ARTISTS' ARTICLE

Lithobox

Exploring Hybrid Crafting Practices through a Collaboration across Digital Fabrication and Fine Arts

JENNIFER WEILER, TODD INGALLS, AND **STACEY KUZNETSOV**

ABSTRACT

New digital and physical fabrication tools are increasingly being integrated with traditional craft techniques to enable hybrid crafting practices. Inspired by the traditional lithophane technique whereby designs are molded in porcelain and visible only when backlit, the authors developed Lithobox: a software system, physical kit and workflow for creating illuminated 3D-printed lithophanes. They explored Lithobox as a creative tool in workshops with nine artists and presented the finished 3D-printed lithophanes and software tool as part of an international art exhibition. Through these collaborations and creative interactions, the authors' work reveals how the amalgamation of material, technology and productive constraints can influence current art practices.

Digital technologies and modern materials are increasingly being incorporated into art practice alongside traditional techniques. The emerging forms of hybrid crafting present exciting possibilities as artists can experiment with new workflows, tools and artifacts, often without specialized equipment. However, such developments also lead us to ask: How might digital technology and modern fabrication tools support rather than replace craftsmanship and technique from traditional fine arts domains? And how are the resulting hybrid tools, materials and processes shaping and being shaped by creative practice?

We explore these questions at the intersection of the traditional ceramic technique of lithophanes, in which thin pieces of hand-shaped porcelain display detailed images when backlit, and 3D printing. While lithophanes have traditionally been carved on flat rectangular surfaces, 3D printing allows designs to be extruded from more complex physical forms that are harder to create by hand. To explore 3D printing as an approach for crafting lithophanes, we created Lithobox, a software and workflow that allows users without prior 3D modeling experience to design, print and assemble illuminated lithophanes. In addition, we designed an easy-to-assemble kit that illuminates the lithophanes and displays them on a rotating platform.

We used Lithobox in a collaboration with artists to design and create several art pieces that were displayed at an international art exhibit, where attendees were able to view the finished pieces along with the Lithobox software (Figs 1,2). In addition, we distributed Lithobox through Instructables, enabling artists and makers from all over the world to create 3D-printed lithophanes. Our work reveals the interplay between creative hybrid crafting and productive material constraints, highlighting how emerging fabrication techniques could support rather than supplant craft in the digital age.

Fig. 1. PLA plastic, 3D-printed lithophanes created with Lithobox. Custom images were mapped and extruded along the lithophanes' inner and outer surfaces and can be seen when lit from within. Photo taken at the 2019 Arts Track Exhibit of the ACM International Conference on Tangible, Embedded and Embodied Interaction (TEI). (© Jennifer Weiler)

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Fig. 2. PLA plastic, close-ups of individual lithophanes, 2018–2019. Each lithophane is 6 in tall and 4.5–6 inches in diameter. (© Jennifer Weiler)

BACKGROUND AND RELATED WORK

Lithophanes were first created in the early eighteenth century in Europe by carving an image into clay and then firing it in a kiln [1]. These early lithophanes were traditionally plaques resembling a bas-relief, in which a sculptural image was depicted with little overall depth. However, when backlit, the thinner parts of the lithophane allow light to shine through, thereby creating a luminescent image. Later, as lithophanes became a popular commercial product, designs were mass-produced by making plaster molds to create multiple copies of the original design. Because they needed to be evenly backlit during the carving process, ceramic lithophanes were generally created as flat tablets, although there were rare cases of lithophanes molded into 3D shapes such as orbs.

Because the images depicted in lithophanes are created by varying the thickness of the material rather than its color, they can be effectively fabricated using single-color 3D printing filament. The concept of lithophanes has recently been explored in 3D printing [2], with several online programs and tutorials allowing users to turn their images into 3D-printable lithophanes on flat plaques or cylinders [3]. However, considering the potential complexity that can be achieved by 3D printing, we contend that the available designs do not take full advantage of 3D-printing capabilities. Lithobox enables the user to create a radially symmetrical lithophane from a custom silhouette, which is possible through additive manufacturing. In addition, Lithobox allows distinct bas-relief textures to be added to both the outer and inner walls of the lithophane, enabling more complex designs.

