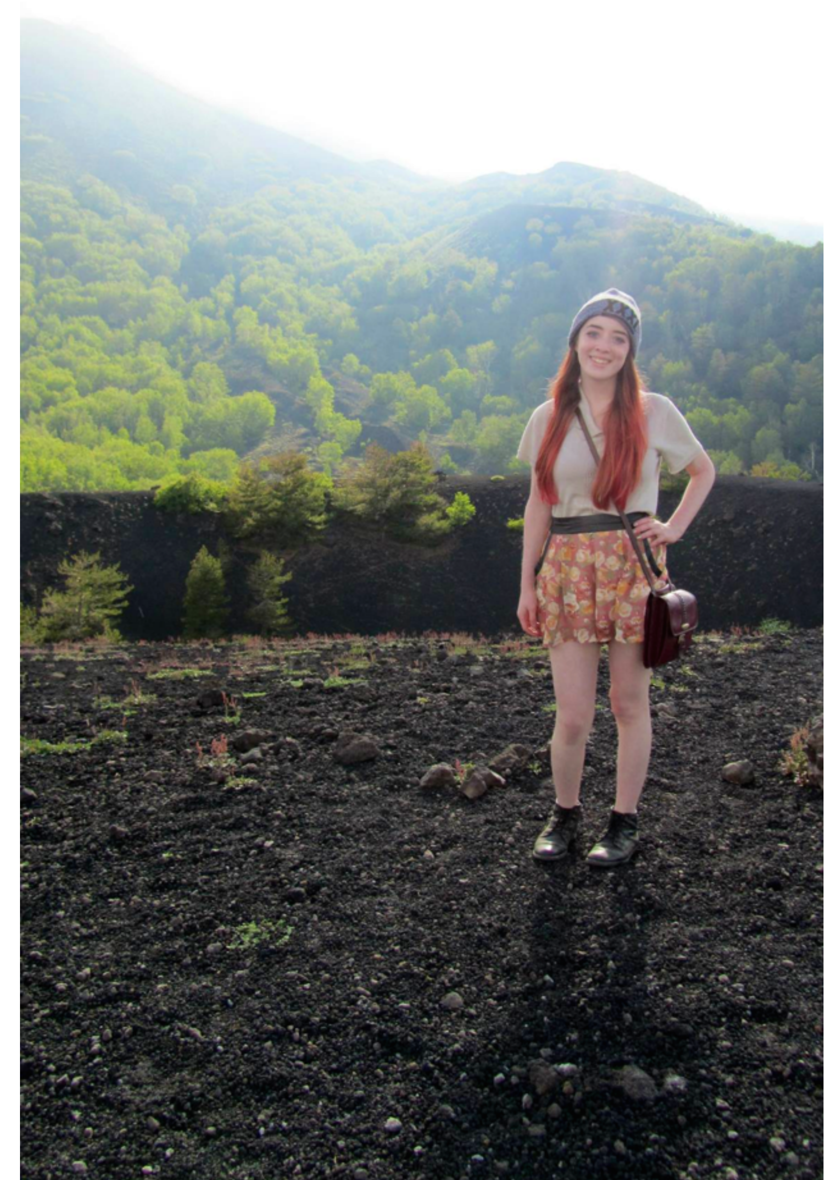
# Archeological Computing in Sicily

My name is Mollene Denton, and I had the amazing opportunity of applying computer graphics to cultural heritage while in the beautiful city of Siracusa, Italy. While living on the island of Sicily, I was able to embrace the Italian lifestyle. I indulged in local cuisine, relaxed on the shore of the Mediterranean, and even learned a fair bit of Italian. Overall, I had an unforgettable and unique experience that I will carry with me for years to come. Here are some photos of some of the adventures I was able to take on while in Italy!

# Mt. Etna

Hiked Mt. Etna with other students in the program and went to a wine tasting afterwards



# Noto

Visited Noto with friends and watched the sunset over beautiful architecture

# Catania

Visited Catania with my professor and the other archeology students to view ancient artifacts and architecture

