Three-Dimensional Geovisualization and Virtual Reality Rendering of Garden of Bomarzo

LEEP Fellows Program 2019

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Abstract

We aim to create open-access three-dimensional (3D) educational model and an integrated virtual reality environment of the site of Sacro Bosco (or Sacred Wood) in Bomarzo, Italy. We will explore different reality capture technology to reconstruct Sacred Wood. One of them is to use laser scanning to obtain high resolution data and then render the data into virtual reality. The final product will be an accurate and holistic visualization of the site, useful for both academic and enrichment purposes. Sacred Wood is one of Italy's most important Renaissance monuments that is wearing down at an alarming rate. Our tool will aid in the monument's preservation by allowing people to learn of its unique design without having to be physically present at the site.

Project Description

I. Introduction

This (sub-)project is intended to assist professors Garton, Magee and other collaborators in a long-term effort to carry out the full project eventually.

Of Italy's many Renaissance monuments, one of the most important in the history of sculpture, gardens and landscape design is the Sacro Bosco (Sacred Wood) in Bomarzo that "push the boundaries of intellectual experiences, nature, and artifice within a multi-layered, disorienting, and awe-inspiring landscape." [7] After centuries of neglect, the Sacred Wood was rediscovered in 1949 by Mario Praz and Salvador Dali. In the decades since, some international architects, landscape designers, and art historians have found inspiration during visits to this privately-owned 29-acre park. Roughly thirty-seven carved monuments and architectural features emerge across a tree-covered hillside; their subjects drawn from history, literature, and mythology. The Sacred Wood constitutes a visual intersection of many disciplines as understood by Renaissance Italians and remains truly unique in the history of landscape design.

However, the Sacred Wood remains inconvenient to visit and harder still for teachers and students to study from isolated photos or video capture. Moreover, heavy flow of visitors has left the friable stone vulnerable to abrasion and erosion. Our goal for this geovisualization project is to incorporate virtual reality rendering to create an enriching and academically impactful tool to visit the site without physical presence. Via our tool, scholars and students can experience the park's terrain, statuary, and now-defunct Renaissance water works in ways that allow for new conclusions about the site's purpose and historic importance.

Through this project, we want to create a fully immersive integrated digital experience that convey the significance of the Sacred Wood state and for it to continue inspire wonder and curiosity for many generations to come.

II. Approach

To lay the foundation for most visualization works in terms of accurate measurement, we will begin by working with Sacred Wood park's owners to understand the conservation needs and access limitations. Our goal is to create an accurate topography of the monument using a combination of digital recording technologies. We will explore the feasibility of using different technology to reconstruct the site in 3D. An often-used technology is Light Detection and Ranging (LiDAR) drone photography to measure the distance to an object and map that location in 3D to ensure high resolution digital imagery from the air and the ground. Another technique in object reconstruction is photogrammetry: using data acquisition from on-site sensors to estimate the 3D relative motions with high accuracy. [3] We will combine both the photogrammetry and LiDAR data to create a 3D surface model of the monument that contains both very accurate geometry as well as high quality texture information. The drawback of this method is the cost-prohibitive equipment and we are unsure of to what extent documentation can be conducted on this privately-owned park. Another approach that is less costly is to harvest ground images both online and from the owners and match the common points between these images and use the extracted data to compute the 3D surface model. The drawback is that there are not many images of the Sacred Wood that are holistic and provide site-relative sense of scale.

Our visualization will put emphasis on accuracy of proportion, preciseness of measurements, and sacrifice details on the "noises." The monuments will appear in a sole schematic topography to achieve the optimal compromise between visual fidelity and quality. Since these statues are quite large, we will use an adjust software "that can solve [large optimization problems] that are encountered in three-dimensional reconstruction problems." [5]

We want to create an immersive and authentic experience; hence, our second biggest benchmark will be to convert the Sacred Wood's 3D reconstruction into virtual reality (VR) environment. One possible rendering technology is Google VR's Seurat, a "[..] scene simplification technology designed to process very complex 3D scenes into a representation that renders efficiently on mobile 6DoF[read: fully-immersive] VR systems." [1] We plan to make our visualization compatible with Cardboard headset, a device that with no more than $20 makes having a very impressive virtual reality experience on a good smartphone possible. [1]

Cardboard will help improving the sense of scale in VR environment since "the phone's gyroscope will tell the application where the head is pointing at, so it can render the right point of view on the screen." [2]

III. Support

The two chief professors that will help me throughout the project is professor John Garton of the Department of Visual and Performing Arts and professor John Magee of Mathematics and Computer science. This summer LEEP project will be a joint effort in a long-term, fully-expanded project with professor Garton, Magee, and other collaborators. Concerning the technicalities of reconstructing the site, there exist many software packages and tools that will simplify the process of 3D reconstruction. There are also many other completed conservation projects that we can reach out to consult or collaborate, e.g. CyArk, University of Washington's GRAIL lab.

Geovisualization, especially implemented via VR, will create an enveloping experience that will bring the time period and location alive. People have strong spatial memory; being engaged in authentic experience and interactive communication will help facilitate a deeper appreciation and interest for the historic site. If this visualization and its VR version can be introduced to students and the public, it will cultivate knowledge and curiosity about one of the most important Italian monuments and raise a lot of awareness about the Sacred Wood specifically and the deteriorating cultural heritage at large.

