FAB at CHI: Digital Fabrication Tools, Design, and Community

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Abstract
This workshop explores the implications and opportunities of digital fabrication for the field of human-computer interaction. We highlight five themes: design tools and interfaces, online collaboration around physical objects, prototyping in the interaction design process, hands-on learning, and unique, personalized artifacts. For each, we provide an overview and a survey of related work. The workshop seeks to foster a network of researchers and others working in these and related areas. It explores potential research directions and ways that the CHI community can make a positive impact on design, craft, and maker culture.

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Fabrication, Interactive Fabrication, Design, CAD, Craft

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces: Prototyping.

Introduction
Digital fabrication is changing the way that people design, produce, and interact with objects and devices. The diversity of accessible fabrication processes – laser-cutting, 3D printing, computer-numeric controlled (CNC) milling, printed circuit board (PCB) fabrication, and many more –

Figure 1: Maker Bot is a sub-$2000 3D printer that can create objects out of plastic.

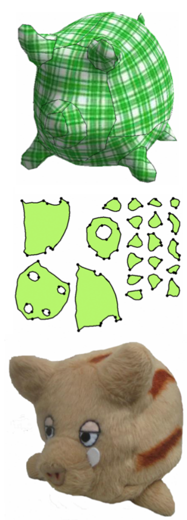

Figure 2: Plushie allows users to easily create plush toys through a sketch based interface. It uses a laser cutter to cut out fabric pieces, which the user assembles.

enable production of parts in a variety of forms and materials. Falling costs for fabrication machines and a growing number of consumer-facing fabrication services make it cheaper and easier for people to translate their digital designs into physical objects. By providing a tighter coupling and faster iteration between the digital and physical, fabrication enables new relationships between objects and interfaces.

Digital fabrication has a number of implications for human-computer interaction. By increasing the audience for computer-aided design (CAD) and computer-aided manufacturing (CAM), it generates a need for new software tools with easy-to-use or specialized interfaces. The ability to share files digitally creates opportunities to support and study online collaboration and the formation of communities around the production of physical artifacts. Fabrication facilitates the prototyping of interfaces, allowing for new design processes and methodologies. It makes it feasible for individuals to design and build their own physical interfaces and devices, changing the relationship between designers and users. This creates opportunities for hands-on learning and craftsmanship. Further, fabrication enables unique and one-off artifacts, many of which would have been impossible or infeasible with traditional manufacturing. This workshop offers an opportunity to bring together researchers from these domains to share knowledge, foster community, and explore future research directions.

The following section surveys these major topics in the relationship between fabrication and HCI. We mix general discussion with references to prior work and potential areas of future investigation. This is followed by a more detailed list of topics of interest and a summary of the goals for the workshop.

Digital Fabrication and Human-Computer Interaction

New Design Interfaces and Tools

Digital fabrication creates a direct and immediate need for new software design interfaces and tools. Domain-specific design tools take advantage of the properties of particular fabrication processes and specific classes of artifacts to create easy-to-use interfaces with embedded domain knowledge. For example, SketchChair [11] allows users to design chairs for assembly from parts fabricated with 2D machines like laser-cutters and CNC routers. Its interface includes tools specialized for this class of artifacts, like the ability to manipulate multiple parts in parallel and to simulate a person sitting in the chair. Other domain specific tools for digital fabrication include Plushie [7] a tool for designing plush dolls, see Fig. 2.

Other research has taken advantage of the immediate nature of digital fabrication to investigate real-time, tangible, or augmented reality interfaces for design. For example, KidCAD [4] uses a deformable interface to allow children to remix physical toys and 3D print their new designs. Interactive Fabrication [15] presents a series of interfaces and machines for real-time design of fabricated artifacts, see Fig. 3. Other work has investigated this tight coupling between human control and digital designs [10, 16]. Additionally, researchers have explored how to augment fabrication tools to provide feedback in the design and fabrication process [3, 8].

Online Communities and Collaboration

Because digital design files can be shared easily, digital fabrication offers unique opportunities for studying collaboration on the creation of physical artifacts. In Rise of the Expert Amateur [5], the authors discuss the practices and motivations of contributors to online

Figure 3: The Shaper is a tool for Interactive Fabrication. New fabrication machines can be designed with interaction in mind.

Figure 4: Midas is a tool for adding touch sensitive elements to any object. It uses a vinyl cutter to create conductive circuits for capacitive sensing.

communities about do-it-yourself (DIY) making. Digital fabrication and sites like Thingiverse (where users share design files) allow online communities to extend to direct collaboration on particular designs, e.g. through open-source hardware. These activities yield data that allows for the study of computer-supported collaboration along the lines of prior research into open-source software development and Wikipedia. They suggest opportunities for new interfaces and tools – for example, to visualize or merge changes to hardware designs, or to remix or combine a number of online designs [1].

Prototyping in the Interaction Design Process
Fabrication can also make the design of physical or tangible interfaces easier, and also allow for end user customizable interfaces. Researchers in the HCI community have been using digital fabrication to make physical interfaces quickly and at a higher fidelity, for example Topobo [9], a construction kit for tangible robot programing. Other researchers have explored how we can 3D print entire working interfaces [14]. New software design tools for end users are beginning to look at how fabrication can allow users to extend or make their own physical interfaces, such as Midas [12], Fig. 4.

Learning & Constructionism
Digital fabrication offers a number of opportunities for the enhancement of education. These are discussed in [2], which highlights three main themes: decoration, personal expression, and intellectual investigation. Other work has also looked at ways to make digital fabrication relevant and accessible to children and for educational contexts.

Fabricated Interfaces and Artifacts
Digital fabrication brings new forms and aesthetics to interfaces and artifacts. Available fabrication processes allow fine and detailed shaping of a variety of materials. Their forms can be generated programmatically, opening up a new space of algorithmic design. The flexibility of digital fabrication enables the creation of unique, personalized designs. Its ease and speed enable rapid iteration, allowing for the thorough and detailed exploration of a design space. Fabricated parts can be combined with other materials, allowing for personalization and meaning through handcraft. In Plywood Punk [13], the authors explore these aesthetics possibilities through the design of a wood and electronic servo motor, offering some general principles for fabricated devices, see Fig. 5. In [6], the authors describe the customization and production of two consumer products by different user groups, drawing conclusions about the possibilities that fabrication offers for device design and production. As digital fabrication processes get better and more accessible, they offer additional opportunities for the exploration of new design spaces – aesthetic, functional, and social.

Topics of Interest

- Design tools for digital fabrication
- Augmented reality and tangible design tools
- Interactive fabrication
- Fabricated interfaces and devices
- End-user design tools for physical interfaces
- Personalized objects and interfaces
- Social implications of fabrication
- Online communities and community-support tools
- Intellectual property implications
- STEM/STEAM education through fabrication
- Algorithmic design
- Relationship between digital design and physical craft

Figure 5: The plywood servo investigates how craft process and digital fabrication technology intersect.

Workshop Goals and Outcomes

With this workshop, we hope to foster a network of researchers working at the intersection of fabrication and HCI. We would like to increase the visibility of fabrication within the CHI generally, as well as specific tools, techniques, and research areas. Additionally, the workshop should serve as an opportunity for researchers to share their work, solicit feedback, and generate new ideas and projects. To reach a broader audience we will document the discussions and activities at the workshop on the workshop's website, which will be publicly accessible. In addition, blog posts written as submissions to the workshop will remain archived and accessible on this website. We will continue to solicit blog posts about fabrication- and HCI-related research and topics from the CHI community and other makers and researchers. We also hope to find ways to further the workshop themes within a research context.

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