# Sharing Conservation Imaging Research with the Public

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## Abstract

Conservation investigation often includes substantial technical analysis, and digital tools now permit visitor engagement with this content in museum galleries. Reflectance Transformation Imaging (RTI) and 3D laser scanning were integral parts of a recent technical study of gilt metalwork performed on an early 19th-c. French table centerpiece at Cooper Hewitt, Smithsonian Design Museum (CHSDM). RTI permitted interactive viewing of surface textures to show toolmarks evident from manufacturing. 3D laser scanning allowed comparison of two closely related figures, one of which is believed to be a *surmoulage* (replacement cast) made from the other.

While historical gilt metalwork has been the focus of conservation research for many decades, these digital tools both support innovative scholarship and provide an entry point for new audiences. CHSDM adapted these digital files to create an in-gallery interactive didactic, allowing visitors to learn more about the conservation project through self-guided content. Given an increasingly digital-savvy museum public, the exhibition didactic allowed the conservators to interface with non-specialists and created a precedent for similar collaboration.


## 1. Introduction

Cooper Hewitt recently completed the conservation and technical study of an elaborate ormolu surtout de table (table centerpiece) made ca. 1805, the focus of the exhibition "Designs for Dining: Tablescapes" (October 2018-April 2019). Technical study of the work's components undertaken during the course of conservation work was shared in the gallery with a custom touchscreen interactive developed with the museum's digital team. Visitors were encouraged to explore historical manufacturing techniques and learn about contemporary conservation treatments through self-guided content chapters. This initiative aimed to translate behind-the-scenes research into accessible material that would facilitate visitors' understanding of the pieces on display as well as the value of conservation in the museum. Part of a larger Smithsonian-wide strategy to promote deeper understanding of collections and greater access to the units' holdings, this work relates to Cooper Hewitt's strategic plan goals to weave digital into everything the museum does, along with increasing accessibility of the collection in multi-faceted ways.

The dining-table centerpiece consists of a ten-foot-long segmented silver-leaf mirrored tray (plateau) set in an ormolu frame and over 50 gilt-brass elements, including tiered servers with cut-glass bowls, candelabra, and other decorative elements that sit atop the mirrors (Figure 1). The decoration is neo-classical in design, incorporating draped figures, putti, satyrs, wreaths of flowers, and five pairs of classically-garbed female figures surrounding the exterior. Gilt metal and mirrored surfaces throughout create a dazzling overall effect.

The surtout exemplifies the highest quality of gilt metalwork as well as mirrored- and cut-glass production; crafts which were at a peak at the time of its creation. Pierre-Philippe Thomire

(1751-1843), its designer, was named chaser-engraver to Napoleon in 1809.[1] Curatorial research suggests that the surtout was gifted to Eugène de Beauharnais by Napoleon himself, and it may be one of the two surtouts which the Beauharnais estate records being later sent to Thomire, Duterne et Cie in 1816 for restoration, which included replacement of missing pieces (Coffin 2018).

Figure 1: Surtout de table on display in Designs for Dining. Surtout De Table (Table Centerpiece) (France); Made by Pierre-Philippe Thomire (French, 1751 - 1843); cast and gilt bronze with hand engraving, cut glass, silvered-mirrored glass; 1991-31-1-a/ww H x W x D (assembled, overall): 76.2 x 327.7 x 77.5 cm. Image credit: Matt Flynn

Conservation treatment of the surtout's unstable silver-mirrored glass plateaus and gilt metal and glass components (54 in all) allowed for close observation of both the overall structure and manufacturing details of the elaborate work (Barack, Walthew, and Anderson 2019; Barack, Walthew, and Godfrey 2019). Extensive chasing and burnishing is present on all metal surfaces, allowing the hard material to capture textures as varied as flesh, fur, and feathers. These finishing techniques also enrich the play of light across the surtout, with contrasting matte and burnished

