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Advancing 3D Digitization for Libraries, Museums, and Archives

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Introduction

Digitizing collections has become a standard practice for libraries, museums, and archives. These collections include flat objects, photographs, negatives, microfilm, audio and video materials. Utilizing established workflows and best practices, these collections are easily accessible through content management systems and shareable through standardized metadata and exchange protocols, exemplified by the success of the Digital Public Library of America (DPLA). While the digitization of 2D objects continues, affordable 3D technologies are advancing opportunities for the same institutions to consider including 3D objects in their digital collections. The combination of low-cost cameras, new laser-based scanning systems, the computational power needed to process large quantities of capture data, and the sufficient penetration of broadband Internet access has made the adoption of 3D technologies feasible for cultural heritage digitization activities (Hess, 2015B; Robson et al., 2012).

While 3D technologies have been used in such fields as: Forensics professions scanning crime scene evidence without disrupting the scene (Gamage et al., 2013); Bioengineering/Medical applications for reconstructive surgery purposes; Geologists surveying landslide activity; Digital gaming; and Archaeological site scans for ancient cities and their artifacts (Ahmed, 2), there is no comprehensive documentation of usage or path towards standardized guidance for culture heritage supporting professions. Over the past few years, two surveys, one national (Urban, 2015) and one international (Hess, 2015) have been conducted regarding the use of 3D imaging and user requirements in cultural heritage institutions. Based on survey results, it is clear that utilizing 3D technologies in libraries, museums and archives is in its infancy. Hess's survey points towards usage possibilities (ability to remotely measure true size of objects) and desired user requirements (easy online viewing and navigation) yet there is no comprehensive understanding of what constitutes 3D image quality and description for exchange, preservation, and access of digital artifacts (Hess, 2015). In 2000, Anne R. Kenney and Oya Y. Rieger with *Moving Theory into Practice: Digital Imaging for Libraries and Archive* developed a much needed and widely implemented guide for 2D object digitization and description. This work paved the way for wide-spread digital collection creation in cultural heritage institutions across the nation. It became the cornerstone for refinement of more specific digital collection standards and provided a checklist for funding agencies desirous of supporting public access to unique and important collections through digitization but reticent to feel those funds were supporting "one offs." The IUPUI University Library Center for Digital Scholarship is working towards a like basis of standards for scanned 3D artifacts in and incorporating those standards into current digital initiatives.

3D Implementation

The IUPUI University Library Center for Digital Scholarship has been working with local libraries, museums, and archives since 2006 to create digital library collections. Like many other urban university libraries and city public libraries, University Library's mission is rooted in community collaboration and civic engagement. The Center has developed a national reputation for partnering with local cultural heritage entities who have unique collections but no means by which to make them widely accessible. To date, the Center has collaborated with over 40 Indiana institutions and provides access to over 80 digital collections.

In 2015, several partnering institutions began inquiring about 3D artifact implementation into their collections, giving the Center the opportunity to explore 3D scanners, hardware, and software. In order to pursue this initiative, the Center recognized the need to consider technology needs and expertise to work with 3D objects. This white paper outlines how the Center for Digital Scholarship is incorporating 3D expertise and technologies into current digitization workflows by: **1) Digitizing** varying objects of color, shapes, sizes, and textures; **2) Developing and testing a set of preliminary conventions for scanning processes and post-processing workflows** by identifying usable file formats, determining a protocol of aligning scan data, and refining various polygon level data (original scan, film/animation quality, video gaming, and augmented/virtual reality derivatives); **3) Fully documenting the processes and decisions** made for digitization.

3D Hardware and Software

Lacking the expertise in 3D technologies, the Center sought experts in the manufacturing industry that have been utilizing 3D scanning technologies for the past 25 years to guide the path to purchase scanners. Online Resources, Inc offered valuable insight into 3D capture and the technology that would meet our project expectations. After thoughtful consideration, and internal grant funding through the IUPUI Arts and Humanities Institute, the Center purchased Creaform's Go!Scan 3D portable, hand-held white light (LED) scanners (Go!Scan 20 and Go!Scan 50). These scanners provide high levels of accuracy and the resolution needed to create master files that can then be repurposed for derivative works.

