Augmented Archaeology: Process Document

B.A. in Interactive Media Studies, Senior Thesis

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Abstract

Engaging the public with the past is an ongoing challenge for museums and educational institutions. Many archaeological sites have little left to see, as most remains have been excavated, looted, or remain in the ground. Augmented reality provides the opportunity for site visitors to engage with historical and archaeological material, and can help bridge the gap between the public and the past. Augmented reality has so far been widely used to recreate an approximation of what archaeological sites would have looked like in the past.

While this provides a fun and visually interesting environment for visitors, it falls short of engaging visitors with actual archaeological material, and the educational benefits associated with it. This thesis proposes to instead use augmented reality to allow visitors to engage with renderings of the artifacts found at that site. In this design, artifacts would be anchored to GPS coordinates, and visitors could explore the site and engage with the artifacts that had been found there. The artifacts would be attached to information including a description of the artifact, and where it is currently located. This thesis should allow visitors to engage more thoroughly with the past by providing them the opportunity to interact with artifacts as they were found.

Bibliography

Bond, Sarah. "After The Success Of 'Pokémon GO,' How Will Augmented Reality Impact Archaeological Sites?" *Forbes*. Forbes, 17 July 2016. Web. 17 Sept. 2016.

Bond's article addresses the ways in which the success of Pokemon Go has inspired archaeologists to think about how AR can be used to get students and the general public involved with the past. It also discusses ways in which archaeologists are exploring how to gamify visits to archaeological sites and museums. This article is helpful to me because it provides background and context for the work that I am currently doing.

Campana, Stefano. "3D Modelling in Archaeology and Cultural Heritage- Theory and Best Practice." *3D Recording and Modelling in Archaeology and Cultural Heritage- Theory and Best Practices*. Ed. Fabio Remondino and Stefano Campana. Oxford, England: Archaeopress British Archaeological Reports Gordon House, 2014. 7-12. Print. BAR International Ser.

Campana's work focuses on the ways that 3D technology can be used to compliment the traditional landscape of excavation records. It also discusses the importance of balancing 3D with reality, and how we can use 3D to promote sharing and communication of archaeological information. This is helpful to me because it discusses the social boundaries of 3D technology within the archaeological profession.

Chung, Namho, Heejeong Han, and Youhee Joun. "Tourists' Intention to Visit a Destination: The Role of Augmented Reality (AR) Application for a Heritage Site." *Computers in Human Behavior* 50 (2015): 588-99.*Elsevier*. Web. 17 Sept. 2016.

This article discusses the ways in which AR is being developed as part of "smart tourism". It focuses primarily on the users' needs, and how to get them connected with AR. It claims that there are three primary factors that encourage visitors to actively use AR- technology readiness, visual interest, and the situational factor. This article is helpful as it helps frame the design of the project from the user's perspective.

Deliyiannis, Ioannis, and Georgios Papaioannou. "Augmented Reality for Archaeological Environments on Mobile Devices: A Novel Open Framework." *Mediterranean Archaeology and Archaeometry* 14.4 (2014): 1-10. *JSTOR [JSTOR]*. Web. 17 Sept. 2016.

This piece discusses the three primary perspectives that need to be taken into consideration when creating an archaeological AR project- the developers (who have the technological knowledge), the content experts (who are the archaeologists who provide information, or use the project), and the users (who typically have expertise in neither). Deliyiannis et al also note that the information used for archaeology AR will need little to no maintenance over time unless something new is added or information is corrected. They discuss the usage of QR codes to engage AR, but note that the presence of a QR code at an archaeological site ruins the aesthetic of the environment. They also discuss the importance of considering the target age group when developing the project. They discuss ways that one could differentiate (including various levels of information provided, and vocabulary used), and suggest that a brief survey could be used at the beginning to determine the user's needs. They also introduce the "infinite triplet" of visual representation, contexts, and audiovisual content. This piece is helpful as it provides a wide range of frameworks and parameters to use while developing a project.

Keil, Jens, Laia Pujol, Maria Roussou, Timo Engelke, Michael Schmitt, Ulrich Bockholt, and Stamatia Eleftheratou. "A Digital Look at Physical Museum Exhibits Designing Personalized Stories with

Handheld Augmented Reality in Museums." *Institute of Electrical and Electronics Engineers*(2013): n. pag. Web. 17 Sept. 2016.