We draw inspiration from other work at the intersection of digital tools, fine arts and new technology-mediated art experiences. For instance, Daniela Rosner and Kimiko Ryokai have developed digital records to attach meaning to the traditional arts activity of needlecrafting [4], while Audrey Desjardins and Timea Tihanyi embedded sound datasets into 3D-printed porcelain cups to explore meaning making [5]. In addition, Rachel Clarke et al. have suggested that current arts practices can be used to provide insights into the role of digital technology in social issues [6], and Courtney Starrett, Susan Reiser and Tom Pacio have explored means of generating artistic 3D objects from data-informed designs [7]. Amit Zoran and Leah Buechley have also explored the merging of digital fabrication and traditional craft [8]. In addition, we draw from literature on fabrication techniques that use lighting and perspective, including works in which light is used as the primary creative medium [9,10].

LITHOBOX

Inspired by these emerging research trajectories, we set out to explore a digitally mediated workflow for crafting lithophanes. Lithobox supports established methods of handcrafted ceramics, which require specialized equipment (e.g. firing kilns) and have limitations in achieving certain types of design. Through a yearlong partnership and series of discussions with local ceramicists, we explored design possibilities for integrating digital technologies into the crafting process. Our goal was to design a system and workflow for creating lithophanes as 3D-printed artifacts with complex extruded shapes that can depict detailed images when backlit. We iterated early versions of our software and workflow in several work sessions with artists and designers. The final Lithobox system consists of software for easily generating 3D print files for complex lithophanes and a physical kit (electronic components including a small motor, LEDs and coin-cell batteries) to build a base that rotates and illuminates the artifacts. We worked with nine artists to create lithophanes with Lithobox and these were presented as part of an international art exhibit (Fig. 1).

The 3D models for lithophanes are generated within Lithobox, a downloadable application composed of three steps (Fig. 3). The user first creates the 3D shape for the lithophane, then selects images to be extruded on the inner and outer surfaces of the lithophane and, finally, indicates the print size. Our system can be used to design any radially symmetrical lithophane shape; such a result is extremely difficult to create by hand in mediums such as ceramics.

We also designed a physical kit and assembly process that illuminates the finished 3D-printed lithophane from the inside and displays it on a rotating platform. The rotation adds an interesting perspective for observing the images that are

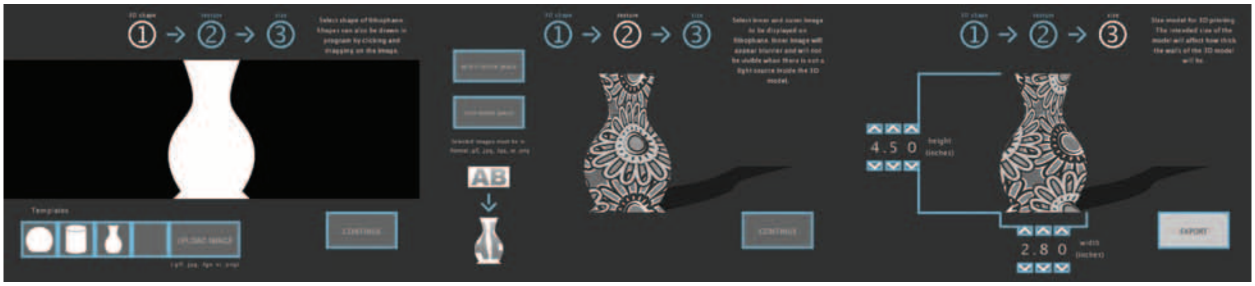

Fig. 3. Lithobox software workflow, left to right. Step 1: user draws outer shape of lithophane; Step 2: user chooses images to be extruded along the inner or outer surface of the 3D shape; Step 3: user selects size of lithophane. (© Jennifer Weiler)

extruded along the lithophanes' surfaces. Beyond the 3D-printed lithophane, the materials required to make this finished assembly include additional 3D-printed or laser-cut parts: a base, a light support tower and a MakerCase box (Figs 4 and 5) [11]. The electronic components include a 6-RPM servo, switch, battery pack, batteries and LEDs.

COLLABORATING WITH ARTISTS

We developed Lithobox to explore how hybrid crafting practices and tools shape and are shaped by artistic practice. We reached out to local arts communities and formed collaborations with nine artists, each of whom is an active art practitioner with 5–20 years of experience in traditional and/or digital arts domains. Three of the artists have a primary focus in mixed-media sculpture (e.g. metal casting, found materials) and two in new media (e.g. sound installation), while others have backgrounds in dance, ceramics, engineering and traditional 2D media. Of our participants, only two had experience with basic 3D printing.

We conducted work sessions whereby our artist collaborators used Lithobox to design and assemble lithophanes and participated in semistructured discussions about current 3D modeling and 3D printing techniques and limitations, as well as the broader affordances of digital fabrication within fine arts domains. We discovered several approaches for supporting integrated fine arts practices alongside digital fabrication methods: (1) selective automation of tasks to allow for more focused or creative iteration, (2) productive constraints to scaffold creative workflows and (3) materially oriented interactions throughout the physical and digital design process. All quotes in the following sections are from our workshop participants, who have been kept anonymous as per the terms of our IRB review of this research.

