A Further Investigation into 3D Printing and 3D Scanning at the Dalhousie University Libraries: a Year Long Case Study

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April 26th, 2013

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Acknowledgements

In gathering the information contained in this report, the author would like to acknowledge the support of Donna Bourne-Tyson, Marc Comeau, Gino Dante Ranieri and the Dalhousie University Libraries; the Canadian Association of Research Libraries; and CBCL Limited Consulting Engineers, for making this research possible.

Contributions

Dalhousie Libraries: $6,895
The Canadian Association of Research Libraries: $2,000
CBCL Limited: $1,000

Introduction

While libraries become increasing involved in the digitization of their various textual collections, little work has been done digitizing and preserving physical collections containing items such as artwork, textiles, insignias, and other historically significant relics (Lampert & Vaughan, 2009). Advancements in 3D scanning technology have made the digitization of physical objects of this kind much more possible though, and developments in technologies such as 3D printing and 3D holograph projection have opened up an entire new way for libraries to provide this information to patrons across the world (Wachowiak & Karas, 2009).

This paper will describe the author's own process in building and cataloging a collection of 3D models on the DalSpace servers at the Dalhousie University Libraries. This paper will then explore other methods for delivering 3D model content to library patrons, including 3D holograph and WebGL technologies.

Following this 3D model repository discussion, this paper will describe how 3D printing technology, implemented as a service at the Dalhousie University Libraries in March of 2012, was used to deliver 3D model content to library patrons; the challenges faced in delivering this service; how this service was used; and finally how successful, overall, this service was.

A Brief Overview of 3D Scanning Technology and its Relation to Historical Preservation

3D scanning technology first came into prominence in the early 1990s, where it was used primarily by engineers for reverse engineering purposes (Petrov, Talapov, Robertson, Lebedev, Zhilyaev, & Polonskiy, 1998). The two main types of 3D scanners used today for artifact preservation are: structured light 3D scanners (often called white or blue light scanners); and laser pulse-based 3D scanners. Different scanners each have their own positives and negatives, such as the amount of data (or points) that they can capture, the size of the objects that they can capture, and the range or distance that they can capture data from (RapidForm, 2012).

One of the first, most popularized attempts to utilize 3D scanning technology for artifact preservation occurred in 1998-1999 when a group of students and professors from both Stanford University and the University of Washington attempted to digitize the sculptures and architecture created by the artist Michelangelo that had been preserved in museums in Italy (Levoy, Pulli, Curless, Rusinkiewicz, Koller, Pereira, ... & Fulk, 2000). This group said that the goal of this project was to “make a 3D archive of as many of his statues as we could scan in a year, and to make that archive as detailed as scanning and computer technology would permit” (Levoy, Pulli, Curless, Rusinkiewicz, Koller, Pereira, ... & Fulk, 2000). In particular, though, this group wanted to scan Michaelangelo’s statue of David and accurately capture the chisel marks on his statues’ surfaces.

While the results of this project were very successful, due to various limitations high resolution 3D scans only exist of Michaelangelo’s statue of David and Statue of St. Matthew. The collected 3D scans created through this project are still available for non-commercial uses through Standford’s website at the following link: http://graphics.stanford.edu/dmich-archive/.

An example of a more recent project is one carried out by two employees at the Smithsonian Institution, Adam Metallo and Vince Rossi, who are currently 3D scanning a number of objects from the Smithsonian Institution’s collection (Terdiman, 2012). They have so far digitized a few of the Smithsonian Institution’s objects and have now built of 3D model collection of various fossils, animal and primate skulls, and a few other objects available through the following link: http://humanorigins.si.edu/evidence/3d-collection. According to Adam Metallo, the ultimate goal of this digitization project is to “build a large collection of 3D scanned objects and archaeological sites that can support the entire Smithsonian complex” (Terdiman, 2012).

Computed tomography (CT) scanners are also becoming more common as a method of artifact preservation. CT scanners are the same scanners traditionally used by hospitals, which work much like an X-ray to build a 3D model of internal structures and provide researchers and doctors with a more in-depth understanding of underlying problems (Mayfield Clinic, 2013). This technology was recently used by researchers in Egypt to look inside the remains of King Tut and try and determine the cause of his death. The fifteen minutes CT scan of King Tut’s remains resulted in 1,700 3D images (Handwerk, 2005). These 3D images, however, have not been made available online.

