Digital Visualization in Web 3.0: A Case Study of Virtual Central Grounds Project

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Abstract: A series of conflicts and controversies around historical monuments and public spaces in the US have signalled the importance of teaching and presenting cultural landscape with authenticity and completeness. University of Virginia's Academical Village, a World Heritage Site, is facing exactly this challenge as the University celebrates its 200th anniversary. This paper presents a web-based Geographic Information System (GIS) project that aims to create a geodatabase to host georeferenced data sets with bibliographic links, and a web map that allows users to explore this important cultural landscape through time, space, and Virtual Reality (VR). By introducing the methodology and technical approach of this project, this paper discusses implications of digital visualization in the Web 3.0 era, and how new technological advances might help presenting a complete and authentic cultural landscape.

Keywords: Web GIS, cultural landscape, Virtual Reality, Web 3.0

1 Introduction

In the summer of 2018, a series of racist and anti-racist rallies rattled several cities in the South of the US where the legacy of the Civil War (1861-1865) remains entrenched in many communities. Charlottesville, a small quiet college town and home to the University of Virginia, was particularly featured in global headlines because of violent conflicts that led to several casualties. Although these events are deeply rooted in the divide of current political and socio-economic environment in the US, the targets, however, are often the monuments and landmarks in our public spaces. Over the years, they have defined our physical environment and cultural identity, but now they evoke different interpretations of their symbolic representations (DEMING & BOONE 2019). From a historical perspective, this is not new. We constantly reshape our physical environment according to our present-day ideologies throughout history. Some transformations have unfortunately been violent and destructive. Scholars believe that this is partially because our common method of attributing significance to landscape has not kept abreast of historical and emerging recognitions of its rich and complex meanings (STEPHENSON 2006). The history of the University of Virginia's Academical Village, a World Heritage Site, is one example. When the University's founding father Thomas Jefferson himself designed the campus two hundred years ago in the hope of fostering enlightenment and democracy in the new American Republic, he wanted the U-shaped Academical Village to be open on the southwest end in order to signal the importance of graduates serving the boarder society. The graduation ceremony every summer was supposed to be staged with students facing the open end towards the outside world, so that they could feel a sense of responsibility at graduation. However, seven decades later, the college board decided to put a new building, the Cabell Hall, right at the southwestern terminus, against Jefferson's original intention. We now know that it was a decision motivated by racial bias in order to block the "unsightly vista" of the African American community that was serving the faculty and students at that time (OFFICE OF THE ARCHITECT 2013). Such ideology-

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charged alteration in our physical environment is prevalent. Nevertheless, the lack of physical presence and inevitable nature of "forgetting" present challenges to teaching cultural landscape with completeness and authenticity in our education (FOREST & JOHNSON 2019).

At the University of Virginia, many efforts have been made in the past to achieve the goal of complete and authentic representation of the history of the Academical Village. Jefferson's University-Early Life (JUEL) project by the Institute for Advanced Technologies in the Humanities (IATH) has assembled large collections of historical documents, images, maps, and created detailed 3D models of landmark buildings from 1819 to 1870. These digital representations are now available on the project website for viewing[1]. The Facility Management office has many historical drawings and photos documenting the construction of different parts of the campus, and has maintained a GIS database of historical building footprints. The University Office of Architects has commissioned a Cultural Landscape Report that documented landscape changes with CAD drawing, sketches, maps, etc. (OFFICE OF THE ARCHITECT 2013). Many archaeological surveys have unearthed remnants of residences and graveyards on grounds recently, including those belonged to the African American Community outside of the University in the early years. Professors in the Department of Architectural History have also conducted surveys with students in several courses to reveal slave life in the Academical Village. Unfortunately, all the digital products from these projects and programs are still fragmented in different collections and formats, with different time periods and spatial coverages.

As the University of Virginia is celebrating its 200th anniversary, it is important to find innovative ways to present a complete history of the Academical Village to the public and future generations. Thanks to the developments in GIS, we now have the opportunity to tag all the relevant documents, images, photos, and 3D models from different efforts spatially and temporally, and bring them together in one depository. With the arrival of Web 3.0 era, we have technologies that can make the web smarter, more interactive, and more 3D. It is time to present all the materials not only as hyperlinked smart 2D objects on a web map, but also as multimedia objects in a 3D immersive environment, allowing spatial and temporal inquiries into the rich history of the University of Virginia's physical environment. That becomes the mission of a new project during the bicentennial celebration, Virtual Central Grounds (VCG): an exploration through time and space.

