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Design and Development of Digitization Workflow for the Medium Format Capture of Oversized Artwork

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Abstract

Over the last decade, medium format imaging solutions have made instantaneous capture of large 2D objects possible, dramatically increasing the throughput and image quality of digitization in cultural heritage applications. Despite this, the process of digitizing oversized objects, such as original artwork and scroll manuscripts is substantially more complicated; little research has been conducted on the efficacy of using such medium format solutions for this purpose. In this study, a workflow for digitizing a collection of oversized artwork according to the Federal Agencies Digital Guidelines Initiative (FADGI) guidelines was developed. Successful development of this process demonstrates the potential this process and others like it have to expand the applications of cultural heritage digitization solutions.

Motivation

The inspiration and motivation for this project to develop a digitization workflow for the medium format capture of oversized artwork came from a digitization request received by the Digital Initiatives lab (DI lab) at the Brigham Young University library from the library's administration. The request was to create a digital preservation copy and a digital public access copy of a 26.5 ft x 8ft mural that was slated to be relocated due to building renovation plans. With about two weeks to complete the digital capture of the mural before the beginning of the construction, full-time staff and student employees had to explore potential workflows and solutions quickly before carrying out the digitization. As a result, that workflow was based off of some readings mentioned below but mostly on pre-existing workflows and an attitude of embracing some element of trial and error, and led to the successful digital capture of this mural. Post-digitization stitching of the resulting 42 master images into a composite access copy is still ongoing, but near completion. Some of the elements of the resulting preliminary workflow are described later on in this paper. Ultimately, adaptability and flexibility were found to be crucial in both the digitization of the above-mentioned mural, and in the subsequent digitization of other oversized cultural heritage materials and artwork that are held by the BYU library.

At present, there is a substantial lack of published research in the area of oversized artwork. In fact, the most current and approved version of the *Technical Guidelines for Digitizing Cultural Heritage Materials* published by FADGI in 2016 includes three different approaches. The first involves capturing the whole item in one capture, the second requires a linear scanner system to capture the item line by line, and the third approach involves capturing the item in small sections then stitching it in specialized software such as Adobe Photoshop. [1] As noted in the guidelines, the approaches can "produce highly accurate images," and/or deliver "poor accuracy." As such, "FADGI does not endorse any one of these approaches…each has their appropriate use." [1] As a result, there have been a multitude of different approaches used for specific projects; work done by the KIK-IRPA in Brussels digitizing the Ghent Altarpiece [2] and the digitization of the Unicorn Tapestries held at the Metropolitan Museum of Art's Cloisters [3] are two such examples.

To address the need for a low-cost, reasonable method for digitizing these oversized cultural heritage items, the Digital Initiatives lab at the Brigham Young University Library developed a case study to determine the impediments to and possibilities of using a medium format digitization solution. Furthermore, this project may provide a starting point for institutions taking on similar projects but do not have the ability to develop a workflow from scratch or outsource their work.

Due to the timeline of the project, much of the research was conducted during eased COVID-19 restrictions, allowing researchers to come in-person to work. Once mandates were lifted, work resumed as normal.

Problem

This project sought to develop a standard, but adaptable, workflow for digitizing oversized cultural heritage items and to provide solutions to common problems that are to be expected when undertaking a project of this nature.

Approach

Inspired by the experience of digitizing the extremely oversized mural described above, two student employees in the DI lab applied for an institutional Experiential Learning Grant to explore the development of a more standardized and solidified workflow for medium format capture of oversized materials and artwork. They received approval, and under the supervision of a full-time staff member of the DI lab, began working towards developing this workflow in January 2022.

In order to develop a standard workflow, three factors were addressed: (1) the number of items to be digitized, (2) the time constraints of the specific project and (3) the technology available to digitize, process, store and deliver the final images. As outlined by Colet et al. [4], a workflow cannot fit every need, but can easily be modified to accommodate for a specific project or task. In this project, multiple approaches were used: a digital camera was used for image capture and the resulting "tiles" were stitched (when necessary) together to form a final image.

Golden Thread Image targets were used for color management and a solid white foam board was used for lens cast control (LCC) profiles. These controls were set in CaptureOne 21 each day. Lights were positioned at 45 degrees with barn doors, set to the appropriate brightness for the proper L*a*b* readouts, as given on the Golden Thread targets.