3D Expertise

As 3D technologies were introduced to current staff and students, it became clear that the Center lacked the expertise and experience needed to build a solid foundation to create 3D collections. Funded partially by a 2017 LYRASIS Catalyst fund, a one-year 3D Project coordinator position was created to facilitate in-house workflows and best practices. The following job description was used to guide the hiring process.

3D Project Coordinator Position Description

The 3D Digitization Project Coordinator will manage 3D projects for the IUPUI University Library Center for Digital Scholarship, which serves the campus as well as regional museums and archives. This position is a key component in a larger initiative to create, preserve and provide access to unique digital collections for research and education. The successful candidate will have the opportunity to help establish 3D digitization workflows and best practices for historic archival artifacts while exploring the application of new technologies for 3D imaging. The 3D Digitization Project Coordinator will report to the Head of Digitization Services for the Center for Digital Scholarship.

Primary Duties and Responsibilities

- Manage the workflow plan of one to multiple part-time 3D Digitization Technicians.
- Considering project deadlines, staff skills and staff availability, appropriately assign workflow tasks to ensure timely completion of all 3D projects.
- Create an appropriate plan for file organization and movement through various stages of processing.
- Perform and manage conversion of physical 3D artifact collections into digital files.
- Utilize appropriate scanning equipment to digitally capture three dimensional artifacts for inclusion into digital collections.
- Train hourly employees in 3D scanning procedures and post-processing procedures and supervise their work.
- Perform and manage post-processing of output files to create three dimensional models.
- Utilize appropriate 3D processing software to clean up, merge and create true-to-original objects
- Conduct quality control check for 3D digitized object.
- Develop an appropriate quality control check for each 3D digital collection and follow these procedures to ensure high quality digital collections.
- Work with part-time employees to correct mistakes and guide future improvement.
- Upload processed 3D files into 3D viewer software-Currently using Sketchpad.

The IUPUI University Library Center for Digital Scholarship 3D project coordinator was hired in January 2018. Over the course of 6 months, a framework was established to create 3D objects among community and cultural heritage partners. 3D digitization guidelines have been created to streamline internal workflows and processes. Specific considerations have been given to format conversion, file naming conventions, preservation, and access.

3D Digitization Guidelines

General Principles

3D Digitization is an always ever-changing field with new technology being created to yield better creations of 3D work. These general principles are not a how-to manual for an exact type of scanner or software package but rather a guide that may be built upon on as technology advances over time. The Center has developed the following three-step digitization process that is being used for all 3D object collections: **1) Capture, 2) Process, and 3) Publish.**



Step 1: Capture

The first step to consider when beginning a 3D digitization project is what is the best way to capture an object. There are a number of evolving methods of capture such as: Photogrammetry, Structured Light Scanning, or Laser Scanning. Not every scanner or camera (photogrammetry) is meant for every type of object, so it's imperative to look at the types of objects that need to be digitized and determine what scanning method works best for the project. Whatever method is selected, it is imperative to allot the time to learn and experiment with the technology. Successful capture is dependent on selecting various hardware and software settings. Using Creafom Go!Scan scanners, Table 1. outlines specific scanner settings used to reach maximum capture potential.

Table 1.

Item Scanner Settings	Size	Scanner	Resolution	Texture Size
Small Statues	< 24 ³ inches	Go! Scan 20	0.25mm	8000 x 8000
Clothing	> 24 ³ inches	Go! Scan 50	0.75mm - 1mm	8000 x 8000
Large Statues	> 24 ³ inches	Go! Scan 50	0.5mm	8000 x 8000
Portraits	> 24 ³ inches	Go! Scan 50	1mm	16000 x 16000
Furniture	> 2 ³ feet	Go! Scan 50	1mm	8000 x 8000
Piano	> 4 ³ feet	Go! Scan 50	2mm	4000 x 4000
Dishware/Silverware	< 24 ³ inches	Go! Scan 20	0.25mm	8000 x 8000
Small Misc. Items	< 24 ³ inches	Go! Scan 20	0.1mm - 0.25mm	8000 x 8000
Medium Misc. Items	> 24 ³ inches	Go! Scan 50	0.25mm - 0.75mm	8000 x 8000
Large Misc. Items	> 4 ³ feet	Go! Scan 50	1mm - 2mm	4000 x 4000

Step 2: Process

Once the object has been captured, the next step is to process the data. Considerations must be taken to **1) Preserve the original data, 2) Convert the original data to a usable format, and 3) Clean the usable format data for access.**

Preserve the original data

Many scanners and scanning methods capture their subject by creating a point cloud of data. The point cloud is the foundation of preserving the original shape and form of your object. Although technologies will advance and evolve, this point cloud data will never change and will be adaptable for any new form of technology. It is imperative your point cloud information be preserved, as everything else after here will depend on your original point cloud data set.

