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Three-Dimensional (3-D) Scanning Within Academic Libraries

Exploring and Considering a New Public Service

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The article discusses the creation of a three-dimensional (3-D) scanning service within an academic library. Academic libraries generally offer two-dimensional (2-D) or flatbed scanning to their patrons—why not 3-D scanning? Inspired by the routine use of the former, the author investigates the reasoning for offering as a service the latter, defining what it is from a library and information science perspective, how it complements the digital repository and digital scholarship projects being supported within academic libraries, and why libraries should consider it as a public service independently from 3-D printing. A technical description of the scanning equipment and an informal, qualitative account are given from experience using a NextEngine 3-D scanner within an academic library, highlighting some of the challenges and opportunities that such a technology might present.

Project Background

What if three-dimensional (3-D) scanning were offered as a public service at your academic library? Would it be worth investigating? Could it be done inexpensively? These were some of the questions that arose in January of 2013 as a student scanned a document for her coursework on a 2-D flatbed scanner—a technology that many academic libraries offer without much marketing fanfare or critical acclaim. Within minutes, the student was busy scanning the documents that she needed without much difficulty, creating digital objects (in this case, digital images) from physical papers. Could similar digital objects be made as effortlessly with a 3-D scanner?

A basic, non-scientific definition of 3-D scanning is that it is the 3-D printing process in reverse, or a complementary process to 3-D printing technology. Three-dimensional printing takes virtual data and makes it into reality, be it a toy, a gear, a medical prosthesis, or even a piece of meat, whereas 3-D scanning takes a physical object and creates a digital object (and also the raw data) from it. If created by faculty and students during scholarly research, digital objects and their data can be of significant interest to academic libraries. Successful research and scientific breakthroughs can elevate the digital objects that produced these successes into a university's digital assets overnight, and academic libraries should be interested in not only providing the technical services needed to collect, organize, preserve, and make accessible these objects, but also in providing the public services needed to conceptualize them and even bridge the digital divide among their patrons. Preliminary research suggests that digital objects can even become digital possessions of sorts (Cushing, 2013), and it is possible that future generations of faculty and students alike will expect a ubiquity of means in their creation as well as in their accessibility and preservation. Within the Pennsylvania State University Libraries, there has been great emphasis placed on ScholarSphere, which is an online repository for many of the digital data or project notes created by faculty and their students throughout the research process.[1] As such, it seems to be an ideal time to begin investigating 3-D scanning as a public service within the Pennsylvania State University Libraries.

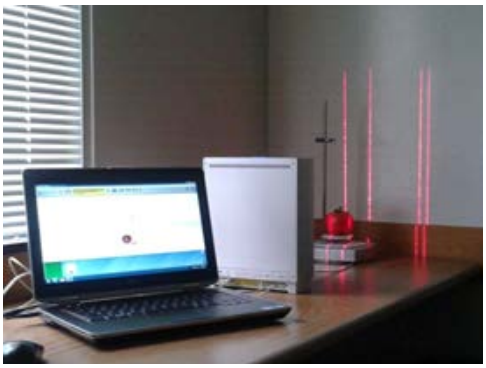

Figure 1

NextEngine 3-D scanner in the Media Commons Lab.

From a public services standpoint, libraries have been experimenting with 3-D printing technology (and sometimes 3-D scanning) for a few years already, and the popularization of 3-D printing as a public service through *makerspaces* or *hackerspaces* is a service that some public and academic libraries now offer (Kalish, 2011). Three-D printing is an interesting technology, but as a library public service it has the potential to become time-consuming and cumbersome to build, maintain, schedule, and troubleshoot the equipment without the proper funding and staff expertise. Bundling of 3-D technology services also can create confusion between scanning and printing processes—it all becomes 3-D printing to the patron and even to some librarians. However 3-D scanning can be offered without 3-D printing as a new public service; it can be a scalable, cost-effective way to invest in 3-D technology and digital creation without the difficulties of 3-D printing.

In the past, 3-D scanning within academic libraries required considerable funding and collaboration with specialized research departments and federal funding, such as the Sheridan Libraries' Digital Hammurabi project at Johns Hopkins University (www.jhu.edu/digitalhammurabi), which cost a little over 1.5 million dollars (Higgins, 2002). Many museums and archives have also adapted this technology to make their collections more accessible, though their efforts have been largely a technical service (Wachowiak & Basiliki, 2009). Recently, the Smithsonian Institution unveiled 3-D scans of some of its collections under the moniker Smithsonian X 3-D (3d.si.edu) (Taylor Sulick & Haberacker, 2013). Patrons now have the ability to browse museum pieces or specimens online or download the digital objects for study in addition to the raw data for 3-D printing. Even in this innovative approach, the initial scanning process remains an internal service to the Smithsonian and not a public service that allows patrons to create personal or localized digital objects or possessions.