SELECTIVE AUTOMATION OF TASKS

What is considered an essential part of creative practice has often changed based on technological innovation. Before the mid-1800s, the practice of painting included grinding pigments and mixing them with binders to create paint. However, with the invention of the paint tube in 1841, artists were able to acquire premade paints and, as a result, could spend more time creatively applying paint to canvas rather than carefully prefabricating their colors [12]. Today, painters can still choose to make their own paints, but the majority tend to opt for the convenience of paint tubes. During our collaborations, several artists acknowledged the potentially freeing aspects of technology. Multiple individuals suggested that the availability of new tools and techniques could provide alternative ways of manifesting ideas:

> If, for instance, I'm someone who is not good with my hands, this offers me an outlet to do something that I wouldn't necessarily otherwise be able to do. . . . It allows you to sculpt without the same limitations that we find when sculpting or working with traditional materials.
>
> I am interested in how we can . . . push these technologies and then also how these technologies relate to traditional craft and technique and how they can—I don't like saying the word "replace"—but how it can stand in place of these more traditional techniques that have been used in the past.

Drawing on our work with Lithobox, we can begin to speculate on how today's emerging technologies could selectively

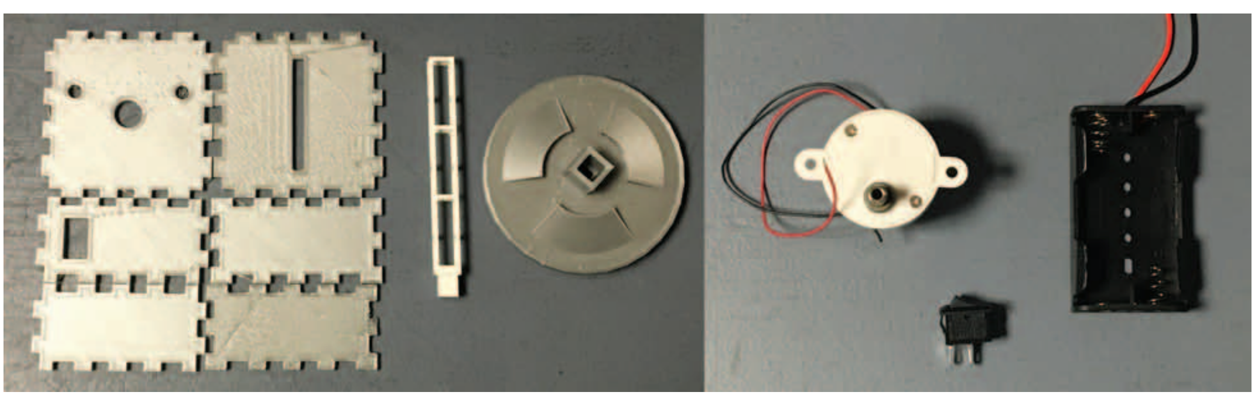

Fig. 4. Physical kit components, left to right: 3D-printed MakerCase box, light support tower, base, 6-RPM servo, switch and battery pack. (© Jennifer Weiler)

Fig. 5. Example of a lithophane with 3D-printed assembly parts: base and support tower, MakerCase box containing Arduino rotator and 3D-printed lithophane. The total height of the assembled lithophane and support structure is 7.5 in, composed of PLA plastic. (© Jennifer Weiler)

automate mundane aspects of creative processes. Such automation could allow artists to spend more time creatively iterating aspects of their projects that interest them or allow them to develop valued skills. Because artists may enjoy different aspects of their craft, ideal automation would be tailored to the desired design practices of the artist. Future systems might study existing practices, identify areas that could be automated and co-design frameworks to support specific art processes in this way. For example, artists who are more interested in the process of metal casting and applying patinas may wish to 3D-print their designs rather than sculpting them from clay or wax.

At the same time, our collaborators valued repeated engagement and exploration of materials by hand and therefore were hesitant to integrate digital tools into creative processes. For instance, when reflecting on why artists that she knew were hesitant to use new fabrication methods, one collaborator suggested that individuals who had cultivated skills over many years did not want to feel replaced by digital machinery:

> The people in those areas [ceramics, painting, fibers] are really devoted and take a lot of pride in the craft—like the time they spent to learn the skills to craft an object, and so I think they are a little skeptical of "Oh wait, now I can just print it?" and so there's an insecurity that happens and I think is part of maybe why people in those areas have not embraced the 3D printers. They still want that time and all of those years they've spent developing this skill to matter.

