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# Making with Data (and Beyond)

Lora Oehlberg  
Wesley Willett  
lora.oehlberg@ucalgary.ca  
wesley.willett@ucalgary.ca  
University of Calgary  
Calgary, Canada

Samuel Huron  
samuel.huron@telecom-paris.fr  
Télécom Paris, CNRS i3 (UMR 9217),  
Institut Polytechnique de Paris  
Palaiseau, France

Till Nagel  
Mannheim University of Applied  
Science  
Mannheim, Germany  
t.nagel@hs-mannheim.de

Alice Thudt  
Freelance Interface Designer &  
Researcher  
Dießen am Ammersee, Germany  
alice.thudt@gmail.com

Ekene Ijeoma  
MIT  
Boston, United States  
ekene@ekeneijeoma.com

Dietmar Offenhuber  
Northeastern University  
Boston, United States  
d.offenhuber@northeastern.edu

Eva Hornecker  
Bauhaus-Universität Weimar  
Weimar, Germany  
eva.hornecker@uni-weimar.de



Figure 1: A physical representation of data created by a paper artist using a mix of digital design and physical crafting techniques.

## ABSTRACT

In this proposed panel, we will discuss the practice of *Making with Data*—the practice of creating physical artifacts that represent a dataset. This topic lies at the intersection of several CHI communities: data visualization, fabrication, and tangible interaction. Our goal is to discuss contemporary practices, but also to envision future ways that we might continue to make physical representations of data in the future, given emerging fabrication techniques, data representation practices, and desired interactions and experiences with data.

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## CCS CONCEPTS

• **Human-centered computing** → **Visualization theory, concepts and paradigms**; **Visualization systems and tools**.

## KEYWORDS

data physicalization, physical data representation, data sculpture, fabrication, design process

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## 1 INTRODUCTION

Humans have created physical representations of data for thousands of years—often because they served as fundamental ways of recording information. While we have since evolved to graphical

and digital means of representing data, the practice of physically representing data still persists across a breadth of communities—from everyday people to artists, designers, and researchers. The creation of these physical representations of data also relies on radically different creation methods ranging from hand crafting to digital fabrication and even computer-controlled actuation. Others require group participation or even leverage direct inputs from the natural environment.

Within the last 20 years, data and information have become more accessible and pervasive in our daily lives—both the information available about the world around us, as well as situated and embedded ways that data can be woven into the world around us [22]. The Human-Computer Interaction research community in response has investigated physical representations of data from multiple perspectives—as a new medium for information visualization, a motivation for new fabrication tools, and a new way of enabling tangible interactions with data. One approach in research is to examine and question the resulting data physicalization artifacts. However, there have also been increasing research attention on extending the information visualization pipeline [7], surveying fabrication processes [4], and proposing new tools [15] and design paradigm [5] that enable physical representations of data to become a reality. By understanding the diverse ways that contemporary creators are making with data, we can also envision a diverse set of future possibilities.

In this panel, we hope to interrogate the diversity of fabrication techniques in use today, building on a set of 5 categories (handcraft, digital fabrication, actuation, participation, and environmental) identified in our recent work [6]. We will invite senior researchers, artists and designers to comment on the challenges and benefits of these different approaches. We also will invite them to challenge the aforementioned categories, question existing definitions, and propose new vocabulary that extends the space of physical data representations. We expect this discussion will be a platform for outlining a new research agenda for the creation of physical data representation.

## 2 PANELISTS

The panelists will include a mix of researchers and practitioners who have been involved in the design and development of data physicalization projects or data sculptures, or have reflected on the practices used in this new discipline. The panel will be facilitated by some of the authors of the book *Making With Data* [6].

**Dietmar Offenhuber** is Associate Professor and Chair of Art + Design at Northeastern University. His research focuses on environmental information and evidence construction, their material/sensory aspects and social implications. He wrote the award-winning monograph *Waste is Information – Infrastructure Legibility and Governance* (MIT Press). His forthcoming monograph at MIT Press examines the idea of *Autographic Data*, which include physical traces and self-inscribing phenomena such as tree rings [10]. He theorizes trace-phenomena as non-symbolic forms of data that play a central role in practices of evidence construction from the sciences to grassroots activism [12]. In the context of data physicalization, designers can use autographic phenomena to make processes such as climate change and environmental pollution experiential.

