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Craft-Based Data Physicalization: Opportunities and Challenges

Bahare Bakhtiari
Computer Science
University of Victoria
Victoria, British Columbia, Canada
baharebakhtiari@uvic.ca

Foroozan Daneshzand
Simon Fraser University
Burnaby, British Columbia, Canada
foroozan_daneshzand@sfu.ca

Kim Sauvé
University of the West of England
Bristol, United Kingdom
kim.sauve@uwe.ac.uk

Nathalie Bressa
LTCI
Télécom Paris, Institut Polytechnique
de Paris
Palaiseau, France
nathalie.bressa@telecom-paris.fr

Samuel Huron
Dpt. SES, CNRS i3
Télécom Paris, Institut Polytechnique
de Paris
Palaiseau, Ile de France, France
samuel.huron@telecom-paris.fr

Lora Oehlberg
University of Calgary
Calgary, Alberta, Canada
lora.oehlberg@ucalgary.ca

Sheelagh Carpendale
Simon Fraser University
Burnaby, British Columbia, Canada
sheelagh@sfu.ca

Sowmya Somanath
Computer Science
University of Victoria
Victoria, British Columbia, Canada
sowmyasomanath@uvic.ca

Charles Perin
Department of Computer Science
University of Victoria
Victoria, British Columbia, Canada
cperin@uvic.ca