As these examples show, 3D scanning technology has long been associated with artifact preservation, but other developments in this technology allow for even further 3D preservation methods. A 3D scanner from a company called MatterPort allow for the quick 3D digitization of room interiors, including all the objects contained within them (Hill, 2012), while a Faro 3D scanner can be used to build 3D models of large buildings and city landscapes (3D Scan Co, 2012).

3D scanning technologies open up many possibilities to preserve our historical record for future generations. The technology has currently reached the point where much can be accomplished with it, while many new forms of 3D information—such as the exterior and interiors of historical buildings, painting and sculptures—can be presented to patrons across the globe in a much more effective, visual manner, greatly expanding the information libraries currently offer.

3D Model Repository at Dalhousie

3D Scanned Objects

The 3D model repository at Dalhousie was created to begin exploring the possibilities for collections of this kind, and to begin building archival standards around 3D data.

Objects used to build the 3D repository came from a variety of information sources. One of the main sources was the Thomas McCulloch Museum on the Dalhousie Campus, which contained a large number of objects related to the fields of biology, human anatomy, chemistry and history. Objects from this collection were 3D scanned using a NextEngine 3D scanner and the ScanStudio HD software that ships with the scanner.

The NextEngine 3D scanner is one of the cheapest on the market, retailing for roughly $3,000, but at this price the scanner comes with many limitations (NextEngine, 2013). While it worked very well on objects such as stone or wood sculptures, whose surfaces are easily read by laser technology, it struggled to capture details of many objects that the author worked with, especially those with concave, slightly reflective, or thin, comb-like surfaces. As such, by using the NextEngine scanner, the author was greatly limited in the types of objects that could be 3D scanned for this project.

After the first two months of using the NextEngine 3D scanner, and discovering what worked best, in order to scan the largest number of objects possible, objects would be selected based on whether or not their shape and surface texture would allow for them to be scanned quickly by the NextEngine scanner. This did much to limit the overall variety we were able to add to our collection. Using the NextEngine scanner, we were also unable to scan smaller biological objects such as insects, which, at Dalhousie University, there was a strong demand for.

While for the price of $3,000, the NextEngine 3D scanner is a starting point for any library, museum or other similar organization to begin creating a 3D collection, to truly take advantage of this technology a higher-end 3D scanner in the range of $100,000-$200,000 would be needed (Wachowiak & Karas, 2009). The Smithsonian Institute, for example, has had much success using a $100,000 Minolta laser scanner (McKendrick, 2012). Two other very good 3D scanners for these types of projects are the Creaform line of 3D scanners (Creaform 3D, 2013) and the Faro line of 3D scanners (Faro, 2013). As these 3D scanners come with a heavy price-tag, researchers or institutions should carry out extensive research before making a purchase, and they should also carefully consider the surface structure of the objects that the institution wishes to preserve.

User submissions

At the Killam Library, of the Dalhousie University Libraries, the NextEngine 3D scanner was made available to any Dalhousie students who wanted to 3D scan and submit any items that they felt were of importance. It proved very difficult to get students to use this 3D scanner though. While it was not overly difficult to learn the basic 3D scanning process, it was much more difficult to merge multiple scans into a single, solid 3D object. Few students were willing to take the time to sit down with the 3D scanner long enough to create usable 3D objects. For students to do this successfully the author believes that any library providing this serve would need to themselves provide students with classes teaching the basics fundamentals of the 3D scanning process, or else be able to direct them to classes of this kind at a partnering institution.

The Dalhousie Libraries' 3D model repository was also left open for anyone interested in it to submit their own 3D models, whether or not they were affiliated with Dalhousie University. The repository had a few submissions from Dalhousie students studying in the fields of architecture and engineering, who had already creating 3D models for their course work. Outside of this, though, the majority of the 3D repository was built through the author's 3D scanning work made possible in a large part through a grant from the Canadian Association of Research Libraries.

The author believes the role of user submissions in building this 3D repository will be of huge importance. Since this is a very new area for libraries to be moving towards, there is still much difficulty in engaging the interested of students and faculty as well as teaching those interested the necessary 3D modelling skills. If libraries can successfully promote and develop 3D repository collections, however, there is huge potential for content development.

In building the 3D model repository on Dalhousie's DalSpace repository, the library decided to apply the principles of open access to the project, ensuring that the information stored in this repository would remain free and universally accessible.

