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Emerald Article: Creating a digital library of three-dimensional objects in CONTENTdm

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Creating a digital library of three-dimensional objects in CONTENTdm

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Abstract

Purpose – This paper aims to describe a project conducted by the University of Oklahoma Libraries to create a digital collection consisting of three-dimensional scientific objects.

Design/methodology/approach – The University of Oklahoma Libraries developed the following methodology for creating a digital collection of three-dimensional objects. Digital still photographs of six sides of each object where created. These photographs were then used to create videos that emphasized the most interesting feature on each side of the object. These videos were then imported into CONTENTdm using the picture cube feature to create the digital representation of the three-dimensional object.

Findings – This method was found to be a good method for representing three-dimensional objects in a two-dimensional format for inclusion in a digital collection. However, some limitations were encountered. For example, only one interesting feature could be emphasized on each side of the object and the software used to create the digital videos, while easy to use, offered only limited features for enhancing the resulting videos.

Practical implications – This paper demonstrates a cost effective and resource efficient method of implementing a digital collection of three-dimensional objects that could be further improved through the use of more advanced video creation software.

Originality/value – This paper offers insight into a new way of representing three-dimensional objects in a digital library. This information will be useful to digital librarians faced with resource and cost constraints who have collections of three-dimensional physical objects that would be of interest to their user community.

Keywords Digital collections, Three dimensional objects, CONTENTdm, Art collections, Digital libraries, Digital images

Paper type Case study

Introduction

The University of Oklahoma Libraries History of Science Collections houses a collection of unusual scientific instruments and historical artifacts. This collection is stored in various physical locations and most library users are unaware of its existence. Therefore this collection presented an ideal candidate for digitization. Digitization would enable users to locate and preview the collection online. Once the

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user had perused the objects in the collection online, they could then visit the objects in person if required. The digital collection would also enable users to obtain pictures of the objects for their own use.

However, this project presented several unique challenges related to the three-dimensional nature of the objects comprising the collection to be digitized. A traditional digital library inherently consists of two-dimensional objects. For example, many digital collections consist of digital photographs or digital representations of two-dimensional documents. Technologies and file formats for creating and storing two-dimensional objects, such as Joint Photographic Experts Group (JPEG) or Portable Document Format (PDF), are widely available, fairly easy to master and reasonably inexpensive. In contrast, while software exists that is able to render accurate digital representations of three-dimensional objects such software is costly and requires specific technical expertise not often found in library organizations. At the present time there is a lack of easy to use, cost effective technologies for creating digital representations of three-dimensional objects. This project was designed to attempt to find solutions to these problems. And while HTML5 offers rendering of simple, symmetrical three-dimensional objects with minimal coding, it is not yet the solution for more complex objects such as are contained in this collection.

Literature review

Librarians and museum curators have been considering the utility and form of three-dimensional digital collections for some time and yet a review of the existing academic literature reveals less than might be expected. The majority of scholarship on the topic can be divided into three occasionally overlapping categories:

(1) pedagogical – how archived and accessible three-dimensional objects will improve teaching and education;

(2) research – the ways three-dimensional objects will improve research about the physical objects and the fields of study the objects belong to; and

(3) how to – similar to this article, this category focuses on how and with what software the digital collection of three-dimensional objects was assembled.

The pedagogical utility of a two-dimensional digital object is sufficient provided the object itself, for example a book page or a photograph, is itself two-dimensional. The additional pedagogical utility of three-dimensional digital object depends on the nature of the object or artifact being digitally captured. If the object has three dimensions, then its digital presentation as a three-dimensional object offers more information for the user. Rowe and Razdan (2003, p. 3) created a prototype digital library for three-dimensional collections, summarizing the state of digital libraries, thusly, "Today digital museum collections and digital libraries include text, graphics, images, and increasingly, video, sound, animation, and sophisticated visual displays. Some now display three-dimensional objects and permit the user to rotate and view an image of the original object in their browser window using QuickTime, plug-ins, or custom applications. Examples range from presentation of objects for research or public access to time-lapse movies of exhibit construction and panoramas of exhibitions." Surprisingly, nearly a decade later this is still largely the technological milieu of three-dimensional digital libraries, though with the advent of HTML5 and web browsers featuring improved support of 3D rendering technological advances are likely to usher in a wave of efficient and affordable capabilities to our digital shores.