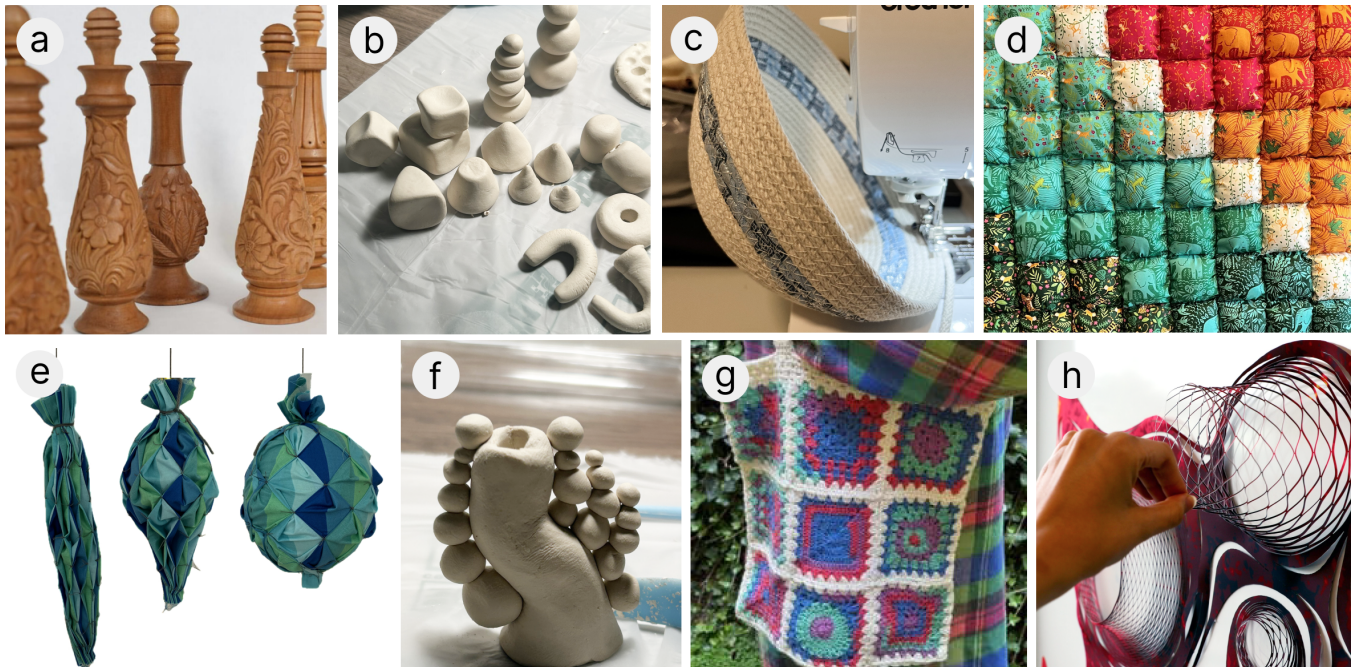


Figure 1: Examples of craft techniques. All images used under CC BY. Items a–d illustrate form possibilities that can support data representation; items e–h show examples of encoding data in physical objects. The items show: a) kohl containers created using wood turning and wood carving (Persian Monabbat) techniques (by Hadi Zare), b) objects made using clay (by Bahare Bakhtiari), c) 3D shapes made through sewing techniques (by Sowmya Somanath), d) grids made through puff quilting technique (by Sowmya Somanath) e) smocking technique representing emotion scale: calm, neutral, and stressed [2] (by Bahare Bakhtiari), f) clay beads and clusters representing number of messages received per day (by Bahare Bakhtiari), g) data-crochet tote bag representing “Conference experience in 18 squares” (by Kim Sauv ), h) Kiriphys representing death by heatwaves across different regions of BC [10] (by Foroozan Daneshzand)

Abstract

This three-hour workshop will gather data visualization and HCI researchers and practitioners to explore the possibilities of data representation using craft techniques. Participants will submit a 2-4 page document including (i) a statement of their craft experience, (ii) representative images of physicalizations they have created using this craft technique, and (iii) a discussion of opportunities and challenges for physicalizing data in their craft domain. During the workshop, participants and organizers will work in groups to brainstorm ways of representing data through their shared craft of interest. Then, every group proposes a synthesis of opportunities and challenges of the craft technique they worked with. Together, the community will chart a research agenda on how craft can expand the design space of data physicalization, inform the creation of more expressive and accessible authoring tools, and raise new questions around aesthetics, accuracy, and the role of slow making in data representation.

CCS Concepts

- **Human-centered computing** → *Visualization*.

Keywords

Data Physicalization, Craft

ACM Reference Format:

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1 Introduction

There has been a growing interest in using different craft techniques to design interactive systems, including textile techniques such as knitting (e.g., [28, 57, 60]), weaving (e.g., [7, 26, 42, 64]), and embroidery (e.g., [26, 51]); paper-based techniques such as origami (e.g., [17, 19, 52, 61, 65]) and kirigami (e.g., [8, 59, 63]); clay work (e.g., [41]); and fabrication techniques (e.g., laser cutting and 3D printing). While these techniques are usually used to design input or output (e.g., using these techniques to attach sensors for input or to attach shape-changing materials for output), they are increasingly used to directly represent data through the artifacts they enable

creating [2, 10, 14, 29] (see Figure 1). Data craft is defined by Thudt et al. as the process of “*manual crafting of functional objects that incorporate personal visualizations*” [54]. Crafting involves a wide range of materials such as textile, clay, paper, wood, and metal, and provides “*new ways of engaging with data through traditional craft*” [54]. The variety in materials and techniques presents both opportunities and challenges for data physicalization – physical representations of data [27].

In this workshop, we will discuss the following opportunities:

- One of the main opportunities lies in leveraging the design space of possible data mappings [22] offered by various materials and their physical properties in terms of geometries, form factors, and sensory channels [62]. We will discuss *how to effectively use this ample design space and map data onto these diverse physical variables*, an area that remains underexplored in the literature.
- Another opportunity in craft-based data representation, which involved hands-on creation and direct manipulation of material, is its potential to make the data representation process more accessible by reducing abstraction and indirection [4, 18, 58]. We aim to discuss *how understanding the process of data representation through craft practices can further inspire researchers to design expressive and accessible data representation authoring tools*.

Additionally, we will discuss the challenges and outline future research directions to address. For instance:

- One challenge in using craft for data representation is the learning curve and the visualization knowledge required [5, 37] to incorporate data attribute selection and physical variable selection steps in the craft process for practitioners. Due to the diverse affordances of different craft techniques—form factors and material properties— it is more difficult than other medium to define standard physical vocabulary (e.g., visual marks and visual variables are standard vocabulary in data visualization [5])

Prior HCI research has explored ways to lower barriers to craft making through visual programming, creative guidance, and assisted fabrication [35]. These efforts have focused on craft mediums such as textiles (e.g., quilting [34], smocking [15]), ceramics [21], and paper [12, 36]. However, there has been limited exploration of how to integrate data mapping into craft practices. Only a few systems attempt to support data mapping in craft-related contexts; however, they primarily rely on digital fabrication rather than hands-on making [12, 53]. *To the best of our knowledge, no prior work has examined manual craft practices in which makers directly engage with materials during the design of data representations.*



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Building on these challenges, opportunities, and gaps in the literature, our workshop aims to gather researchers and practitioners interested in exploring the possibilities of representing data using these craft techniques, to foster a discussion around the scenarios in which crafting can be a medium to express different data types, and to establish a research agenda on opportunities, challenges, strategies, and benefits of expressing data using craft practices. By doing so, we aim to advance the design of systems that integrate data representation within craft practices.

