to its impact on people, society and the environment.

Prior to joining the CU Boulder faculty, Rivera was a 2021 Computing Innovation Fellow and post-doctoral researcher at the ATLAS Institute. He completed an MSE in computer graphics and game technology and a BSE in digital media design at the University of Pennsylvania. He earned his PhD and master's in Human-Computer Interaction at Carnegie Mellon University.

A Desktop Biofiber Spinning Machine for Smart Textiles Design

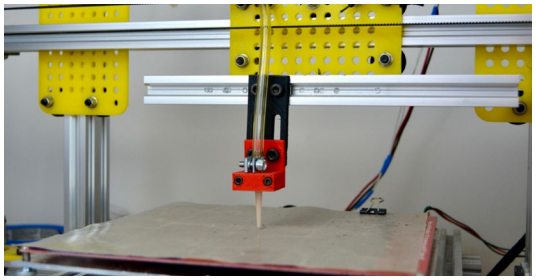
Collaboration with the Living Matter and Unstable Design Labs

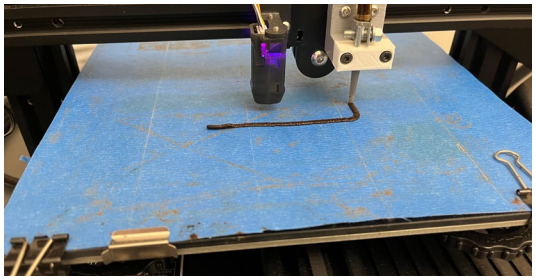
The desktop biofiber spinning machine, like a 3D printer, enables prototyping and experimenting with bio-based fibers. The fibers can be tuned with different properties and then spun to create yarns. Importantly, these fibers can be easily dissolved, enabling electrical components to be recovered and recycled.

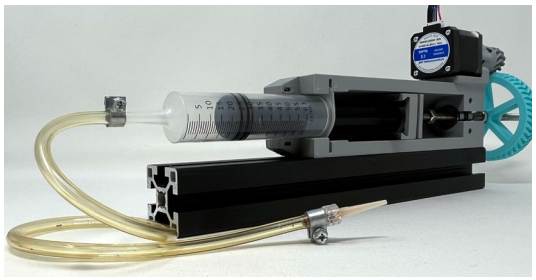


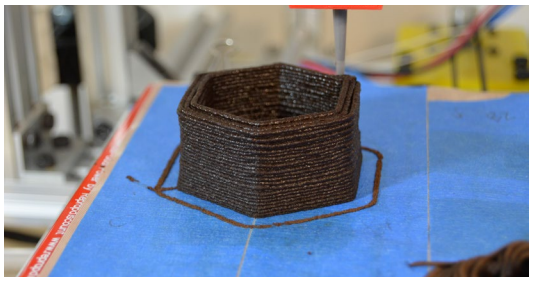
3D Printing with Spent Coffee Grounds

The widespread adoption of 3D printers exacerbates environmental challenges as these machines increase energy consumption, waste output and the use of plastics. The choice of material for 3D printing is tightly connected to these challenges. Bio-based materials – particularly ones that are commonly wasted – have huge potential to reshape the sustainability of 3D printing. This work explores spent coffee grounds recovered from local coffee shops as a sustainable material for prototyping with 3D printing. In contrast to thermoplastics typically used in 3D printing, objects made of coffee grounds are easily recycled and composted.



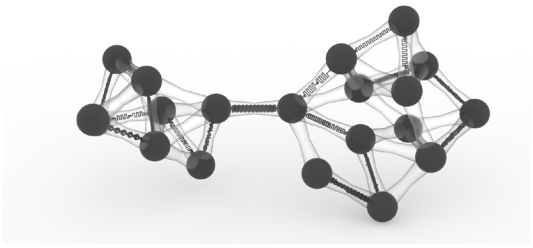


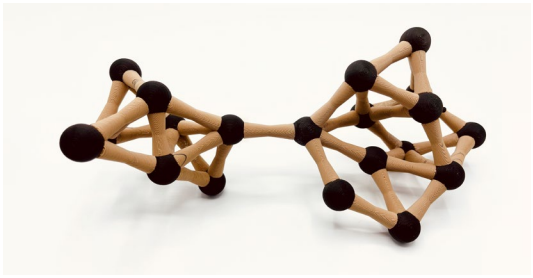




3D Printed Multi-Point Capacitive Touch Sensing

Designing interactive devices is a challenging task that requires careful mechanical design and wiring to integrate electronics. Using multi-material 3D printing and computational tools, this work demonstrates an approach to generate and fabricate conductive traces within objects to support capacitive touch sensing. Touching different parts of an object produces a unique delay in the electrical signal across the integrated electrical circuit. The signal delay allows users to sense exactly where someone touches an object.