# Greek Theatre

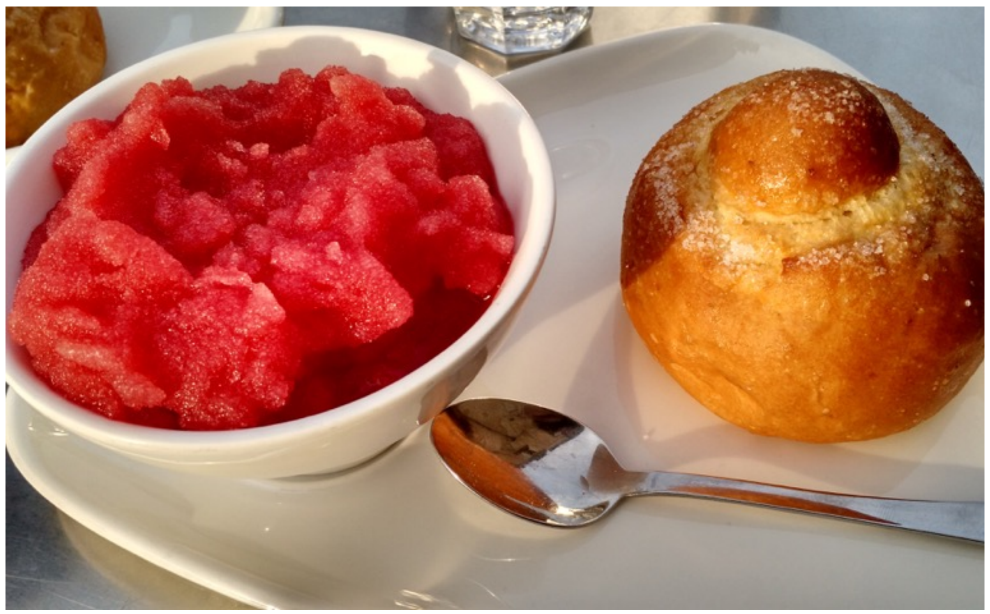
Saw a play performed with other students at an ancient Greek theatre in Siracusa

# Aeolian Islands

Visited the beautiful Aeolian Islands with my professor and other students

# Food

Had amazing and fresh local cuisine such as granita, pizza, pasta, and seafood



# Friends

Made friends with local Sicilians as well as other students in the program

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# Archeological Computing Capstone Essay

## Defining Archeological Computing

The role and identity of archeological computing is unclear in the archeological world— even 40 years after its establishment. Many wonder if this ambiguity is due to lack of confidence, or rather a signal of growth. Archeology and digital archeology have been defined in many different, sometimes overlapping ways, so it is understandable that this field is currently experiencing a kind of identity crisis. The tensions of naming and renaming can reflect an "anxiety discourse", which questions the significance and relevance of the field itself. Yet, this constant change of terminology may also be associated with fundamental changes within the field.

It is difficult to measure the impact of archeological computing, which leads some to believe it is more "practice based", and therefore under-theorized. There is a lot of overlap between those active in archeology, and those active in digital archeology, suggesting that digital archeology is simply just an application of archeology. In addition, there is only one journal of archeological computing, although archeological computing related papers appear in a number of mainstream archeology journals. This pushes us to further analyze the relationship between archeological computing and traditional archeology, and what ultimately differentiates them. For archeological computing to become an established field, it needs to prove itself as less of a methodology for archeology, and more as a way to rethink archeology.

Jeremy Huggett summarizes these ideas in his research paper "Disciplinary Issues: Challenging the Research and Practice of Computer Applications in Archaeology", as he states:

> One of the dangers for a subject area which derives much of its methods from other disciplines, disciplines, and which is seen as promoting technique and technology over theory, is that it is always seen as peripheral, ever playing a supporting role, and lacking a coherent central core which provides a clear-cut identity. (17)

He later argues that computational archeology needs to take on a "grand challenge" that will alter the boundaries of our current knowledge, in order to define itself as a field separate from archeology. Grand challenges are defined by Winter, S.J., and B.S. Butler in their 2011 paper "Creating bigger problems. Grand challenges as boundary objects and the legitimacy of the information systems field" as issues that:

> Seek to drastically alter the boundaries of existing knowledge, established disciplines, and available capabilities ... [they] require cooperation perspectives over years and decades. New norms, Structures, and practices must be developed to provide the support and incentives necessary to sustain these long-term, large-scale collaborative participation from members of many relevant academic, practitioner, and policy-oriented communities. (100).

Pursuing a grand challenge requires community involvement, participation, and commitment. It's argued that if archeological computing cannot agree on a grand challenge or does not see the value in a grand challenge, the field is not yet mature enough— or perhaps it will never establish a clear identity. Overall, it is clear that the field of archeological computing must carry out some form of self-analysis in order to construct an established identity for the discipline.

**Different Scanning Methodology**

In the world of archeological computing, there are many tools and programs to aid in the scanning and modeling of 3D artifacts. These tools come with varying levels of price, accuracy, speed, etc. Therefore, it is important to take note of the advantages of each method, as well as the disadvantages.