[1] Prior to founding his own firm, Thomire worked with the preeminent bronze maker Pierre Gouthiere (1732-1813). Curatorial research into the surtout's provenance supports patronage by Napoleon, as a gift to his stepson Eugène de Beauharnais. The swans on the exterior framework of the plateau are indeed linked to Eugene, as they were a decorative motif favored in his Paris home, the Hotel Beauharnais (Leben 2016).

sections. To better understand these features, technical study utilized Reflectance Transformation Imaging (RTI) and compositional analysis through X-ray Fluorescence spectroscopy (XRF). For one pair of matched female figures, closer investigation with these techniques also revealed a significant difference in both form and finish.[2] At New York University's Laguardia Advanced Imaging studio, these two components were laser scanned to compare their shapes and provide 3D documentation.

While both imaging methods (RTI, 3D scanning) are commonly used in cultural heritage, it is less common to see the results of conservation investigations in interactive gallery displays. This project created an opportunity for the conservators to collaborate across museum departments in order to share this research with the public. Cooper Hewitt's grand reopening in 2014 after a major renovation cemented its place as a leader in digital interactivity in the museum world (Rhodes 2014, Meyer 2015). Cooper Hewitt has since then prioritized the inclusion of digital content in every exhibition, presenting supplemental catalogue information and detailed zoomable images on digital screens of varying scales (Chan and Cope 2015). Digital tables and interactive pens allow visitors to save object information and draw directly on the screens, acting as designers in the galleries (Levin 2018, Geismar 2018). This project was nonetheless a first for using the museum's innovative digital techniques to shine light on conservation behind the scenes, setting a new precedent for the museum.

The addition of conservation topics in exhibition interactives built on the museum's experience in this area and followed the museum's overarching digital strategy of delivering rich, accessible content to visitors. Content strategy was co-developed with the museum's videographer and digital team, who guided the conservators in the museum's language and conventions for presentation to the public, helping to streamline the presentation of the technical data in an accessible way. However, challenges to smooth collaboration were raised by the novel file types: the museum's digital developers needed to adapt existing templates to allow 3d scans and RTI files to be manipulated on a 32" touch screen mounted in a slanted pedestal base in the gallery.

## 2. Methods

### I. Reflectance Transformation Imaging (RTI)

Reflectance Transformation Imaging is a low-cost, open-source imaging tool, using modeling techniques first developed by scientists at Hewlett Packard (Malzbender et al. 2000, Malzbender et al. 2006). Images are captured and processed using computer algorithms in the RTIBuilder open source software (Cultural Heritage Imaging 2019). Combining many (ca.40-80) photographs from different angles of light produces an interactive relighting of the subject. RTI Viewer software is used to display the resulting .rti or .ptm files, and includes specular enhancement and other mathematical manipulation modes which aid interpretation of surface morphology (Earl et al. 2010, Serrota 2014, Dittus 2016).

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[2] While most of these pairs were nearly identical in appearance, impeccably modelled, cast, and finished, one member of the pair in question presented clumsier details that lacked the refinement present in its mate. Its surface tonality differed as well, lacking the bright lemon color of the rest of the surtout components.

Photographs were taken with a Nikon D700 DSLR camera with 100 mm macro lens tethered to shoot in Live view with Nikon remote capture software. Two reflective spheres were included in each image. An LED flashlight was used to provide incident light from different angles, and a string was used to establish consistent distance from the scene. While an X-rite color checker was included in the images for color reference and white balance, color accuracy was not a major concern of this investigation. RTI Builder was used to process the images using the Cultural Heritage Imaging processing protocols (Cultural Heritage Imaging 2011).

II. Compositional Analysis

A Bruker Tracer III SD X-Ray Fluorescence spectroscopy unit was used to identify major metal composition elements, utilizing 30 second scans at 40 kV, 12.5 uA, carried out without vacuum or filter. Element matching in Artex 7.0 software (Bruker) employed Bayesian deconvolution for accurate elemental identification.