Borgman *et al.* (2000, p. 228) studied the pedagogical utility of digital libraries and their role in developing students' scientific thinking stating, "Digital libraries offer a wealth of opportunities to improve access to information resources in support of both 'traditional' on-campus instruction and distance-independent learning." Therefore it is important that librarians become adept at representing three-dimensional objects digitally in order to best serve user communities. Borgman *et al.* (2000, p. 232) notes, "By understanding how students will use a digital library in the context of scientific thinking, it is possible to construct the digital library in a way that will support the underlying processes. In short, digital libraries are more than storehouses of information; they should be aids to the question-asking, information-gathering, information-organizing, information-analyzing, and question-answering processes of users." The more information provided by a digital object the greater the utility of that object for the digital library patron.

Not to be overlooked is the novelty of three-dimensional digital objects. The researchers Liesaputra and Witten (2009, pp. 116-117) found that adding a feature as simple as three-dimensional page turning increased user retention of information. The researchers discovered users were more engaged and "answered questions faster using the page-turning model than the other two formats.[. . .] The difference between the page-turning model and its closest competitor [were] statistically significant[.]" Qualitatively, the subjects studied commented that they preferred the page-turning model, particularly for longer digital books, "because the pagination breaks up the flow of information and helps them remember where things are in terms of their physical position on the page, allowing them to concentrate on searching rather than navigation. All subjects judged the page-turning book to be the format that is most engaging, natural and intuitive." In this case, mere novelty increased the pedagogical value of the digital object.

The increasing sophistication and affordability of the necessary technology to support digital libraries will soon present libraries and archives with a wealth of opportunity to make resources available online. As Eden (2007, p. 247) argued, "The appearance of the Internet in human culture [. . .] has produced the capacity to graphically and visually represent ideas, problems, challenges, solutions, and results, not as one-dimensional paradigms or presentations as in previous centuries, but in two or more dimensions, allowing the human mind to radically and instantly perceive new ways of solving and representing information." Three-dimensional objects contain the capacity to reshape research, in addition to providing new avenues for research partnerships across locales. It is imperative that information professionals, such as librarians, begin to shape the methods in which these three-dimensional objects are archived, accessed, and made discoverable for present and future generations. As Eden (2007, p. 247) emphasizes, "[T]he next generation has been preparing itself for a future in which virtual collaboration with others globally will be the norm instead of the exception, and the fields of secondary and higher education are well behind the curve in addressing the learning needs of the future." Not only do digital objects, three-dimensional or otherwise, serve as a pedagogical tool with which to increase instruction but also as a practical mode of collaboration.

Moreover, the three-dimensional physical objects that libraries, special collections, and museums choose to digitize are often rare, antique, or fragile. Enabling access to digital representations of these types of objects helps to reduce the hazards presented by repeated physical access of the objects by numerous individuals. Seulin *et al.* (2004, p. 120) generated three-dimensional digital objects of ancient wooden stamps that were engraved to illustrate manuscripts. The digital objects permitted the user "interactive, realistic and non-photorealistic visualization of engraved stamps via local or remote access [...]" thus preventing wear and tear on the original physical object. Not only was damage averted but researchers from distant locations were able to inspect the stamps in detail, with some researchers using the depictions and metadata obtained from the digital library to create facsimiles for their own study.

Similarly, in 2004, IBM partnered with the Egyptian government to render three-dimensional digital animations of ancient Egyptian artifacts such as the throne of King Tutankhamen. The project, titled Eternal Egypt, "produced multimedia animations, 360-degree image sequences, panoramas of important locations, virtual environments, three-dimensional scans, real-time photos from web cameras and thousands of high-resolution images of ancient artifacts that weave together seven millennia of Egyptian culture and civilization" (www.eternalegypt.org). Again, this illustrates the growing and diverse ways in which three-dimensional digital objects may aid scholars in their endeavors.