This article discusses the importance of looking beyond merely attracting and entertaining audiences- there is a need to provide information. They discuss a case study in which visitors use AR to interact with exhibits within a museum. Visitors can see the bright colors that once adorned the ancient marble sculptures, and children has animated narrators to guide them through the exhibit. They did note that user experience was impacted by traffic at the museum. Visitors did not have many opportunities to fully use the program when they could not freely navigate the museum. This article is helpful because it emphasizes the importance of taking the audience and environment into consideration, and the ways in which they are successfully and unsuccessfully being used now.

Kysela, Jiří, and Pavla Štorková. "Using Augmented Reality as a Medium for Teaching History and Tourism." *Procedia - Social and Behavioral Sciences* 174 (2015): 926-31. *Elsevier*. Web. 17 Sept. 2016.

This article discusses the ways in which AR allows users to be immersed in a digital world while remaining fully immersed in the real world. It emphasizes the importance of constraints on the programs, especially in regard to battery draining and data usage for mobile devices. This article is helpful because it explores the various ways to develop an AR program, as well as how to keep mobile device constraints in mind.

Magalhaes, Luis Gonzaga, Joaquim Sousa Joao, Ricardo Bento, Telmo Adao, Francisco Pereira, Vitor Filipe, and Emanuel Peres. "Proposal of an Information System for an Adaptive Mixed Reality System for Archaeological Sites." *Procedia Technology* 16 (2014): 499-507. *Elsevier*. Web. 17 Sept. 2016.

This article focuses heavily on what is currently being done in the field. It discusses the ways in which AR is being used to reconstruct monuments and buildings, as well as recreate archaeological sites as they are interpreted to have once been. This article is helpful because it explains what is and has been done in the field.

Initial Design and Planning

When developing my initial design, I consulted archaeologists, museum directors, people who are interested in archaeological sites. I received overwhelmingly positive feedback from each of the groups I spoke with. The initial opinion I received from each person was that the idea is “very cool”. Each person I interviewed also said that they would be willing to use the program while visiting a site.

After conducting some initial interviews, I began planning in earnest. I knew that I wanted a street view option, in which users could look through the camera of their phone and see 3D artifacts in the areas that they were found. I was inspired by an archaeological site I worked at during the summer of 2016. We found numerous interesting artifacts, including a highly decorated piece of pottery, but from the surface level, the site was a flat field in a local park. Visitors likely had no idea that there were many artifacts being excavated each summer. I wanted a way to make sites such as that one more engaging for visitors.

From a visual standpoint, I knew that I wanted the program to feature lots of brown and sepia tones, as well as antique maps. My goal for this is to appeal to users' expectations for what something archaeological should look like. Having a crisp, contemporary design doesn't make sense for my designated topic.

Initial Development

I started out with a plan to use ARIS, which according to its website is "ARIS is user-friendly, open-source platform for creating and playing mobile games, tours and interactive stories. Using GPS and QR Codes, ARIS players experience a hybrid world of virtual interactive characters, items, and media placed in physical space." (arisgames.org, 2016). I watched numerous tutorial videos to familiarize myself with the way that the program works, and the best ways to use the features. I then worked on developing the program. I used their scene developer to create a starting scene, a navigation scene, a menu scene, a collections scene, and an artifact details scene.

I worked extensively in ARIS for several weeks, and I was determined to make it work for my needs. However, as I was working I noticed several key shortfalls of the program for my intended work. First, ARIS is intended more for general geographical area than for specific geographical area. This would make it an ideal program for finding archaeological sites from the highway, but it would be significantly less helpful once a user was in the archaeological site and wandering around. Second, I would be unable

to create a "street view" that would allow users to see objects placed realistically in their environments. A significant part of the appeal of this program is the ability to artifacts embedded in the archaeological site where they were originally found. I felt that a google map style augmented reality, similar to the style used in *Pokémon Go* would take away from the user's experience.

As this project was out of my comfort zone in terms of prior experience, I was hesitant to stray from the program that had been recommended to me. It wasn't until the first demo day that I finally fully acknowledged that ARIS wasn't going to be able to meet my needs, and that I was wasting precious time in refusing to let it go.