While data physicalization and craft practices are separately explored topics at CHI, we think the community would benefit from discussing the intersection of the two fields, like has been the case at some previous workshops in other venues such as the *Data Crafting* workshop in 2020 [56] and the *VISions of the Future* workshop on sustainability within visualization and physicalization in 2024 [38]. Yet, most craft-based physicalizations come from practice outside of academia (See Figure 1), while the HCI community has developed foundational knowledge in data physicalization and craft. We see great potential in gathering researchers to discuss future research opportunities in craft-based data physicalization, which can then facilitate identifying future research directions to design systems to support practitioners in creating craft-based data physicalizations. Based on our own physicalization practices, and in-class physicalization education [39], we have identified the following open questions:

- **What is the synergy between craft techniques and encoding possibilities?** Each craft technique provides different form factors and different variables to play with. For example, woodworking using the milling technique enables the creation of various circular shapes where the diameter can change in different sections of a bar, and pottery wheels afford radial data mappings in clay work. However, other woodworking and clayworking techniques, such as engraving, enable representing data in different shapes engraved on the surface.
- **What are the impacts of craft techniques on the physicalization authoring process and on the data thinking process?** Different craft techniques require different fabrication operations, including shaping, modeling, sewing, assembling, and subtracting materials. It is known that assembling could support dynamic data mapping [23, 24] and low-level data thinking processes. However, little is known about other fabrication operations that might support data thinking.
- **What are the tensions between creating aesthetically appealing and accurate data representations?** Many data physicalizations are created to be art pieces. However, there are tensions between the accuracy of a representation and its aesthetic appeal or artistic value.
- **What are opportunities and challenges when using slow craft practices to represent data? And how could we design systems to support craft practitioners to represent data through their practice?** Most craft techniques involve a laborious, slow creation process, particularly when they involve manual making. While this provides the opportunity for self-reflection [55], it questions the practicality of

some of these craft practices for data physicalization. There is a need to conduct research on the pros and cons of technological support for craft data physicalization.

2 Workshop Goals

The goals of this workshop are:

- (1) to gather researchers and practitioners interested in the intersection of craft techniques and data physicalization to build a community for future collaborations;
- (2) to identify opportunities and challenges of using craft techniques to represent data to identify research priorities for the future; and
- (3) to discuss how we could design systems to support practitioners in representing data through craft techniques, and to identify future research directions to design systems to make craft-based data physicalization more accessible.

3 Workshop Organizers

We brought together researchers in data visualization, data physicalization, and craft within HCI to collaboratively explore this multi-disciplinary space. Some of our co-authors also have hands-on experience with manual craft practices such as crochet, clay work, and sewing, enriching the conversations with embodied and material knowledge.

Bahare Bakhtiari is a PhD candidate in Computer Science at the University of Victoria. Her research interests include data physicalization and tangible user interfaces. Her work has explored the new interactive systems and materials/techniques in physical data representations involving multi-sensory experiences [2, 3].

Foroozan Daneshzand is a postdoctoral researcher in the Computer Science Department at Simon Fraser University. Her research intersects Human-Computer Interaction (HCI), data visualization, and design. Her PhD [9] focused on data physicalization, introducing a new physicalization technique with tangible variables to explore how people interact with data through tactile representations [10], demonstrated with over 20 physicalizations.

Kim Sauv e is a Lecturer at UWE Bristol specializing in Human-Data Interaction (HDI) and data physicalization. Her research combines empirical studies and design practice to explore how tangible representations make complex data more accessible and experiential. She has developed systems such as LOOP [44], Econun-drum [43], and Edo [47] and has organized workshops on data physicalization, emphasizing its application across domains [45] and addressing contemporary challenges in the field [46].