III. 3D laser scanning

Laser scanning is widely used for accurate three-dimensional documentation of objects in industrial applications, architectural trades, and the cultural heritage field (Wachowiak and Karas 2009, Webb 2017). Shiny surfaces were at one time difficult to image, since reflections interfered with white light laser scanners' shape interpretation (for this same reason, they are incompatible with photogrammetry, another commonly used 3D documentation technique). Using blue light laser scanners eliminates this problem, as they can scan reflective surfaces effectively without any temporarily applied anti-glare surface coating. A Faro Edge blue light laser scanner was used to scan the two figures. Post-processing cleanup of extraneous information in the scan was performed by Taylor Absher (NYU Laguardia Studio). Files were delivered in .stl (stereolithography) format, a common 3D file type (Figure 2).

Figure 2: 3D laser scans of two figures produced with a Faro Edge Blue Light Laser scanner

IV. Digital interactive design

Cooper Hewitt's approach for developing custom interactives is to build them on web-based technology to evolve with the rapid development of web tools and plugins. The museum's designers strategized a way to integrate the new types of content with the existing digital interaction templates as part of a uniform aesthetic and interaction standard across museum exhibitions. Adapting the ISTI-CNR Visual Computing Lab's open source WebRTIviewer (Palma 2014) allowed this integration with existing CHSDM requirements, but required creativity. Modifications to the out-of-the-box viewer enabled users to use the tools at their fingertips, i.e. their fingertips.  While the standard web viewer is built for mouse control on a desktop, the in-gallery version is built for touch controls and matches the museum's interactive design standards. View controls in the upper and lower left of the original web viewer were stripped away; left click, scroll controls, full screen mode, and "pinch to zoom" also were disabled. Removing unneeded functionality created a visitor-friendly version that only required one finger to use. Extensive user-testing of prototypes in the digital interaction office allowed an intuitive interface to emerge through an iterative design process. Including a custom video graphic of a finger over the image encouraged visitors to dive in, swiping to change the lighting position in the images (Figure 3).