Demo Day 1

I was nervous going into my first demo day. At this point in time, I had a very concrete idea of what I wanted the program to do, and even how I wanted the program to look, but I was still uncertain of how to get the program to work. I was still hoping that I could make ARIS work, and possibly receive advice from those more familiar with the program. I presented my idea, research, and wireframes at the first meeting. I described how I wanted to create something different than the modern interpretations of what archaeological sites and their people *might* have looked like. Several of these types of recreations are problematic because they are either based largely in artistic interpretation to fill to fill in gaps in the archaeological record, or, as a worst case scenario, they feature blatantly racist and/or culturally insensitive depictions of indigenous people. After my presented, I received great feedback from my first demo day. Some of the feedback I received included:

- Try to use something other than ARIS, as it's very technically limited
- Consider switching to Unity to develop the program
- Consider gamifying the program so that users can earn rewards for collecting artifacts
- Consider adding Native Americans or Native American tour guides

The advice to switch from ARIS came from the person who originally recommended the program to me, so I knew I had to find an alternative. One IMS faculty member recommended that I use Unity instead of

ARIS. I was hesitant, as I've never used Unity, or had any experience with game development programs. I told the recommender that the majority of my background was in web development and design, and he advised that Unity wouldn't be too difficult to pick up if I already know JavaScript.

I was also recommended to consider gamifying the program. There were concerns that a program that just allowed users to interact with an artifact at the site wouldn't be engaging enough to hold visitors' attention. It was recommended that I add some kind of points system, possibly for collecting artifacts.

I also received advice to add Native Americans or a Native American tour guide. While I understood the appeal of the idea- it could make the program more interactive and engaging for users- I strongly felt that featuring a Native American would be problematic for the reasons stated above, as well as conflicting with my anthropological background. The process of properly depicting a Native group would require contacting the tribe in question, gaining their permission, getting their recommendations for how the person should look, act and speak, and allowing them to review and modify the new digital person. Given that the specific tribes who created the archaeological sites in Ohio are difficult to map directly onto modern tribes, it seemed like a more difficult option than the scope of my project would permit.

I took the feedback on switching from ARIS to Unity and adding a game component very seriously. I downloaded Unity onto my computer, and began watching numerous tutorials online to familiarize myself with the program.

Pivoting towards Unity

Once I received the advice to switch to Unity, I started researching the program intensively. I needed to know everything from the basics of how the interface worked, to how I could use it to create an augmented reality program. At the time I was planning on creating a mobile app, so I focused on tutorials that would allow me to do that. Some of the sites I referenced are those below:

- How to make an AR app in 5 minutes with Unity and Vuforia (http://www.justapixel.co.uk/how-to-make-an-ar-app-in-5-minutes-with-unity-and-vuforia/)
- How I became a Unity 3D and Augmented Reality developer | Marxent @ Work (http://www.marxentlabs.com/job/how-i-became-a-unity-3d-and-augmented-reality-developer-marxent-work/)
- ARToolKit for Unity (http://artoolkit.org/documentation/doku.php?id=6_Unity:unity_about)
- How to Build an AR Android App with Vuforia and Unity (https://www.sitepoint.com/how-to-build-an-ar-android-app-with-vuforia-and-unity/)
- Introduction into Augmented Reality with Vuforia (http://www.marcofolio.net/other/introduction_into_augmented_reality_with_vuforia.html)
- Mobile Development (https://unity3d.com/learn/tutorials/topics/mobile-touch/mobile-development)
- How To Make A Video Game [Unity3D Basics] Part 1 (https://www.youtube.com/watch?v=5-X-Ebh1kYA&list=PLtzBAyzPCP3314xyL6RiKIU87PP1Jg8kW)
- Documentation, Unity Scripting Languages and You (https://blogs.unity3d.com/2014/09/03/documentation-unity-scripting-languages-and-you/)

After reading several articles, watching numerous tutorial videos, and attempting to write some code in Unity on my own, I still did not feel comfortable in my ability to successfully create my program in Unity. I asked Dr. Eric Hodgson, one of my faculty advisors for the project, if he could meet with me to go over some of my concerns. I was rather anxious, especially seeing as our second demo day was quickly approaching.

On the same day that I was scheduled to meet with Dr. Hodgson, a program called Argon was brought to my attention by Dr. Mark Peterson, Chair of the Department of Anthropology. Dr. Peterson, along with Dr. Jeb Card, Visiting Assistant Professor of Anthropology, were both deeply invested in the augmented archaeology program from its conception. I had frequent informal (and often spontaneous) meetings with them discussing my progress, ideas, and struggles. After expressing my concerns over using Unity with them, Dr. Peterson spoke to his son, who dabbles in game development. He asked his son if he was familiar with any programs that might be beneficial for me. They found a new program called Argon, under development at the Georgia Institute of Technology.

Later that day, when I met with Dr. Hodgson, I discussed my struggles with Unity, and asked him if he had heard anything about the new Argon program. He had not heard of Argon, and recommended that I speak with Artie Kuhn, Assistant Director of the AIMS program, about it, as Argon is primarily a JavaScript based program. I presented my concerns with Unity to Artie, and I also presented the new Argon program. At that time, I hadn't had any time between learning of the program and the meeting to experiment.