Academic libraries have spent significant time and money in creating their own 3-D collections over the past decade to meet the accessibility demands of online patrons, yet it seems puzzling that they have not considered 3-D scanning as a public service to support new models of scholarly research and digital object production. The creation of digital repository services, the drop in the cost of 3-D scanning combined with the development of intelligent scanner software, and the interest in digital projects in the arts, humanities, and sciences all seem to indicate strategic

investment in this technology. Already there are efforts underway at the Swiss Federal Institute of Technology in Zurich (ETHZ) to develop a mobile app that allows for 3-D scans from a smartphone or tablet. [2] Nevertheless, academic libraries still have an opportunity to fill a public service niche that student and faculty require for projects, along with fostering a social and technological equity in making this a public service. Almost any library can accommodate a 3-D scanner with a modicum of space set aside, and both patrons and librarians alike no longer need a great deal of technical skill to set up, maintain, and troubleshoot the latest generation of 3-D scanners. The centrality of the library on many campuses ensures that access to 3-D scanning across all disciplines is possible and not limited to the work schedule of any one academic department or discipline.

At the time of the initial research for this project in April 2013, few academic librarians were in the process of writing and publishing about 3-D scanning as a public service, with the notable exception of fellow librarians at Dalhousie University Libraries in Halifax, Nova Scotia (Groenendyk & Gallant, 2013). Others had begun to offer printing and scanning services similar to Dalhousie in 2013 or earlier but had not published their findings or impressions of the technology within the corpus of library literature.[3] This lacuna compelled the author to include some of his exploratory and technical experience with 3-D scanning in an academic library, along with some early observations about the technology and its place in public service, independent of the bundling of 3-D technology service that many libraries are offering.

The Equipment

An investigation of the technology of 3-D scanning was conducted in April of 2013. Two of the most important factors that guided the investigation were providing a scanner that required as little training as possible and choosing a scanner that met the quality needs of even the most discerning of faculty. The NextEngine 3-D scanner manufactured by Shape Tools, LLC, was affordable, easy-to-use, of professional quality, and small enough not to dominate or permanently alter a public space within the Pennsylvania State University Libraries' Schuylkill campus location (also known as the Ciletti Memorial Library). Other scanners were considered, including the MakerBot Digitizer, but the quality level of individual scans and the potential to scan large objects was the deciding factor for future development. After discussion with the campus instructional designer, teaching faculty, and fellow library colleagues, enough of an interest was expressed to pursue an innovative microgrant internal to the Pennsylvania State University Libraries that would allow collaboration on a new library service that students could use within their coursework and projects.[4] While a 64-bit Windows operating system is preferred (XP, Vista, or 7), a 32-bit Windows environment will also work, though scanning and editing concurrently is not as efficient—there is some lag-time when attempting to do both. If possible, it is recommended to run in a 64-bit Windows environment with a 2.5 GHz Dual-Core processor (or higher), 4 GB of RAM, and a dedicated graphics card of 512 MB capacity.

The Scanning Process

The NextEngine scanner emits a twin array of four Class 1M, 10 mW solid state lasers with custom optics 650 nm wavelength that scan in parallel across the surface of an object using a MultiStripe Laser Triangulation technology. This allows the scanner to cross-validate the geometric data it collects and results in a smooth, nearly flawless surface scan. Options within the ScanStudio HD software allow for close-up or macro scans, standard scans, and an upgrade that allows for large, composite scans. Scanned objects can be either placed on the AutoDrive, which is a platform that communicates directly with the scanner via wired hookup (as seen in Figure 1) and rotates the object in pre-defined intervals, or scanned freestanding, which requires the user to move the object or the scanner for additional scans. The time it takes to scan an object is largely dependent on the specified resolution and the number of scans. A high-resolution scan with 10 or more intervals can take up to 45 minutes, whereas a low-resolution,

single-shot or triptych scan can take 5 to 10 minutes. If the patron's need is form over function, it is recommended to do the scanning in a dark space to allow the scanner's lighting and photographic system to image the surface of the object. If the objective is to have a functional scan for later printing or production without qualms over surface image quality, then it can be scanned in nearly any moderately lit space.