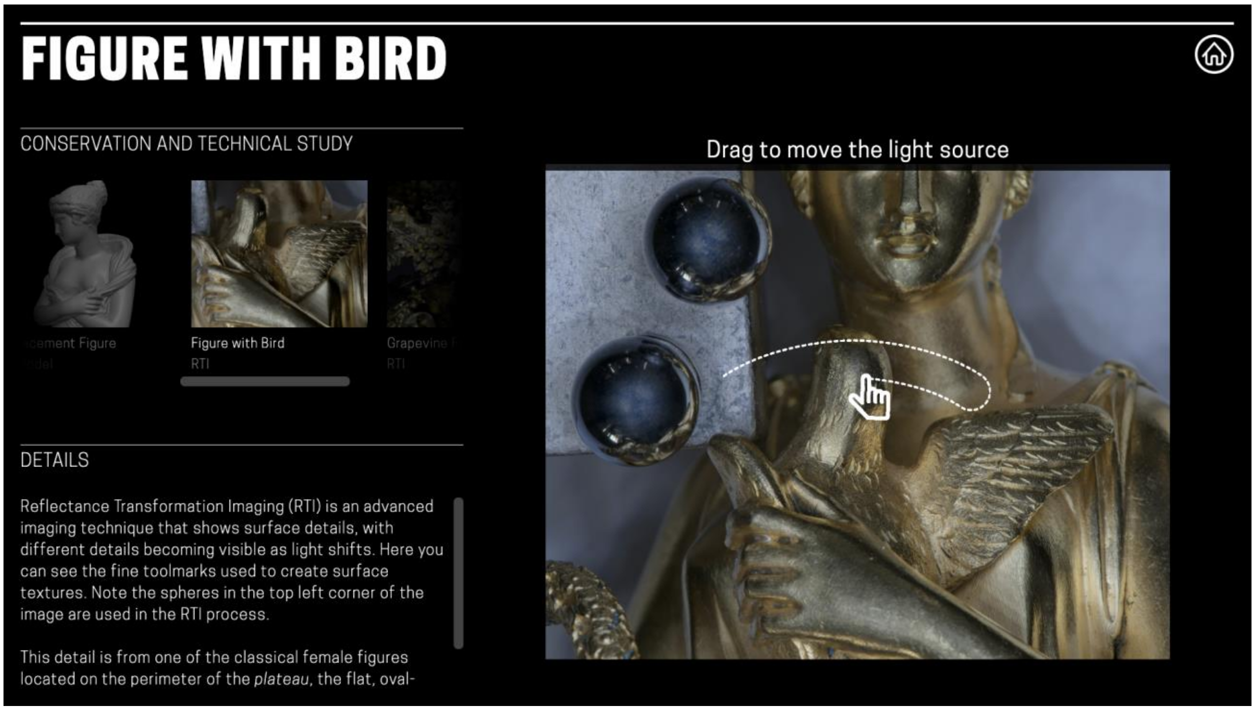


Figure 3: Digital interactive homepage with embedded RTI viewer

File load rates and resolution concerns are two interrelated issues that can interfere with a good digital interactive experience. One option is to down-res files to allow them to load faster over a web protocol, but this sacrifices just the level of detail the didactic was intended to share with visitors. A different strategy allowed for a "seamless" digital experience: interactives hosted locally on Mac mini computers hidden under the touchscreens, allowing high-resolution images in the local web environment. To avoid lag, the application preloaded the files upon startup each morning. Hosting locally and preloading allowed full-resolution images without fear of slow loading times, typically found on remote, web-based interfaces.

To repurpose the RTI content for longer-term web hosting on the museum's Conservation Channel (Walthew 2019), different modifications were needed. The WebRTIViewer used in the galleries was highly modified for touch interactions and stripped down for ease of use. For viewing on the museum's website, the stripped-down interface was maintained. The source code was further modified to respond to mouse hover, so that users on desktop didn't need to click and drag to move the light source. Small changes were made to the styling of the viewer so that it would fill its container and resize appropriately on different screens. The JavaScript code for this modified version of the WebRTIViewer was then added to the source code for the website. Functions were added so that anytime an "rti_viewer" shortcode was included in a post, a corresponding call to the createRtiViewer function would be made during the rendering of the page. Since the width of the viewers on the website will not exceed 770px (the width of the blog post container), this enabled processing the RTI files with a lower quality value, which sped up loading times on the website. Finally, the collection of image files used for each RTI viewer needed to be uploaded to a server using FTP (File Transfer Protocol), since WordPress (the underlying architecture of the Cooper Hewitt website) does not allow users to upload directories of images. These modifications allow interactive RTI (as opposed to video screen captures commonly used today) in Conservation blogposts, and in galleries using tablets that cannot run locally-hosted web environments.

Hosting the 3d files was more straightforward, as an existing embedded 3d viewer worked nicely with the museum's web-based, gallery interactive templates. Since it was designed for the web, the viewer was designed for mouse interactions and not a multi-touch display, so the digital team modified the code of the 3d viewer to suit a touchscreen interaction. Special care was given to removing certain controls like horizontal panning, click wheel zooming, and 2-axis rotation to limit the user's interaction abilities. This reduction in functionality allowed for single-finger operability to reduce the learning curve. The 3d javascript library Three.js allowed loading STL files. This standard file format is absent of color data, which worked perfectly with this project's needs, as visitors were better able to examine the details of a matte finished object to inspect surface differences (Figure 4).