Publications

Designing a Sustainable Material for 3D Printing with Spent Coffee Grounds. Michael L. Rivera, S. Sandra Bae, Scott E. Hudson. *Proceedings of the 2023 Conference on Designing Interactive Systems Conference*, Pittsburgh, PA. 2023

A Computational Design Process to Fabricate Sensing Network Physicalizations. S. Sandra Bae, Takanori Fujiwara, Anders Ynnerman, Ellen Yi-Luen Do, Michael L. Rivera, Danielle Albers Szafir. *Proceedings of the IEEE Transactions on Visualization & Computer Graphics*, Melbourne, Australia. 2023

Sponsorship

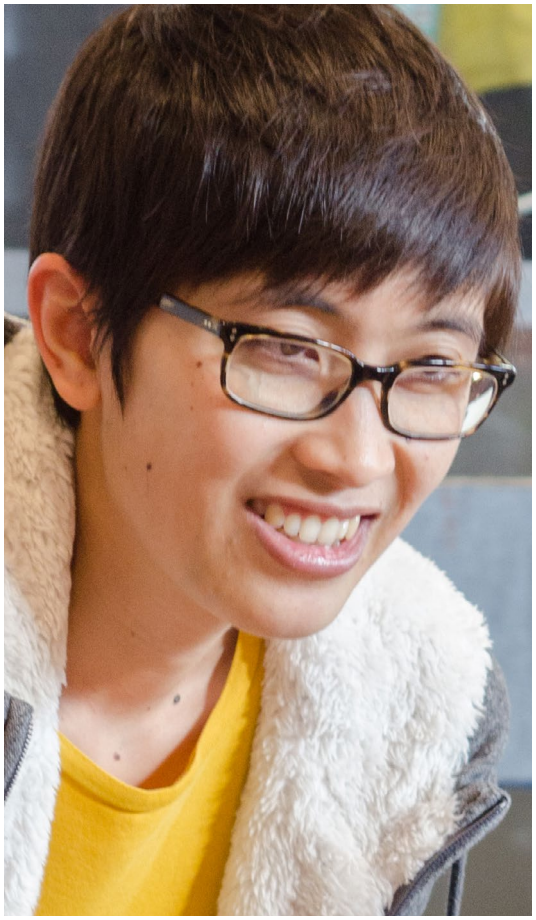
Supporting Explainable AI for Future Analysts with Interactive Physicalizations University of Colorado Boulder, Engineering Education and AI-Augmented Learning Interdisciplinary Research Theme

Open-Source Fiber-Spinning for Sustainable Resilient Infrastructure. University of Colorado Boulder, Resilient Infrastructure with Sustainability and Equity (RISE) Interdisciplinary Research Theme

Computationally-Supported Craft: Design Tools for Sustainable Smart Textiles Manufacturing. Computing Innovation Fellowship, NSF, Computing Research Association and Computing Community Consortium

The Creative Communities Group explores how to engage people to create, play and learn together. The lab brings together researchers, students, designers and educators committed to designing and studying learning experiences for young people to create things they care about, develop identities as creators and shape the world around them.