As for my difficulties with Unity, Artie recommended that I speak with Matthew Board, a professor with extensive experience in Unity and game development. It just so happened that Matt was walking by at that time, and Artie was able to grab his attention. I once again relayed my difficulties with Unity, and that Argon had just been presented to me as a potential option. Matt felt that it was possible for me to learn Unity, as I already knew JavaScript, but that Argon might be a better fit for my project.

Pivoting towards Argon

After my meeting with three faculty members in the AIMS department, I decided to scrap the Unity approach and focus on Argon. I once again did research online, pouring over documentation and GitHub. I followed the tutorials on Argon's documentation website in order to create a basic AR page. Argon works as an AR-enabled web browser. It is an app that can be downloaded from the Apple app store (as of fall 2016, there has not been an android release). Once in the app, a user can type in the URL of the AR web page, and Argon will use the mobile device's camera to incorporate street view. To host 3D objects, Argon incorporates three.js. I started with the one page 3D box tutorial. It took a considerable amount of work to get the first part of the tutorial running.

To begin, I, somewhat foolishly, didn't realize that I wouldn't be able to test the program on my computer, and I would instead have to upload it to a server, and then test it using my mobile tablet. This has proved to be one of the most time consuming challenges of using Argon. For each edit, I had to upload my file to a server through an ftp connection, and then reload the page through the Argon app.

While trying to put together the first part of the tutorial, I ran into some difficulty getting the program to work, especially in regards to “the box”, the 3D element in the tutorial. In particular, I was having difficulty getting the various parts of code provided both in the tutorial and on GitHub to work together to create a functioning demo. I was eventually able to get the first part of the tutorial working, which just displayed a 3D box in a location near your current position.

After I managed to get the initial tutorial working, I focused on getting an HTML content box to appear with the object. I saw this as a valuable component, because I would need to add some feature that would allow users to learn more about the artifact in question. After several attempts to get it to work, I was finally able to get it to load. I then had to experiment with the kinds of text I could put inside it, as lengthy text had difficulty rendering properly.

By this time, the second demo day was quickly approaching, and I began preparing for my presentation. I felt more confident than I had for the first demo day, but I was still nervous about my ability to complete the program before the end of the semester.

Demo Day 2

For the second demo day, I summarized the change in development program, what I had done thus far, and what I was still planning to do. I discussed how my goal was to set up a program that allows visitors to view 3D artifacts through a street view, collect those artifacts, gain points, and redeem those points at a corresponding museum (such as where the artifacts are housed). I showed screenshots of my program, as I knew that people would otherwise need to crowd around my small screen. Some feedback I received included:

- Please clarify how the point system works for artifact collection
- Be more confident while expressing new ideas

I didn’t receive as much feedback as I did during my first demo day, which was both a good thing, as fewer things needed redoing, and a bad thing, as it was less feedback for me to build upon. At the end of my presentation, during the question section, I discussed how I intended for users to get a set number

of points, for example 50 points for each artifact collected. Depending on the number of artifacts at the site, it might vary as to how many points result in a reward. For rewards, I would like to partner with the museum, to make the reward redeemable through their institution. This would also benefit the museum, as it would encourage site visitors to also stop by the museum center. Possible rewards could include free passes, discounted passes, discounts at the gift shop, or free parking passes (depending on whether or not the museum charges for parking). If the museum is in a financial situation that doesn't permit financial rewards for participation, competition boards or spotlights on their website could be a cheap/free alternative.

After the end of the second demo day, I immediately began working on the program again.

Continuing Argon Development

Following the second demo day, I immediately focused on solving two tasks: how to create a clickable HTML menu, and how to get 3D artifact models to render.

As part of the program, I wanted to have the option to go to a menu screen that would allow you to get general information about the site, see the artifacts you've found so far, and return to the street view. I initially planned for this to be a small, square icon in the lower right corner of the screen. This, however, proved to be a difficult task. I tried several different methods, but none of them seemed to work. I met with Dr. Hodgson to try to figure out why it wasn't working. He advised that I speak to Artie, as he was more familiar with JavaScript.

I met with Artie, who helped me discover that the problem resulted from trying to place 2D clickable content in a 3D environment. I was also concerned with my inability to click on objects, or their HTML description tags. Artie helped me figure out that clicking on an artifact wouldn't be possible unless I wrote code that searched for the first 3D object in the linear path of where I clicked. In other words, just because it looks like it's in (x,y) position on the screen does not mean that it actually exists at those

coordinates. That's just where it happens to be when looking through the glass of the screen (similar to looking out a window).

