A Personal Design Manifesto

Jan Borchers
RWTH Aachen University
borchers@cs.rwth-aachen.de

René Bohne
RWTH Aachen University
bohne@cs.rwth-aachen.de

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Abstract
Personal fabrication technology has opened up the potential for *personal design*: a radical change in how we may design, fabricate, and distribute physical objects for personal use. However, the user interface of digital object design tools is currently blocking wider adoption of personal design. We propose a starting point for a Personal Design Manifesto that expresses this problem, proposes approaches to solutions, and shows how our discipline of HCI can contribute. We expect some of our claims to closely match the spirit of our budding community, while others will hopefully be the subject of lively discussion. We hope that these can lead to a manifesto representing and helping to grown our community. We close with VisiCut, FabScan and FabCenter as three examples of ongoing projects that provide points in the resulting space of design and research approaches.

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Personal design, personal fabrication, digital fabrication, design tools

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User Interfaces—Graphical User Interfaces (GUI)

Introduction
Computer-controlled manufacturing tools such as laser-cutters and 3D printers have recently become affordable to a wide audience outside research and industrial

labs, thanks to technological advances and rapid price drops. These digital tools promise a future of Personal Fabrication [1,2] in which we use them at home to fabricate individualized objects for our personal use, from gadgets such as custom cell phone covers and simple, small plastic replacement parts for our household appliances, to custom-made braces and similar customized assistive technologies that are becoming crucial for our aging population.

The potential societal impact of this new trend is fundamental: It questions the traditional industrial mass-fabrication process, replacing it with a distributed, individualized, make-on-demand model [3], and it raises critical issues such as copyright protection for physical objects and their design. Thus, many expect this third digital revolution to bring about even more fundamental changes than the first two digital revolutions that computer science and information technology have enabled: widely available digital data processing (the "PC revolution") and widely available digital communication (the "internet revolution").

This prediction has one fundamental flaw, however:

It is not clear how non-experts would actually operate, interact with, and use these digital software and hardware tools and machines to create and design their custom physical objects.

For example, early adopters are already using home 3D plastic printers today to print out simple items like a special stand for their smartphone. However, instead of creatively designing such objects themselves, they mostly download designs for these items that are provided by only a few knowledgeable members of the community, because today's software tools for modeling 3D physical objects are designed for professional designers and far from usable without special training.

This is an HCI research problem. The PC revolution had its major breakthrough only after the Graphical User Interface was invented and the typesetting knowledge encoded into Desktop Publishing tools enabled a wide audience to write letters, draw graphics, and design presentations. Similarly, finding the missing interaction concepts, user interface metaphors, interaction techniques, peripheral devices and software technologies to make personal fabrication tools usable will enable us to move from the technical concept of Personal Fabrication to the actual vision, which we call *Personal Design.*

We hope that outlining the major points of this fairly new research area in a manifesto can help grow our community, and provide a starting point for this below, before describing several explorations into this R&D space.

A Personal Design Manifesto

For illustration, we refer to examples from 3D printing.

1. **Personal Design, not Digital Fabrication, is the 3rd Digital Revolution.** Affordable personal digital fabrication technologies only enable a third digital revolution of Personal Design whose potential impact on society reaches far beyond the previous PC and internet revolutions.

2. **Personal Design Demands New UIs.** To move from mere personal fabrication *technology* to truly personal *design* as a mass phenomenon requires HCI to radically re-think current interfaces between

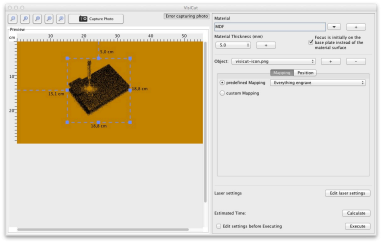

Figure 1. VisiCut user interface.

the user and these tools, to make them accessible to a general audience.

3. **Personal Design Tools Require Encoding Domain-Specific Knowledge.** To let non-professionals design physical objects, tools will need to provide some level of guidance through constraints, patterns, or other forms of domain-specific design knowledge, whether built into the tool or mediated from other users via collaboration, crowdsourcing, etc. This requires understanding the differences in conceptual models between amateurs and professionals, and modeling this knowledge in digital form (similar to Desktop Publishing tools encoding rules of typography). At the same time, some traditional professional knowledge needs to be adapted to the new technical possibilities of modern personal digital fabrication tools.

4. **Personal Design Offers a Continuum of Options.** Today, personal fabrication users owners mostly download existing models to manufacture them at home, without changing the designs themselves (think Thingiverse). At the other end of the spectrum is the designer or artist that creates and prints a digital model from scratch (think SolidWorks). In between are parameterized models that allow small changes (think OpenSCAD), or constraint-based design tools that enforce some domain-specific rules while providing more freedom to the designer at home (think SketchChair).

5. **Personal Design and Personal Fabrication Are Orthogonal.** Future users may choose to design their own products as digital models, or choose an existing design (or anything in between, see 4.). They may also choose to manufacture these at home (think MakerBot), or outsource production to an external entity (think Shapeways).