Lab Director
Ricarose Roque

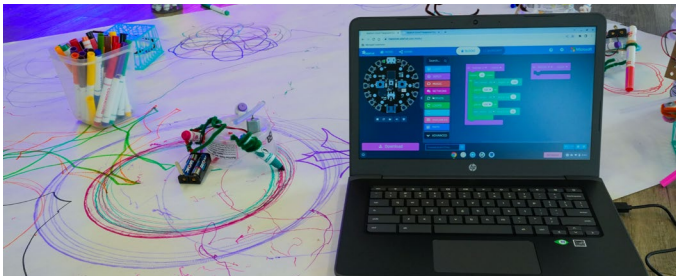


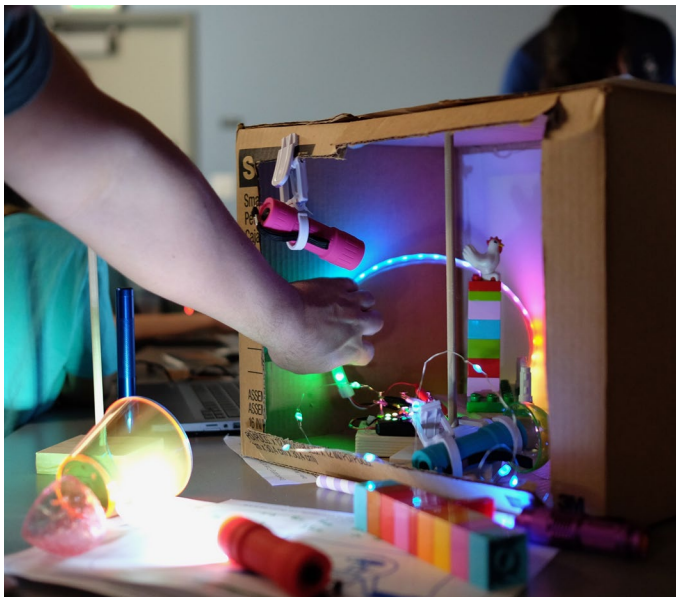
Ricarose Roque, assistant professor of information science and faculty affiliate of the ATLAS Institute, designs and studies equitable learning environments that enable young people to use computing to create things they care about, develop identities as creators and imagine ways they can shape the world. She draws on community-engaged, design-based and ethnographic methods to study the role that social context plays in supporting children's participation in computing, especially children from non-dominant groups who have been marginalized from opportunities because of race, ethnicity, immigration status and/or socioeconomic status.

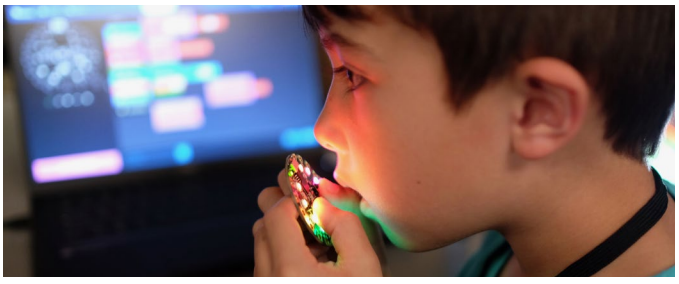
She was previously a member of the Lifelong Kindergarten research group at the MIT Media Lab, a member of the MIT Scratch Team, and faculty associate at the Berkman Klein Center for Internet and Society at Harvard University. Roque holds master's degrees in media arts and sciences and computer science and engineering and a PhD in media arts and sciences, all from the Massachusetts Institute of Technology.

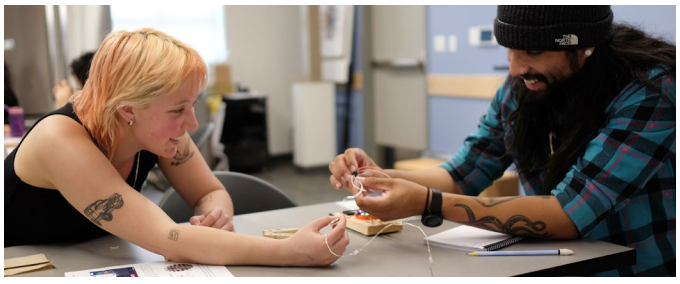
Facilitating Computational Tinkering

Facilitating Computational Tinkering is a collaborative project to engage youth and families in out-of-school spaces in creative and equitable learning experiences to express themselves with computing. We work with educators and facilitators in these spaces to understand the barriers they face, to co-design resources and to support them with professional development opportunities that amplify their capacities to engage their communities in computational tinkering. Tinkering-based approaches to learning and creating with computational tools combined with equitable facilitation practices can support nondominant youth and families in feeling welcome and valued in computing spaces.