2 Methodology and Technical Approach

This ambitious project, funded by the Jefferson Trust Fund, first expands the study area from the traditional Academical Village to the entire central grounds and environs in order to include outside communities and landscape features that had supported the founding and growth of the University in the early years (Figure 1). For example, the African-American community right to the south of the Academical Village has long been omitted in historical paintings and drawings but now is included in the scope of the project. The expansion of the extent also brings an opportunity to show Thomas Jefferson's initial vision for the entire University beyond the Academical Village, even though many of his ideas have never been realized.

[1] http://juel.iath.virginia.edu

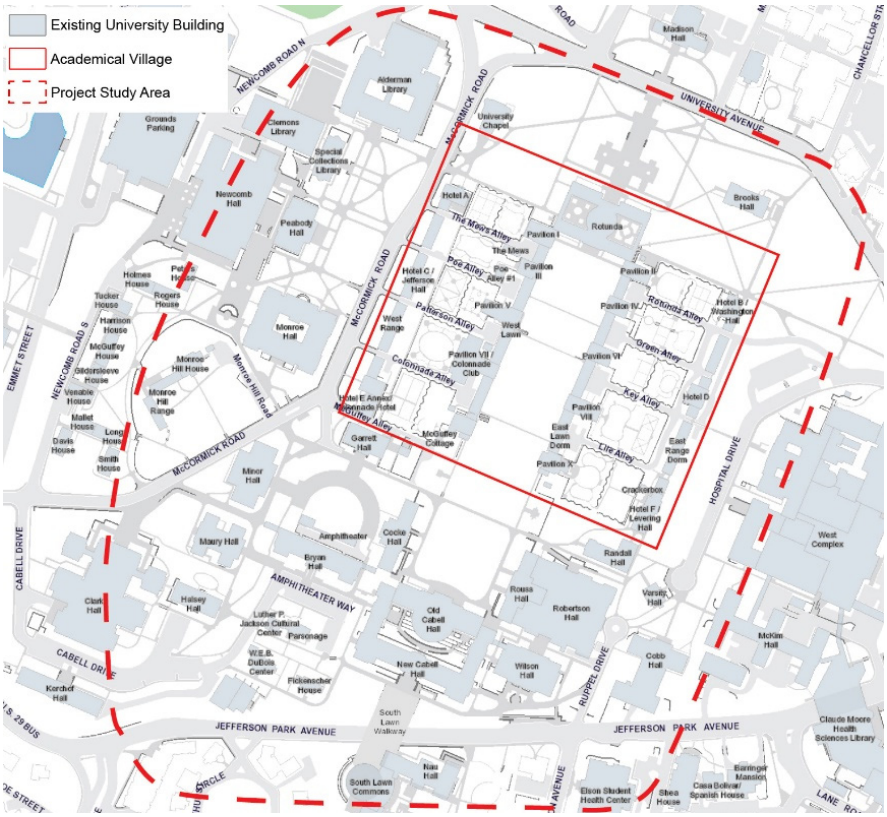

Fig. 1: Project study area

The core of this project is a spatially – and temporally – enabled database that serves as a depositary of all the large data collections mentioned above. Relationships and links are established internally between data sets, as well as externally to connect to library catalogs and other databases (Figure 2). Topography is one of the first data sets in the database because it not only serves as the reference for georeferencing historical data, but also as the foundation for 3D modeling work. The latest 2016 LiDAR (Light Detection and Ranging) survey is used to recalibrate many of the previous GIS data sets. By removing existing buildings and structures retrospectively, we are able to interpolate and regenerate historical topography and hydrography in different time periods. Many historical maps and drawings from different studies and collections are georeferenced and digitized. The 2013 Cultural Landscape Report commissioned by the Office of Architects is the first comprehensive landscape survey of the Academical Village, covering changes of vegetation, topography, pavement, buildings, etc. in the past 200 years. We not only converted and georeferenced all the CAD drawings produced for the report into GIS, but also sort features into thematic GIS layers. Some notable trees and structures that have significance in history are documented and highlighted in the process. Another important GIS data set comes from the historical photo collection curated by the University Library. Because most of the historical photos were taken by medium format camera in the late 19th and early 20th century, we are able to estimate the angle of view and identify the approximate location where the photo was taken for each photo. This indus-

trious effort creates data points that connect to the library's historical photo catalog, so that users can find historical photos by keyword, location, or time.

