CrossFAB: Bridging the Gap between Personal Fabrication Research in HCI, Computer Graphics, Robotics, Art, Architecture, and Material Science.

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Abstract
Since 2012, personal fabrication has emerged as a new topic in the HCI community with an increasing number of publications every year. While within HCI, fabrication researchers have already built a strong community; almost no collaboration with other related disciplines, such as computer graphics, robotics, art, architecture, and material science, exists. We believe that especially in the context of HCI, collaboration with other fields can provide valuable input and create new perspectives on HCI challenges. This one-day workshop aims at bridging the gap between related disciplines in the area of personal fabrication by bringing together researchers from different fields. The focus of this workshop is to form connections across disciplines that can give rise to ongoing collaborations and to inspire HCI researchers to reach out into other topic areas for future research.

Author Keywords
personal fabrication; interdisciplinary research.

ACM Classification Keywords
H.5.2

Background

Personal fabrication devices, such as 3D printers, allow users to create customized objects. While the topic of manufacturing has a long history in industry, the decreasing costs of 3D printers now also allow home-users to fabricate their own objects, opening up a new mass market. This comes with new research challenges, especially from a Human Computer Interaction perspective, as it is unclear how traditional industrial technologies are approached and understood by new audiences with a diverse range of goals and expertise.

Since 2012, human computer interaction researchers tackle this challenge by developing new prototyping environments that abstract domain knowledge, thereby allowing users to build increasingly complex objects *(e.g. Sauron* [19]); moving the creation process from the digital environment to the physical environment, thereby allowing for hands-on editing *(Interactive Fabrication* [23], *Smart Handheld Tools* [25], Tactum [7]); speeding up fabrication so that faster design iteration becomes possible (e.g. *low-fidelity Fabrication* [15]); exploring the role fabrication technologies play within expressive craft and meaning-making activities (e.g. *Being the* Machine [6]); and exploring novel fabrication processes, such as printing soft materials *(layered-fabric printer* [17]), e.g. for wearable interfaces.

In 2013, a first workshop on personal fabrication at CHI called *FAB at CHI* [13] helped bring together HCI researchers that started the field. This first workshop helped framing personal fabrication research in the context of HCI. A similar small-scale workshop *PerFab* [11] was held later that year at Ubicomb'13.

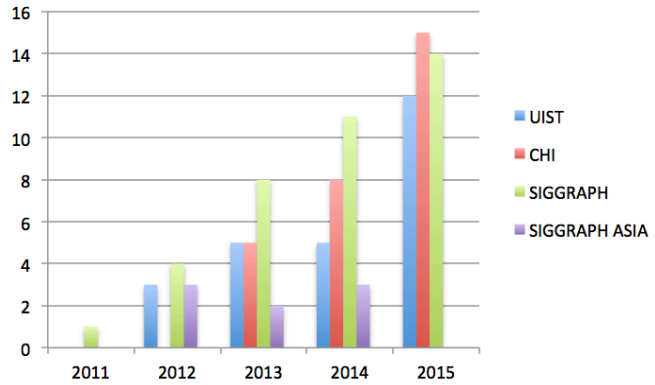

Figure 1: Number of paper publications in HCI and computer graphics conferences since 2011.

These workshops have fulfilled their goals: personal fabrication is now an established sub-discipline within HCI with more and more researchers joining the field every year (see Figure 1). To foster further growth, it is now time to broaden the field by reaching out to related disciplines in personal fabrication, such as computer graphics, robotics, art, architecture, and materials.

Inspired by interdisciplinary workshops outside of CHI, such as *The New Making Renaissance: Programmable Matter and Things* [5] and *Computational Aspects of Fabrication* [3], we have put together a one-day workshop program to form connections across disciplines that can give rise to future collaborations.

Related Disciplines in Personal Fabrication

Personal Fabrication is a hot topic in many different disciplines. Our workshop will offer insights and perspectives from the following fields:

Computer graphics: A main focus in graphics research has been to support users in predicting physical behavior, such as preventing thin parts from breaking *(Stress relief* [21]) or by providing users with feedback on dynamic behavior *(Pteronyms* [22]). Graphics researchers also looked at how to convert animated digital characters into their mechanical counterparts by automatically generating the driving mechanisms from gears and linkages [4], and have worked on simulating different materials using a single material (meta-materials [20]).