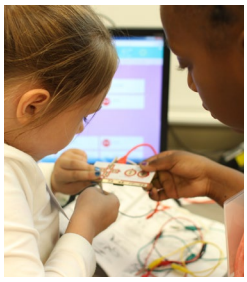






Family Creative Learning

Technology pervades all aspects of our lives and young people grow up playing, learning and connecting with technology. We recognize that families have a wealth of knowledge and cultural resources along with rich histories and stories. Family Creative Learning is a community program and design-based research project that engages children and their families to learn together – as designers and inventors – through the use of creative technologies. The workshops build on families' relationships and cultural backgrounds and strengthen their social support and expertise around computing. These workshops leverage the learning dynamics that families already use in activities like literacy development and support families in using them in the context of computing. This enables adult caregivers and children to become more empowered learning partners.



Making Learning Visible

"How can we help children find the meaning of what they do, what they encounter, and what they experience? How can we do this for ourselves?" The team has been inspired by the Reggio Emilia approach to making learning visible as alternative, sociocultural approaches to assessment and documentation that respond to children's inquiry and collaborative processes. The Reggio Emilia approach to documentation is "an act of caring, an act of love and interaction" – echoing other sociocultural frameworks that situate learning as relational, built on caring and cultivated relationships. Documentation plays a critical role in demonstrating this strong image of the child. Documentation through images, dialog, artifacts and other media allows educators to communicate to key stakeholders (e.g. families and community members) the experiences of children and the value of what and how they learn. It is also an opportunity for teachers to reflect on their practice, learners' experiences and the design of their activities.

Publications

Revealing the Tuning Practices of Creative Learning Experience Designers. Celeste Moreno, Ricarose Roque. *Proceedings of the Conference on Creativity and Cognition*, online. 2023

Expanding and Focusing Infrastructuring Analysis for Informal STEM Education. Ronni Hayden, Stephanie Hladik, Ricarose Roque. *Proceedings of the International Society of Learning Sciences,* Montreal, QC. 2023

Imagining Alternative Visions of Computing: Photo-Visuals of Material, Social, and Emotional Contexts from Family Creative Learning. Ricarose Roque. *Proceedings of the ACM Interaction Design and Children Conference*, Chicago, IL. 2023

Taking Play and Tinkering Seriously in AI Education: Cases from Drag vs AI Teen Workshops. J. Ruppert, D. Velazquez-Ramos, R. Roque, R.B. Shapiro. *Learning, Media, and Technology*. 2023

Exploring Computational Thinking with Physical Play Through Design. Junnan Yu, Ronni Hayden, Ricarose Roque. *Proceedings of the ACM Interaction Design and Children Conference*, Chicago, IL. 2023

Sponsorship

Tinkering and Making Strategies to Engage Children and Families in Creating with Code. NSF DRL-2005764

Designing and Researching a Program for Preparing Teachers as Facilitators of Computational Making Activities in Classroom and Informal Learning Environments. NSF DRL-1908351

Families Creating Together: Engaging Children and Parents in Design-Based Activities for the Cultivation of Computational Literacy. Institute of Museum and Library Services lg-96-17-0176-17

Startups Cultivated at the ATLAS Institute

HYPRSKN & Magic Ink
Professor Carson Bruns

HYPRSKN is a nanobiotechnology company developing microscopic skin implants to expand and amplify human ability in the domains of health, beauty and creativity. Its subsidiary, Magic Ink, offers the world's first rewritable tattoo ink for radiation therapy and body art.

Edboard
PhD student Ruhan Yang

EdBoard is a simple and intuitive circuit-building platform with easy-to-use magnetic electronic components. It is screenless, hands-on and easily adaptable, making it the perfect addition to any home or classroom. We teach kids about circuits in easy-to-understand ways so they will be emboldened to invent without inhibition.

