Data Materialization: A Hybrid Process of Crafting a Teapot

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ABSTRACT

Data materialization is a workflow developed to create 3D objects from data-informed designs. Building upon traditional metalwork and craft, and new technology's data visualization with generative art, this workflow expresses conceptually relevant data through 3D forms which are fabricated in traditional media. The process allows for the subtle application of data in visual art, allowing the aesthetic allure of the art object or installation to inspire intellectual intrigue. This paper describes the technical and creative process of *Modern Dowry*, a silver-plated 3D-print teapot on view at the Museum of the City of New York, June 2017–June 2018.

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Data Materialization

A giant teapot loomed across the sky in a parody of Kubrick's *2001: A Space Odyssey* playing on the big screen during SIGGRAPH's Electronic Theater Opening Sequence in 2001 [1]. This digital short paid homage to the teapot, an iconic object. In 1974, University of Utah graduate student Martin Newell was looking for a complex surface on which to test reflections, and his wife, Sandra, suggested that he use their Melitta teapot as a model. That virtual teapot model lives on in the world of computer graphics [2]. Its now familiar shape influenced and continues to influence a myriad of digital models. The process presented in this paper takes a reverse approach: A digital application and 3D print are used to fabricate a physical object: a silver-plated teapot, *Modern Dowry* (Fig. 1).

The teapot's story began when the Museum commissioned me to develop a piece for "New York Silver: Then and Now," an exhibition independently curated by Jeannine Falino. Through the piece, I wanted to bridge two seemingly disparate creative disciplines, silversmithing and computer graphics. I reached out to my collaborator, Susan Reiser, an educator in computer science, new media and mechatronics. This work melds craft and digital fabrication by augmenting digital tools, techniques, finishes and materials with their traditional alternatives. I used conceptually relevant statistical data to inform the geometry of the work in a process my collaborators and I call *data materialization*, a process inspired by data visualization—the intersection of data communication and design. However, there is an important distinction between the two: Data visualization prioritizes the clear and accurate communication of data while data materialization prioritizes the design. In other words, the object's looks are more important than the direct communication of the data. The input data set may be revised if the resulting form is unappealing or uninteresting. For example, if plotting a curve and all inputs were equal, the end result would be a flat line. Because a single flat line is not visually interesting, it would be replaced with a dataset that remained conceptually relevant but resulted in a more dynamic curve. This process is not data visualization because the statistics are analyzed and curated to identify datasets that produce interesting results within design constraints. In the following sections, the data materialization workflow is described from concept and design to fabrication, which is infused with historical

Fig. 1. The *Modern Dowry* teapot. Nylon polyamide, copper and sterling silver. 22.1 × 23.9 × 24 cm, 2017. (Photo: © Courtney Starrett)

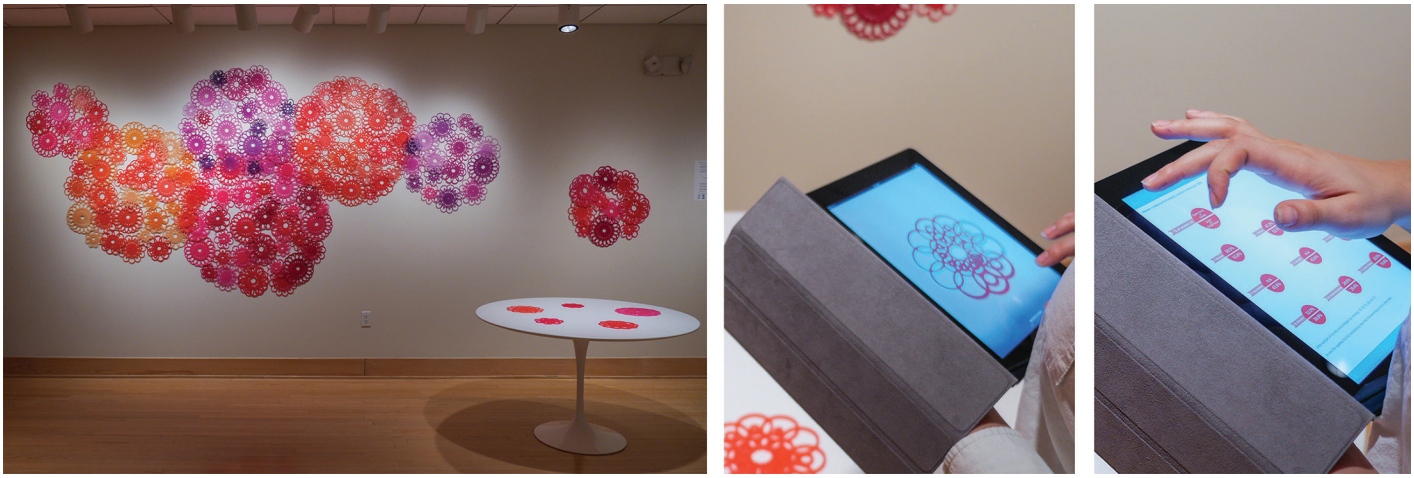

Fig. 2a. *Clever on Sunday* (2016), silicone rubber, pins and Saarinen Tulip table courtesy of Knoll and iPad, 18 × 10 × 6 ft. Installed at the Samuel Dorsky Museum of Art in 2016. Fig. 2b. User interacting with QR code doily and information graphics at the Samuel Dorsky Museum of Art in 2016. (© Courtney Starrett. Photo: Esther Joy.)

context and interdisciplinarity. The initial projects, *Clever on Sunday* (2016) and *Layer Chiffon* (2017) lay the foundation for *Modern Dowry* and the data materialization workflow.