For librarians tasked with implementing a digital library containing three-dimensional objects, explicit explanations of protocols, processes, and procedures that have been used successfully to create such collections is vital to an effective implementation and an efficient use of resources. The previously mentioned articles by Rowe and Razdan, Liesaputra and Witten, and Seulin *et al.* also describe the specific methods they developed to create their digital collections. Their techniques varied widely and were contingent upon their specific resources and desired outcomes. As Politus *et al.* (2005, p. 1) note there are two necessary elements of any three-dimensional digital object collection: "a database where all information about the exhibits, models, etc. is kept and a renderer which is responsible for graphically representing all this information on the computers screen." Librarians are familiar with the need to couple data and metadata, be it a book and catalog card or a digital object and its related digital metadata. Librarians must ensure the data and metadata continues to be functional as the tides of technology transform and new methods of retrieval and presentation become available. Doyle *et al.* (2009, p. 46) studied the issue of digital preservation of three-dimensional data stating, "Two of our primary preservation requirements were to ensure that the preserved object remains authentic and usable through time for our future users, allowing them to access, view and interact with the object in the same way as users in the past could." They accomplished this by taking care to preserve the software used as well as the digital object itself, and by applying a metadata framework that was thorough and interpretable to the user.

Existing collections

In additional to the academic literature on the topic, existing digital libraries can be studied to determine how institutions have represented three-dimensional objects. The following projects provide a representative sample of such collections.

- The Digital Library of South Dakota maintains a collection entitled "The Altered Books Collection". This collection is comprised of books. However, these are not typical books. Rather they are works of art made from books. This digital library presents one picture of each object, arranged in the best view for each three-dimensional object.

- Claremont College houses a collection of ceramic objects; again with one picture each, with each object adjusted for optimal view. These objects could benefit from more than one photo each.
- University at Buffalo's Edgar R. McGuire Historical Medical Instrument Collection has from one to several photographs of each object. Simpler objects have one. They do the same for their Universal Design Product Collection. A model of the human brain, for example, has four.
- Virginia Commonwealth University's Medical Artifact Collection provides one picture for each three dimensional object. Some are very complex and could use more views.
- Texas Woman's University Libraries University Archives contains some three-dimensional objects but provides only one picture for each.
- The Oregon Health & Science University Digital Resources Library Historical Collections and Archives holds some three dimensional objects, but offers only one picture in most cases and occasionally two.
- The MOMA in New York City has some sculpture and other three-dimensional objects in its online collections but only has one picture of each.
- The Metropolitan Museum of Art also offers only one picture of three-dimensional works of art.
- The Perseus project, from Tufts University, offers anywhere from one to thirty-one pictures of sculptures to focus in on various details. This is the collection that shows the most views and takes into account that a three-dimensional object must be shown from several angles for the user to understand the object completely.
- The Digital Library of Appalachia has a picture of each three-dimensional art object and also has videos of the object spinning. The videos cannot be paused or slowed down. On a fast computer they spin very fast. While this digital library is recognizing that three-dimensional objects need to be viewed from every angle, it is not user friendly as the object is spinning so fast.
- The University of Oklahoma Health Sciences Library is also working on a collection of scientific instruments. They are using three-dimensional photography using a two-lens system that attaches to a one-lens camera. This system takes two simultaneous pictures that can be displayed side by side. When one looks at these pictures through three-dimensional glasses a three-dimensional image appears. However, this system has limitations in terms of display, as the user needs three-dimensional glasses.

The project

Software exists to enable a detailed rendering of a three-dimensional model of a physical object that can be manipulated in three-dimensions on a computer screen. This software is typically used for scientific, architectural or medical projects where each detail and measurement must be precise and where the object must be able to be viewed in detail from any angle. While this type of software was considered for use in developing the scientific instrument digital collection it was rejected for three reasons. First, such software is prohibitively expensive. Second, such software is difficult to use and would require significant and time consuming training before it could be effectively used by library staff or the retention of an expensive consultant with the required knowledge and skills. Third, extreme detail and accuracy in three-dimensional digital representation and manipulation were not required for this project.

Nevertheless, the project did require realistic digital photographs and videos that even the most sophisticated, expensive, and labor-intensive photorealistic graphical rendering – be it two-dimensional vector graphics simulating three-dimensions or JavaScript animations and data visualization tools – would fall short of the demands of the project. While HTML5 seems perched to permit better rendering of simple and sophisticated three-dimensional digital objects, the constant considerations of time and cost can quickly become prohibitive. Unlike the data that populates the graphs and computer models of an engineer, the data contained within this collection consists of the components and composition of the physical object itself. Data such as the authentication page of the an early twentieth century milliammeter that notes where the object was manufactured and, if fortune were to favor, where and to whom it was sent or the method by which one component connects glass or steel thereby revealing the tools used in the construction of the instrument, those characteristics are types of data contained within the collection of scientific instruments. As such unaltered digital imagery is essential. The improvements in the multimedia functionality in CONTENTdm version 6 and soon to be available in HTML5 made examination and analysis of the collection timely and worthwhile.