FlaVR Labs
Professor Ellen Yi-Luen Do

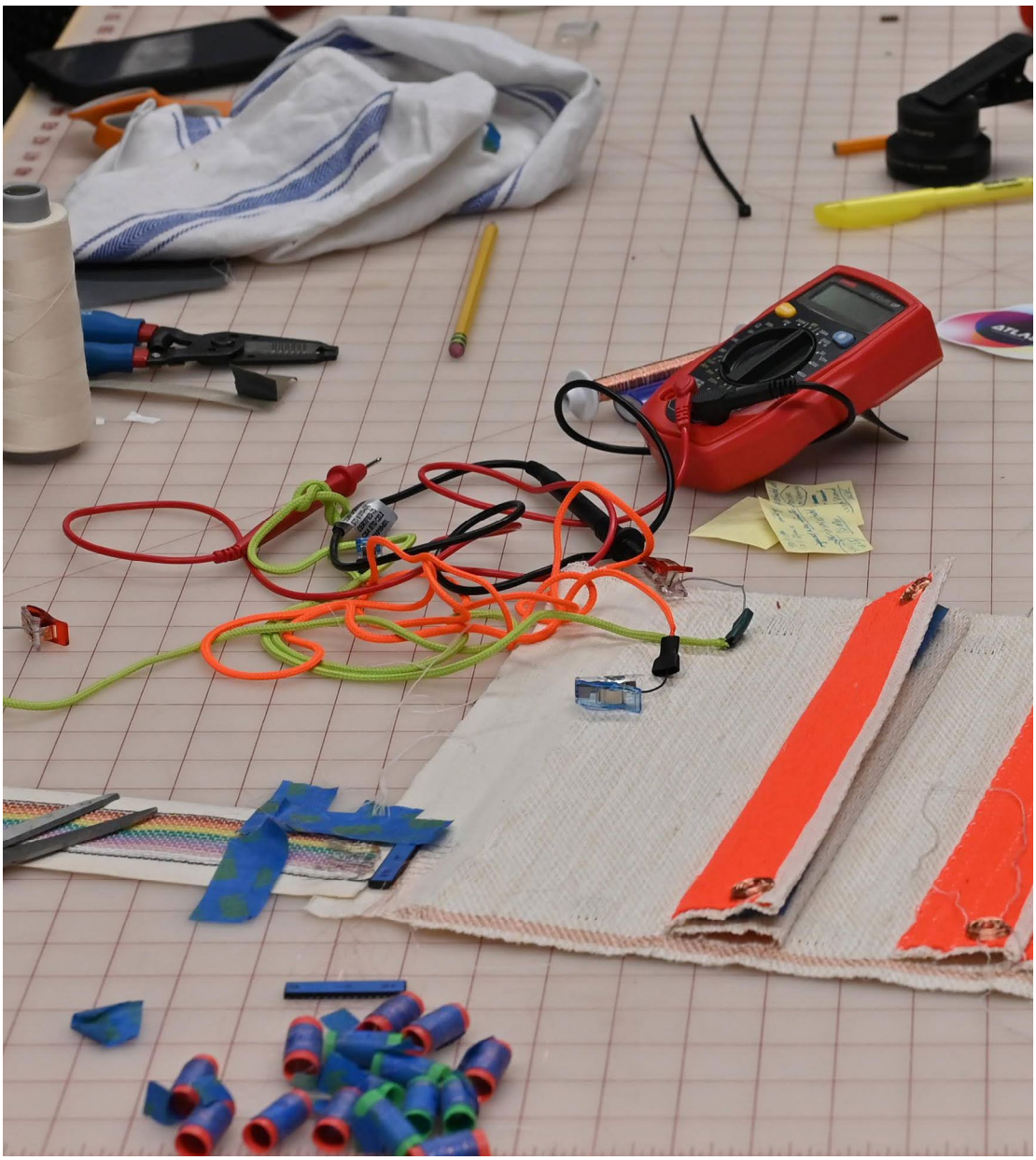
FlaVR Labs is changing the way we experience flavor. Imagine being able to make plain water taste like any flavored beverage without the addition of chemicals, sweeteners, aromas or colors. Imagine being able to make solid foods taste "better" without the addition of salt or chemical flavor enhancers.