Architecture & Robotics: With a main focus on large-scale fabrication, research in architecture has explored many novel fabrication tools, processes, and materials. Within architecture, robots that are repurposed as fabrication tools play a major role. For instance, *Mini-builders* [14] are moving printing robots that address the question how to build artifacts that are larger than the printing volume (e.g. to print entire houses as suggested in *contour crafting* [10]). Architecture researchers also recently started to investigate how to interactively construct together with a robot [8]. In addition, architecture is experimenting with novel printing materials, such as cement [24] for large-scale extrusion.

Art: Artists engage in fabrication in several different ways blurring the distinctions between art, craft, and design. Some artists create fabrication systems to augment their existing practices with new digitally informed capabilities *(Hektor* [12], *SolarSinter* [9]). Within such work, the movements of the machine and contexts of fabrication take on increasing role for the meaning of the artwork. Artistic explorations also provide cultural and political perspectives on fabrication practice. For instance, Allahyari's 3D printed replicas of the artifacts destroyed by ISIS present 3D printing as a form of "resistance and documentation" [1].

Material Science: With only a small number of 3D printable materials being available today, material scientists are working on expanding what can be printed. For instance, Lewis et al. research on printing conductive material [2] has lead to the first commercially available conductive 3D printer. In a completely different direction, material scientists in biology are working on how to print tissue or even entire organs [16].

Workshop Goals and Outcomes
By inviting researchers from each discipline, we hope to build an interdisciplinary network of researchers. Our goal is to use the workshop as a platform to learn about each other's work—the challenges, tools and techniques being used. We believe that joining the forces in such interdisciplinary work is a key to moving the field of personal fabrication forward.

Organizers

Stefanie Mueller (main contact person) is a PhD student in HCI working with Prof. Patrick Baudisch at Hasso Plattner Institute. In her research, she develops new interfaces for interacting with personal fabrication machines. For her work, she has received multiple best paper and honorable mention awards. She is a program committee member for CHI 2016 and UIST 2016 and has participated in all former fabrication workshops.

Laura Devendorf is a PhD Candidate at the UC Berkeley School of Information with a designated emphasis in new media and an Aritst-in-Residence at Autodesk. As a practicing artist and HCI researcher, Laura explores the way in which digital fabrication technologies

shape creative practice. Her work has received honorable mention awards at CHI, earned her invitations to speak at events hosted by the California College of the Arts and the American Craft Council, and was featured on National Public Radio.

Dr. Stelian Coros is an assistant professor in Carnegie Mellon University's Robotics Institute. Before joining CMU, Stelian was a research scientist at Disney Research, Zurich. He is interested in developing models of motor control, motion planning algorithms, physics-based simulation tools and computational design methods for mechanical structures with controllable material properties.

Yoichi Ochiai is an assistant professor at the University of Tsukuba. His research focus is to establish new relationships between human and computational resources called as Digital Nature. His papers were published in Transaction on Graphics and LEONARDO. He is also known as a New Media Artist. His art works were exhibited in the Ars Electronica Festival, the Ars Electronica Center and the SIGGRAPH Art Gallery.

Madeline Gannon is the head of MADLAB.CC, a research studio exploring the future of digital making, and is a PhD candidate in computational design at Carnegie Mellon University. Her research develops gestural user interfaces for designing and fabricating with industrial robots, CNC routers, laser cutters, and 3D printers. Her work is transdisciplinary in nature, and is published across design, architectural robotics and HCI communities. In addition, Madeline has taught digital fabrication courses at Carnegie Mellon University's School of Architecture.

Patrick Baudisch is a professor in Computer Science at Hasso Plattner Institute at Potsdam University and chair of the Human Computer Interaction Lab. His research focuses on natural user interfaces and interactive devices, including miniature mobile devices, touch input, interactive floors and rooms, and most recently interactive fabrication.

Website

Our website http://crossfab-workshop.com contains the motivation and rational behind the workshop. The website serves as a platform for advertising the call for participants before the workshop, for archiving information about each submission, and for collecting documentation and outcomes from the workshop.

