3D Printing: Non Experts to Design and Fabricate Objects

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ABSTRACT
3D printers are becoming more popular and are starting to be available at a low cost. However, it still requires technical 3D rendering skills which creates a barrier for many potential users. Many of the tools available are not well suited for non-designers who don't have enough technical skills. Although there are some tools created to work at the level of a non-designer, this is only useful for very simple objects which don't serve enough purpose for everyday life. Also something we cannot avoid is the fact that novice users will eventually master the simple tool and will start demanding more complex functionality, which again leads to a suggestion of professional engineering tools. Although this is a complicated messy situation, people are very fascinated and interested in making their own things. This suggests an idea of digital literacy that's not already there. The usability of the tools and interface will play a key role in the widespread of 3D printing. A complex tool with high barriers into entry will limit the target users and will serve as a mass manufacturing or research tool rather than a personal one. To develop a good tool, a user study must be done.

INTRODUCTION

Due to the drop in price for 3D printers, the interest for using it as a personal machine has risen. There are many developments of tools to design and fabricate objects. A major issue currently is that it is very difficult for a non-expert to quickly design and print something as it requires some degree of learning 3D design skills. New tools such as MixFab has been introduced, which reduces the barrier into entry by letting users interact with Kinect and use gestures to manipulate with the object on the screen.

In order for a good software/interface to exist we must first know what kind of things regular users would make. Then we can figure out how they want to make them. This raises a problem because the user would not have the knowledge of how something can be made, which leads to them producing something too simple or unrealistic. This literature focuses on the non-expert user and the tools in these following issues:

1) What are the user's wants and needs with 3D printing?
2) How the user would like to design and fabricate the object?
3) Does the user's knowledge of the capabilities of 3D printing affect their wants and needs?

WHAT ARE THE USER'S WANTS AND NEEDS REGARDING 3D PRINTING?

In 2005 Neil Gershenfeld states that in the near future most people will have a personal fabricator. In 3D printing there is a bigger implication compared to earlier transition from mainframe to PC because our physical world and objects are being personalized rather than digital information. This starts to change the way users think about manufacturing. For the past century there has been a democratization of mass production and consumption, known as the industrial revolution. The next revolution, given the fact that people now have access to production technology and design tools is to individually manufacture objects for creative, business and personal reasons. This motivation comes from the do-it-yourself (DIY) movement. [2]

Until 2007; it was very complex for an individual to be able to convert an idea into a physical product. The price for 3D printers in 2001 was $45,000 which fell down to between $1000-10000, which makes them more affordable and accessible. [3] Currently, there are services such as Ponoko which lets people "crowdsource" a custom product by asking the community of designers to make it. Within 3 years, the company has grown substantially in terms of the number of users and also the variety of services. This shows a need for individuals for personal fabrication. [4]

Study 1: Faux 3D Printer

Article states that there has been very little research to examine the potential uses of 3D printing at home. To approach this problem they conducted a study where 10

households with 28 individuals kept a faux 3D printer at home for a month. All of the participants had very little prior knowledge of 3D printing. [6]

Methods

The participants were asked to design and keep logs of things they would like to print. Due to the fact that there are limitations to current technology they chose a low-tech method to encourage participation in the design process and lower the learning complexity. The faux printer was a prototype which just consisted of a box with Kraft paper to decorate, pens and index cards to write ideas and documentation down and a camera to take photos of the items they want to print. Using a real 3D printer in this study could have affected the creative though processes limiting the variety of objects the participants would design

The study began with asking the participants to be involved in activities that were in the pre-determined category. This was to get the user thinking about uses for the printer. The categories which were not disclosed to the participants were:

1) Giving and Helping
2) Replacing and Repairing
3) Creativity and Crafting
4) Customizing and Modifying
5) Experimental

An example of a prompt for 1) was to create a gift for a family member for their birthday. The participants were then involved in unprompted design. The study also looks into the purpose for creating each of these objects.