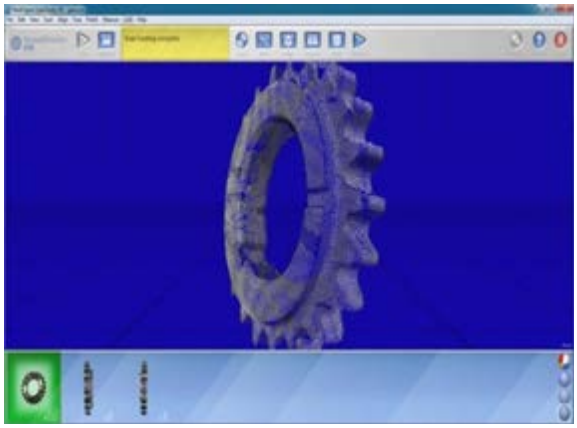

Figure 2
A mesh view of a gear in ScanStudio HD.

The ScanStudio HD (Figure 2) software is intuitive and accommodates all levels of expertise. Many functions have the ability to autocorrect or extrapolate user needs, such as filling holes in the scan, creating a water-tight model for later printing or milling, trimming out material not needed within a scan, or aligning separate scans to create a 3-D model with a few mouse clicks. The degree of depth in the scan is impressive (in both high- and low-resolution scans), and even the most minute features of an object can be edited easily. Also, intelligent software features can be turned off for more advanced users who require greater precision. Once an object is scanned, a patron has the option of viewing the scan in four different modes: color, shaded, mesh, and points, all of which provide a different perspective and means to edit the scan.

Scans can be saved in a native file format (SCN) that does not require importing and exporting of work for future use. If a patron needs to save in another file format for post-scan editing or use in another application, files can be saved as other file extensions within the ScanStudio HD software. For example, the OBJ or object file extension stores the object code or raw scanning data and could be computed and analyzed with customized programs, or a PLY (polygon file format) file extension, which stores the code in a polygon file format that includes color, transparency, and texture coordinates, could be further edited or manipulated by photo-editing software for projects, presentations, and displays. Other file formats, such as IGES (initial graphics exchange interface), STL (stereolithography or Standard Tessellation Language), and STEP (standard for the exchange of product data), allow for the easy exchange of digital data within design software, such as CAD, or for rapid prototyping and manufacture.

Figure 3
Fossilized fern scan converted to JPEG format.

Not all objects have to be scanned in a 360-degree perspective, and the scanning software allows considerable latitude in how a user scans an object. Successive scans of an object can be merged into a more complete scan if desired. For instance, one of the first scans conducted was a flat piece of shale that included the fossilized remains of an extinct fern (Figure 3).[5] The scan did not need to be entirely three-dimensional, as the fossilized remains were found only on one side of the shale piece. Thus a high-definition, one-shot scan was taken multiple times and all the images were merged together and edited, a process that took 10 to 20 minutes to complete. After saving it as an OBJ file to preserve its colors, the file was opened in Adobe's Photoshop

CS6 and from there saved as a JPEG file to be used on the library's website or as a backdrop to a professional poster or display.

From an online or distance learning perspective, the ability to scan unique, real-world objects to enhance learning beyond the textbook and share online is significant. Faculty teaching any class, be it in-person, blended, or strictly online, would have the ability to share unique or fragile items without the danger of damage to the object. Objects from special collections libraries or from a faculty member or campus collection can be opened up in ways that encourage a more idiosyncratic approach to learning in higher education. Similarly students with access to this technology can now create their own scans of objects to share in conference poster sessions or class presentations without having to resort to generic stock photos or images.

3-D Scanning as a Public Service

As of mid-January 2014, the scanner is now available for checkout and use within the University Libraries' Media Commons room at the Pennsylvania State University, Schuylkill campus. While the scanner is designed for mobility (it has a threaded hole in the bottom to be mounted to a commercial-grade tripod), it was decided to keep the scanner within the library initially on a renewable four-hour checkout. The scanner and peripherals are housed in a secure case rather than the shipment box for further protection and security. The scanner software was installed on a laptop and is available for checkout on the same terms as well. The instruction manual is available within the software as a PDF and is also available in a printed copy with some setup best practices to be included. It is hoped that the scanner will find a more permanent place within the library with a dedicated workstation that will obviate the setup/teardown procedure, but until that time, the laptop checkout is the only option available as determined by the Pennsylvania State University Libraries' Digital Library Technology Department. Depending on demand, there may be a need to offer a scheduling process to use the scanner in the future as well. The 3-D scanner was set up late in the fall semester of 2013. Some advertising of the new service was done on campus *bluescreens* (digital signage throughout campus) and the libraries' website, which generated some initial inquiries from campus students from a variety of academic backgrounds and intended majors. During spring semester of 2014, undergraduate students began working with campus faculty on a multi-semester project that would require 3-D scanning.