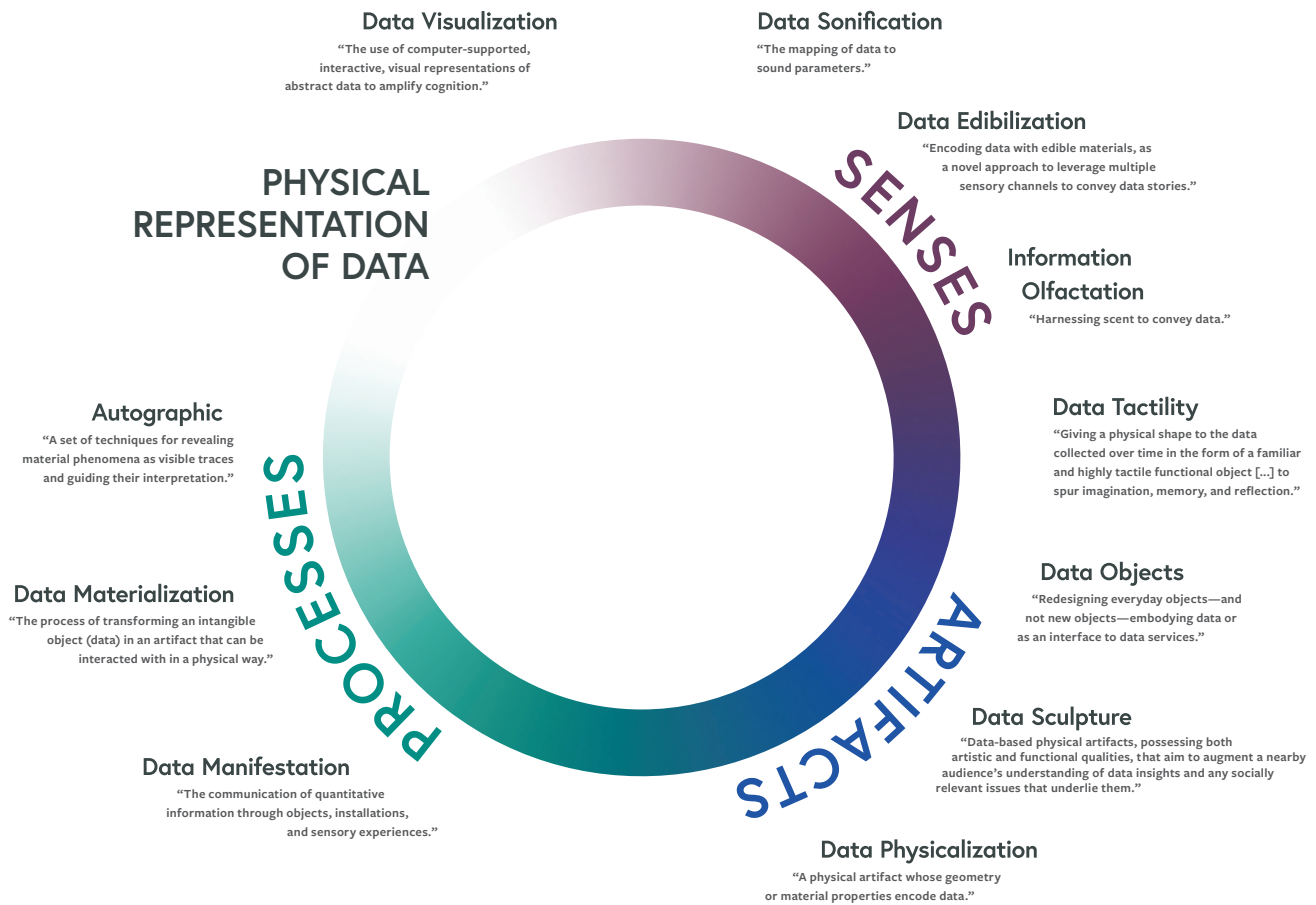
**Alice Thudt** is a freelance data visualization designer. She received her PhD in Computational Media Design from the University of Calgary. Her PhD research focused on individual meaning-making with personal data through diverse reflective and expressive practices [16, 17]. As part of her research she explored physicalization and data craft as a means for self-reflection and expression. She has further integrated personal data into her own creative practice as a hobby ceramicist. In her series “Life in Clay”, she created functional everyday objects, decorated with visual patterns based on personal data as mementos of cherished relationships and experiences.