The Digital Initiatives lab at the Brigham Young University library seeks to be FADGI 3-4 star capable and/or compliant. The DI lab doesn't seek to be FADGI compliant due to the private nature of the Library's parent institution, and their reliance on private funding through endowment funds, gift-based funding, and other private funding resources through the University. As such, the DI lab seeks to be FADGI 3-star or 4-star *capable* as often and consistently as possible. In order to ensure this, the DI lab utilizes current FADGI documentation to determine digitization requirements for different projects, and known evaluation tools to perform FADGI evaluation on our equipment and digitization set-ups. The currently used evaluation tools are: OpenDICE and Delt.ae with captured images of Golden Thread Image targets. Currently, the DI lab's DT iXH, DT Titan, and DT AutoColumn digitization set-up is FADGI 4-star capable per reports from OpenDICE.

When determining digitization requirements for this project, the FADGI (2016) guidelines for "Oversize Items" and "Paintings

and Other Two-Dimensional Art" were consulted. While the guidelines for these two groupings are similar, there are some substantial differences in what standards are considered FADGI 3-star and 4-star compliant (or in our case, capable) between the two groupings. For instance, at both the 3-star and 4-star level, the guidelines for capturing master images of "Oversize Items" list either 8 or 16-bit depth, either sRGB or AdobeRGB color spaces, either grayscale or color capture, and either JPEG 2000 or TIFF file formats as being acceptable. Additionally, the 3-star level only requires a 300 ppi resolution and the 4-star level only requires 400 ppi.[5] In contrast, the guidelines for "Paintings and Other Two-Dimensional Art" at both the 3-star and 4-star level are more restrictive and require TIFF master files, 16-bit depth, AdobeRGB color space, and color capture. At the 3-star level of compliance, a minimum of 10,000 pixels along the long edge or at least 600 ppi resolution is required, and at the 4-star level a minimum of 12,000 pixels along the long edge or at least 600 ppi resolution is required. [6] Naturally additional color spaces such as ProPhoto and ECIRGBv2 are also acceptable at these levels. Once these guidelines were determined to be the best ones to guide the digitization of oversized cultural heritage items (that were most often paintings and other pieces of artwork), they were discussed with the primary stakeholders of this digitization project - the Digital Initiatives Department Head and Digital Content Manager and the Visual Arts Librarian. From discussions with these stakeholders, it was decided that in order to balance the need to capture at a high-quality, reach the goal of being FADGI 3-star or 4-star capable, and also do so efficiently, that the digitization guidelines for this project would be as follows: master image files would be captured as 600 ppi, 16-bit full color TIFFs captured in the AdobeRGB color space. This would provide us with the most flexibility for capturing oversized items with a wide range of sizes while also maintaining high quality and ensuring master files would be as close to being FADGI 3-star and 4-star capable for "Paintings and Other Two-Dimensional Art."

In January 2022, 120 items were selected for this project. All the items were in varying conditions with different conservation concerns, although none of them required intensive care or restoration. The paintings were divided into two groups: reflective (those composed of a reflective media and/or had glazing in the frame, noted as R) and non-reflective (those composed on a non-reflective media and/or had no glazing in the frame, noted as NR). Once divided into R/NR groups, image capture constraints were factored in.

The Digital Transitions (DT) iXH 150MP camera system with a 72mm MkII lens was used for digitization. In order to determine the capture area of one frame, the number of active pixels along the long side of the sensor is divided by the PPI. The result is the dimension of the long side, in inches, of the capture area. The same operation can be applied for the short side. For this project, 600 PPI was used for image capture, as directed by FADGI guidelines for artwork. For the DT iXH, the capture area at 600 PPI was 26.67 by 17.75 inches. This same operation can be done with any other camera/lens combination, granted the lens used corresponds to the camera's crop factor.

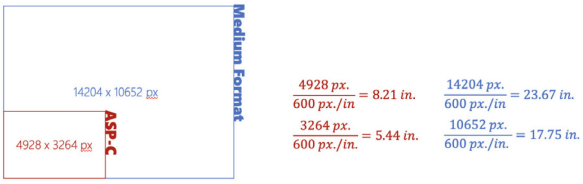

Figure 1. Capture Area calculation.