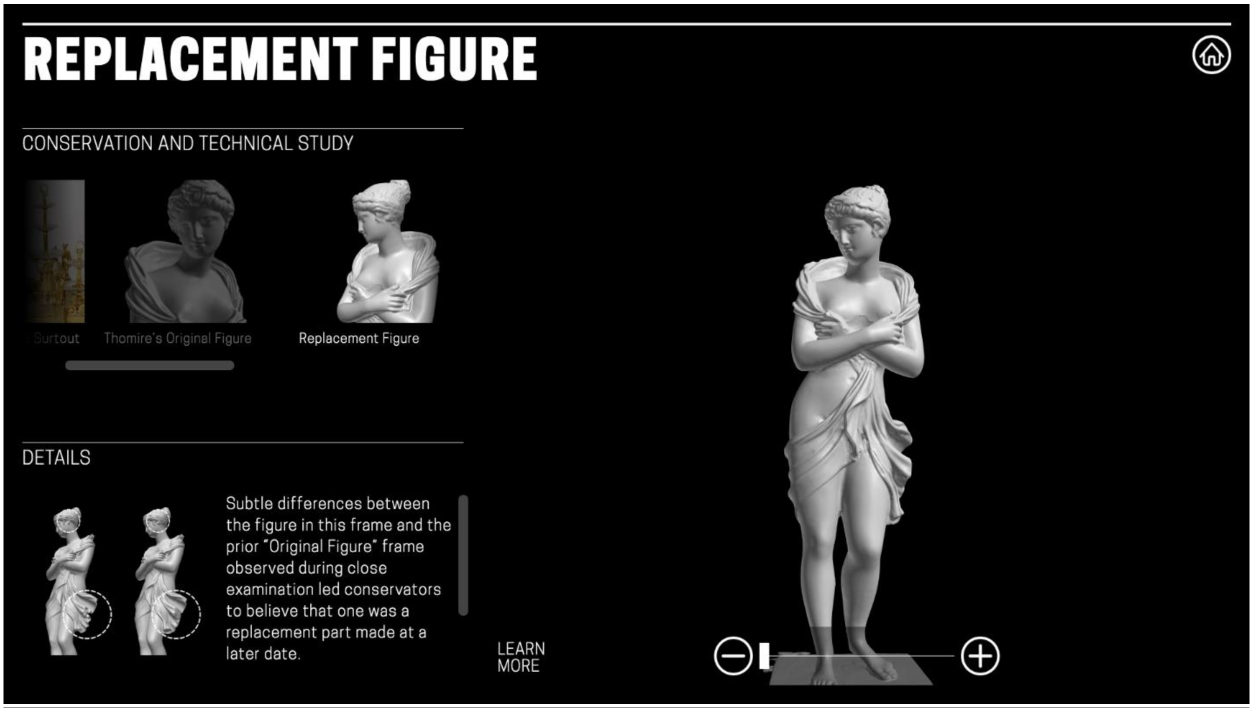


Figure 4: Digital interactive homepage with 3D viewer

3. Results & Discussion

RTI documented a variety of matte and shiny surfaces, and great finesse evident in the handling of toolmarks to describe flesh, fur, feathers, and other textures. The overall cleaning of the gilt metal components brought back these contrasts in texture. In addition to adjusting the overall tone from brassy to lemony gilding overall, this was the main effect of the otherwise subtle (yet time consuming) cleaning.

3D scanning and X-ray Fluorescence Spectroscopy contributed valuable information to understand the differences observed between two draped figures. As is evident in the 3D models, the "original" figure presents exceptionally fine finishing which contrasts with the clumsier details of the replacement. Qualitative compositional analysis of the metal surfaces with XRF confirmed that the two were made of different alloys and gilt using different techniques. Alloy compositions vary as well, with "original" pieces cast from a brass base alloy (predominantly Cu + Zn + other minor elements) and the "replacement" piece made of a bronze alloy (i.e. Cu + Sn + other minor elements). While gilding was applied to both pieces, XRF detected mercury in addition to gold on the "original" figure, consistent with the rest of the components. The second figure presented gold without any detectable mercury, suggesting a different gilding technique. These results suggest that one is a later 19th-century replacement, possibly a *surmoulage* cast from the original. Although no additional diagnostic metallographic work was conducted, we suspect the object may have been electroplated, which would date the "replacement" to the latter 19th century (Lins 2000).