To solve the issue, he recommended that I reduce the size of the Argon 3D viewer to around 90%, and add a button bar in the bottom 10% that would allow users to see more details for an object that they approach. This approach would eliminate the issues with clickable content in the 3D environment, as I would be segmenting my screen into 90% 3D and 10% 2D. It took a few rounds of trial and error, but I was able to successfully reduce the size of the 3D screen and add the 2D button. I created the button using Adobe Photoshop. I specifically chose an antique map background that filled the entirety of the 10% space, with a brown button and typewriter font. These stylistic choices were intended to allude to popular ideas of archaeology, which users are likely to expect, without venturing into fictional depictions that distract from the goal of the program.

Meanwhile, I was trying to figure out a way to get 3D artifacts to appear on screen. OBJ files are a popular choice for museums and academic intuitions when creating 3D scans of artifacts. As a result, I have focused specifically on getting OBJ files to render in Argon. After going through documentation on GitHub and Argon's website, I hadn't found any references to being able to display OBJ files. Concerned, I emailed Dr. Blair MacIntyre, the project director for the Argon program. I found his contact information on Argon's website, which advised that I should contact him with questions regarding development. I reached out to him and explained my thesis project, and I asked him whether or not Argon was able to support OBJ files. His response to me was as follows:

> "Argon4 [their current web browser as of fall 2016] can render anything a web page can; it's "just" a web browser. argon.js does not dictate anything about rendering, it tries to expose the various technologies into the web browser. Our examples use three.js, and aframe.io (which also uses three.js), so anything three.js can do, you can get a start on from our examples. three.js has an obj loader, so loading and rendering objs should be easy."

With this advice in hand, I began reading various tutorials on three.js, looking at documentation, and trying to dissect samples that featured OBJ files.

Finding 3D models to use in a proof of concept was not the challenging part of this process. There are downloadable artifact files on SketchFab, and the Miami University Department of Anthropology has numerous 3D scans, and they were generous in allowing me to use some of them. All of these files were OBJs. The challenging part of this process turned out to be getting them to appear on the screen. I closely followed the three.js documentation, mimicked examples, and checked my code line by line for errors. I couldn't find anything wrong with my code, but my OBJ files still weren't rendering. I decided to go to Artie again, to see if he could detect a problem that I couldn't.

After looking over my code, Artie also couldn't easily find a code-based problem. He recommended that I speak with Matthew Board again, as he has extensive experience working with OBJ files. I met with Matt, and he found that the polygon count on my file was too high to render in a web browser, and that my objects were not centered on their vertices. Matt offered to reduce the polygon count and center the object, as it would "take him all of 3 minutes" using Maya at his home. Matt emailed me the fix files, and the object displayed in the "view details" page, which simply renders the object on a black background. Unfortunately, though, the object appeared very small and only showed up at the very bottom of the box.

Unfortunately, when I uploaded this to my live site, the OBJ file and viewer didn't appear at all. In order to figure out why it wasn't working, I looked over the code to see if anything stood out to me in particular. I focused first on the container, as that's the part that appeared to be disproportioned. I commented out each line of code from the example one at a time to see how they affected the page. I found that I needed to eliminate the object position line of code from the example to center my object on the screen.

After I fixed the position issue, I still had issues with the object appearing incredibly small in the viewing window. In addition to this issue, I was also still struggling to get the OBJ files to load on my home page. I contacted Danny Capaccio, an adjunct professor in the AIMS department, to help me with

some of my coding issues related to OBJ files. He was able to help me determine that the "camera.position.z=" line of code was causing my object to appear smaller, or further away depending on how you approach it. By reducing the value from 250 to 25, I was able to make the object appear larger in the screen.

Even with Danny's assistance, though, I struggled to get the OBJ file to load on the home page. I tried replacing the portion of the box example with the code that implemented the OBJ file in the view details page, but to no avail. As of Thursday, December 15, 2016, I am still working on getting this part to load.

This project has been an immense personal learning experience, and I plan to continue working on this project to see it through to fruition. Some future goals I have, once the OBJ files completely load, are:

- Adding the ability to collect points for finding each artifact
    - Will likely use a Boolean trigger to ensure that artifacts cannot be triggered more than once, which would allow users to artificially inflate their point count
- Adding the ability to match artifacts found onsite with the real objects in a museum
    - Will likely feature either a QR code at the museum, or an image match to allow users to match their collected artifacts to the artifacts in the museum
- Implementing a fully functional (including gamification) prototype at an archaeological site for user testing