Determining File Standards

There are an extremely large number of 3D file formats and standards. The majority of these file formats are unique to the 3D modelling programs they are created with, and a smaller number of formats are interchangeable amongst a larger numberof 3D modelling and CAD-based software programs (McHenry & Bajcsy, 2008). There is then the additional problem that many 3D scanners save their scans in unique file formats customized to each scanner. These unique and proprietary file formats create a problem for building a sharable open repository.

Researching these various file formats, the author determined that the file format most commonly interchangeable between all of these software programs is the Wavefront Object format (.OBJ). Also easily interchangeable is the native Computer Aided Design format (.CAD). In terms of the 3D repository, in order to preserve the original 3D model in the most lossless method possible, all these models were preserved in their native file format and then, if possible, the .OBJ file format, for more accessible viewing in a wider variety of 3D-based software programs, including many free programs such as MeshLab (MeshLab, 2013).

An attempt was also made, when possible, to convert the 3D files to the Stereolithography file format (.STL). The .STL file format has been associated with 3D printing since the implementation of this technology. 3D files were stored in this format to create a link to the Dalhousie Libraries newly implement 3D printing service, and to allow those accessing to repository to have the option to quickly reproduce any 3D file on a 3D printer.

One problem with the .STL file format, though, is that editing or modifying information saved in this format is very difficult (Wah, 1999). Thus all 3D files that were converted to the .STL format were also preserved in their original file formats, as mentioned above, to ensure that no information was lost, and to maximize the usability of this information.

Method of Cataloging

To catalog the 3D models in the Dalhousie Libraries 3D model repository, the rules for cataloging realia or physical objects as defined in the second addition of the Anglo-American Cataloging Rules (AACR2), was used as the main reference (Google, 2013), noting the updates made in the Resource Description and Access (RDA) rules (McRee, 2013).

Importance was also given to note whether the 3D model was born-digital or else digitized through the use of a 3D scanner. If the 3D model was created through the use of a 3D scanner, the model brand of the 3D scanner was recorded. If the model was born-digital, the 3D modelling software used to create it was noted.

Copyrighted Models

All models stored on the 3D model repository exist under a Creative Commons license (Creative Commons, 2013), specifically an Attribution - Non-commercial license. This copyright agreement allows for 3D models to be downloaded and altered by other users, building new work that uses the original model as a base (similar to tracing a 2D drawing before creating your own design). The licence does not allow for these 3D models to be used for commercial uses, though, or for a person other than the creator to profit financially from the work.

Allowing the ability for others to build on existing 3D models in the repository was very important to the author in regards to the idea of open-source knowledge sharing and collaboration. Allowing others to modify existing models opens up the potential for collaborative projects, involving diverse ranges of 3D data such including building structures and CAD-designed machinery.

Methods of Display and Interaction

Besides downloading a 3D model and viewing it on a software program, a user may employ other methods of visualizing 3D data. Four important, progressive methods are covered below.

VRML, WebGL

Virtual Reality Modelling Language, more commonly called VRML, has been associated with 3D-based web pages since the mid-nineties, and is still used to some extent today. The purpose of VRML was to provide web designers the ability to port 3D graphics to their web pages, enhancing their users' experiences. In past examples VRML has been used to allow webpage visitors to virtually tour museums and explore different landscapes (World Wide Web Consortium, 2013).

New developments in WebGL, or the Web Graphics Library, though, show much promise in replacing VRML with a more efficient and more capable method of placing high-end 3D graphics inside web browsers. One notable user of WebGL is the GoogleMaps application, and there are also many web-based video games making use of this technology (Mozilla Developer Network, 2013).

With the growing popularity of tablets and other mobile technologies, as well as the increasing level of bandwidth and internet connection speeds available to users, virtual environments and virtual collections are becoming more and more realistic (MacArthur, 2007).

By utilizing a variety of 3D scanners, libraries, museums and other preservation-focused organizations can now create virtual spaces where patrons can browse architectural spaces and physical collections through a computer screen from anywhere in the world, in addition to having access to digital books and journals. The benefits of this would be vastly increased access to architectural spaces and collections, as well as 24 hour availability.

As seen by the popularity of online communities (Spaulding, 2010), moving libraries into a virtual realm does not isolate users, but can actually help build communities, engage individuals, and promote the open exchange of ideas.