Once capture dimensions were calculated, the items were divided into groups based on the number of shots needed to capture the entire item with enough overlap (for stitching and quality); two groups were made, a one-shot group (for items that could be captured in one shot that are less than 26.67 by 17.75 inches) and a multi-shot group (for items any larger than the capture area of 26.67 by 17.75 inches). For example, an item measuring 4 feet by 4 feet would be in the multi-shot group since it would require 2.4 capture areas. It is important to note that each calculated number was rounded up to the nearest whole number, since partial frames were not captured. (See Figures 1 and 2).

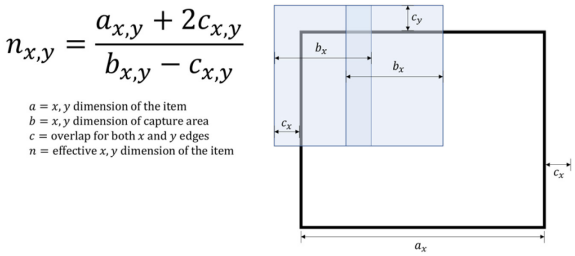

Figure 2. Methodology for calculating number of captures needed for digitization.

Since each group has different characteristics, the project was divided into four main phases, one for each group. The one-shot items were captured first. Items were shot using the DT AutoColumn and DT Titan in coordination with the DT iXH camera, which is a top-down scanning system. Due to the limitations of the digitization space, large, multi-shot items generally could not be captured using this system. A larger space was used for these items, where the artwork was placed vertically against a wall and the camera was mounted atop a tripod and moved to capture the frames, row by row, right to left, top to bottom. This method allowed for the efficient capture of each section of the item. The lights were turned vertically to match the orientation of the painting and centered to match the vertical midpoint. A light meter was used to ensure that lighting conditions were consistent across the entire painting before scanning. Throughout this process, the lighting remained unchanged once the lights were oriented and adjusted for the space. Once the lighting and the artwork were set up properly, the camera was focused using the Golden Thread color target. The iXH Camera has an auto focus feature which will automatically focus the camera stating the PPI the camera can see from where it is placed. After finding the distance that showed 600 PPI (with margin of error of 10 ppi preferred), a laser alignment tool was placed on the tripod to find the exact point on the floor where the middle of the tripod needed to be placed. A tape measure tool was then used to measure the distance from the wall to the point on the floor and a piece of tape was placed parallel form the artwork at the measured distance extending slightly beyond both the edges of the painting. Without a camera with auto-focus capability, the camera would be focused on the target manually, an image would be captured, this image would then be exported at full resolution. Then, this image file would be opened in Photoshop and cropped to 1 inch wide x 1 pixel tall. Checking the image size dialogue would then provide the total pixels per inch. If necessary, the process would need to be

repeated while moving the camera towards or away from the subject until the desired ppi was reached. At the beginning of each shot, the color target is placed against the painting to focus the camera and ensure it is positioned at the right distance.

In terms of conservation of the artwork, it is best if the color target doesn't touch the artwork, however this is not always possible. The best solution is to use a clamp that can stand beside the painting, however it can be difficult to align it to be the exact distance from the camera as the front of the artwork. The practice that was adapted was to wash hands before holding up the color card as advised by the conservation lab at Brigham Young University. Using latex gloves or placing a piece of paper between the painting and the color target can decrease dexterity and can increase the threat of damage to the painting.

Once images were captured, RAW images were processed as 600 PPI, 16-bit TIFFs in AdobeRGB color space, as set forth in the FADGI guidelines and the project requirements. For multi-shot items, the original 600 PPI TIFF files acted as the master files. In Photoshop, the original TIFF files were resized to 200 PPI JPEG images, and then used for stitching to create a composite access image file.