**Ekene Ijeoma** researches how social, political, and environmental systems affect people and develops sound, video, sculpture, installation, and performance using poetic and computational strategies. Across these various media, his work exposes the systems unjustly affecting people and engages people in communally changing these systems. His data-driven artworks sonify and materialize data on overlooked aspects of sociopolitical systems through cultural artifacts. For example, *Deconstructed Anthems*, a series of compositions, sonifies the increasing loss of Black Americans to prisons and jails by repeating the Star-Spangled Banner and removing notes based on incarceration rates. Similarly, *Wage Islands*, a series of sculptures, materializes the increasing costs of housing for poor New Yorkers by submerging a topographic map of the city in a water tank based on housing-to-income ratios. His work has been presented by Bemis Center for Contemporary Art, Contemporary Art Museum of St. Louis, Museum of Contemporary Art Denver, Contemporary Art Museum of Houston, The Kennedy Center, Museum of the City of New York, Neuberger Museum of Art, Storefront for Art and Architecture and Museum of Modern Art among others. He is an Assistant Professor at MIT and the Director of Poetic Justice Group at Media Lab.

**Eva Hornecker** is a Professor of HCI at the Bauhaus-Universität Weimar. She is one of the initiators of the ACM TEI conference. Her research sits at the intersection of technology, design and social sciences, with a specific interest in the roles of tangibility, materiality, and embodiment, and in human sense-making and collaboration. One of her research interests in the past decade has been the role of data representation modality on user experience and the user experience of data physicalization. She and her group have taught a number of creative project-based courses on data physicalization over the last few years, and reflected on the process of data curation as well on how engaging with physicalization can change our view of what data are [18, 20].

## 3 PANEL MODERATORS

**Lora Oehlberg** (online moderator) is one of the authors of *Making with Data*. She is an Associate Professor of Computer Science at the University of Calgary. Her research addresses how technology can better support creativity, collaboration, and curiosity in a range of domains, including interaction design, electronic fashion, improvised digital fabrication, physical data representations, improvised theatre, and healthcare innovation. She leads the Curio Lab, and is one of the faculty leaders of the Interactions Lab, a human-computer interaction research collective. She is currently the director of the Computational Media Design graduate program,



**Figure 2: Existing definitions and categories related to the concept of making with data.**

and part of the University of Calgary’s Makerspace community of practice group. In 2018 she was awarded a Peak Scholar of Entrepreneurship, Innovation, and Knowledge Engagement from the University of Calgary for her work in “People-Centred Technology for Creativity and Collaboration”. She was an Inria Silicon Valley postdoctoral fellow with the InSitu group at Inria Saclay. She has a PhD and MSc in Mechanical Engineering from the University of California at Berkeley, and a BSc in Mechanical Engineering from Stanford University.

**Wesley Willett** (online moderator) is one of the authors of *Making with Data*. He is an Associate Professor of Computer Science at the University of Calgary where he holds a Canada Research Chair in Visual Analytics. His interests span information visualization, social computing, new media, and human-computer interaction, and his research focuses on pairing data and interactivity to support collaboration, learning, and discovery. At the UofC, Dr. Willett leads the Data Experience Lab and is a member of the Interactions Lab, the university’s human-computer interaction research collective.

**Samuel Huron** (in-person moderator) is one of the authors of *Making with Data*. He is an information designer and associate professor in Design of Information Technologies in the Social and

Economical Science department of Télécom Paris at the Institut Polytechnique de Paris, and part of the CNRS Institut Interdisciplinaire de l’Innovation. His research addresses how humans create, visual and physical representations of abstract information to think, collaborate, learn, analyze, explore, and design new data representations, systems and information artefacts. He leads the design studio at Telecom Paris and he is part of the Interact and Diva teams.

