



Embracing Imperfection in the Age of Digital Reproduction



Figure 1: On the left, the Original Ennion's Blue Jug. On the right, the first item in the chain of reproductions.

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Abstract

Technology plays a major role in reproduction of art and craft. While increasing their accessibility to the public, reproduction also raises questions concerning authenticity and quality. 3D Scanning and Printing have extended reproduction boundaries, positioning it as a candidate for taking part in the artistic process. In this work we suggest to consider the imperfection in the reproduction process as a distinguishing element that adds to authenticity. We present a "chain of digital reproductions", a series of 3D printed objects, beginning from a reproduction of the original Ennion's Blue Jug. Next to the last reproduction, a 3D Printer and scanner will print the next reproduction in the chain. The exhibited work will demonstrate how reproductions can gradually become independent of the original artwork and have their own unique meaning and aesthetics.

Author Keywords

Reproduction; Fabrication; 3D Printing; 3D Scanning; Art; Exhibition; Ennion Jug.

CCS Concepts

•Human-centered computing → Human computer interaction (HCI); Visualization techniques; HCI theory, concepts and models;

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Figure 2: The "chain of digital reproductions", continuous reproduction process increases imperfection and leads to unique aesthetics.

Introduction

The concept and practice of reproduction sparked interest and debate since its origins, and is still being discussed in the digital age, raising questions concerning value, authenticity, quality and *aura* [1]. On the other hand, reproduction is increasing accessibility of art to the public [1, 5], and is believed to contribute to the value of original artworks, as the process of making a reproduction, indicates the esteem in which the original is held [5].

Technology has always played a key role in re-defining the meaning of reproduction. In recent decades, 3D Scanning and 3D Printing have been introduced as new reproduction technologies, in the context of the fourth industrial revolution. With the increasing adoption of these technologies, digital reproduction of physical artworks will become a common practice [5], and will allow for new forms of hybrid creation [6], positioning reproduction processes as candidates for taking part in the artistic process itself.

Another implication of technological developments is the possibility to create a chain of reproductions, where each reproduction is created based on a previous reproduction

and becomes less dependent on the original artwork. This method is typically used for preserving the memory of an original fading artwork [5]. Reproduction tools have greatly improved over the last years, but are still far from producing a perfect replication. Thus, Chain reproductions are imperfect and unpredictably different from the original artwork, resurfacing the intellectual concerns suggested by Benjamin Walters, regarding context, quality and authenticity.

In this work we present a novel point of view that is connected to old ideas. We suggest to consider the imperfection of reproduction as an integral part of the artistic process, and to explore a "chain of digital reproductions" that leads to unpredictable forms and aesthetics. The chain's reproductions gradually become independent of the original artwork, providing an opportunity to explore how the imperfection in digital reproduction processes produces outcomes that have their own unique meaning and aesthetics.

The experience

The Chain of Reproductions

The original artwork: Ennion was a well-known master of Roman glass who lived and worked in Tzidon (today's



Figure 3: Exhibition setup: 3D printer, Scanning station, Jug reproductions.

Lebanon). He was the first known maker of decorated mold-blown glass. "Ennion's Blue Jug" aged to the first half of 1st century CE is perhaps the finest of the thirty or so pieces unearthed so far bearing his signature. The jug was blown into three separate molds, and then the blown parts were connected together into one object [2]. At the time it was a novel process to produce glass blown objects[3]. *The reproductions:* We present a series of 3D printed jug reproductions, all 3D printed, beginning from a reproduction of the original Ennion's Blue Jug, followed by a set of reproduced objects with gradually decreasing fidelity. The last item in the series is printed in real-time by a 3D printer that is placed along the line of objects. The original object was scanned at the Eretz Israel Museum in Tel-Aviv, Israel. Each reproduction was then scanned and printed again, creating the chain of reproductions that are gradually becoming less dependent on the original "Ennion's Blue Jug".

The exhibition

The exhibition includes a series of dark-blue 24cm high jugs presented on a long robust stand. The left-most jug is the highest fidelity jug, most similar to the original Ennion's

Blue Jug. Each following object has slightly decreased fidelity. The jugs' form gradually transforms into an independent form with a unique existence. The exhibition will also include "artwork postcards", presenting the specific reproduction and the original Jug, allowing viewers to observe the "imperfect fidelity". Each postcard will also include a QR code that links to the object's 3D file.