Pre-Workshop Plan

We are inviting submissions that focus on cross-disciplinary research in the area of fabrication. Submissions can be of two types: (1) *envisioned cross-disciplinary research projects*, i.e. project ideas that require skills or perspectives from several fields. (2) *experience reports on cross-disciplinary research projects,* i.e. in-progress or finished projects in which the authors are collaborating across disciplines.

We will post our call for participants on our website shortly after notification. We will distribute the call for participation among our network, which includes researchers in all relevant disciplines. Participants must submit papers by January 31 and will be notified of acceptance by February 5. Afterwards, we will send a list of participants to the workshop chairs. In order to allow ample time for discussion of each project and experience, a maximum of 15 submissions will be accepted. However, we will allow for up to 25 participants

TENTATIVE SCHEDULE

09.00 – 09.30
welcome
and ice breaker

09.30 – 10.45
ambassador panel

10.45 – 11.00
break

11.00 – 12.30
focused brainstorming I

12.30 – 13.30
lunch

13.30 – 14.20
experience reports

14.20 – 15.10
focused brainstorming II

15.30 – 16.00
coffee break

16.00 – 16.40
group + organizer summaries

in the workshop in case more than one author of a submission would like to attend the workshop.

To align the composition of the organizing team with the goals of the workshop, the main organizers Stefanie Mueller (HCI) and Patrick Baudisch (HCI) have already reached out to researchers of related disciplines and invited them to join the workshop organization.

As a result, the organizing team now also has members from art (Laura Devendorf), graphics and robotics (Stelian Coros), material science and physics (Yoichi Ochiai), and architecture (Madeline Gannon). These organizers will act as ambassadors for their respective fields, i.e. they will provide an overview of research from their discipline and will help to connect HCI researchers with potential collaborators in their field.

Workshop Structure

To run an interactive one-day workshop, we will use the following activities. The time devoted to each activity will depend on the range of submissions received:

(1) ambassador panel: The panel consists of short talks of each organizer/ambassador highlighting recent research, challenges, and opportunities from their field. Afterwards, participants will be invited to ask questions and discuss their own perspectives with the panelists. The goal of the panel and accompanying discussion section is to foster a better understanding of each other's field and to stimulate cross-disciplinary discussions.

(2) *focused brainstorms*: Participants will give 3 minute talks about their cross-disciplinary workshop proposals. We will have short sessions with four presentations in a row, followed by an interactive brainstorming activity. For the brainstorming activity, we will prepare four whiteboards, one for each talk. Participants will gather at the whiteboard for the talk that most piqued their interest. After 15 minutes of small group brainstorming on future research directions and the challenges discussed in the talk, each group presents their results in an informal way to the other participants. The benefit of this activity is that each project receives in-depth feedback, participants further get to know each other in small groups (groups change for each brainstorm session), and every participant is actively involved.

(3) *experience reports:* What does a successful cross disciplinary project look like? Participants who submitted experience reports will be invited to individually share their experiences to the group. A discussion among all participants will follow and will be facilitated by the organizers with the goal of drawing out factors that lead to sustainable and productive collaborations.

Post-Workshop

After the workshop, with permission from the participants, we will share the contact data of all participants with each other to stay connected. During the workshop, we will capture the discussions and presentations and will publish on our webpage for future reference.

Call for Papers

Since 2012, personal fabrication has emerged as a new topic in the HCI community with an increasing number of publications every year. While within HCI, fabrication researchers have already built a strong community; almost no collaboration with other related disciplines, such as computer graphics, robotics, art, architecture, and material science, exists. We believe that especially in the context of HCI, collaboration with other fields can provide valuable input and create new perspectives on HCI challenges.

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Submissions can be of two types: (1) *envisioned cross-disciplinary research projects*, i.e. project ideas that require skills or perspectives from several fields. (2) *experience reports on cross-disciplinary research projects,* i.e. a report of an in-progress or finished project in which the authors are collaborating across disciplines.

Workshop-Website: http://crossfab-workshop.com

Please send your submissions (maximum 4 pages, CHI EA format, pdf) until January 31 to:

crossfabworkshop@gmail.com

Participants submitting an envisioned cross-disciplinary research project are required to include one sketch/image that showcases their idea.

At least one author of each accepted position paper must attend the workshop and register for the workshop and for at least one day of the conference.

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