To make sure the final product reflects academic rigor, a Zotero online reference database is created to host all the journal articles, books, and other references we have used to create our geographic features in GIS. This way, we can always trace back from web visualization to scholarly research as a way to authenticate visualization according to current research. Because Zotero is cloud-based, it is convenient to make future additions and corrections if new researches present new findings.

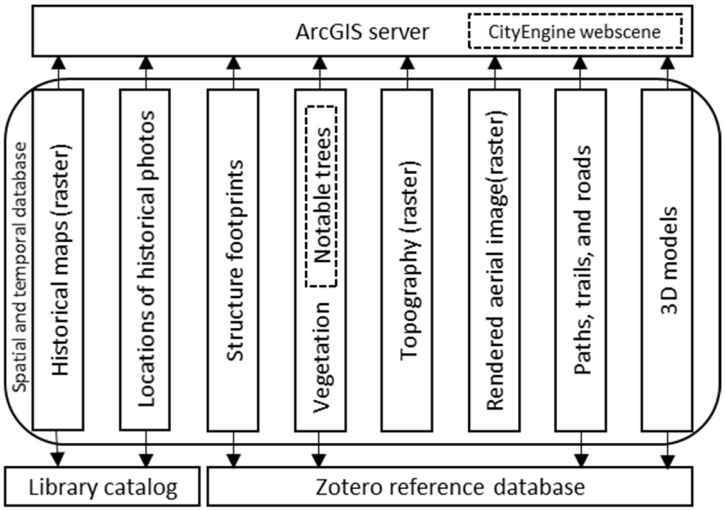

Fig. 2:
Database structure

Finally, all the time-enabled data layers are overlaid, symbolized, and published onto an ArcGIS Server. The web interface is created by using ArcGIS Online's Webapp Builder. It allows users to query this rich geodatabase, reference database, and library's multiple catalogs by theme, time, or space (Figure 3).

The most challenging task in the project is the 3D modeling part. Although we have topographic data digitized from historical maps and the 2013 Culture Landscape Report, they are largely inaccurate when compared to modern day high-resolution LiDAR data. A lot of calibrations of historical topographic data by matching geographic features have to be done. The VCG project has also inherited some 3D digital models of buildings from previous research projects, but additional modeling work is needed for many non-landmark structures in history, including shelters, kitchens, and work yards in which enslaved labors used to work (UNIVERSITY OF VIRGINIA 2018). For example, in the VCG project, we noticed an addition of a circular winter gymnasium right in the middle of the Academical Village on some maps dated in the 1860s. Unfortunately, due to the lack of historical photos and descriptions for this non-landmark building, there are not enough materials available to make a realistic 3D model of this winter gymnasium. Student researcher has to dive into early Proctor's papers for the construction expenses in order to determine if it had a tin roof, and the number of windows, etc. Even though the 3D presentation is difficult to be accurate, the research driven by 3D modeling is still valuable. The outcome model is in digital format that could be im-

proved over time when more information becomes available (REKITTKE & PAAR 2010). 3D modeling work based on historical topographical maps and buildings opens up new possibilities to simulate different historical scenes for analysis and investigation at multiple scales (KOLIJI 2011). But most importantly, it helps develop a more complete narrative about the history of physical environment beyond landmark buildings.