The Scientific Instruments and Historical Artifacts digital collection presently features historical scientific instruments from the nineteenth and twentieth centuries, as well as a cuneiform tablet from the thirteenth century. These particular instruments were selected for the initial trial phase of the collection for their physical accessibility, scope, and novelty. The collection currently contains a McGraw-Edison Edisette Cassette Tape Recorder with a microphone for audio note taking, a Thomas Scientific gas sampling bottle used in gas chromatography to separate chemical mixtures, a Hoppler Viscosimeter to measure the viscosity of fluids (Plate 1), a Bausch & Lomb abbe type refractometer used to measure the refractive index, or the passing of light, through an item (Plate 2), a late nineteenth century Bausch & Lomb optical microscope, a slide box for glass microscope slides, and early twentieth century Weston Electrical milliammeter and voltmeter. Additionally included are stills of an ancient Mesopotamian cuneiform tablet from a ziggurat located in southwestern Iran in the Khuzestan province (Plate 3). Each of these items required functional and realistic digital photographs and videos in order to capture the important facets of the instruments.

As the use of advanced rendering software was rejected other approaches were designed and tested to determine how best to meet the needs of the project. Initially, experiments were conducted using a digital video camera to record the object. At first the camera was moved around the object in an attempt to film all sides of the object. However, the resulting video suffered from excessive camera vibration and it was difficult to maintain a consistent distance from the object for the entire length of the video. To attempt to address these issues the object was placed on a rotating platform and the camera was mounted in a stationary position. This solution addressed the

Plate 1.

problems of camera shake and uneven distance, but such a methodology only captured four sides of the object and did not allow for the filming of the top or bottom of the object. There was also the fact that a video of a spinning object is not good for researchers wanting to focus on a certain feature of the object.

As a result of these unsuccessful video tests the use of multiple still photographs to represent the object was considered. Photographs were taken of each object from six viewpoints – all four sides and the top and bottom of each object. While these photographs provided a good overall representation of the object from a fixed distance, many of the objects contained interesting details that were not visible due to the scale of photograph. Consideration was given to providing close up photographs of these areas, however, as such photographs would not be directly associated with their location on the larger object, and as many of the objects contained multiple detailed areas of interest, this idea was rejected as potentially confusing to the viewer.

Based on these experiments a final methodology was developed. It was determined that the best solution would be to take still photographs of the object and then create videos based on these photographs (Plate 4). These videos would zoom in on the

Plate 2.

Plate 3.

important areas of interest on the object to enable the user to view those areas close up and in detail (Plates 5 and 6). In addition, it was decided that a single still photographic image that best represented the entire object would also be included for the use of patrons who wanted a single image that represented the object for use in presentations, scholarly papers and for whatever purpose they desired.

The specific methodology used was as follows. Photographs were taken of each object from six viewpoints – all four sides and the top and bottom of each object. Adobe Photoshop was used to crop each photograph. Each picture was cropped twice.

Plate 4.