File conversion

As great and flexible point clouds will be in terms of longevity, they suffer in practical usability. Point clouds are difficult for many 3D programs to properly display, and digest. In order to fix this problem, files need to be converted from a point cloud to a polygon (.obj file). Polygons are widely compatible with most 3D software packages. The polygon is made up of a mesh. A polygon mesh is a collection of vertices, and polygons that define the shape of an object in 3D.

When considering file formatting, Table 2. outlines the file specifications for Original, High Resolution, and Preview File formats.

Table 2.

General File Specifications	Original	High Resolution	Preview
File Format	point cloud	.obj	.obj
Polygon Count	N/A	> 200,000	< 100,000
Texture Format	BMP	PNG	PNG
Texture Resolution	8000 x 8000	8000 x 8000	2000 x 2000
Texture Type	Color	Color	Color + Normal Map

Clean-up

Once the polygon (.obj file) has been created, the next step is to clean the mesh. 3D image capture results in issues of holes within the mesh, texture issues, or even areas that were captured poorly. These issues can be resolved using a variety of different 3D editing software such as Maya, Mudbox, Zbrush, VX Elements, Substance Painter, and many more.

Step 3: Publish

After a polygon mesh is cleaned up and finalized, the third step is to publish the work. There are many ways to define what "Publish" will mean within the project. The most common form is to upload a polygon mesh to a web 3D viewer. A web 3D viewer is a website that runs a program that can view, and properly display a 3D model so that it is viewable on the internet.

Common 3D viewers include: Sketchfab, and Google Poly. Once the object is uploaded to a 3D viewer site, the object can be embedded, shared, and made openly available. Publishing objects provides flexibility of use outside of access and preservation. Websites such as Shapeways, Thingiverse, and Turbosquid provide services for printing and usage by a wider public 3D community.

The IUPUI University Library Center for Digital Scholarship is currently using Sketchfab to host 3D objects. To date, over 400 objects have been uploaded for open access. Partners include: the Benjamin Harrison Presidential Site, Madame Walker Theater, the Indianapolis Motor Speedway Museum, and the IU School of Dentistry. In addition to using Sketchfab to provide access to the objects, the Center is embedding the Sketchfab viewer into CONTENTdm so that the 3D objects are included with all Center-hosted digital collections.

Future Directives

The IUPUI University Library Center for Digital Scholarship has created a framework to support 3D digital projects. While the Center has established internal best practices and workflows, national standards for access and preservation remain unresolved. National initiatives are moving forward.

Led by Virginia Tech in collaboration with Indiana University/IUPUI Libraries and University of Oklahoma Libraries, an IMLS Leadership grant was awarded in 2017 titled: *Developing Library Strategy for 3D and Virtual Reality Collection Development* to organize a National Forum to develop a roadmap and white paper for library adoption of 3D and Virtual Reality (VR) services. A team of up to fifty-seven researchers, practitioners, and other leaders in imaging science and engineering, digital preservation, and digital libraries will participate to advance knowledge in archival and curation challenges in 3D/VR collections.

In addition to participating in national initiatives, the Center will locally continue to modify and improve scanning and processing techniques. The 3D project coordinator is leading student outreach efforts with the School of Informatics and Computing to provide student employee opportunities for 3D digital projects.

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[IUPUI University Library Center for Digital Scholarship Digital Collections](#)

[IUPUI Center for Digital Scholarship 3D Sketchfab collections](#)

[CONTENTdm 3D Viewer embedded collection-Benjamin Harrison Presidential Site](#)

[2018 IMLS Leadership Grant- Developing Library Strategy for 3D and Virtual Reality Collection Development](#)