Inclusive Digital Fabrication Technologies: Emerging Opportunities for People with Sensory Impairment

OUSSAMA METATLA, University of Bristol
FENG FENG, University of Bristol
ANNE ROUDAUT, University of Bristol
ÉMELINE BRULÉ, University of Sussex
MICHAEL J PROULX, University of Bath

1 WORKSHOP MOTIVATION

Emerging hardware and software prototyping platforms have democratized digital fabrication (i.e., open-source microcontroller and online software platforms), enabling the takeoff of the "Maker" movement. They are reshaping the design-fabrication circle: researchers and design practitioners are able to sketch, fabricate and evaluate their creative ideas and solutions fairly easily and cheaply [5]. However, very few of these tools leverage people's multisensory capabilities in the process of fabrication [12]. Focusing on multisensory making processes could support their accessibility to people with sensory and other impairments.

Digital fabrication tools have the potential to empower disabled makers and designers in building their very own assistive technologies and to make education more inclusive [6]. Yet this potential is still to be realised [4, 9]. This workshop aims at supporting the development of multisensory and accessible making and fabrication tools, and builds on the insights and community developed through events ran at CHI 2018 [10] and CHI 2019 [7] that aim to develop an agenda for inclusive technologies for people with and without disabilities.

2 WORKSHOP GOALS

Digital fabrication techniques have opened new opportunities for empowering people with different levels of sensory impairment in various areas [9]. However, most computer-aided design and making platforms are primarily visual and fairly complex, and the potential for multisensory and multimodal fabrication and accessible making environments is still largely to be explored. Previous work on this topic includes tools enabling to scan and assemble existing objects [8], conceptual exploration of maker spaces [1], and investigation of organisations pairing making experts with people with sensory impairments [11]. On the one hand, the challenges for increasing how inclusion is experienced in this space vary greatly depending on the types and levels of sensory impairment. For instance, people with visual impairments would have difficulties using CAD software, whereas Deaf people may encounter safety issues during fabrication. On the other hand, much efforts have been placed on simplifying design tools (e.g., [3], the Tinkercad software) and towards bridging craft and digital fabrication techniques [2]. Consideration for inclusive and accessible design could inspire new tools and methods in this community.

In this workshop, we will bring together several communities to explore this topic: HCI experts on inclusive technologies, experts in cross-sensory design/tools, as well as in digital fabrication. We will call for papers and endeavour to map existing and prospective research on the following topics:

- **Novel fabrication techniques:** How could we increase the accessibility of novel fabrication techniques, which should also improve their use by the general public?
- **Cognition and perception in fabrication:** How do we leverage cognition and perception research to facilitate inclusive fabrication, making and innovation? We are particularly

interested in the contribution that researchers on sensory substitution and cross-modality could bring to the table, as well as insights into how engaging in making helps people in developing new skills.

- **Collaborative fabrication, innovation and inclusion:** How to increase the accessibility of fabrication not only for individual needs but also for collaborative activities?
- **Design supporting toolkits:** How to keep consistent engagement with the toolkits to bind processes of learning, fabrication/making, innovation and production?
- **Community building:** How can novel fabrication techniques support learning for all potential users of digital fabrication tools? How to increase multisensory accessibility through cross-sensory sharing between learning/making peers, over distance and time course, and across generations? How to involve other actors of the maker movement?
- **Evaluation** How to evaluate the multi-facet process of inclusive fabrication? What theoretical and practical account need to be considered? At the current stage, we are still in need of an evaluation framework to first evaluate fabrication outcomes including its quality, efficiency, the cost of time, effort and materials; second, usability of inclusive fabrication toolkits; third, fabrication/making experiences, either as individuals or as groups.

