

GT VR Tour: A location-based web VR campus tour solution for everyday-use

Junshu “Ted” Liu, Dr. Jay Bolter, Dr. Michael Nitsche,
Dr. Janet Murray
Georgia Institute of Technology
School of Literature, Media, and Communication
Digital Media

Abstract. GT VR Tour is a virtual reality (VR) application for people to take a virtual campus tour directly from web browsers. With the 3D model of the campus plus additional information and graphical decorations presented by multiple kinds of media (i.e. text, images, hyperlinks, etc.), The three-dimensional VR experience offers an intuitive and immersive perspective of the campus, along with information on hot spots and tourist attractions that helps people to learn Georgia Tech’s history and campus culture & tradition, which results in a fun, efficient, and interactive information visualization and story-telling. It runs on mobile with all WebVR-supported modern browsers, and with real-time location access enabled, users can see what’s around them directly from where they are standing. It also runs on desktop browsers as a standard web VR application, plus VR headset support as an optional choice for users. GT VR Tour is developed in A-Frame, a web framework for building virtual reality experiences, which makes our app possible to run on any WebVR-supported browser with outstanding graphical performance. Besides, users don’t need to install any third-party app on their devices, which makes people easier to access our app as first-time users. Finally, both the VR components for the information and the web elements for navigation and customization made up a user interface specifically designed for our web VR application. The great performance, ease of access, and friendly UI provides users a seamless user experience.

Keywords: virtual reality (VR), mixed reality (XR), three-dimension (3D), location-based, geolocation, web app, campus tour, information design, information visualization, story-telling, user interface design, history and culture

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Introduction

Ideation

Found in 1885, Located in Atlanta, Georgia Institute of Technology has a unique and profound history, culture, and tradition. As a new visitor, when you come to the Georgia Tech campus for the first time, you may have a lot of questions about where you are, what’s around, what is this sculpture and what’s the meaning of it, what is this building called, and which school/division/institute associated with it, and is there any event happening, etc.

Taking a guided tour on campus is something that people who are interested in GaTech especially would like to do. However, in the past 136 years, the way people take tours at GaTech has not yet been changed a lot.

- A popular option is to attend an in-person guided tour. Georgia Tech offers guided tours for visitors, and people can make a reservation for the tour; our school also offering FASET orientation for onboarding freshmen. That was helpful, but it was not flexible (reservation needed) and only happened once (if you need more information, you might don’t want to attend another tour again; instead, you have to search and ask other people for information by yourself).
- With the help of the Internet, there are more ways to discover GaTech from websites, videos, or a “Google Street View-like” virtual tour. However, these solutions are not interactive enough since users are getting information from multiple places and the information users received are fragmented, and the current solution of the virtual tour

is decent but did not offer enough detailed information, plus users have to take the guided tour by following a designed route, which is limited and not customized.

Our idea is to make a web application in the form of virtual reality to help users to explore the campus in an easy and fun way, which means that user - wherever they are - can visualize the information that they need about GaTech and its history, culture, facilities, and latest news from an intuitive user interface with a 3D virtual space. If they are on campus looking at something, they don't have to ask other people or search to find out what this place is about. Besides, they can take a campus tour with this app anytime, without the need to wait for a scheduled time. If they are off-campus, they can see and play with a complete, interactive 3D view of the whole campus, along with the information of each area, buildings, roads, and facilities on campus presented by texts, images, and videos. It also offers a recommended path of visit, while users have the freedom to visit anywhere on campus by their own preference.

At first, I was thinking about making an Augmented Reality experience specifically for on-site mobile usage. The issue is that we can't guarantee that if the information and media can be placed at the exact geolocation, which will cause an uncertain or even worse user experience. Using AR could also reduce battery life, especially for a mobile application that will be used when people are outside. One other problem is that making an AR app will make it only available for mobile. Plus, in light of the COVID-19 pandemic, people currently prefer to reduce traveling and may prefer not to visit places on-site for convenience and safety, so we should not ignore people who would like to take a virtual tour at home using a regular desktop app. Another reason to adopt the off-campus VR solution is that the off-site virtual campus tour also offers an advantage in promoting & advertising Georgia Tech to people before they visit our campus, or who haven't had a plan or unable to come to visit. Finally, make it in VR means that it will be compatible and accessible through more platforms including desktop browsers, and even hardware devices like VR headsets that can enhance the VR experience.

From other VR/AR/XR case studies, there are several types of research, projects, or futuristic concepts that led me to the direction of a VR interface while offering an AR/XR-like interactive experience. An augmented reality application for cultural heritage communication that was used in a museum is a great example for mixing real-life artifacts and virtual

artifacts with extra information. In this example, users can hold their phone in front of an artifact to see what it used to look like originally in historical periods[1]. This became my major inspiration to switch my idea from a camera-based AR app to a location-based virtual reality app that also offering interactive, mixed reality functionalities. Besides, another Augment Reality concept, "Hyper-Reality"[2], shows a fantastical feature of what the world could look like in the first-person view, with more information shows up based on the real-life objects. While this is an exaggerated example and shows the side effects of information overload, its positive side and futuristic looking became an inspiration for me to design a 3D world with information that is intuitive for users to view and interact with.