Clever on Sunday (2016) is an installation (Fig. 2a) consisting of about 200 hand-cast silicone rubber doilies with designs computed from statistical data on gender balance and imbalance in education and the professional world. Working backwards from a vision and concept, we began with a computer-generated design, the output of a custom program. The program takes spreadsheet data (percentages) and converts them to a radial pattern of overlapping circles of different radii. Each "spoke" represents one column in a dataset; for example, female students in a particular STEM major. Each circle along the spoke represents a different spreadsheet row; in the preceding example, a particular year. In other words, the size of a circle's radius corresponds to the relative size of the number of majors in that particular year. Each doily pattern was laser cut, and the model was used to construct a silicone mold. The doilies were then hand-cast from the molds using custom-tinted silicone rubber. Exhibit viewers could scan an individual doily which acted as a "QR" code and hyperlinked to a webpage infographic explaining its underlying statistics (Fig. 2b). As part of the exhibit, a few of the doilies were displayed on a table. A surprisingly high number of guests touched or picked up the silicone pieces off the table, which inspired the use of silicone forms as sensors in *Layer Chiffon*.

Fig. 3. *Layer Chiffon* (2017) silicone rubber, projector, various electronic components (Arduino, etc.) and table, 3 × 10 × 8 ft. Installed at Vassar College in 2017. (Photo: © Courtney Starrett)

Layer Chiffon (2017) is a hands-on interactive installation (Fig. 3) inviting viewers to explore a sampled history of food, materials and gender roles in mid–twentieth-century America. The exhibit consists of a traditional table with three colorful silicone Bundt®-like forms, and a projector that displays video and animated commentary based on viewer interactions with the silicone forms. Videos include

archival commercial advertising footage and custom animated data visualizations. The data materialization workflow was again used to create the silicone forms. A custom script used spreadsheet inputs to create the relative sizes of the curves at the bottom of the bespoke forms. These curves were merged and lofted in a modeling application to produce 3D forms. The models were CNC-milled in polystyrene foam which were then used to create plaster molds. Custom silicone forms were hand-cast, in layers, from the molds. Once displayed, the jiggly, Jello®-like objects invite the viewers' touch; force-sensitive resistors detect pressure. In turn, each selected form or combination of forms causes a different video to project, allowing the viewer to interpret a custom narrative.

The Teapot

Modern Dowry began with background research on silver in colonial New York. Through conversations with Falino, an expert in the history of American metal and ceramics, I learned that prior to an official currency in the colonies, silver had monetary value and was often made into functional objects and kept in the home for security, as well as a demonstration of wealth to visitors. Thus, the cupboard became the bank account in Colonial America, and the silversmith the banker. Traditionally, functional and decorative silver pieces were wedding presents from a bride's family—a dowry—and symbolic representations of wealth and status. These gifts and other inherited assets automatically became the property of a bride's husband [3]. Conversely, typical newlyweds of today bring some combination of student, mortgage, car and credit card debt to a marriage. Today's bride may be an equal equity partner in marriage and, as in my case, may acquire more debt than wealth—resulting in the designation of the title "*Modern Dowry*." To apply this concept, I used autobiographical financial data in the data materialization workflow to reinterpret a teapot body. Echoing the deliberate selection of the form and its underlying conceptual data, a variety of fabrication techniques and materials were also identified and evaluated. The use of a nylon core layered with copper and, finally, plated with sterling silver references the illusion of wealth in the 21st century (Fig. 4). One may carry a six-figure debt, yet appear to be financially stable, thanks to credit.

Fig. 4. Details of the teapot (from left to right) in SLS nylon polyamide, copper electroform and silver plate. (Photo: © Courtney Starrett)

Initially inspired by John Crawford's 1825 teapot in The Museum of the City of New York's collection, the choice to work with the teapot compliments our backgrounds in art, design and computer graphics. The teapot has iconic significance in multiple realms: the Utah teapot in computer graphics and the sterling silver teapot as a status symbol and a literal representation of wealth in Colonial America. *Modern Dowry* references the iconic status of the teapot in multiple domains and represents a fresh approach to object-making by combining the relevant tools and techniques with contemporary context.