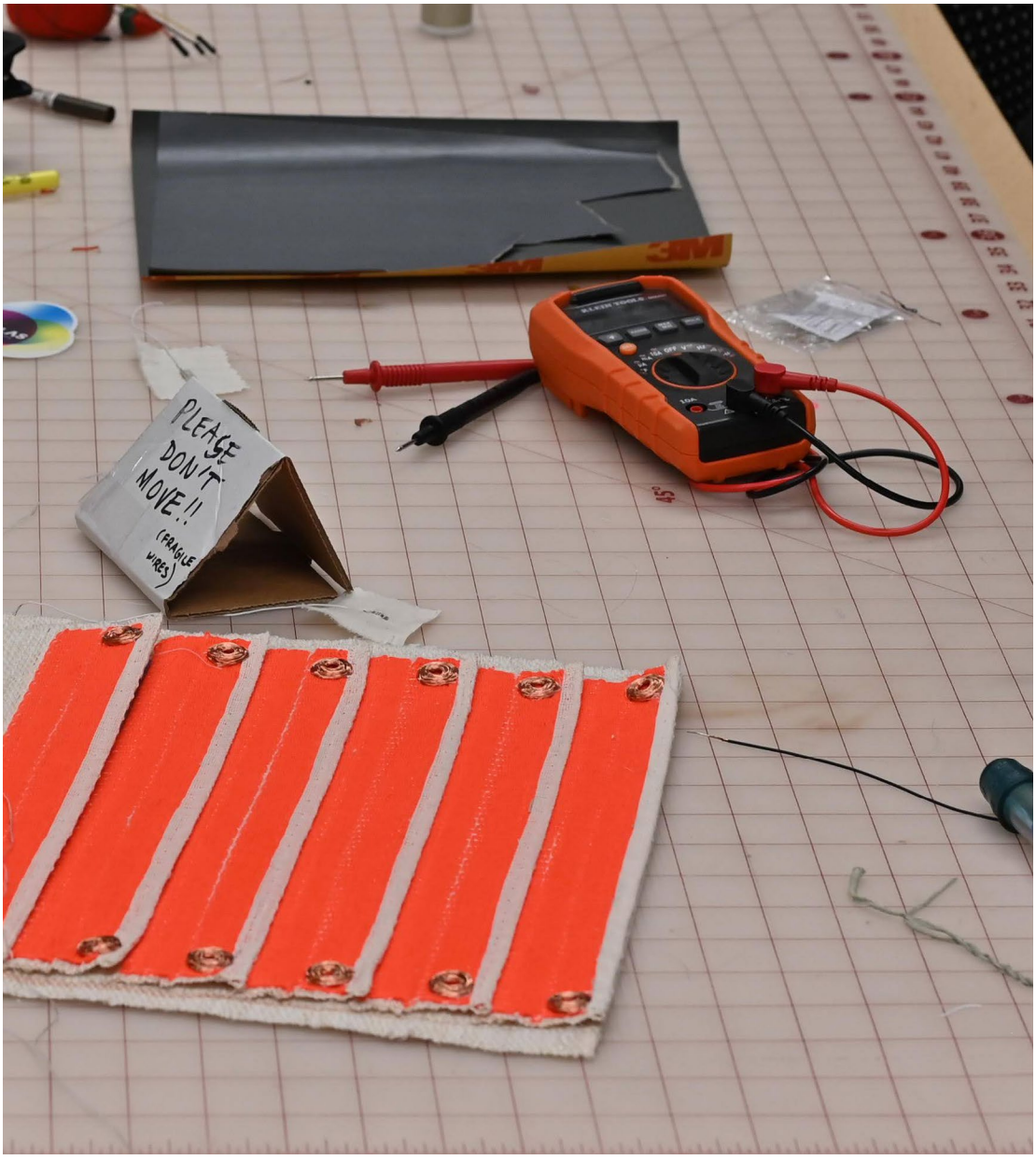
Chembotix
PhD candidate Kailey Shara

Making molecules in current laboratory settings is typically time consuming and dangerous, but it is essential to pharmaceutical and industrial research and development. By automating organic chemistry processes through a robotic system made from a unique marriage of chemistry and engineering, Chembotix can not only create molecules 16 times faster than typical methods but do so more safely and consistently, and at a cheaper cost.

Partners

The ATLAS Institute is grateful for the support of our partners.

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Join Our Vibrant Community

In the university setting, nothing happens without the interest and support of external stakeholders. You bring real-world challenges and opportunities into our labs, and we apply engineering expertise and creative insight to addressing them. We have many ways you can participate in the ATLAS Institute. Get in touch to learn more.

Mark D Gross
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Professor of Computer Science
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Back Cover Art
From left to right, bottom to top:

Utility Research Lab
3D Printing with Spent Coffee Grounds

Brain Music Lab
Multimodal Brain and Body Music Interfaces

ACME Lab
Beholder

Living Matter Lab
Designing with Bioluminescence

TYPO Lab
The Distance Between Words

THING Lab
Together Apart

Laboratory for Emergent Nanomaterials
Laboratory Automation

Creative Communities Group
Facilitating Computational Tinkering

Unstable Design Lab
Experimental Weaving Residency

ATLAS is an interdisciplinary institute for radical creativity and invention.

University of Colorado Boulder