In this quote, and throughout other discussions with our collaborators, the perceived ease of digital fabrication is put in tension with traditional, skilled craft practices. This underlines the importance of designing and implementing technology in a way that enables and prioritizes rather than superseding creative craftsmanship, including material interactions.

PRODUCTIVE CONSTRAINTS TO SCAFFOLD CREATIVE WORKFLOWS

Often, tools, programs and processes are designed with the goal of giving users as much agency and freedom of choice as possible. However, this could have the downside of complex, overwhelming systems not clearly conveying what they can contribute to an artist's preexisting creative practice. As part of the design process for Lithobox, we wanted to make the complex process of designing and creating lithophanes more accessible. When using Lithobox, artists who had little or no 3D modeling experience were able to design a complex 3D print with relative ease. The specific workflow supported by Lithobox enabled artists to quickly begin crafting their lithophanes without investing much time to learn 3D modeling software with more features (e.g. Solidworks). As one artist put it:

> For a beginner like me, having some ramp into the process . . . I would be a lot more likely to actually go through the whole process than I would if I just had a complete open sandbox. . . . That would be too intimidating and would take too much time for me to get something that is like actually printable.

Moreover, several artists also reflected on how our system allowed them to begin engaging in 3D fabrication more generally. For many who had struggled with or avoided 3D modeling software in the past, the ability to quickly generate a finished model was seen as a substantial accomplishment and led to further interest in 3D modeling.

In parallel, through digital interfaces and fabrication techniques, technology can make specialized workflows, such as sculpting techniques, more accessible to people of various backgrounds and skill levels. This could not only allow novices to experiment with unfamiliar processes and materials, but also allow artists to actualize design ideas across a broad range of mediums. For instance, 3D prints could be used as molds for modeling ceramics or casting metal, allowing artists to translate their design ideas from one medium into another. New workflows with a range of materials, tools and processes could serve as gateways to traditional crafting techniques that were previously inaccessible to most artists.

DESIGNING FOR MATERIALLY ORIENTED INTERACTIONS

All of our artist collaborators worked extensively with physical materials in their practices, and we found that they highly valued the tactile feedback provided by physical interaction, including when they interacted with their 3D prints:

> I have this embedded idea of sculpting being something I am generating or doing with my physical body, so it is hard to say that the moments in which I was creating on the computer were sculpting, but because they manifested as something that I am now holding in my hand I feel like they became sculpting.
>
> There's something about touching stuff that makes you know things in a different way. Especially the textures, I think I saw that in the image but . . . it's much more apparent in the actual object.

Material interactions are often essential to how humans perceive and engage with the world and are vital to the creative practices of many artists as we saw from our research. Currently, there are crucial limitations in available fabrication techniques, such as the types of materials that can be used in 3D printing, as well as 3D modeling software that presupposes certain skill sets. As we found in our study, such limitations should be carefully communicated to artists and the general public in order to avoid unrealistic expectations or fear of the new technologies. This also suggests opportunities to design fabrication techniques that support intuitive material interactions [13]. In the future, for example, these trends could be extended into systems that enable artists to sculpt objects out of physical materials before digitizing them for further manipulation through the use of 3D scanners. Similarly, pressure sensing and motion capturing systems could be used to capture more sensitive interactions, such as the movement of an artist's pencil on paper. By such means, artists could create both physical and digital copies of their works simultaneously, while also having a digitized record of their artistic processes.

Future work could also focus on malleable fabrication techniques to overcome the perceived finality of 3D prints expressed by our participants, who valued longer-term engagement with their projects. As research continues to innovate techniques for building on existing 3D prints [14], new processes could allow for physical iteration such that users can modify and reconfigure 3D-printed objects into new forms. The malleability of 3D prints could also be supported by using alternative, flexible 3D-printed material, including deformable plastics or traditional materials (e.g. clay). If the prints can be physically manipulated after they are created, 3D printing could be viewed as part of an iterative creative process, rather than solely as a means to make finalized objects.

CONCLUSION

Inspired by the traditional technique of lithophanes, we created Lithobox, a software system, physical kit and workflow, which we used to collaborate with artists to create complex 3D-printed lithophanes. Our work reveals how modern fabrication methods could be incorporated with traditional fine arts techniques to support existing craft practices through selective automation, productive constraints and materially oriented interactions. We hope that our work has sculpted a future trajectory for physical-digital crafting approaches at the intersection of emerging technologies and fine arts.

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