Traditional 2D Projection

There are a number of free software applications available on the internet, such as Meshlab (Meshlab, 2013), that allow for the viewing of 3D models. Since these programs are so accessible, by making 3D models available online it is fairly easy for people through the world to download and view these models. Most of these programs also provide the ability to rotate 3D models a full 360 degrees, as well as magnify and re-colour their surfaces.

In a library space, 3D model viewing software can be easily linked to a traditional video projector such as those commonly used in classrooms. This would allow teachers or students presenting to a group to pull 3D information up on the screen and manipulate it, pointing out key details, and in general enhancing their ability to teach or explain their ideas.

Hologram Projection

In building a collection of 3D models, the presentation of these models can also be linked to hologram projection technology, which has made a number of advancements in recent years.

There are a few companies, such as Dimensional Studios, capable of bringing 3D models to life on stage, which could be used to provide a dramatic visual impact during presentation.

In a more closed, personal setting, the company Zebra Imaging can transfer a 3D model on a printed surface that, when light is shone on it, brings a 3D model to life, allowing people to see it in full 3D without the need of glasses (Zebra Imaging, 2013). Another company, Tribal3D, is also capable of creating 3D holographic museum or general exhibition displays (Tribal3D, 2013).

As hologram/holograph projection technology continues to make advancements, there will be lots of potential for more interactive museum and library displays, where patrons will be able to load 3D models and view and interact with them in a hologram format. Compared to having items stored in locked cases, or in back rooms with extremely limited access, this could do a lot to completely open up valuable physical collections and put them in the hands of those interested in them. The added benefit of this is, too, that 3D models can be shipped across the world at no expense, and shown at different locations through these various holograph projection methods.

3D Printing

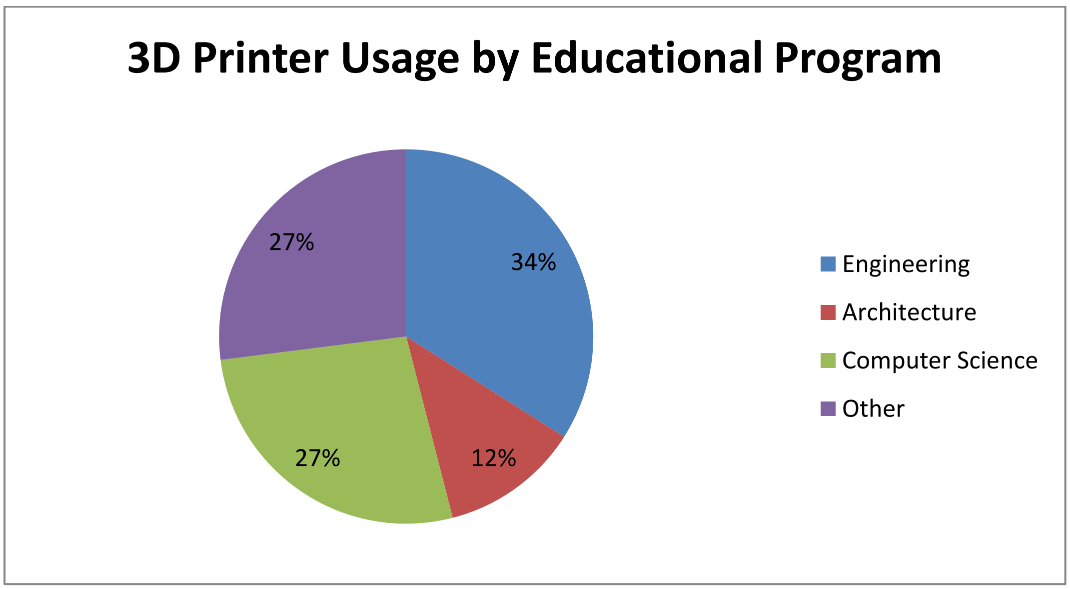
Another way of providing 3D models to patrons is through the use of 3D printing technology. A few 3D printers produced by the companies 3D Systems and Stratasys, such as their Objet and ZCorp 3D printers, are capable of reproducing fairly exact replicas of any 3D models stored in a collection (ZCorp, 2013). These replicas would allow for students or other patrons to have direct, hands on access to collected items. The other benefit of 3D printing is that digital models of fragile or extremely valuable items could be sent digitally across the world, where replicas could then be 3D printed and put on display for an audience that would normally have much difficulty accessing these objects.