There are many things to consider when choosing a method of scanning. In “Quick and dirty : streamlined 3D scanning in archaeology”, it’s argued that “[time-consuming] processes force a separation between ongoing interpretive work and capture” (1366). Therefore, the authors believe that a ‘quick and dirty’ method of capturing is the most effective, as it will allow for a greater integration of excavation and interpretation. They defend “lightweight” capture methods, arguing:

> [Capture technologies] have come to be appropriated in particular ways in the context of archeological practice that subsequently shape and constrain their relationship with the different locales of interpretation on- and off-site. The concerns go beyond what the different representational outputs of these capture technologies enable the archeologists to record, see and analyse. Rather there are a broad set of factors and practical considerations arising in the preparation work and production work involved in different forms of capture that come to bear on the relationship these technologies have to the locales of archeological interpretation. Indeed, even those capture technologies that on the face of it might be regarded as lightweight can often have heavyweight methodologies associated with their use on site. (1367)

They therefore go on to highlight and advocate the use of a portable wireless 3D modeling system, emphasizing the need for real-time capturing over resolution. This kind of methodology seems most similar to the Structure scans I made, as the device was very portable, quick, and wireless, although the scans created were lacking in detail.

Another common method of scanning to consider is image-based modeling. In their essay “Image-based Modeling Techniques for Architectural Heritage 3D Digitalization: Limits and Potentialities”, authors C. Santagati, L. Inzerillo, and F. Di Paola discuss the advantages and disadvantages involved in image-based modeling. Specifically, the authors analyzed the effectiveness of image-based modeling by considering the models made by two different applications: Autodesk 123D Catch and LIDAR. It was seen that “the obtained models [from imaged-based modeling] are beginning to challenge the precision of laser-based reconstructions” (555).

My experience with using Photoscan has been similar— I’ve been able to produce models at very high levels of detail. But unlike the Structure, image-based modeling is not instantaneous, and requires a decent amount of time in the lab. Apart from these two methodologies, I used a Kinect paired with the software Skanect to create models. This modeling system was similar to the Structure in that you rotated around an object with a sensor to produce a model, but the Kinect took longer to use and Skanect took longer to process your model. But although it lacks some of the convenience of the Structure, it produces a significantly more detailed model.

**First Scan**

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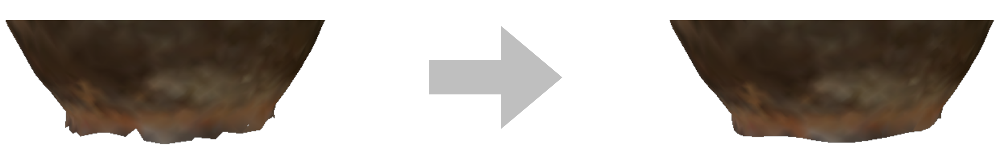
The first artifact I scanned was an ancient Greek vessel. I used image based scanning methods in order to create a 3D model of the vase. In making this model, I learned a lot of basic techniques for the Photoscan software, as well as Meshlab. For example, I learned about the different file types for a 3D model, and their respective advantages/disadvantages. For this specific model, Meshlab was unable to open a .obj or a .ply file, so I used a .dae extension. This filetype worked, but drastically changed the lighting/colors on the model given to me by the Photoscan software. So, a .dae is reliable, but can have unexpected changes on quality. Luckily, I was able to alter the lighting in Meshlab, so the model came out well.

While editing the vase in Meshlab, I was able to experiment around with the different tools offered within the program. The first thing I needed to do for this model was remove what the Photoscan picked up of the pedestal the vase had been sitting on. This allowed me to play around with two different area selection tools: selecting faces in a rectangular region and selecting faces using a paintbrush. I learned that the rectangular tool was helpful to start with, to delete very large areas. After this, it is beneficial to switch to the paintbrush tool, and paint over smaller areas that are very close to the object itself. The paintbrush can help for accuracy, but is slow at removing larger sections of a model.

After removing the pedestal, the bottom of my vase was very sharp and choppy. I wanted a smoother looking bottom, so I looking into the assorted smoothing filters offered by Meshlab. The best filter I found was the Laplacian Smooth, where you could select the area you wanted to smooth, and apply the filter at various intensities. It’s important to select the area you wish to smooth, because otherwise the whole object will be smoothed and quality will be lost. This smoothing created a much nicer looking base.