The two tools used for stitching the tiles together in Photoshop are the Photomerge feature, where the computer stitches the image together, and the Puppet Warp tool, which allows the user to manually move pixels. The Photomerge tool will make a new document with the stitched image automatically whereas when using the puppet warp a new document needs to be created as a space to stitch the tiles together. Ideally, the computer can stitch the pieces together using the Photomerge tool leaving no room for human error, but the computer is not always able to detect matching pixels resulting in a low quality final copy. It is sometimes necessary to stitch each piece together using Puppet Warp to achieve the highest quality stitched image, although there will be discrepancies in the final copy due to the nature of the tool causing slight manipulations caused from moving pixels around. If the Photomerge tool cannot create the final copy, the best way to minimize using Puppet Warp, which can be time consuming and cause higher inaccuracy in the final stitch, is to use a hybrid approach of both tools. This is done by taking pairs of tiles and using Photomerge to stitch them together and then subsequently using Puppet Warp to stitch and align the larger tiles produced from Photomerge together. This both decreases the amount of time spent stitching by the user and creates a better stitch than if Puppet Warp was solely used.

Each of the images are captured with approximately 2-3 inches of overlap between each tile, this overlap serves as a guide for stitching. The two pieces are roughly aligned in the new document in Photoshop and the top layer of the two pieces is turned down to 50% opacity. The overlap from the back layer then serves as a guide to align the pixels. Always stitch using grid lines in Photoshop to ensure that the image is not slowly becoming overly warped, which can be caused when focusing on aligning the pixels that match on one side and not adjusting the pixels on the opposite side to match the movement.

Unlike the master TIFFs, the final stitched 200ppi JPEG copy does not meet FADGI guidelines due to manipulation caused during the stitching process and the file specifications. The stitched copy serves as a final product to show online as a final result, while the 600ppi TIFF images will serve as master files in the BYU library's digital preservation system.

By the beginning of April, 106 of the 120 items were captured, processed, checked for quality, and stitched and in the process of being delivered.

The management of this workflow development project was perhaps different than the management of other projects undertaken by the DI lab. This was due to the nature of the project as a part of an Experiential Learning Grant from the BYU library that has as its focus to provide experiential learning opportunities to undergraduate students. The two student employees involved in this project proposed the idea to develop a more standardized workflow for oversized artwork digitization, and as such much of the direction of research and methodologies was directed by them. The staff supervisor provided direction, guidance, and at times final decisions on the students' proposals. She often acted similar to bumpers on a bowling lane by providing direction to keep the students on track moving towards their goals, and to keep them from going too far afield. This was accomplished via regular check-in meetings, frequent emails, and a project tracking spreadsheet so that all involved knew the status of different parts of the project. Watching the two student employees work through the difficulties of this project, problem solve, and explore possible solutions was inspiring for the future of cultural heritage imaging. Partly as a result of this experiential learning opportunity, both student employees intend to enter the cultural heritage imaging field.

Results

To date, all final master images captured were compliant with FADGI 4* standards, as determined by analysis in OpenDICEv2.5; 18 multi-shot items remain. These remaining items will be captured as time permits between other DI lab projects following the methodologies developed and laid out here.

Conclusions

At the conclusion of this project, it is expected that all final master images will be FADGI 4* compliant. These results indicate that digitizing oversized artwork is possible using the proposed method and can provide quality, FADGI-compliant results. The equipment used in this study are not required to take on a similar project. The basic principles of lighting, image capture and FADGI-compliance are the same in any digitization lab; thus the application of these results may prove beneficial to any digitization lab interested in taking on a project of this nature.

Next steps include refining the workflow for a wider variety of cultural heritage items (textiles, irregular media types and 3D objects were not a part of this collection) and pursuing FADGI 4* compliance. Reaching both of these objectives will require further research, collaboration, and experimentation.

References

[1] Thomas Rieger, Technical Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Files (Federal Agencies Digital Guidelines Initiative), pg. 29.

[2] "Ghent Altarpiece." The Getty Foundation. https://www.getty.edu/foundation/initiatives/past/panelpaintings/panel_paintings_ghent.html

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[4] Colet, L. S., D'Amato, D., Frey, F. and Williams, D. (2000). Guides to Quality in Visual Resource Imaging. Council on Library and Information Sciences. https://old.diglib.org/pubs/dlf091/

[5] Thomas Rieger, Technical Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Files (Federal Agencies Digital Guidelines Initiative), pg. 28.

[6] Thomas Rieger, Technical Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Files (Federal Agencies Digital Guidelines Initiative), pg. 46.

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