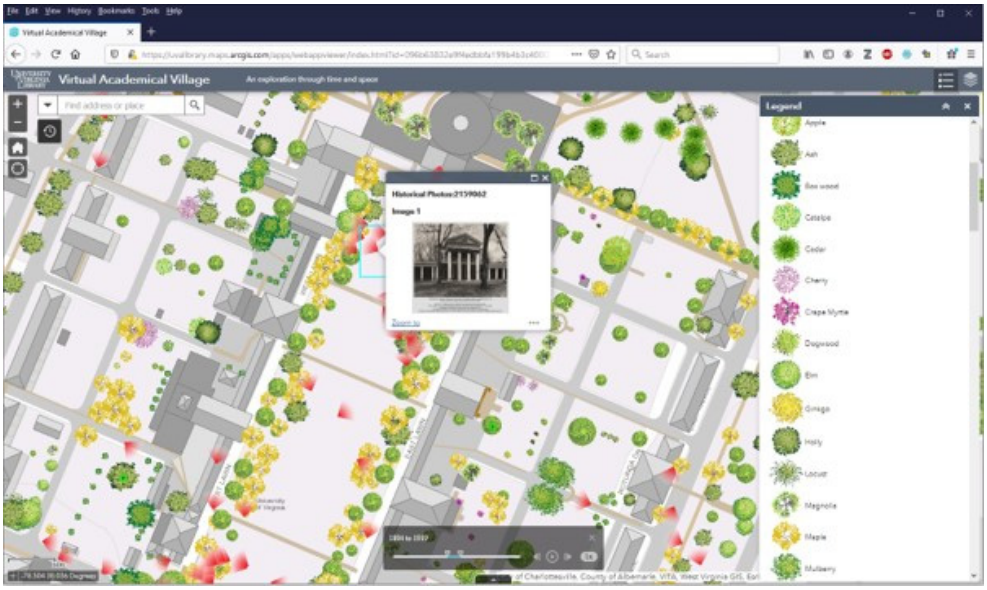

Fig. 3: A beta version of the final website that features historical buildings, vegetation, photos, etc. It allows users to query by spatial location and time slider. The red viewshed symbol is connected to a photo entry in the historical photo collection at the library.[2]

Most of the buildings are modeled in Trimble SketchUp or Autodesk 3DS max, and assigned real world coordinates in ArcGIS Desktop. The modeling of other auxiliary features, such as trees and roads, as well as the final integration are done in ESRI CityEngine thanks to the procedural modeling techniques. All the 3D contents are published to ArcGIS server and ArcGIS Online for public viewing. The time stamps associated with 2D features are carried over into the attributes of 3D objects, opening possibility of interactive 3D time animation on the web when technology matures. VCG project also uses 360 VR function in CityEngine to create immersive scenes that can amaze the public and achieve pedagogical goals. Selected VR scenes are created to highlight important views in history, and published to ArcGIS Online and Roundme.com website, for easy sharing on the web (Figure 4).

[2] The final website is still under construction, and expected to release in the summer of 2020. A beta version is now available for preview at http://gis.arch.virginia.edu/vcg/.

Fig. 4: Bottom: Today's view of the southwestern end of the Academical Village with the Old Cabell Hall at the end of the Lawn. Above: Virtual Reality scene showing a Pre-1898 view of the southwestern end of the Academical Village which was open to an African American community at that time.

3 Discussion

Although the project is still ongoing, and probably will never become finished because of new researches and new findings, it has already set up an expandable framework to stitch together vast collections of photos, documents, maps, and digital models using a spatial and temporal GIS database. With every piece of evidence geographically and bibliographically referenced, the system is now able to make a more authentic representation of the University's history. By modeling buildings, landscapes, and many other non-landmark objects such as shelters and kitchens, we now present a more complete narrative in which this World Heritage Site is not a group of landmark buildings, but a functional network of geographic features that have supported the operation of the university. Contributions from notable persons, professors, students, as well as enslaved labors and staff have been acknowledged throughout the project.

