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Integrating Digitization and Advanced Imaging of HMML Icons

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Abstract

HMML (The Hill Museum & Manuscript Library) digitized and hosted online a recently donated collection of Orthodox 19th Century religious icons. With R.B. Toth Associates they also conducted collaborative testing of multispectral imaging on these unique HMML collection objects. A joint team digitized all the icons in conjunction with multispectral imaging of a select few icons to analyze the dyes, paints and other materials. The goal of this testing helped determine the feasibility of using multispectral imaging as an art history research tool. The image data enabled digital cataloguing of the collection, which proved indispensable during Covid on-site access restrictions. Digitization and advanced imaging with standardized digitization and data management practices is providing new insights into these unique historic works that are applicable to other icon collections, as well as potentially other artwork on wood and solid substrates.

Icon Digitization and Cataloging

In July 2021, HMML acquired a large donation of Russian Orthodox icons, mostly 19th century, from the collection of Chicago collector Edmund Gronkiewicz. All are typical painted icons, done in egg tempera on wood panels.

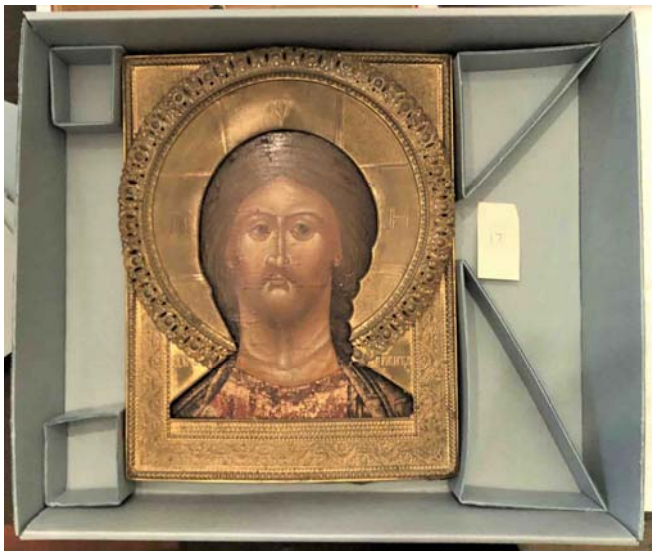

Figure 1: *Transportation bracing for the icon and riza cover Christ "Fiery Eye." (AAJ0982)*

Following transport to HMML in Collegeville, Minnesota, photography began on site. Many of the icons are composed of two parts— the icon and a riza. The rizas are covers (usually metal) that hide most of the icon from view.[1] Some of these could be removed before digitization, while some were fastened together so tightly they could not be safely removed.

Egg tempera is made by adding ground pigments to a binding medium, usually egg yolk (without the white). While it is generally colorfast and long-lasting, tempera is not flexible. As a consequence, though painted icons maintain their colors, the paint chips and flakes easily and a small area of damage can very quickly become a much larger area. Additionally, the wood used for icons has often warped, adding to the fragility of the painted surface.[2]

Thus, HMML icons were handled carefully by the bottom and the sides of the panels. To minimize packing and repacking (and thus handling), a room at HMML was temporarily designated as the staging area for icons ready to be imaged. During imaging, icons were carried and imaged flat.

Imaging at HMML was conducted with a Nikon D800 36-megapixel camera with a 60mm macro lens mounted above the icons on copy stand. Two flash units with softbox diffusers were used to top light the icons with an even field of light with minimal shadows. A white reflector card positioned below the icon provided the fill light.

HMML is best known for its digitization of manuscripts and for its online *Reading Room*, which makes these high-resolution digital files and associated cataloguing information available for scholars and others. HMML has several sites around the world where local personnel are actively digitizing manuscripts at any one time, focused on areas of political and natural instability – places where manuscripts may be at risk. These manuscripts remain in situ.[3]

HMML also has an onsite permanent collection of rare books and artworks at its location at St. John's University. In 2019, HMML began re-cataloguing its collection of art and making the catalogue and high-resolution images available on a newly in-house-built online catalogue known as *Museum*. *Museum* is hosted online and is publicly available. A restricted section with internal and sensitive information is only accessible to the cataloguers. It uses a Mirador viewer, which allows the cataloguers and visitors to Museum to zoom in closely on details. In addition to HMML's art collection, *Museum* also makes available the art collections of sister organizations like the Mużew Nazzjonali tal-Arti in Valetta, Malta.[4]

While many of the art objects had been photographed appropriately before, some of the art collection has been re-photographed using HMML's previously described setup. As with other recently accessioned objects in the HMML collection, this cataloguing and digitizing effort includes the Gronkiewicz collection of icons.