For the last sixteen months the Dalhousie University Libraries has been providing open access to a MakerBot Replicator 3D printer. The MakerBot Replicator is a lower end, hobby grade 3D printer incapable the precise detail of 3D printers such as the Objet or ZCorp 3D printers mentioned above. As such the MakerBot Replicator is not well suited for reproducing 3D scanned objects. Yet many other uses have come out of offering 3D printing as a library service, which this paper will now describe in more detail.

3D Printing at the Dalhousie University Libraries

As discussed in a previous paper (Groenenyk & Gallant, 2013), in April of 2013 a Makerbot Replicator 3D printer was installed in the Killam Library, the central library of the Dalhousie University Libraries. In the past year we have seen the service have a visible shift in its user base as the service developed and more students and faculty members became aware of it.

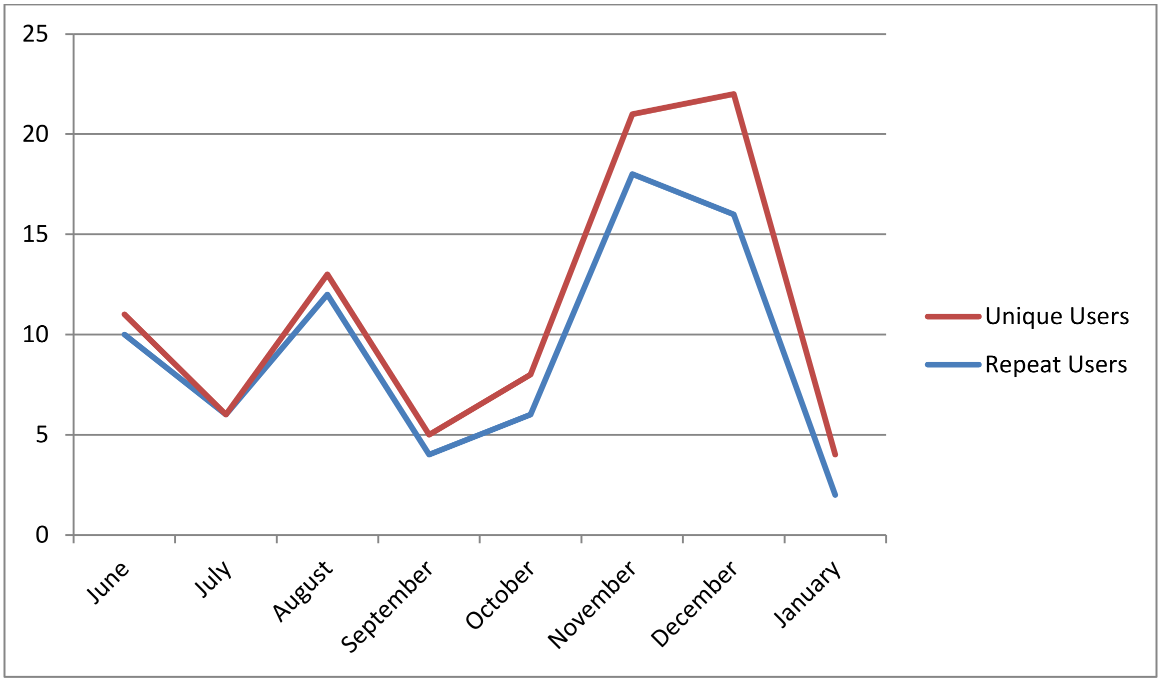
At the launch of the 3D printing service, the user base came from students in the faculties of engineering and architecture – who already had experience with 3D printing technology. Throughout the next eight months engineering students remained the dominant users of this service but we began to see a little more diversity. Over this eight month period the large increase in users came from the faculty of computer science. At this point computer science students are the second heaviest users of the 3D printing service, after engineering students, with architecture students in a distant third.



Overall, few students outside of engineering and computer science have used the 3D printing service. The total users from all faculties outside of engineering and computer science were about equal to the number of student users from engineering and computer science. At this time though, at least one student from nearly all faculties at Dalhousie University has used the 3D printing service for a class project.

When the Dalhousie Libraries launched the 3D printing service, the majority of models submitted for 3D printing were downloaded from internet sources rather than models users created themselves (about 70% of models came from alternative sources). As service has developed the number of submitted models created by users has increased significantly though. At this point about 67% of the users of the 3D printing service submitting 3D models they created themselves. The only exception to this was at the end of December when a number of requests came in for 3D prints of downloaded models that were intended to be given away as gifts.