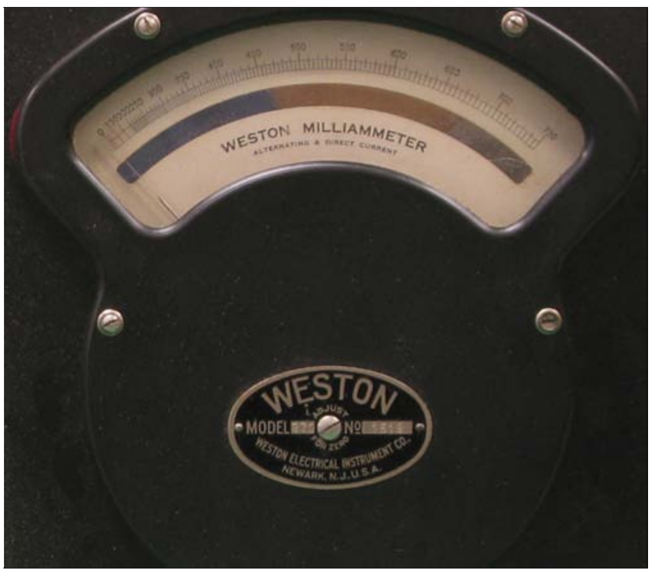
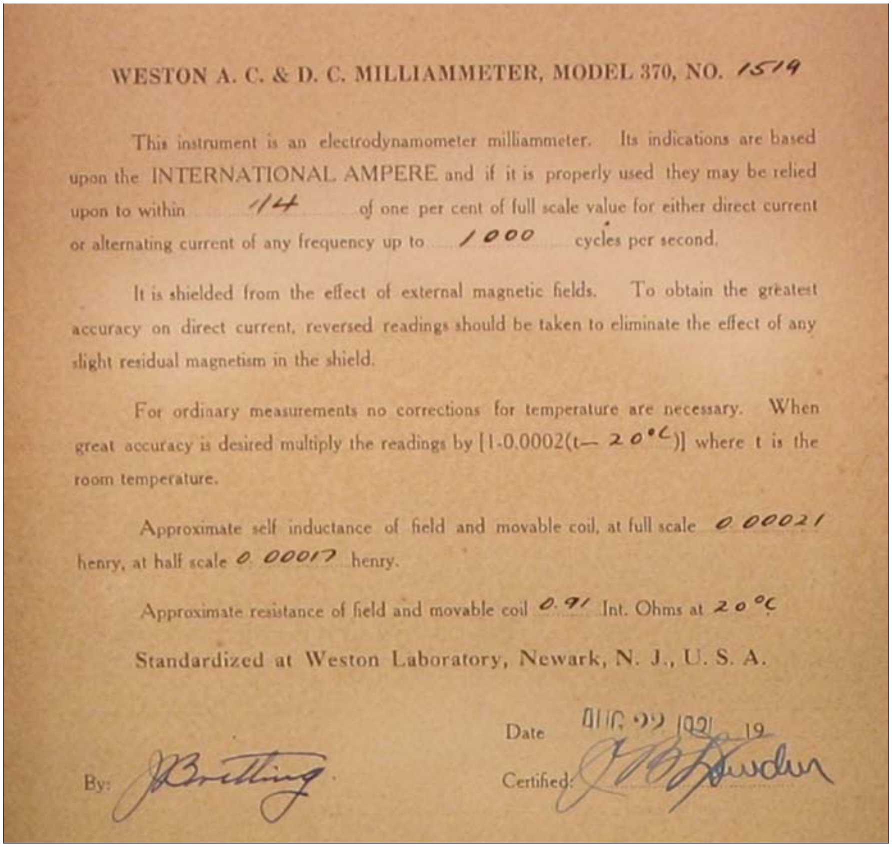


Plate 5.



WESTON A. C. & D. C. MILLIAMMETER, MODEL 370, NO. 1519

This instrument is an electrodynamometer milliammeter. Its indications are based upon the INTERNATIONAL AMPERE and if it is properly used they may be relied upon to within 1/4 of one per cent of full scale value for either direct current or alternating current of any frequency up to 1000 cycles per second.

It is shielded from the effect of external magnetic fields. To obtain the greatest accuracy on direct current, reversed readings should be taken to eliminate the effect of any slight residual magnetism in the shield.

For ordinary measurements no corrections for temperature are necessary. When great accuracy is desired multiply the readings by [1-0.0002(t— 20°C)] where t is the room temperature.

Approximate self inductance of field and movable coil, at full scale 0.00021 henry, at half scale 0.00017 henry.

Approximate resistance of field and movable coil 0.91 Int. Ohms at 20°C

Standardized at Weston Laboratory, Newark, N. J., U. S. A.

Date AUG 22 1921 19

By:

Certified:

Plate 6.

In the first instance, the photographs were cropped in such a way that the image best filled the frame. In the second instance, the pictures were cropped to the dimensions needed for use in iMovie. This photograph was then imported into iMovie. The slow zoom technique known as the Ken Burns Effect was utilized to focus on the most interesting detail presented by that view of the object.