Digital imaging tools communicate conservation research in powerful ways, enabling interaction in galleries to bring life to sometimes dry technical research. The surtout de table didactic encouraged visitors to consider the conservator's perspective by looking closely at manufacturing details and the object's history (in contrast, the elemental analysis was not referred to in the digital interactive, as it did not lend itself as well to visually appealing and easily accessible content). Visitors toggled between three different chapters as they wished: a static video about the conservation treatment, 3 minutes in duration; a section on 3D scanning with the two 3D files produced at the LaGuardia Studio; and an RTI viewer with three examples showing different textures. The 3D and RTI chapters supported interactivity, and users were able to manipulate the 3D files to compare the two figures in the round, in order to see differences that were not likely apparent given the visitors' distance from the objects on view.

An exploratory approach for the visitor interaction design promoted deeper engagement with the technical imaging assets: visitors were given tools to make discoveries on their own by examining the images firsthand. By moving their fingers across the RTI viewer, users zoomed in beyond the limits of the gallery presentation, bearing witness to extreme surface details such as tool marks and other artifacts not readily observable without the benefit of the intimate contact afforded to conservators during handling and examination of museum objects. Gentle prompts with short explanatory sentences and graphics such as circled features provided some guidance, however the user decided how long to dwell on each section and in what order to navigate. This freedom to explore suited both the content and the existing interaction paradigms, matching the museum's experiential design throughout the other exhibitions on view.

Though quantitative data was not available for all aspects of this exhibition feature, the available data largely confirm the popularity of this feature. The digital team tracked two different metrics: the number of times the didactic entered an idle state (after 3 minutes of non-interactivity, assuming the visitor walked away), yielding an approximate number of how many times the content was engaged, and how many times users selected a new subject, for instance clicking on the treatment video or the RTI section. Taking holidays and museum closures into account, the didactic was activated about 21 times a day and users moved through content chapters around 58 times a day. Altogether, the users of the interactive viewed the video, the 3D models, and the RTIs well upwards of 10,500 times over the 27 weeks of the exhibition run. It should be noted that the museum was closed during the federal furlough and no visitors could enter the exhibition for approximately 25 days. Given that CHSDM has not included interactive conservation content in exhibitions prior to this project, no comparable historic data exists. However, the metrics support anecdotal information passed on by museum guards stationed nearby, which is that visitors very much enjoyed the interactive content. Noting both the ongoing technical imaging conducted by the museum's conservators and the success of this display, senior management has supported the inclusion of additional studies in upcoming exhibitions.

## 4. Conclusion

Visitor engagement with the collection using digital methods was an explicit goal of the project, but rather than present research findings as completed and the sole purview of experts, the interactive's design aimed to spark independent discovery. This framing resulted in a synergistic use of digital technologies on both sides, i.e. in producing the research materials in the first place, and in their presentation. Though further studies of the impact of such didactics would be best evaluated by visitor interaction data not available for this project, the impact of this work has extended past the close of the exhibition. Along with the creation of the department's Instagram account, the interactive successfully increased exposure to Conservation's behind-the-scenes role and initiated new collaborations with other departments. Conservators are now involved in leading lectures and tours for members through Development, collaborating with Education to create K-12, educator, and adult programming, and participating in Accessibility initiatives through visual description tours led from a conservation perspective.

With ample institutional support, Cooper Hewitt's surtout de table received both a detailed conservation treatment and technical study. The work provided impetus for a novel collaboration between the digital development, conservation, and exhibitions teams, cementing a strong foundation for future partnerships. The gallery interactive and its popularity with visitors illustrate how advanced imaging techniques can yield important scholarly information while also engaging the general public. All told, this project broadened the department's reach both within and beyond the museum, introducing a wider audience to conservation's active role in collections research.

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Figure captions

Figure 1: Surtout de table on display in Designs for Dining. Surtout De Table (Table Centerpiece) (France); Made by Pierre-Philippe Thomire (French, 1751 - 1843); cast and gilt bronze with hand engraving, cut glass, silvered-mirrored glass; 1991-31-1-a/ww Image: Matt Flynn

Figure 2: 3D laser scans of two figures produced with a Faro Edge Blue Light Laser scanner

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