Platform & Frameworks

To create an app that is easy to access for everyone, especially new users, we decided to make it a web-based application. Users, in any case, don't need to install any third-party app. This avoids the extra steps for first-time users to go to the App Store, search the app, install the app. Extra steps would only discourage first-time users to try the app in the first place.

To make a web-based VR app, we chose A-Frame, a virtual-reality development framework. An A-Frame app allows users to view and interact with VR components directly from any modern web browser that supports WebVR [3], either on mobile, tablet, or desktop. Besides, A-Frame also natively supports selected models of VR headsets for a more immersive user experience [4].

We have also adopted some other third-party frameworks based on A-Frame, including the A-Frame HTML Component to display HTML elements that can be customized with CSS styling, which improves the design of the VR user interface.

Finally, for location mapping, I used plain JavaScript to map the 3D model upon the A-Frame coordinate with the geolocation coordinate, which made the location feature possible.

We are using JavaScript for the development of this app. Besides, we are also using HTML and CSS to develop UI for both the VR space and the navigation and customization panel. Also, because the embedded HTML components in A-Frame and the general web page have different styling, I used Sass to easily manage styling for each class associated with each interface by nesting CSS selectors.

Target Users

GT VR Tour is designed for everyone, especially people who are interested in Georgia Tech and its campus culture, or in need of getting the latest information (i.e. events) of GaTech associated with the location.

Prospective students (i.e. new high school graduates) who want to apply for/are admitted to GaTech need this web app to explore the campus when they are presented on the site (mobile), or even before they visit for the first time (desktop).

Current students who need more knowledge of the campus they spend most of the time on can use this web app to get to know the latest events happening nearby. This app will also be helpful when students explore new areas on campus that they have just accessed by telling the history behind this place.

This app is designed for everyone; users do not need to have previous experiences or knowledge in VR/AR games or apps.

Design

Our goal is to design a next-generation campus tour experience that is immersive, informative, and interactive.

I. Immersive

With a well-crafted 3D world that replicates the Georgia Tech campus in a virtual space running on the web, GT VR Tour offers an immersive visual experience for mobile, tablet, desktop, and VR headsets.

Design Guideline 1: Know what's around you from exactly where you're standing at

When using it on a mobile device, such as a smartphone or tablet, users will be able to view where they are located but represented in a virtual 3D space, in either bird view or first-person point-of-view (POV). Users need to hold their devices like they are taking pictures. While holding the device and applied real-time location positioning, the virtual campus view is now relocated to exactly where they are presenting. Users can now manually swiping camera view using their finger to locate the exact building/area/artifact they're looking at, and change their device's orientation by holding their device while rotating their body (in other words, changing where the device is pointing at) for more surroundings, to browse and learn what's around and get their question answered. With the help of the location feature, the information is showing up right in front of them, which offers an immersive, mixed reality experience; and since users are questioning about what is in front of them, holding the phone, locate, and pointing at

this building/space/artifact is a natural user experience compared to searching through the web.



Figure 1. Know what's around you directly from where you're standing at.

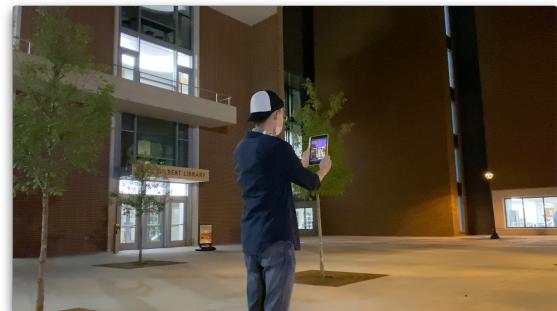


Figure 2. This is a picture of me testing the application, which also shows what a user will use this app when they're on campus.

When using it on a desktop browser, users have the freedom to browse the virtual GaTech campus using their mouse and keyboard. Natively, both WASD and direction keys are supported in A-Frame for changing camera positions. This is easy for users who have gaming experiences on PC. Users can also switch between bird view and first-person point of view.

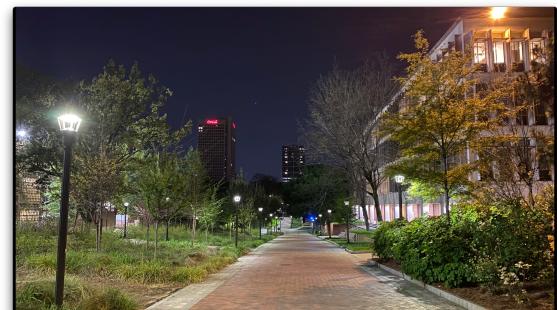




Figure 3. A comparison between the real campus and GT VR Tour's virtual campus, representing the same location and viewing angle.