Figure 2. *Section of St. Catherine of Alexandria. (AAJ1005) icon covered with an intricate riza of glass beads and pearls (top) and without riza (bottom).*

Cataloguing of the icons primarily was done digitally using the resulting high-resolution images. While the curator had examined each icon during packing and photography, the quality of these images allowed for close investigation without necessitating further handling. Digital cataloging from the images also enabled completion of the acquisition and public access in timely fashion, even amid restricted access to the collection objects during Covid closures. Prior to the packing back in Chicago, the icons had received preliminary packing numbers and at HMML each was assigned a unique and permanent HMML catalogue number – AAJ0966-AAJ01123.

Narrowband Multispectral Imaging

Narrowband multispectral imaging has enabled scholars to read the scrubbed off underwriting in palimpsests and effaced and faded text in manuscripts. Applying these techniques to the icons now in the HMML collection has revealed features and other details not visible to the human eye. Current multispectral systems and work processes proved applicable to the capture, processing and preservation of the multispectral image data and metadata from these fragile objects.

Soon after the icons were transferred to HMML and unpacked, Michael B. Toth of R.B. Toth Associates LLC travelled to HMML and supported the multispectral imaging in a HMML imaging suite with a portable integrated multispectral imaging system. This included an achromatic 100 Megapixel (MP) Phase One camera and the latest generation of Equipoise Imaging narrowband illuminators.[5] The goal of this imaging was to assess and characterize the optimum multispectral imaging techniques for imaging a range of HMML objects, including maps, manuscripts, drawing and other items from the collection, including these newly acquired icons. This imaging enabled study of these different types of objects with a broader range of light than visible to the human eye. The joint R.B. Toth Associates-HMML team were able to efficiently and quickly set-up the portable system on the standard copy stand and light stands at HMML. After imaging with different wavelengths, the images were then digitally processed with advanced statistical tools and the image data and metadata were organized for hosting online in standard format for access and research.[6]

The joint team conducted imaging in multiple narrowband illuminations, including 16 wavelengths of light. These provided reflected light images in wavelengths from 365 nm ultraviolet (UV) light through visible light wavelengths and into the infrared wavelengths up to 940nm. They also collected images with filters under shorter UV and blue wavelengths to detect fluorescence emitted from the components of the object. The team adjusted exposures and illumination after inspecting the histograms to gather as much information as possible from the available wavelengths. Each image scene includes a standard color chart and metric ruler.

The narrowband multispectral imaging system used for this project included commercial-off-the-shelf hardware and software for digital spectral image capture and viewing with the integrated system. It also includes integrated image processing software for processing and exploitation of the spectral images, utilizing techniques from other cultural heritage studies. The achromatic camera captured a series of high-quality digital images, each illuminated by a specific wavelength of light from the light emitting diodes (LEDs) in the narrowband illumination panels.

Collaborative Digital Processing and Analysis

Four icons were chosen for the multispectral imaging. First was *The Annunciation* (AAJ0998), an icon with a darkened olifa, or linseed oil protective varnish, probably made in the early 19th century. The icon's metal filigree riza (cover) was removed prior to imaging. Second was *The Mother of God of Tenderness* (AAJ0997), an icon with the usual gold leaf worn away, exposing

the bole, a mix of white clay and animal glue. Third was the *Mother of God of Volokolamskaya* (AAJ0996). The icon was painted in the 18th century and its riza (removed before imaging) was created in 1857 by the workshop of Mikhail Borodulin. [7]