As this service has progressed, the Dalhousie Libraries has had a high number of repeat users. At this point 72% of users who have used the 3D printing service have used it a second time. Over the past three months the majority of submissions have been coming from users who have previously used the service, and the service is still steadily adding new users every month.



A large problem that the Dalhousie Libraries continues to address is that many students and faculty members interested in 3D printing have no idea how to create their own 3D models. To this end Dalhousie Libraries staff is recommending easier to use 3D modelling programs, such as SketchUp, and beyond this the Dalhousie Libraries is also looking into offering weekly instructional sessions on 3D modelling.

Looking back on the service as it developed, the most well received aspects of it were the accessibility of the 3D printing and the very low cost ($1 per hour) that we charged for users to 3D print their models. In contrast to this though, because we were using lower-end, hobby-grade 3D printing equipment, we were very limited in the types of models we were able to print, and the quality of the models we were able to produce. The Dalhousie Libraries has investigated if there is an opportunity for providing a higher end 3D printing service, but, because the low printing cost has been well received, we do not believe that the much higher cost of higher grade printing will be as well received, and thus we would not be able to generate a user base large enough to justify the purchase of this equipment.

Conclusion

While the 3D scanning archive has potential, and while the NextEngine 3D scanner allowed us to effectively digitize a select number of objects, the limitations imposed on us due to our budget restriction were a definite handicap. Though we were able to create digital copies of many physical objects, the quality of these copies was not high enough to satisfy stricter archival standards or in any way replace the original. In order to achieve this level of accuracy a much more expensive 3D scanner would be needed – closer to $50,000, which we could not afford.

In terms of the 3D model archive we have begun building, to make this archive more attractive to users a much higher-end 3D scanner is needed or else the quality of the cheaper 3D scanners needs to improve, and this could still take a long time to happen.

As mentioned above, the 3D scanner itself is not nearly as complicated as one would original assume. The complexity – or the art, really – comes in when the separate scans must be assembled. While this does involve a steeper learning curve and a lot of inherent talent, it can be learned. Once a person has learned to do this she or he can then become them be the centralized force for assembling scans others have completed.

While we believe 3D scanners are a great way of opening library, archival and museum up to a much wider audience, and helping provide time stamps of the object themselves, until higher end 3D scanning technology becomes more accessible, projects of this kind will still be hindered by low-end 3D scanning technology limitations.

The same is true of 3D printing in its current state as well. While this technology is much easier to learn that one would believe, working with the lower-end of 3D printing technology can be extremely frustrating. Problems are constantly arising, making even simple models very difficult to print correctly. And so, again, while the higher end of 3D printing technology has solved many of these problems for years already – and allowed people to create amazing prototypes assembled from a number of different materials – the costs are very prohibitive, and so we wait for either the costs on the high-end to drop, or else the quality of the low-end to improve.

We do not mean that this lack of capability should be discouraging, however. In the experience of the Dalhousie Libraries, our patrons and our collaborators, there was and still is a very strong interest around these technologies and how they can be used to enhance current methods to display preserved objects, and help encourage creativity and innovation. But librarians, archivists, curators and anyone else looking towards these methods of 3D preservation and reproduction must be aware of the limitations that currently exist. For our own project, looking back on it now, we see it more as laying down groundwork for what might come later – when the prices of these technologies do come down and they become much more capable of doing what we need them to do for us. 3D scanning and 3D printing technologies, as they are currently available to libraries and smaller museums, are not ends in themselves. Right now represent small steps towards a very different future for preservation-focused institutions, and anyone interested in pursuing the additional of these technologies to their own library, archive or museum should be aware of the challenges that they will face in doing this.

Works Cited

3D Scan Co. (2012). FARO Photon 120/80/20. Retrieved February 24th 2013 from: http://www.3dscanco.com/products/3d-scanners/large-volume-metrology/faro/

Creaform 3D. (2012). Portable 3D Scanners. Retrieved February 24th 2013 from: http://www.creaform3d.com/en/metrology-solutions/portable-3d-scanner-handyscan-3d

Creative Commons. (2013). About the Licenses: Creative Commons. Retrieved February 24th 2013 from: http://creativecommons.org/licenses/

Faro. (2013). Faro Edge Scanner. Retrieved February 24th 2013 from: http://www.faro.com/edge/us/scanner

Google. (2013). AACR2 Chapter 10 - Three-Dimensional Artifacts and Realia. Retrieved February 9th 2013 from: https://sites.google.com/site/opencatalogingrules/aa-2

Groenendyk, M., & Gallant, R. (2013). 3D printing and scanning at the Dalhousie University Libraries: a pilot project. *Library Hi Tech*, *31*(1), 3-3.