Live printing

Next to the right-most jug, a 3D Printer and scanner are placed, printing the next reproduction in the chain, in an iterative endless process. Each day the 3D printer will print one more reproduction in the series, and DIS participants will be able to experience how the sequence increases and the fidelity decreases. All digital 3D models will be available for the general public.

The Design Process

Scanning of the original object

Ennion's jug is a fragile object, created approximately 2000 years ago, therefore scanning such a sensitive object should utilize non-contact scanning to minimize the risk for potential damage. 3D scanning techniques that include sticker marks or dust spray were therefore excluded. Another challenge was related to the object's delicate shape. The jug's surface contains fine decorative details and texture, requiring high resolution 3D scanning, that would capture these details. Lastly, the object's material is semi-transparent dark blue glass, making it difficult to scan due to the high translucency. Our attempt to use Structured-light 3D-Scanning technology failed, as the 3D scanner could not scan the transparent object due to light reflection and refraction. After additional research into 3D scanning technologies [4], we leveraged Photogrammetry Scanning Technology, that uses high-resolution photography to capture the object from various angles, then process the images using dedicated

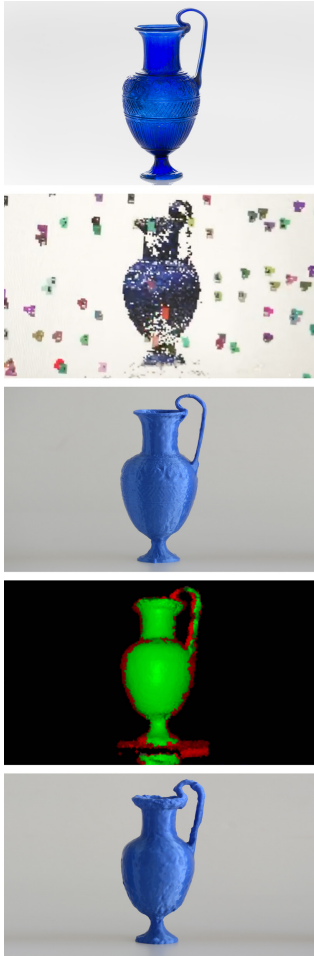


Figure 4: Scanning Process: 1. Original Ennion's jug 2. Photogrammetry point cloud 3. First reproduction 4. Structure scanning process 5. Second reproduction.

software to re-create the object as a 3D file. This technique enabled scanning of the object at the museum without contact. During the scan process, 332 hi-resolution photos were taken and converted into an accurate 3D model, using the 3DF Zephyr photogrammetry software.

3D printing the first object

The 3D file was printed by the FDM Ultimaker S5. The reproduction was printed in a high 0.15mm resolution allowing to capture the fine details and texture of the original object. We used deep blue PLA filament so that the appearance of the 3D printed object will be as similar as possible to the original "Ennion's Blue Jug". The same materials and settings were used for all following reproductions.

The continuous scanning process

After the first object was 3D printed, the scanning process was simpler, as the reproductions were opaque. We used the Structure 3D Scanner (Laser triangulation 3D scanning technology) to scan the printed object, and then printed the next reproduction using the 3D printer. We followed the exact same process over and over again, each time creating a reproduction of the latest reproduction. After each iteration, the object's fidelity was reduced, and after several iterations the form of the reproduction became somewhat independent of the original "Ennion's Blue Jug". The jug's shape became rounder in some areas and deformed in others.

Conclusions

In this work we wish to raise questions that are not new, but are given new context within the digital revolution. When digital technologies are leveraged to create a chain of reproductions, what is lost in every iteration from the original object's essence, and what is gained? Can a "fading fidelity" reproduction create new meaning by challenging the known "accuracy" of digital technologies? Can we lever-

age the errors and imperfection of digital reproduction technologies as a distinguishing element that adds authenticity, making every copy unique, in a similar way to the human touch of a craftsman? These questions can be asked from two perspectives, embracing imperfection as an open-ended outcome of the reproduction process that creates unique aesthetics, or an "error" that can be steered in a specific direction as a controlled "design choice" by the designer. While the latter is a promising future direction, we focused on the former, highlighting the tension between original and reproduction, mass manufacturing and customization, perfection and imperfection.

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