Results

Categories of objects: It was found that most of the objects were household items. 19% was in the "Home and Kitchen", 11% in the "Tools and Home Improvement", 10% in "Toys and Games", 9% in "Kitchen and Dining" and 8% in "Sports and Outdoors".

Types of material: In the participants' designs various types of materials were used. They also wanted to use a combination of materials, with the most common ones being wood and metal, and plastic and metal. Other materials included rubber, glass, fabric, paper etc. Many of the designs also included mechanical moving parts for electronic devices.

Purpose of creating objects: The study looked into the purpose of creating those objects. The most frequent (81%) was replicating existing items. This was to replace unique items and complete the set. The second purpose (15%) was modifying and customizing. This was either to repair or to improve the functionality of an object. The least common purpose (4%) was creating custom objects. This was due to the fact that it would require a significant design process. The request also seemed to push the boundaries of 3D printing such as mechanical devices or electric circuits.

Relevance

This study is relevant to this topic as it shows the ways in which typical users who are not technology enthusiast or early adapters would like to interact with the emerging technology. This would help the design and development of software for 3D printing. The first 2 purposes also suggest that users would like to integrate existing objects during the design process to fabricate the new one. This supports an idea for a mixed reality environment where users can interact with virtual and real objects in an augmented reality environment.

HOW WOULD THE USER LIKE TO DESIGN AND FABRICATE THE OBJECT?

This article "Design-To-Fabricate: Maker Hardware Requires Maker Software" explores the current problems with non-experts using the available software and tools of 3D printing. Although a tool such as CAD software exists, they are expensive and have a steep learning curve which is not in not appealing to the typical user. And due to the fact that 3D-printing hardware has become more accessible and there is a growing community of "makers" looking for software, researchers have tried to solve the problem by creating user friendly software to fabricate objects. Tools such as Cookie Caster and Crayon Creatures take sketches and turn them into 3D model, while tools like the 3D printing Kissing Booth uses features of Microsoft Kinect to create a scan of the participants. A problem arises when novices inevitably master the given tool and start to demand more complex capability. This usually ends with a suggestion that the looks into professional tools like Blender. However, this is not ideal as the goal is for an interface with minimal required training. Other issues seen were overheads and orientation issues, where most users didn't think about the fact that the orientation of the object affects the printing itself. It concludes that improvement in the interface would increase the audience for 3D printing. [5]

This article is related to the topic because it shows that the capability of the printing software is as vital as the capability of the hardware. It addresses the fact that although current tools exist, only professionals have enough skills to use them at the moment. A tool that is easy to learn for non-experts and scalable in complexity will spread the engagement of 3D printing amongst the world whereas a hard to learn tool will be focused of a specific audience with a lot of barriers into entry.

Study 2: MixFab

In the article "MixFab: A Mixed-Reality Environment for Personal Fabrication" addresses solution to the problem above by introducing a mixed-reality environment called MixFab. This tool combines an augmented reality for design with the possibility for the use to interact with virtual and real objects. This system is designed to lower the barrier into entry for personal design. It is able to recognize gestures through the use of Kinect acquire 3D shapes and recognize drawn sketches. A study was done with 12 participants where they were asked to do the following tasks:

1) Create primitives – this consisted of creating a box and a cylinder. While the users preferred to draw the outline of a square and extrude it, they preferred to describe the cylinder with their hand as they were able to define the curvature. This shows that what might be desirable with one area, could be undesirable in the other.

2) Rotate, move, scale and remove the box – for all of these the users suggested hand gestures. This was due to the fact that users these tasks relate to everyday tasks.

3) Scanning an object - this proved to be difficult as users did not perform this in their everyday task. They suggested placing and object and waiting a certain amount of time.