At this point, the vase was still lacking a solid base at the bottom, so I needed to figure out how to create one. The best method I found was to use a reconstruction filter called “Surface Reconstruction: Poisson”. This filter automatically created a new mesh with a completely solidified (colorless) model of the vase. Since I already had most of the vase and only really needed the bottom, I used the deletion tools discussed earlier to removed all of the poisson mesh, except for the very base. At this point, my vase had a colorless base, so I needed to figure out how to color it to match the rest of the vessel. The simplest way I was able to do this was by using the dropper tool to select the dark black color from another part of the vase, and manually coloring over the poisson mesh with this color. This created a base that matched the rest of the vessel quite well, ultimately giving me a completed model.

**Catacomb Artifacts**

While in the catacombs, I was instructed to create Photoscans of a collection of artifacts that the archeologists had found. Here are some examples of Photoscans I made:

SL05

SL08

SL09

SL11

SL13

SL15

SL16

SL17

SL20

For each model, I needed to take around 50 photos from a multitude of angles, either rotating the object or rotating myself after each photo. Since the lighting in the catacombs was very limited, we only had one source of lighting angled at the object. Therefore, we decided the most effective way to scan the object was to keep the camera stationary, and rotate the artifact. This way, the lighting would be consistent. After taking photos of the artifact from each rotational position at two or three different heights (depending on the size of the model), I would have to flip it over, in order to capture the base of the artifact that was previously concealed. In this new orientation, I would repeat the process used previously, so I could later align all of the photos to create a singular model.

In having to create many Photoscans, I learned a lot about how to use the software. For example, I learned what kinds of photos to use. For some of my models, the Photoscan software was returning very undesirable models (such as a very sparse, scattered stream of points). To remedy this issue, I went through every photo I took of that object, and cropped them to only include the object itself, effectively minimizing the background noise. Rerunning the Photoscan software with the cropped photos gave me a much better, detailed model. This ultimately taught me that I needed to either take photos with very small amounts of excess background, or I needed to be prepared to manually crop up to 100 photos.

An issue I ran into with many of the archeological artifacts was that the Photoscan software was unable to construct the base of the model. I tried to get the software to model the base using two different methods. First, I tried to upload photos of the artifact in two different orientations into one single chunk (thus capturing every side of the object), and then see if the software was able to reconstruct all sides of the model by distinguishing the different angles. Most of the time, this was unsuccessful, and the resulting model would be missing one side. The second method I tried was uploading one position of the artifact into one chunk, and then a different orientation into a second chunk. Then, after aligning these photos separately, I tried to get Photoscan to align the two chunks. Then, if that worked, I would merge the two chunks into one model. This method worked a couple of times, but would also commonly fail.

So, to ultimately get bases onto these models, I had to manually reconstruct them using Meshlab. The only issue with manual reconstruction was that it removed a lot of detail from the artifacts. For example, consider these two models of the same object, SL05:

with a reconstructed base

without a reconstructed base

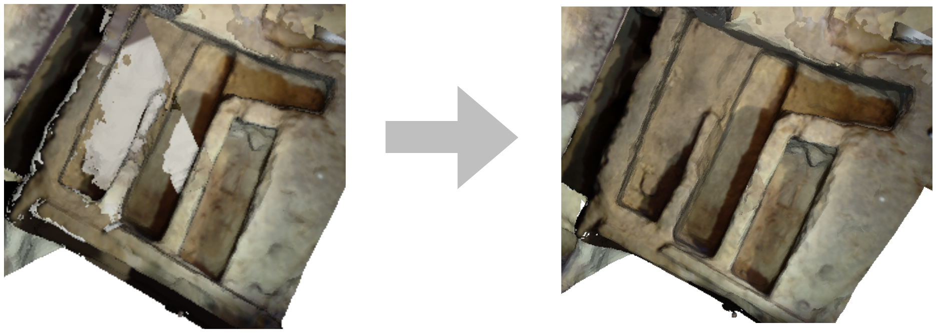
As you can see, the model with a reconstructed base has lost a dramatic amount of quality. Therefore, it was decided that these models were better left without a base, to preserve their detail. Although missing a side, it would be a better representation of the artifact as a whole.

**Catacomb Section Reconstruction**

Another project I worked on while in the catacombs was the reconstruction of an archeological site using the Structure. This was my final model after aligned all of the scans I took:

I had various troubles while taking these scans, and subsequently merging them. One thing I learned about the Structure during scanning was that if a scanned area was too large, the program would crash. So I had to be careful to take more, smaller scans, rather than one large scan. Also, Structure would occasionally crash while attempting to add color to a scan I took. I suspect this was due to inadequate and/or inconsistent lighting, although I'm not sure.