For scholarly interest, after we obtain the 3D surface model of the Sacred Wood, we can produce a set of other derivatives that pertain to this purpose. For example, during this process, we will create a relative topography of the site that has value for modern drainage, runoff, and site preservation. The tubing, hydrology and water works of this Orsini landscape are mentioned in Renaissance sources as tremendously impressive. [6] The features that so impressed many Renaissance figures remain mostly hidden today. Our tool will aim to reveal the water works and original pipes still in the ground. All these derivatives, and the project itself, have great significance regarding academic contributions and future conservation efforts.

IV. Outcome

The long-term final project's most important overall outcome is to obtain a compelling visualization of the site and its monuments in 3D that allows the viewer to see the entire grounds, space, and monuments within their respective positions in nature and according to the natural terrain and slope of ground. Our deliverable during Summer 2019 will be a preliminary 3D visualization of the Sacred Wood. At minimum, our model will include navigation of the whole map and zoom-in areas. Site-relative measurements are another important outcome since we want scholars to be able to gain new information through our tool. The representation of the site and its features will be accurate so as to allow measurement from monument base to monument base. The 3D surface model will be useful to site managers in the ongoing management and restoration of monuments. We will also write up a report detailing the approach, technology, cost, estimated time, and other related factors for different ways of 3D reconstruction to discuss further with the park owners.

Furthermore, as a by-product of constructing the VR visualization for the Sacred Wood, we hope to come up with a generalized, reproducible, and affordable approach to render lesser-known sites into VR construction that other academics or conservationists can implement for their point of interest in lieu of complex tools that might not be easily accessible. Our methodology will give academics, students, educators, and individuals who might not be familiar with VR and construct one an opportunity to recreate a VR environment of various locations.

Publication-wise, we want our digital documentation of Sacred Wood to be accessible and made known to the public. If achieve a satisfactory methodology for VR construction, we also want to publish that to local and national conferences and journals. Additionally, we would like to publish the finished product onto Google's Expeditions, where students and educators can get access the immersive experience via affordable technologies.

One of the most employed techniques in this project will be photogrammetry and other technical software. Having hands-on experience and familiarity with visualizing geographic sites and related software is incredibly useful as the technology is widely used across all subject areas. Moreover, I also want to present this project at Fall Fest, Academic Spree Day and submit the project to Clark's SURJ. The conservation efforts do not stop after this project, and thus, I would love to attract more students and teachers who might be interested in the cause.

Preliminary Bibliography

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Budget and Budget Justification

Category	Expenses	Usage
Camera (x1)	$150	test 3D reconstruction by feeding test images (req: shoots > 10 megapixel)
Tripod (x1)	$50	
Light kit (x1) and turntable (x1)	$480	Photogrammetry equiment. See: https://sustainableheritagenetwork.org/system/files/atoms/file/1.27_PhotogrammetryDigitizationEquipment.pdf
External hard drive (x1)	$65	for processing images (eg Seagate 2TB portable harddrive + Adobe)
Software license (x1)	$100	photogrammetry software to reconstruct from 2D (eg 3DF Zephyr, RealityCapture)
Google Cardboard (x2)	$25	test VR system
Transportation	$80	meetings with grad students at Boston University with prof Magee
Housing	$1,350	450 per month
Food and unexpected needs	$200	
TOTAL	2,500.00	

Link for sample equipment for photogrammetry projects: here.

Timeline and Benchmarks

The project will take approximately 10 weeks to complete. Short daily debriefs, biweekly meetings and reports will take place and documented.

The three benchmarks for the project will be to settle on the reconstruction method, obtain a preliminary 3D surface model, and report on scaling time for both visualization and VR rendering. Other tasks are as equally important in their contribution to the project.

Week	Objectives	Note
1	Contact Sacred Wood's owners to lay out expectations. Discuss with Dr. Garton to understand the key components of the gardens. Second round of preliminary reseach.	Response time can potentially delay the process. Method research will be the main task instead if this happens.
2	Write a detailed report on different approach: cost, technology, documentation needs. Reach out to geography students or similar conducted projects to consult. Semi-settle on reconstruction methods. Make a prioritized task list.	Applicable adjustments will be made per correspondence with experts throughout the project.
3	Obtain measurements and site objects; study the maps and identify key areas. Figure out what map types will be utilized. Re-assess methodology and task list after correspondence. Have a substantial meeting with both professors and make any necessary changes	
4	Settle on reconstruction methods and research deeper. Finalize equipment shopping list. Purchase and test capture equipment.	Delivery time and/or broken items will be taken into account.
5	Get familiar with the mapping software. Test-run all the apparatus and report any abnormalities/noticings Digitally map the important maps (eg sculpture location, waterworks, park path)	
6	Test a sample object 3D reconstruction and estimate scaling time and resources for the garden. Request and harvest images of the garden and match common points; obtain preliminary visualization.	
7	Send out preliminary deliverables for feedback. Purchase VR equipment. Test sample VR scenes Get familiar with VR rendering software	Feedback time will be taken into account.
8	Do a simple VR scene. Use noticings to adjust expectations or approach to render the garden. Estimate scaling time.	
9	Have a holistic reassessment of the project and make any necessary changes according to current findings and/or feedback.	
10	Push minor changes and write a final report. Wrap up and conclude the project	

LEEP Essay