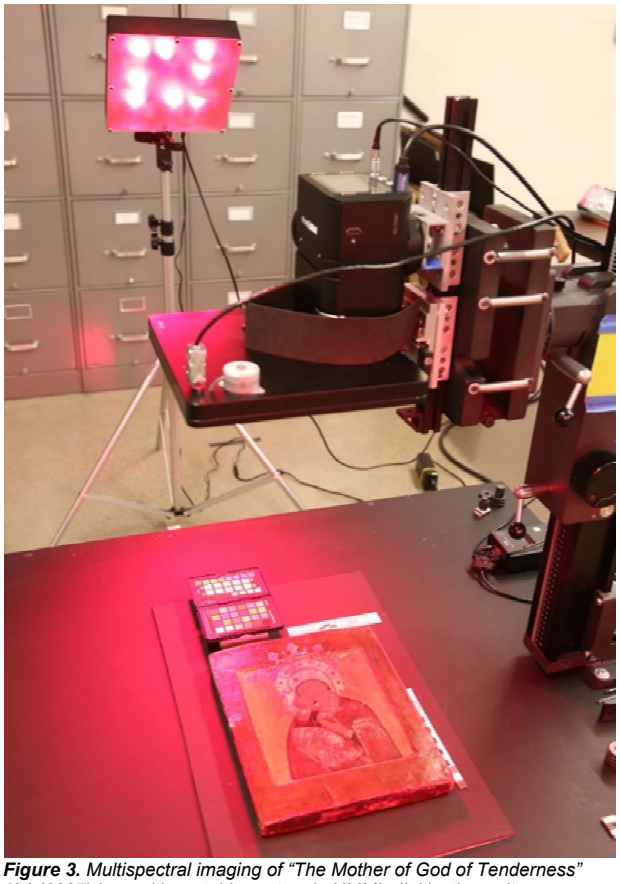

Figure 3. *Multispectral imaging of "The Mother of God of Tenderness" (AAJ0997) icon with portable system in HMML digitization suite.*

The fourth icon chosen, a highly detailed and undamaged example of the 19th century "The All-Seeing-Eye of God" type (AAJ0999), proved to be most interesting. These four icons offered insights into some of the various components associated with many Orthodox icons and their production.

Technical-scholarly collaboration was important to optimization of the multispectral imaging. After imaging each icon, the team examined the resulting image stack to see what was revealed in the various spectral bands. The near-IR images in 725, 850 and 930 nm frequently provided the most useful new information for the researchers, since the longer wavelengths could penetrate the surface layer of tempura. Some of the filtered images captured with the shorter wavelengths also demonstrated fluorescence from the paint, which provided additional information about the composition and application of the paints and other materials.

Following imaging of a typical stack of 25 images, the team used the Paleo toolbox to statistically process and combine the image stack to reveal artifacts, residues and features that are not visible to the human eye in natural light. The Paleo Toolbox uses ImageJ macros and plugins customized for processing the output files from the multispectral imaging system to streamline PCA and pseudocolor renderings of structured multispectral data. With automated features and single-button functions, it is designed to provide both non-technical researchers and experts with the ability to perform their own processing on their own systems. This semi-automated statistical tool allowed the team to quickly create processed images of the icons in both greyscale and pseudocolor that presented the greatest spectral responses from each image stack. These allowed better visualization of the spectral responses for research into the materials and processes used for the creation of these icons.

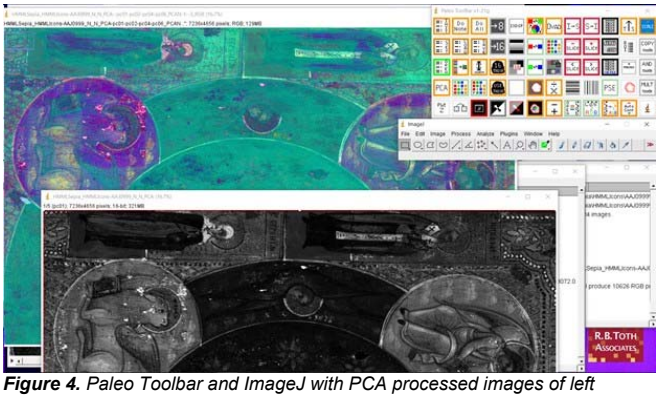

Figure 4. *Paleo Toolbar and ImageJ with PCA processed images of left section of "All-Seeing" icon (AAJ0999) rotated 90° clockwise.*

Five rectangular anomalies appeared on the "All-Seeing" icon (AAJ0999), centered on the faces of the four evangelists and Christ Emmanuel, making it clear that the original faces had been carefully removed and repainted in a way that essentially erased the cut lines.

Figure 5. *Infrared light image of "All-Seeing" icon (AAJ0999) with repainted heads of figures visible as lighter squares around the heads.*

While over-painting (painting over the existing tempera) of icons is common, re-painting (removing existing tempera) is less common and these anomalies revealed by the multispectral imaging are a surprising result. The potential reasoning for the re-painting of this icon has proved a puzzle for the curator and colleagues, with additional research opportunities.[8]

Data Management and Open Access

Both HMML digitization and the R.B. Toth Associates multispectral imaging image files are captured and saved with standardized filenames based on a project name (usually referencing the object collection) and institutional shelfmark, Both make use of underscores to separate key elements in the file name. The single digital images of each icon are managed as standard digital objects, but the sets of 25 registered multispectral images of each icon must be maintained and managed in a common folder with standardized filenames for future storage, access and processing. The International Image Interoperability Framework (IIIF) offers a cookbook recipe "Multiple Choice of Images in a Single View (Canvas)" that offers potential application to multispectral images to organizations that have the resources and need to apply it to this type of image data set. [9]

After the cataloguing was completed, all the digital images of the collection were hosted in the HMML Cloud for storage, archiving, and backup of all the digital data. This IIIF hosting service allows HMML digitization and cataloging projects to make their collections visible and searchable to the public. This allows public online access to these images on HMML's collection website, www.vhmml.org. [10] The high-resolution images taken of each icon are viewable using the Mirador viewer in this catalogue. HMML images are hosted under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) license.[11] The digitization and online availability of images in the Gronkiewicz collection offers an unusual opportunity for public access on the niche subject of icons.