Nathalie Bressa is an Assistant Professor at the Institut Polytechnique de Paris, T el ecom Paris, working at the intersection of human-computer interaction and information visualization. She is particularly interested in situated visualization, participatory visualization design, and how visualizations can be used for data input. She has prior experience in organizing conference workshops on physicalization [20] and conducting participatory design workshops to create situated data visualizations [6].

Samuel Huron is an Associate Professor of Interaction Design at the Social Sciences department of T el ecom Paris and Institut Polytechnique de Paris. His research interests include data physicalization, visualization authoring, digital civics, and the negative

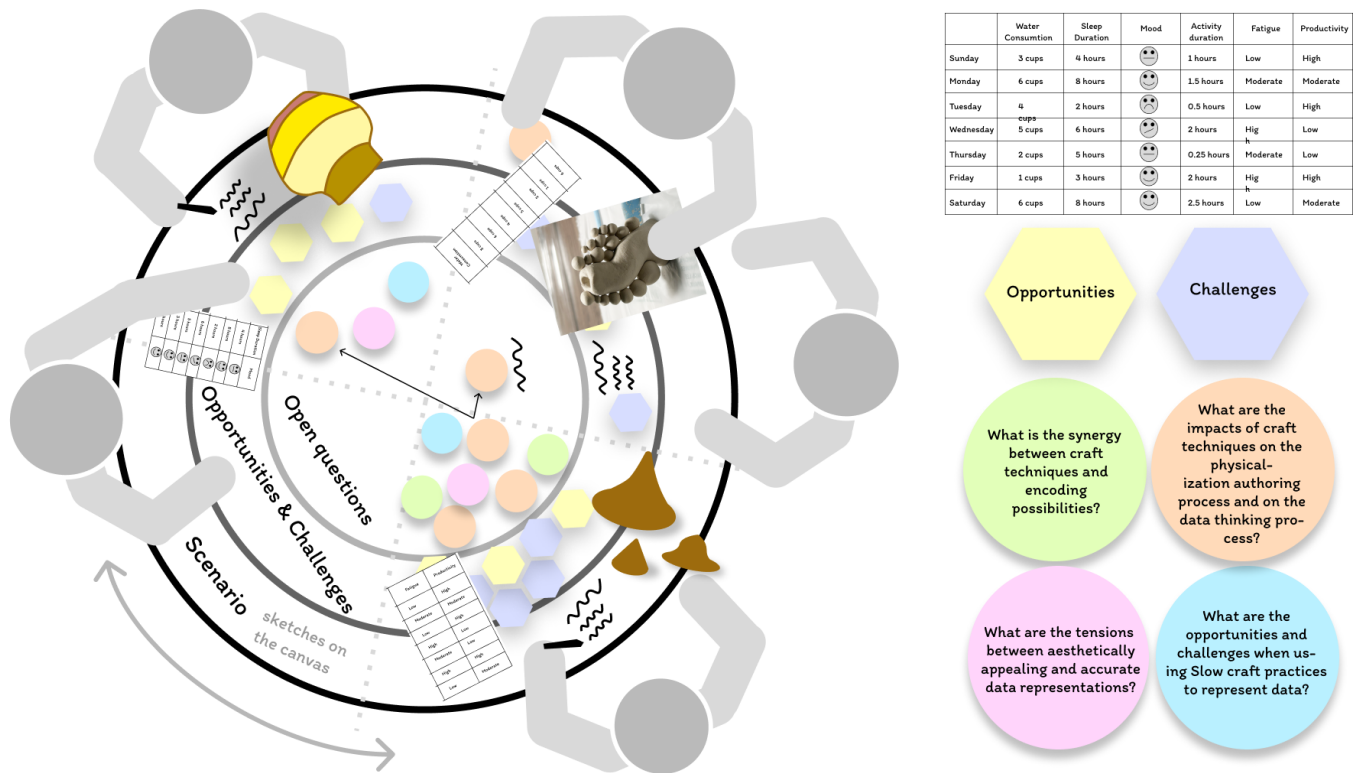


Figure 2: Simplified structure and materials provided for the hands-on, group activities

impact of digital technology. He is the co-editor of the book *Making with Data* [25] and has done research on data representation construction in the past 10 years.