3   ORGANISERS

Oussama Metatla is a Senior Lecturer and EPSRC Senior Research Fellow in the Department of Computer Science at the University of Bristol. His research interests include multisensory interaction, sensory and cognitive impairments and co-designing with and for people with disabilities. He currently leads a project focusing on inclusive educational technology for mixed-ability groups in mainstream schools.
o.metatatla@bristol.ac.uk

   Feng Feng is a research associate in the Department of Computer Science at the University of Bristol. Her research is concerned with understanding how perception, action and cognition are laced together. Her projects fall into two areas: multi-sensory embodiment and human-computer interaction, and unified by a focus on gestural input activities and, in particular, on the integration process between tactile, auditory and visual perception, and how this process facilitates interaction with both rigid and soft interfaces.
f.feng@bristol.ac.uk

   Anne Roudaut is a Reader in the Department of Computer Science at the University of Bristol. She leads the Bristol Interaction Group and is promoting a highly multi-disciplinary research agenda to radically rethink the way we build digital technologies. She works with researchers from Material Engineering and Robotics to understand the underlying science behind interaction with arbitrary shaped and reconfigurable devices as well as to create the innovative interactive metamaterials that can transform our future interactive landscape.
Anne.Roudaut@bristol.ac.uk

   Émeline Brulé is a Lecturer at University of Sussex. Her research focuses on inclusive design: both in developing new technologies or design frameworks and developing adequate ways of teaching it in higher education.
e.t.brule@sussex.ac.uk

   Michael J Proulx is a Reader in the Department of Psychology at the University of Bath. He is also the founding Deputy Director of the REVEAL (REal and Virtual Environments Augmentation Labs) Research Center in Computer Science, and Director of the Crossmodal Cognition Laboratory. His research includes vision impairment, multi-sensory perception, neural plasticity, cognition and interactive technologies such as AR and VR. He also develops and assesses sensory substitution

devices, including both auditory and tactile displays.
m.j.proulx@bath.ac.uk

4 PAPER SUBMISSION AND REVIEW PROCEDURE

A call for paper will be shared on social media, relevant mailing lists as well as the website made by the organizing team to centralise resources about designing inclusive technologies for education (http://www.inclusiveeducation.tech/). We estimate attendance at 15 participants. The workshop will be advertised at the beginning of March, with a submission deadline mid-June. Submitted papers will be reviewed by the organisers and an invited panel of expert reviewers. Following the alt-chi model, neither reviews nor articles are anonymised. Authors will receive notification by the end of June enabling ample time to register for the conference.

5 EXPECTED OUTCOMES AND IMPACT

All activities in the workshop have clear expected deliverables, that will then be shared with the wider community. As this topic is of interest beyond the academic community (e.g. special education teachers and schools, disability community, libraries with making programs), we will also write a summary about accessible tools for disbaled people for a wider audience, either on Medium or The Conversation, and share it with relevant stakeholders in our network. We are expecting that this will help HCI researchers and beyond to lend attention to this topic and will help cementing new collaborations and research in this area.

6 WORKSHOP SCHEDULE

The workshop will be organised by co-occurring thematic tables moderated by an organizer, with a shared digital and paper document on which all participants will be able to add references and contribute to mapping the state of research. At each table, we will try having a mix of inclusive design and digital fabrication experts.

- **Morning sessions**
  9:00-9:30: Short introduction of all participants and constitution of groups based on interest and expertise.
  9:30-10:30:The first session maps out all participants research interests and research contributions on this topic
  10:30-11:00: Coffee break
  11:00-12:00: Discussion tables on the design and fabrication processes. These tables will either discuss the different sensory modes involved in fabrication; current fabrication techniques and attempts to make them accessible and inclusive.
- **Afternoon sessions**
  13:30-14:30: The third session shares resources for teaching inclusive fabrication, then discusses accessible methods for increasing inclusion in the circle of design-prototyping-fabrication
  14:30-15:00: Coffee break
  15:00-16:00: Nurturing community around inclusive fabrication technology; Evaluation approaches for and beyond the individual maker
  16:00-16:30: Summarises workshop topics, wrapping up key points covering opportunities, challenges for increasing inclusion in digital fabrication.
  From 18:00: Drinks and dinner

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