Handwerk, B. (2005). King Tut not murdered violently, CT scans show. *National Geographic News*. Retrieved February 24th 2013 from: http://news.nationalgeographic.com/news/2005/03/0308_050308_kingtutmurder.html

Hill, D. (2012). Handeld 3D scanner lets you digitize objects and room in minutes. *Singularity Hub*. Retrieved February 24th 2013 from: http://singularityhub.com/2012/05/03/handheld-3d-scanner-lets-you-digitize-objects-and-rooms-in-minutes/

Lampert, C. K., & Vaughan, J. (2009). Insights into the Cultivation and Sustainability of Academic Library Digitization Programs: Success Factors and Challenge Threats.

Levoy, M., Pulli, K., Curless, B., Rusinkiewicz, S., Koller, D., Pereira, L., ... & Fulk, D. (2000, July). The digital Michelangelo project: 3D scanning of large statues. In *Proceedings of the 27th annual conference on Computer graphics and interactive techniques* (pp. 131-144). ACM Press/Addison-Wesley Publishing Co..

MacArthur, M. (2007). Can museums allow online users to become participants. Washington: AAM.

Mayfield Clinic. (2013). Computed tomography (CT) and CT angiography. Retrieved February 24th 2013 from: http://www.mayfieldclinic.com/PE-CT.htm

McHenry, K., & Bajcsy, P. (2008). *An overview of 3d data content, file formats and viewers*. Technical Report ISDA08-002.

McKendrick, J. (2012). Smithsonian employs 3D printing to replicate collections. *Smart Planet*. Retrieved February 24th 2013 from: http://www.smartplanet.com/blog/business-brains/smithsonian-employs-3d-printing-to-replicate-collections/22276

McRee, J. (2013). Equipment Cataloging. Retrieved March 9th from: http://special-cataloguing.com/node/1412

MeshLab. (2013). MeshLab. Retrieved February 24th 2013 from: http://meshlab.sourceforge.net/

Mozzila Developer Network. (2013). Getting started with WebGL. Retrieved March 9th from: https://developer.mozilla.org/en-US/docs/WebGL/Getting_started_with_WebGL

NextEngine. (2013). NextEngine 3D Laser Scanner. Retrieved from: http://www.nextengine.com/

Petrov, M., Talapov, A., Robertson, T., Lebedev, A., Zhilyaev, A., & Polonskiy, L. (1998). Optical 3D digitizers: Bringing life to the virtual world. *Computer Graphics and Applications, IEEE*, *18*(3), 28-37.

RapidForm. (2012). 3D Scanners: A Guide to 3D Scanning Technology. Retrieved February 24th 2013 from: http://www.rapidform.com/3d-scanners/

Spaulding, T. (2010). How can virtual communities create value for business?. *Electronic Commerce Research and Applications*, 9(1), 38-49.

Terdiman, D. (2012). Smithsonian turns to 3D to bring collection to the world. *CNet*. Retrieved February 24th 2013 from: http://news.cnet.com/8301-13772_3-57384166-52/smithsonian-turns-to-3d-to-bring-collection-to-the-world/

Tribal3D. (2013). Holographic printing. Retrieved March 10th from http://www.tribal3d.com/museums_exhibitions/

Wachowiak, M. J., & Karas, B. V. (2009). 3d Scanning and Replication for Museum and Cultural Heritage Applications. *Journal of the American Institute for Conservation*, 141-158.

Wah, W. H. (1999). Introduction to STL format. *Polytechnical University of Hong Kong.* Retrieved February 24th 2013 from: http://rpdrc. ic. polyu. edu. hk/old_files/stl_introduction. htm.

World Wide Web Consortium. (2013). VRML – Virtual Reality Markup Language. Retrieved March 9th from: http://www.w3.org/MarkUp/VRML/

ZCorp. (2013). 3D printers. Retrieved March 10th from: http://www.zcorp.com/en/Products/3D-Printers/spage.aspx

Zebra Imaging. (2013). A whole new way to go 3D. Retrieved March 10th from: http://www.zebraimaging.com/products/print-a-hologram