The Virtual Central Ground project has become a good case in understanding how knowledge distribution and acquisition might be changed in the new Web 3.0 era. Two decades ago, the standardization of protocols for sharing georeferenced maps over the internet led to an explosive growth of web mapping with mash-up technology in the web 2.0 era. Today, Web 3.0 has promised more intelligent and interactive web in the future. Web-based geospatial

platforms and projects will serve as new gateways for accessing knowledge and launching new intellectual inquiries. Several key features of Web 3.0 (SHARMA 2018) have been embodied in the project:

- Semantic Web

Future web is going to be a web of linked data. We have seen the evolution from static web in the Web1.0 era to interactive web in the Web2.0 era. The next era is to build a technology stack that allows people to create data on the web, and build vocabularies and rules for both humans and machines to query and handle data (W3C, n.d.). In order to achieve that, relationships among data sets are critical. In the VCG project, great efforts are made not only to convert data into common formats in GIS, but also to annotate the data collections in order to establish spatial, temporal, thematic, and bibliographic connections. On the VCG website, a user can go from buildings to vegetation, from historical maps to historical photos, from drawings of archaeological site to scholarly publications. VCG is presenting this important cultural landscape from different dimensions and perspectives with the support of multiple interconnected online databases.

- 3D Graphics

We have already witnessed strong growth of multimedia contents on the web. But the Web3.0 is introducing more 3D graphics onto the web supported by new hardware and software. Digital visualization is not for the sake of visualization any more. As shown in the VCG project, digital visualization is increasingly becoming an engaging gateway for learners and users to access vast knowledge organized as linked databases. On the other hand, visualization on Web 3.0 will be more human centric and care more about human experience with the help of VR. The purpose of presenting 3D contents in realistic and immersive environment with authenticity also drives new intellectual inquiry, as evidenced by the example of winter gymnasium mentioned above. What is important is that such new architectural history research driven by 3D modeling effort will help us better understand student life and university operation during that time period. The contribution of VR to a democratic and bottom-up decision-making process has already been noted in the planning and design practice (HEHL-LANGE & LANGE 2016, MOURAL et al. 2018). It's role in education of culture landscape is equally important. Especially when digital contents become publicly available on internet in a complete and authentic way, it provides an opportunity for the general public and future citizens to acquire the knowledge of real history, values, and dispositions necessary to enable them to be more effective in their democratic decision-making process (Print et al. 2002).

- Ubiquity

Another important feature of Web3.0 is its ubiquitous presence on different platforms and devices, including mobile and wearable devices thanks to the Internet of Things (IoT) revolution. The final web-based product of VCG supports multiple platforms, making it convenient to use. Future visitors to the University of Virginia can walk around the Central Grounds with VCG webapp loaded on their smart phone, location sensitive app will show nearby interesting sites, trees, and relevant documents for visitors to learn and explore. It is also possible to switch to a historical 3D view for a given time period. Because the webapp currently shares VR contents through links to Roundme.com, visitors will be able to turn on 3D immersive representation quickly, and use a VR viewer such as Google Cardboard to compare the historical scene to the existing one. When smart glasses become popular in the future,

users will even be able to project historical photos onto the glasses in order to have a hybrid view of past and now. Just as Humphry Repton (1752-1818) used Red Books to compare representations of before and after, these side by side or hybrid representations of past and now are helpful in expanding and correcting our imagination of past landscapes, or at least setting up stage for intellectual discussion and inquiry (REKITTKE & PAAR 2010).

Thomas Jefferson, the founding father of the University of Virginia and author of Declaration of Independence, embraced new technologies and science during his lifetime, believing they could help build a successful and independent democracy (MEIER 1986). Today, even though we are facing a crossroad of whether the Internet and new digital communication technology will tear our society apart or bring people together through shared values, the current dispute around monuments and landmarks gives us an opportunity to rethink the possibilities of digital technology in our education. When polarized views flood social media sites, we have to acknowledge that a history of biased views and opposing ideologies has prevented us from telling a complete and authentic history of the built environment. Even digital visualization has been used intentionally or unintentionally to misrepresent reality. Without ground-truthed evidence and educated citizens, it is difficult to have shared values. Fortunately, we also have digital technologies that can associate reconstructed historical environment with primary sources and scholarly researches to offer a more complete narrative.

Although many challenges, such as ownership and maintenance in the future, still remain, the VCG project has produced rich contents tailored for sharing a more complete history of this World Heritage Site with the public in the Web 3.0 era. Future users can witness and experience critical moments and evidence in history that are not visible in todays' physical environment. It is the intention of this VCG project that they can become more qualified and responsible citizens to participate in the democratic process reshaping our future physical environment.

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