6. **Open-Source Hardware Supports Personal Design.** The opportunities for rapid social collaboration on new and existing physical designs that social media provide are tantalizing, but may only unfold their true potential if the underlying design is made available in an open-source format.

Example 1: VisiCut

The success of the early PC is often attributed to *VisiCalc* which brought the spreadsheet metaphor of manipulating data in real time to a wide audience. Similarly, *VisiCut* aims to provide non-professionals with a more natural way of operating lasercutters. Today, most design software treats lasercutters like printers, and requires detailed understanding (and much experimentation) depending on the actual material and machine.

VisiCut instead is a cross-platform, open-source software tool that encodes domain-specific knowledge about lasercutting. It lets the user specify tasks such as "cut 4mm acrylic", and maps these to profiles for a specific material and machine. A simple webcam mounted on the lasercutter provides previews of the result.

We are currently extending VisiCut to include design constraints (such as a minimum hole diameter), and to an augmented reality approach for personal design that lets users put sketches and drawings directly on top of the material, transferring the approach of CopyCAD [4] to lasercutters. VisiCut is compatible with the open-source LAOS laser cutter firmware, which enables real-

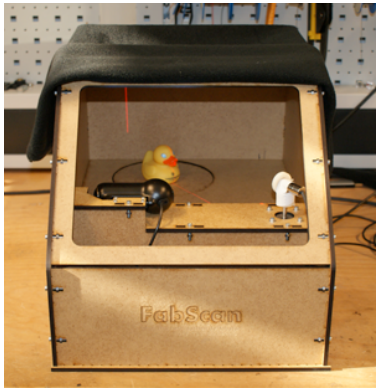

Figure 2. FabScan.

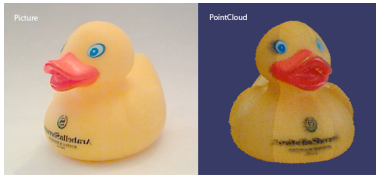

Figure 3. Photo of original object, and 3D scan made with FabScan.

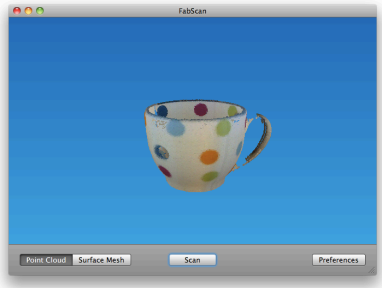

Figure 4. FabScan UI after scanning an object.

time laser control for additional interaction techniques in the future. (http://hci.rwth-aachen.de/visicut)

Example 2: FabScan—3D Scanning for the Rest of Us

One point on the Personal Design Continuum is acquiring a digital model by digitizing an existing physical object. FabScan is an open-source low-cost 3D scanner to create 360º 3D color scans of objects. The object is placed on a turntable. A camera takes one picture with and one without a red laser line projected onto the object. The difference image shows where the laser hit the surface. Then the turntable rotates by a small angle and the process repeats, using triangulation to acquire a 3D point cloud at sub-millimeter accuracy that is then turned into a 3D mesh and STL file ready for 3D printing. FabScan can be built in a standard Fab Lab for around $100 in parts. (http://hci.rwth-aachen.de/fabscan)

Example 3: Fabiji, FabCenter, FabReview—Community Support for Digital Fabrication

Personal Design greatly benefits from users sharing their designs as open source with the community. Fabiji makes it easy to document a project completed in a Fab Lab. It combines a hardware kiosk station with an iPad running a custom app with web services. (http://hci.rwth-aachen.de/fabiji)

FabCenter is an ongoing research project to overcome the need for custom, platform-specific, engineering-oriented software when using digital fabrication machines. It also provides an overview of projects available at participating Fab Labs, web services to use machines such as 3D printers, lasercutters (via VisiCut) and PCB mills, and for domain-specific design tools. A user could create a custom digital object, select the Fab Lab she will visit, and have her creation 3D-printed or lasercut on any of the machines available at her lab, all from inside her web browser. FabReview extends FabCenter to conduct hardware peer reviews.

Workshop Activity Proposal

If people are interested, we would be happy to coordinate an activity during the workshop to flesh out the idea of a manifesto and a research agenda for our community. We can also bring a few FabScans to try out.

Acknowledgements

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References

[1] Gershenfeld, N.: *FAB: the coming digital revolution on your desktop—from personal computers to personal fabrication*. Basic Books, New York, 2005.

[2] Malone, E. and Lipson, H.: Fab@Home: The Personal Desktop Fabricator Kit. *Rapid Prototyping Journal,* vol. 13, no. 4, 2007, pp. 245–255.

[3] Piller, F. and Tseng, M. (editors): *Handbook of Research in Mass Customization and Personalization.* World Scientific Press, New York 2009.

[4] Follmer, S., Carr, D., Lovell, E., and Ishii, H. Copycad: remixing physical objects with copy and paste from the real world. *Adjunct Proc. UIST '10.*