Following this, they were told to create a desktop organizer that holds a glue stick and a pen. When interviewed most of the user had quickly understood how to use the MixFab tool. All of the users also said that introducing existing objects into the design was useful.[8]

DOES THE USER'S KNOWLEDGE OF THE CAPABILITIES OF 3D PRINTING AFFECT THEIR WANTS AND NEEDS?

The faux printer study targets what people want to print and the reasons behind it, and the MixFab study targets how people want to print objects given the capabilities. Each of the study did not take into account the other factor. In the Faux Printer study, users did not know the capability of a 3D printer. Hence some of the design they created were physically impossible to manufacture. In the same manner creating a digital-specified object in MixFab may not be possible to exist in a physical form.

Challenges with Digital Fabrication

In the article "Supporting the Design and Fabrication of Physical Visualizations" it identifies areas where problems arise. It starts with the problem of manufacturing being physically impossible to print even if a digital object exists. Many users also don't have an understanding of balance, stability and strength of the object. [7]

In the faux printer study, the user did not have any idea of the constraints to the printing process. They were also not introduced to emerging technology like MixFab. If they were aware of these, perhaps the objects they designed would have been different.

SUMMARY

Due to the availability of fabrication machines and tools, an interest in having a 3D printer at home has risen. However, not enough studies have been done for the typical user. The faux 3D printing experiment showed that majority of the users wanted to either replicate or customize existing objects. Most of the items designed by the participants were household items. In the MixFab study, we noticed how the user would print objects. Users found it easy to manipulate with a virtual object using natural gestures. In both of the studies participants suggested the use of existing objects in the system.

There are many new technologies emerging regularly for personal fabrication. However, there are also current constraints to it. A non-expert user won't be aware of these and therefore it impacts the way they are thinking about 3D printing.

FUTURE WORK

To find out the real potential for 3D printing, further research needs to be conducted using a real 3D printer instead of a "fake" one. This will help in developing better software tools for fabrication.

The correlation between what the user wants to make and how objects can be made suggests an introduction for recursion by designing an object, fabricating and taking into account its physical form back into the design process. A combination of the MixFab and faux 3D printing studies may produce more successful results by providing a semi-interactive fabrication process.

REFERENCES

1. Agrawal, H., Jain, R., Kumar, P. and Yammiyavar, P. FabCode. In *Proc. IDC*, ACM(2014). http://dx.doi.org/10.1145/2593968.2610490

2. Hodges, S. A Revolution in the Making. IEEE 13,3 (2014),18-21 http://dx.doi.org/10.1109/MPRV.2014.40

3. Hurst, A. and Kane, S. Making making accessible. In *Proc. IDC*, ACM(2013), 635-638. http://dl.acm.org.ezproxy.auckland.ac.nz/citation.cfm?id=2485760.2485883&coll=DL&dl=GUIDE.

4. Mota, C. The rise of personal fabrication. In *Proc. CNC*, ACM(2011),.279-288. http://dl.acm.org/citation.cfm?id=2069665.

5. Schmidt, R. and Ratto, M. Design-to-Fabricate: Maker Hardware Requires Maker Software. *Computer Graphics and Applications, IEEE*, 33,6,26-34. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6682940.

6. Shewbridge, R., Hurst, A. and Kane, S. Everyday making: identifying future uses for 3D printing in the home. In *Proc. DIS 2014*, ACM(2014), 815-824. http://dl.acm.org/citation.cfm?id=2598544.

7. Swaminathan, S., Shi, C., Jansen, Y., Dragicevic, P., Oehlberg, L. and Fekete, J. (2014). Supporting the design and fabrication of physical visualizations. In *Proc. HCI*, ACM(2014), 3845-3854. http://dl.acm.org/citation.cfm?id=2557310.

8. Weichel, C., Lau, M., Kim, D., Villar, N. and Gellersen, H. MixFab: a mixed-reality environment for personal fabrication. In *Proc. CHI 2014*, ACM(2014), 2855-3864. http://dl.acm.org/citation.cfm?id=2557090.