Lora Oehlberg is an Associate Professor of Computer Science at the University of Calgary. Her research interests include data physicalization, creative design process, and creativity-support tools. She is the co-editor of the book *Making with Data* [25], and co-wrote the introduction the section on Handcraft with Sheelagh Carpendale. During a 2018 sabbatical, Oehlberg worked on a series of data crochet projects, and is investigating the nature of crafting and manual fabrication as a form of reflective data experience.

Sheelagh Carpendale is Professor and Canada Research Chair in Data Visualization at Simon Fraser University. Her research interests span data making, data empowerment, data physicalization, community co-design, and dependable data in storytelling, as she is interested in leveraging human-data interaction to combat the current prevalence of mis- and dis-information. Her work in data physicalization draws upon her decade of professional artisan/craftperson experience.

Sowmya Somanath is an Associate Professor of Computer Science at the University of Victoria, Canada. Her research focuses on studying and designing novel software and hardware-based systems to foster creativity and happiness. Her projects have explored different craft and computational techniques for making physical objects such as digital fabrication [1, 16, 30, 49, 50], augmented-reality and electronics [48], and fabric-based techniques [2, 31, 32].

Charles Perin is an Associate Professor of Computer Science at the University of Victoria. His research focuses on designing and studying new interactions for visualizations and on understanding how people may make use of and interact with visualizations in their everyday lives, including mobile and physical visualization. In the last decade, he has co-organized half a dozen workshops at international conferences and published data physicalization research [2, 10, 11, 13, 33, 39, 40].

4 Pre-Workshop Plans

Review of Submissions: Submissions to this workshop will be in the form of short statements (e.g., 500 words) showcasing the craft interest or expertise of the participants, accompanied by figures and visuals of their creations, completed or speculative. Submissions can be in the format of a poster, pictorial, or a statement with complementary visuals. We will encourage authors to discuss their experiences of encoding data with their craft techniques and the opportunities and challenges that appeared in their practice. We will also encourage authors to provide detailed visuals of both final objects and images of their work-in-progress. Authors who have not tried representing data via craft may also submit a speculative discussion of the opportunities and challenges they envision, grounded in a particular craft practice. We will review submissions according to the following criteria: 1) the submission discusses a craft technique; 2) the submission includes some discussion in relation to data representation (already physicalized data or speculation of opportunities); and 3) the submission will be of interest to

the workshop audience. As this workshop has a fairly large group of organizers, each submission will be reviewed by at least two organizers who are not in conflict with the authors. In case the authors are in conflict with most of the organizers, we will invite non-conflicted scholars outside the organizer group with relevant experience to review the submission.

Pre-Workshop Online Engagement: To efficiently use the workshop time and in-person interaction, we will arrange an online pre-workshop engagement. To this end, we will initiate a Slack channel where participants will introduce themselves and provide a brief description of their proposed craft and its data representation opportunities, along with their submission document. In the week prior to the workshop, we will ask all participants to go through all accepted submissions and write a brief review for each, focusing on one opportunity and/or one challenge that they think applies to the submission. The purpose of the mini-review process is to foster discussions and familiarize participants with each other's submissions for the main workshop.

4.1 Activities

This will be a three-hour, hands-on, and in-person workshop. To best use the workshop time and actively involve the participants (as opposed to organizing a mini-conference), we do not plan to include a keynote speaker. We plan the following activities:

Opening and Outline: We will begin with a 15-minute session dedicated to introducing the workshop organizers, goals, schedule, and expected outcomes. Participants will also be invited to explore the workshop materials (datasets, question cards, and canvases), and ask any questions they have.

Authors' Introduction and Group Making: Authors of accepted submissions will be given about 15 minutes in total to introduce themselves. We will encourage authors to bring physical samples they have created using their craft technique(s), if feasible. Participants who cannot bring physical samples will be encouraged to bring high-quality images of their work (printed in advance of the workshop). After the introductions, participants will walk around the room to view the posters and physicalizations, and form groups based on their shared craft interests.