The University of Oklahoma Libraries uses CONTENTdm to host its digital collections. CONTENTdm includes a picture cube feature, which allows six views of a single digital object. This cube may contain still photographs or digital videos. For each object two picture cubes were created. One contained the six still photos of the object and the other contained the six videos of the object's detail sections. The use of two cubes allowed the user to access the still photograph or the video representation of the objects as required.

A final challenging aspect of the project relates to the development of effective and accurate metadata for the objects. While some of the objects and their uses were easily identified by History of Science faculty or by associated documentation others were of unknown origin and function. For the unknown objects various methods were used to obtain the data needed. For example, in one case a professor in the chemistry department used a chemistry listserv to contact experts in the subject worldwide.

Working together they determined that the object was a gas sampling bottle (Plate 7). In other cases manufacturer information could be obtained from markings on the instrument. In such cases the manufacturers' websites and representatives were consulted and the required information was obtained.

Results

This process resulted in a usable collection of three-dimensional objects. The user can see all six sides of each object in full view by using the picture cube containing the still images. The user can download any still picture desired for use in their projects. The user can also see interesting features on each side of the object in detail by accessing the picture cube, which contains the videos. By referencing the associated metadata the user could also find a similar item for sale and add it to his collection.

Lessons learned

There were many lessons learned during the implementation of this project. One of the primary lessons was that although the digitization methodology was developed in advance numerous unforeseen and time consuming issues remained to be solved

Plate 7.

throughout the actual process of digital photographic capture. For example, the initial round of photographs was rejected due to problems with the appearance of the background placed behind the objects during the photographic process. Black velvet was initially used but it was impossible to keep this material from wrinkling, creating a background that distracted from the object itself. An iron could not be used on scene to remove the wrinkles as there are sensitive heat sensors in the History of Science Collections area and use of an iron would have risked setting off the chemical fire prevention system. For the next attempt to film the objects a large roll of green paper was used. This paper could not be folded without wrinkling so it was draped over a support structure and this provided a good non-wrinkled background. However, when the resulting photographs were examined the paper had shifted in many photographs causing parts of the object to be obscured. Based on these experiences it was decided to purchase a professional photographic background for use on the project. A MyStudio Seamless Tabletop Background Sweep Cyclorama was obtained and used successfully. The time saved by not having to reshoot numerous photographs justified this purchase.

Another lesson learned related to the use of iMovie to create the required videos. While iMovie is an easy to use product, it sacrifices features for ease of use. The limitations of the pan and zoom effect were of particular interest on this project. To enable easy use of this feature, known as the Ken Burns Effect, iMovie only allows the user basic control over how the pan and zoom will occur. The user simply sets a starting rectangle and an ending rectangle and then iMovie creates the pan and zoom effect. However, the user cannot control the size or shape of the rectangles or the speed and precise direction of the transition. However, this limitation is also why iMovie is so easy to use. More advanced and expensive software, such as Adobe Premiere, offers control over the entire video editing process and numerous advanced video editing features. However, it has a steep learning curve that must be considered relative to available staff time and expertise. If the video was to be created for more advanced research or if greater video editing control was needed for a particular project such software should be considered.

Another learning opportunity presented itself when CONTENTdm version 5 displayed administrative metadata in the title bar of the video window. CONTENTdm created its own naming system and presented that information in the title bar of each video as it played. Administrative metadata cannot be changed or deleted in CONTENTdm and this could be confusing for users. Therefore, a request for the ability to edit this metadata was submitted to the producers of CONTENTdm and such a revision is in process. CONTENTdm version 6 incorporates a more coherent and user-friendly metadata display, dispensing with the issue.

A final lesson learned was that the creation of three-dimensional digital collections is the process that is still in its infancy. Librarians interested in these types of collections will benefit by sharing their experiences with others and by learning from the experiences of other librarians. Advanced imaging software is in constant development and the technologies used to create three-dimensional digital representations of physical objects will continue to advance and improve. Digital librarians need to remain in the forefront of these developments so that they may provide the most effective digital resources for their user community.

Future projects

Based on the lessons learned and the success of this project future projects using this same technology have been added to the digital initiatives queue. The knowledge attained through the trials, errors, and successes of the initial creation of the Scientific Instruments and Historical Artifacts collection will serve as a blueprint to begin incorporating additional instruments, artifacts, and artwork with the primary purpose being the facilitation of further research.

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