The teapot footprint depicts my monthly finances: debt payments and potential savings (Fig. 5). A custom script converts spreadsheet data into a circular pattern of adjacent circles. The curves are trimmed and joined to be a continuous path of alternating convex and concave curves. Each concave arc represents the relative size of a debt payment, and each convex arc is relatively sized and repeatedly inserted as a separator

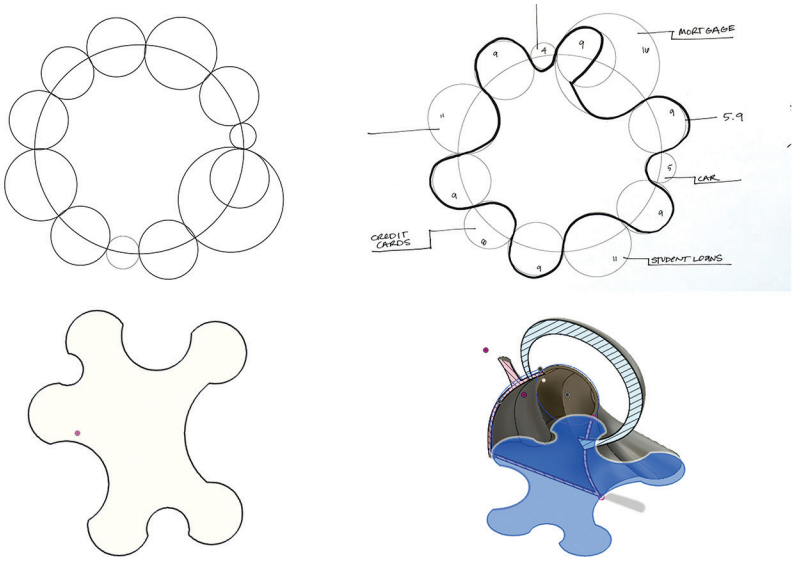

Fig. 5. The evolution of the *Modern Dowry* teapot footprint from the script produced adjacent circles to profile curve of the three-dimensional model. (© Courtney Starrett)

(savings) between the debts. The teapot body was 3D modeled from the profile; and a spout, lid and handle were added to complement it. Ultimately, the teapot was exported and fabricated by selective laser sintering (SLS) in white nylon (a polyamide), hand-sanded, copper electroformed and plated with sterling silver.

Context

While working with Tom Pacio at our summer residency at Vassar College, we contemplated where this work fits into the broader context of art, science and technology. We questioned how the work relates to traditional craft mediums, new media art, data art, data visualization, installation art, generative art and data sculpture. Although similarities were found in many of these categories, several examples resonated more than others.

While at first glance this work appears to exemplify data visualization, it is not "readable and recognizable" as a visualization, a minimal requirement for such designation [4]. Without an external explanation, one cannot infer what data *Modern Dowry* communicates. Similarly, it could be called information art, a subset of ambient visualization, but the work fails to meet information art's three data communication requirements posited by Skog et al.—that the viewer comprehends (1) "*that* something is visualized," (2) "*what* is visualized?" and (3) "*how* the data is visualized?" [5]. The teapot could be considered a data physicalization, defined by Jansen et. al. to be "a physical artifact whose geometry or material properties encode data," but their definition omits a reference to design or art [6]. Based on a literature review, we believe *Modern Dowry*, along with our other work, is best categorized as data sculpture, a type of physicalization, exemplified by artists such as Nathalie Miebach [7] and Doug Bucci [8] and defined by Zhao and Moere to be "a data-based physical artifact, possessing both artistic and functional qualities, that aims to augment a nearby audience's understanding of data insights and any socially relevant issues that underlie it" [9]. Even so, we will continue to use the term data materialization because, as described previously, they prototype different datasets in the design process.

Lev Manovich claims "data visualization moves from the concrete to the abstract and then again to the concrete," and cites Benjamin Fry's visualization *Anemone* (2004) as representative of another new quality of modern visualizations called "reversibility." When the viewer clicks on any part of the active representation a label describing the data is presented, allowing the viewer to access the data that generated the visualization, making the process "reversible" [10]. One challenge in the data materialization workflow is how to balance referencing the data, inherently crucial to the concept, with the aesthetics without being overly literal from the visual art perspective. "Reversing" the data is important to this work, although labels are too direct. *Clever on Sunday*'s QR code doilies, which link information graphics presenting the data in a tertiary way, are examples of the efforts to connect the data to the form.

Conclusion

The Utah teapot began as a ceramic teapot which was converted to a digital representation with both self-reflective and environmentally reflective surfaces, meant to coexist with the virtual environment, and presented as a 2D image. Conversely, the *Modern Dowry* teapot began with spreadsheet data, from which I generated curves and 3D virtual surfaces, which are fabricated to produce a functional silver-plated teapot. *Modern Dowry* employs a new interdisciplinary approach to making 3D data materializations through a unique workflow. Harvard's Peter Galison compared interdisciplinary work to a "trading zone" in which a new language of collaboration can be formed and in which we can coordinate action and belief across academic silos [11]. Although each collaborator brings different skills and techniques to the table, their shared goals and design process inform how they work together in interdisciplinary, interinstitutional projects. The data materialization workflow described in this paper utilizes both traditional and emergent processes and tools to create a functional and visually compelling teapot that inherently represents the concept-relevant data.

Acknowledgments

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