**Till Nagel** (in-person moderator) is one of the authors of *Making with Data*. He is a Research Professor of Visual Analytics at the Mannheim University of Applied Sciences. His interests are in information visualization, interaction design and data literacy. He heads the Human Data Interaction Lab, which investigates new ways of supporting different target groups with interactive data representations. A major focus of his research is around the themes of urban data and mobility visualizations, and in the democratization of visualization tools. He was the general chair of the IEEE VIS Arts Program 2018 and 2019. Dr. Nagel has a background in media and computer science, and received his PhD at the Human Computer Interaction group at KU Leuven. He was a visiting scholar at the MIT Senseable City Lab in Boston and Singapore, a postdoctoral fellow at the FHP Urban Complexity Lab, and a guest professor at

Burg Giebichenstein University of Arts and Design. His work has been exhibited at, among others: Venice Biennale of Architecture, Shanghai Design Exhibition, and UN Habitat X Change.

## 4 PANEL FORMAT

The panel will include 3 moderators and 4 panelists. The panel—if possible—will be designed as a hybrid event, such that we will use online systems to interact with both the in-person and virtual audience to moderate questions and discussion. Two moderators will be leading the in-person conversation, while one moderator will be dedicated to fostering conversation online and bringing questions and discussion points from the online conversation into the physical conversation.

Before the panel, we will share a list of definitions of different types of data physicalizations (see Figure 2): Data Visualization [2], Data Sonification [9], Data Edification [21], Information Olfaction [1], Data Tactility [3], Data Objects [13], Data Sculpture [23], Data Physicalization [8], Data Manifestation [19], Data Materialization [14], and Autographic Visualization [11].

We will also include the list of themes from *Making with Data* [6]: Handcraft, Participation, Digital Fabrication, Actuation, and Environment. We will ask each panelist to focus on one or two case studies—telling the story of how specific data physicalization projects went from conception to final implementation. We will ask each panelist to position the piece(s) in terms of existing definitions, themes, and methods. We will encourage panelists to select case studies that are provocative, introduce questions, and challenge existing definitions and categories.

The panel itself will be organized into several phases, including initial presentations, discussion, audience engagement, and a summary wrap-up.

### 4.1 Initial Presentations

First, the moderators will present a set of definitions used to describe physical representations of data (see Figure 2), and five themes from *Making with Data* [6]. Next, each panelist will introduce themselves, and be given a few minutes (and two to four slides) to present a case study of a physical representation of data with a compelling story of how it came to be.

### 4.2 Discussion

The moderators will ask questions to the panelists, including:

- What are the challenges and benefits of each fabrication technique they've mentioned?
- Given the current set of definitions, where do you see opportunities to extend or connect them to each other?
- What types of expertise and literacy are needed to create physical representations of data?
- How do physical representations of data address or exacerbate issues of equity and inclusivity?
- The act of creating a physical representation of data can often lead creators to a deeper experience of that data than their audiences ultimately achieve. Does readability of the final artifact matter? Why or why not?
- What research and design directions related to physicalization could and should be explored in the future?

We will also invite and introduce questions from the local and online audience to the panelists for discussion.

### 4.3 Interactivity and Audience Engagement

We will set up a participatory physicalization at the entrance of the panel room, and encourage audience members to respond to simple prompts (Has the audience created a physical representation of data themselves? Which keywords describe their research interests? etc.). For remote attendees, we will provide a Miro board with the same prompts, and gather responses digitally. The online moderator will integrate online responses into the on-site data physicalization. Near the end of the panel, the resulting object will be moved to the stage, and both the panelists and audience members will have an opportunity to discuss the responses and reflect on the participatory construction process.

In addition, we plan to foster backchannel engagement from both in-person and remote participants during the panel session. On our open, collaborative Miro board, we will offer audience an opportunity to respond to a set of prompts:

- What fabrication techniques from other domains could be used to render data representations?
- What other graphical visualization techniques could be applied to physical data representation?
- What tangible interaction techniques could be applied to create new data-driven experiences?

We will also encourage audience participation through social media, by asking attendees to share their own experiences and insights on constructing physical data representations using the conference hashtag.

### 4.4 Wrap-Up

At the end of the panel, the two in-person moderators will have 5 minutes to summarize the comments, ideas, and highlights from the panel to conclude the discussion.

## 5 CONCLUSION

We believe that our panel will attract attendees at CHI from multiple research areas, particularly information visualization, fabrication, and tangible interaction. The panel will provide a unique opportunity for attendees to learn about the challenges and opportunities of creating physical data representations—with a focus on diverse fabrication and rendering approaches—and to share their own experiences and insights on this topic.

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