Group Work: Each group will work with the following materials: i) physical samples that authors would have brought that relate to the technique, including crafting tools and materials (e.g., crochet hooks and yarn; ceramic objects, and paper-based crafts). Participants will be able to purchase some materials in Barcelona, and we will share links to local stores on the workshop website; ii) images of craft-based data physicalization examples (provided by workshop organizers); iii) a small dataset with quantitative, nominal, and ordinal data dimensions; and iv) a structured template for reporting. Groups will be asked to brainstorm ways of representing the provided dataset with their craft technique, while drawing inspiration from the physical samples and printed images. They will use the template to guide their discussions and collaboratively document opportunities and challenges of the craft technique for data physicalization, how this technique might address some of the

general challenges we have already identified, and how the craft technique might inform the design of digital visualization design support tools. Figure 2 shows an overview of the group activity. The workshop structure allows rotating around the tables and having a broader discussion among the entire group of participants. This will ensure that participants get a chance to discuss with others participants, with different perspectives and backgrounds.

Wrap-up Discussion Groups will present the result of their work following the structured template. Informed by these reflections, we will then collectively discuss possible research directions for craft-based data physicalizations as well as the potential of leveraging craft techniques in digital visualization design tools.

5 Post Workshop Plans

Submissions will be disseminated as short position statements/work-in-progress notes. We will create a website on which we will post the workshop information and material, accepted submissions, and the workshop outcomes. We will discuss the possibility of contributing to a research article we would write on the topic of the workshop (for a relevant HCI or visualization venue) and invite attendees to participate. Additionally, we will use the Slack channel to connect participants and open it to the broader HCI community members who are interested in using craft in data physicalization. We will use this channel for further discussion of the topic and opportunities for collaboration in future research within the domain.

6 Workshop Format

We will arrange a workshop in a long format (three-hour workshop with a half-hour break) (see Table 1). We expect to have approximately 20 participants attending the workshop. Due to the hands-on and collaborative nature of the workshop, it will be held in person only. To this end, we propose various considerations to support group activities and to support participants with accessibility needs. Additionally, to promote the topic among a broader HCI audience who are not attending the workshop and to foster future discussions and collaborations, we will propose strategies for offline engagement both before and after the workshop.

6.1 Room and Equipment Request

Due to the collaborative nature of the workshop, we request a room that can accommodate group work, ideally with a few large tables and movable chairs. Additionally, we request approximately five poster slots or a large pinboard for us to print and attach the participants' visual samples for the introduction, idea generation, and discussion phases. We will also need a projector.

6.2 Accessibility

We will address accessibility needs before and during the workshop. We will contact workshop participants in advance in order to accommodate their accessibility needs. Additionally, we will provide accessible material on the workshop website, and we will ask authors to improve accessibility of their submissions by adding alt text to the figures. During the workshop, we will provide both

Time	Activity
13:00–13:15	Opening and Outline
13:15–13:45	Introductions by authors
13:45–14:30	Group Work part 1: brainstorming on ways to represent a predefined dataset using craft practices
14:30–15:00	Coffee Break
15:00–15:30	Group Work part 2: reflection on the ways to represent data using craft practices, documentation, and preparation of short presentation
15:30–16:15	Presentations of group work outcomes and discussion
16:15–16:30	General discussion, wrap-up and next steps

Table 1: Workshop Schedule

verbal and written instructions. Additionally, we will arrange for live captioning.

6.3 Offline Material

As mentioned in the post-workshop plans, we will publish accepted submissions to the workshop website prior to the workshop taking place, so that those not attending the workshop can have access. We will publish a post on the website to present the outcomes and the summary of the discussions. Additionally, we will encourage further discussions on the Slack channel.

7 Call for Participation

We invite Data visualization and HCI researchers, and craft practitioners who are interested in the intersection of craft and data physicalization to submit short statements (e.g., 500 words) accompanied by visuals of their craft technique of interest and how they have represented data through their craft practice, or how they would envision doing so. Our goal is to gather researchers and practitioners to establish a research agenda on opportunities and challenges of representing data through craft practices. Our workshop will be three hours long and held in person. In the workshop, participants will engage in hands-on group activities of representing data in their common craft of interest within their group. The hands-on activities will be followed by discussions among group members and then among all participants in the workshop to discuss opportunities and challenges in data encoding possibilities, the impact on the authoring process, tensions between aesthetics and accuracy, and implications of slow practices. Finally, participants will discuss how we could design systems and processes to support craft practitioners in using their medium to represent data. Authors can submit their statements via Google Form. Upon reviewing the workshop submissions, we will notify the authors about their acceptance and confirm that at least one author of each submission must attend the workshop in person. Accepted submissions will be published on the workshop website. We expect to have approximately 20 participants to register and attend the workshop.

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