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Figure 6. *HMML IIIF manifest for "The Mother of God of Tenderness" (AAJ0997)*

For multispectral imaging the image capture software organizes the image files in a predetermined hierarchical folder structure with an image naming convention for each captured image that includes wavelength and other information about the object and imaging. This also allows the Paleo Toolbar analytical and processing operations to select multiple images for statistical processing of the entire stack of 25 images, [12]

The data set of multispectral images for the four icons is part of a broader HMML multispectral image data set that includes a total of 40 narrowband image stacks with 188 GB of captured and processed image data.[13] All these are currently hosted on HMML servers as flat files in image stack folders, with plans to host them online with other HMML advanced imaging data from prior multispectral and x-ray fluorescence imaging.

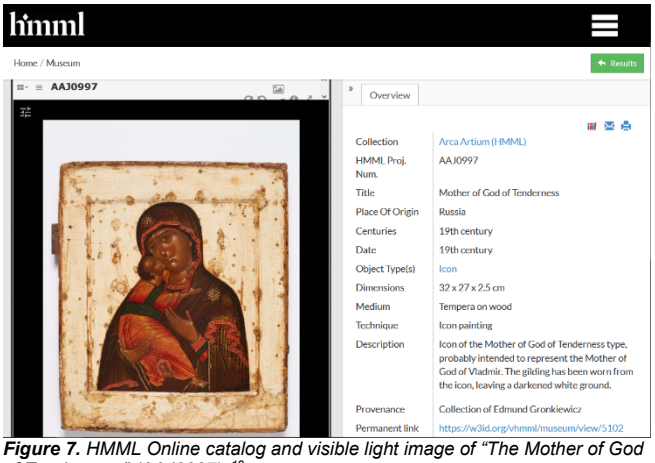

Figure 7. *HMML Online catalog and visible light image of "The Mother of God of Tenderness" (AAJ0997).* [12]

Conclusions

High quality digitization and multispectral imaging offer new insights into icons as art and religious objects by providing broader digital access to the objects with additional information about their composition and production. This can support art history research both virtually and in conjunction with direct study of the objects.

Digitization of these unique collection objects in both white light and with narrowband multispectral illumination offered some unique imaging challenges. Imaging the wood and tempura was straightforward, but the reflection from the gold leaf and ornamentation could yield small highly overexposed areas. This required continued adjustments of the illumination and positioning of the lighting to minimize reflections. For the multispectral imaging, in some cases these incidental reflections had to masked out before digital processing, or they would skew the statistical processing and create artifacts in the resulting processed images.

Integration of the actual multispectral imaging in conjunction with standard digitization proved straightforward with current equipment, set-up and established work processes. Standard interfaces enabled rapid set-up of the multispectral imaging equipment. Handling and mounting the objects below the camera at nadir with standard color targets in this image scene was the same for both types of imaging.

Hosting the multispectral image data in parallel with the visible light images currently requires extra work to ensure the stacks of individual images of the same object remain linked together. For

small projects like this one, it is currently easier and cheaper to just host the images as flat files. IIIF offers methodologies for hosting the images from multispectral wavelengths in a manifest, processing them as registered layers, and for visualizing these layers. Implementation of IIIF with established recipes requires institutions to devote the resources to implementing this on a project with a significant number of stacks of captured multispectral images. Implementation of IIIF for the visualization of multiple images in a multispectral stack will greatly enhance the ability of researchers to visualize the digital representations of objects of interest.

Implementation of standardized methods for collecting, processing, accessing and archiving the digital data from these objects will offer new opportunities for collaboration and comparison of similar icons from multiple institutions. Building a digital library of these icons at HMML is a first step toward this goal. Multispectral images of a standard set of sample materials used in the production of various icons could be used to compare the spectral response of icons from in different collections and production facilities.

Ultimately a broader collaborative database could contribute to applications of new processing techniques with Artificial Intelligence and machine learning that could allow recognition and identification of common features and production techniques, as well as differences between different artists and production methods. A collaborative database supported by a suite of computer analysis tools could allow curators and conservators to conduct advanced research themselves without advanced technical and scientific support.

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Author Biography

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