Another trouble I encountered while taking these scans was the issue of lighting. The catacombs have very limited lighting, so I had to attempt to light each area with just one or two lamps. This involved changing the lighting with each scan, which ultimately caused me trouble when piecing the area together. After aligning the various scans, the model did not look continuous, as the lighting was drastically different for each section. Therefore, I had to recolor and readjust parts of the scans in order to make it look like a singular connected model.



Ultimately, for the reconstruction of this area, the scans and alignment were fairly quick, but the most difficult aspect was dealing with the lighting. When you're working underground, it's nearly impossible to get perfectly consistent lighting, so a lot of readjusting and retouching needs to be done during the modeling process.

**Archeological Museum**

In the archeological museum, I scanned two objects— a model of a temple, and a statue of a magistrate. For the temple, I scanned it using two different methods. I first scanned it with the Structure, and then took photos of it, which I used to construct a Photoscan of it. For the magistrate, I used three different methods. In addition to the Structure and the Photoscan, I scanned it using the Kinect. There were benefits to each method, as well as drawbacks.

**THE TEMPLE**

First, let's analyze the temple. Here are some images of the temple created from the Structure:

The scan was very quick, but as we can see, a lot of detail was lost. There are also a few holes on top of the model, as it was hard for me to hold the Structure high enough and at the right angle to fill those holes. There are also some interesting dark shadows on the top and back of the model, which probably has something to do with the state of the lighting at the time I took the scan. Since the temple was restricted by it's placement in the museum (including the wall and  surrounding artifacts), it was difficult for me to walk around it and capture all angles in a continuous movement. But overall, the general shape of the temple was preserved within the Structure scan.

Now, let's consider the scan created by image based methods:

As we can see, this scan was able to preserve a lot more of the detail of the model. The colors and textures of the temple are more rich and complex. Although, similar to the Structure model, the Photoscan was unable to perfectly capture the coloring and characteristics of the very top of the temple (as shown below).

This again occurred due to factors outside of my control, such as the fixed position of the artifact, and my height.

**THE MAGISTRATE:**

Next, I scanned the statue of a magistrate. First, we'll look at the scan created by the Structure:

The scan turned out decently, but as we can see, there is a hole at the very top of his head. This was due to the fact that I was unable to position the Structure at the correct angle to capture that portion. The colors are also slightly off at the top of the model, likely for the same reason. But overall, I was content with the Structure's ability to model the many folds in the magistrate's robe, capturing all of the crevices and creases in the statue. The main issue of detail was in the face and head of the magistrate— the attributes are less crisp, and appear slightly smoothed out.

Let's now look at the model generated by the Kinect:

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This model is actually a combination of two separate models. The first Kinect scan I took of the magistrate was missing sections of the head and shoulders, due to the limitations of my height. Therefore, one of my peers who is significantly taller than me took an additional scan of just the head and shoulders. I then had to align and merge these two scans into one single model. Unfortunately, the two scans had very different lighting, so after merging the two meshes, it would not have worked to just transfer the old colors to the new model. Therefore, to recolor the statue, I used the paintbrush tool to manually paint over the model. The detail on this model is sharper than the Structure model, capturing the depth of every fold and depression in the original statue. This model also more complete at the top, as I was able to get these portions from an additional scan.

Now let's consider the model created by image based modeling:

This method of scanning was able to transfer the most detail to the final model, such as the folding of his robes, his facial characteristics, and the colors of the statue itself. The only issue with the Photoscan was its inability to accurately represent the top of the magistrate's head. I was unfortunately too short, even while standing on a bench, to reach an appropriate height to capture the very top of the statue. Therefore, the Photoscan software attempted to construct the top of the head the best it could using the photos I gave it, resulting in a head that is rather malformed and incorrectly lit. But ultimately, this model appears to be the most detailed and accurate depiction of the statue of the magistrate.

**Conclusion**

Archeological computing is still an underdeveloped field, with a lot of potential to establish a concrete identity and role in the archeological world. The many capture technologies developed for archeological computing allow for different methodologies for scanning and modeling archeological artifacts. In some cases, it may be more beneficial to use a scanning method like the Structure, which can produce a lower quality scan in little time and effort. Yet there are also situations where it is better to put in more time to create a more detailed model, like in the case of the Kinect or the image-based modeling software Photoscan.

Overall, in taking this course and in creating many models, I was able to learn the best situations to use each respective software. In addition, I learned many tricks for using these softwares in order to create the most complete, most detailed models. The field of archeological computing has very powerful programs to accompany it, and the longer I was able to use the software, the more depth and capability I found within it. Although I have only been exposed to the world of archeological computing for a brief amount of time, seeing what can be accomplished with current resources makes me excited for future developments and exploits of the field.

**Sources:**

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