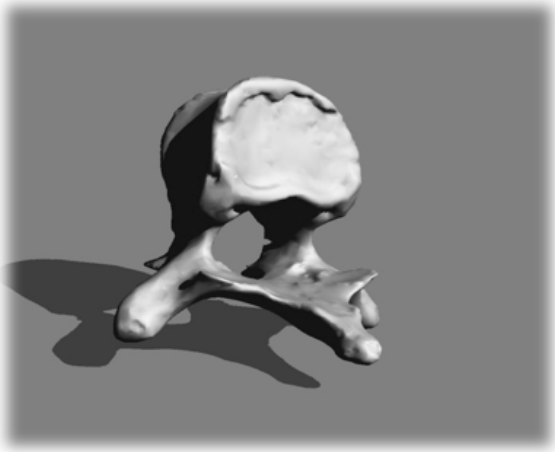

Figure 4

Scan of a human vertebra rendered in a JPEG format as a prototype for the campus grant proposal.

At the time of the microgrant proposal (April 2013), faculty in the humanities expressed an interest in scanning artifacts that would supplement their lectures and online discussions in literature and history, but those interests and needs have largely been eclipsed by Information Sciences and Technology (IST) and Biology faculty, who received a grant to pursue the development of a mobile application that will utilize the scanner. This app will largely be developed by students for students studying human anatomy and physiology, with scans of various bones being utilized in a mobile app that will both inform and quiz students in a game environment (Figure 4). An informal workshop was given in December of 2013 to familiarize IST students and faculty working on the project with setup and use of the scanner with more workshops planned as needed. Penn State students unaffiliated with the Schuylkill campus have expressed interest

in using the 3-D scanner for course-related projects, though travel time and distance was the limiting factor in their utilization of the scanner. It is hoped that the combined faculty and student interest in formal project work will create word-of-mouth interest within the campus community.

Tentative Outcomes

Preliminary discussion with students using the scanner indicates that the scanner itself is easy-to-use. However, the AutoDrive (the rotating platform that holds scanned objects) operates erratically at times, especially when the additional peripherals are attached. It is unclear whether this is due to poor design of the AutoDrive or faulty manufacturing, but the piece was returned under warranty and awaits replacement. Because of this small setback, the students are working on the programming of the game rather than the scanning of the bones at present. As this is a multi-semester project, the students have indicated that they plan to scan the majority of the bones over the summer sessions. A survey will be sent to the students working with the scanner to gauge their interest in the technology and their thoughts about its usability and the effectiveness of the scanner as it supports their learning. If the suggestions are positive, there is the possibility to apply for further funding to purchase additional hardware or the more robust version of the ScanStudio HD software, which allows for composite scans. There is also the possibility of creating a practical workflow for other Pennsylvania State University Commonwealth Campus Libraries to easily adopt this new technology and service at their locations.

Conclusion

Three-dimensional scanning is a realistic option for academic libraries to pursue as a new public service. It is a way for libraries to explore digital object creation without investing too heavily in equipment, physical space, and outside technical expertise while complementing the digital repository services being offered to patrons. Academic libraries are uniquely positioned to offer a means to create digital objects, facilitate collaboration, and foster creativity and innovation in developing digital objects and information for scholarly and scientific research among all library patrons.

Notes

[1] For more about ScholarSphere, see scholarsphere.psu.edu/about/

[2] For more on the Swiss 3-D scanning mobile app, see the ETH Computer Vision and Geometry Group's project site, Turning Mobile Phones into 3-D Scanners, cvg.ethz.ch/mobile/

[3] For instance, see the University of Texas at Arlington's public scanning and printing services website (library.uta.edu/3D), the University of Omaha's Criss Library (library.unomaha.edu/services/3dprinting.php), or North Carolina State University Libraries' Makerspace (www.lib.ncsu.edu/spaces/makerspace) for ideas about how these services are marketed and offered online.

[4] For details on the Pennsylvania State University Libraries Innovation Microgrant program, see www.libraries.psu.edu/psul/admin/microgrant-program.html

[5] Possibly from the *Neuropteris* genus found in nearby St. Clair, Pennsylvania—a gift to the library a long time ago (sadly without any accompanying metadata or backstory).

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