II. Informative

Besides the 3D models of buildings and sculptures on campus, including text, image, and hyperlinks & buttons placed on campus' hot spots gives information about these places, which helps users to learn about these places without the need of searching. The way GT VR Tour tells stories is visually intuitive.

Design Guideline 2: Information Design for a 3D interface

Unlike designing a story-telling, informative web/mobile app in a 2D interface, design for a 3D virtual space needs more thought and testing based on multiple user scenarios.

The information should be easy to access. For on-site users, when people saw an artifact, area, or architecture and need information about it, our app should help them visualize information as fast as possible. Therefore, the place to put information is considered. For buildings, information should be placed at front of all entrances; for sculptures, depends on the shape, the information should be placed wherever users are likely to stop and observe.

User Scenario: What's Around?

Robert is visiting the Georgia Tech campus in Atlanta for the first time. Around him are a large green grass area, a building under construction, and another few buildings on the other side. He opened GT VR Tour on his iPhone. After enabling location and orientation, he can see a virtual Georgia Tech campus. By pressing the “Get my location”, wait for a second, and then pressing the “Position me on the virtual map” button, the campus view now switched to exactly where he is standing. The camera orientation for the 3D campus view also changes when his camera is moving. He can also use his finger to modify the camera orientation manually.

User Scenario: Coffee

Georgia Tech students cannot live without coffee. By the time I'm writing this paragraph, it's 1:01 AM and I'm extremely exhausted because this paper is due today. So as any Tech students that have tons of work to do, a coffee shop is important than anything on campus, especially when you decided to have a late-night study in the library. Before you visit the library, you might want to grab a cup of coffee from Starbucks, but unfortunately, the one at Clough has closed.

Jennifer standing in front of Clough just found this out is disappointed. As well as Paul, who has already heard this news, realized that he need some caffeine when he almost arrived at Price Gilbert.

Jen opened the GT VR Tour app, holding the phone and looking around to see what happened. She knows that the Starbucks is temporarily closed from April 3 to May 15, but for now, there's another alternative nearby, which is a new coffee shop located on the Ground floor at Crosland Tower. An arrow directs Jennifer to walk to the tower.

So as Paul in front of the entrance of Price Gilbert and Crosland Tower, who just found out that there's a coffee shop downstairs at Crosland Tower and he can access through either Price Gilbert or Crosland since these two buildings are connected.

III. Interactive

1. Location-based

As mentioned in the “immersive” session, the application allows users to view what they're looking at with more information at the same angle, by holding the device in front of their eyes.

2. Hyperlinks/Buttons

Design Guideline 3: Get information in the first place, without more users' actions

In front of an artifact, area, or architecture, besides a paragraph of introduction, there are also buttons or hyperlinks that help users to learn more about this place, and even help them to access the resources of this place for their potential needs, which offers an easy way for users to access extra information without user's further actions like searching on the web.

User Scenario: Book a Room in the Library

Tom is a freshman at Georgia Tech. He brought three of his friends, Samantha and Nicole together as a study group to visit the Crosland Tower, as known as the library, for the first time. Before they arrived at the library, they discussed and think that it would be better to study in a private room, if there are

any in the library. However, they didn't know and haven't tried how to book a room in the library. Instead of searching on Google or browsing through the school's website, Tom opened GT VR Tour on his iPhone and pointing at the Crosland Tower's building. He can see the building's name, one paragraph of the introduction of this building, and a button called "Reserve a Room". By clicking on this link, Tom was redirected to a webpage that is for Tom to reserve a room at this library for him and his friends. Therefore, in front of the library's entrance, they have just reserved a room that will be available for the next 10 minutes. Before the room being vacated, they can either wait or buy a coffee on the Ground floor in the library.



Figure 4. Information placed in front of the Crosland Tower, along with a button for users to access the room reservation system for this building.

Development

Part 1. Contents and Materials

In order to offer an immersive, informative, and interactive campus tour, contents and materials are needed for implementation.

1. 3D Models

The use of 3D models provides an intuitive and immersive view of the 3D virtual space of the whole Georgia Tech and other nearby buildings. These 3D models are provided by Georgia Tech's Interactive Media Architecture Group in Education lab (IMAGINE Lab).

The 3D model package includes a massing model of the whole Georgia Tech campus without textures, and also a textured model with selected areas that is the most important part of the campus tour. Both versions provide terrains, while I kept the terrain for the textured model since it looks cleaner in the A-Frame virtual space when browsing in both the bird view and point-of-view. Both 3D model files are in OBJ format.

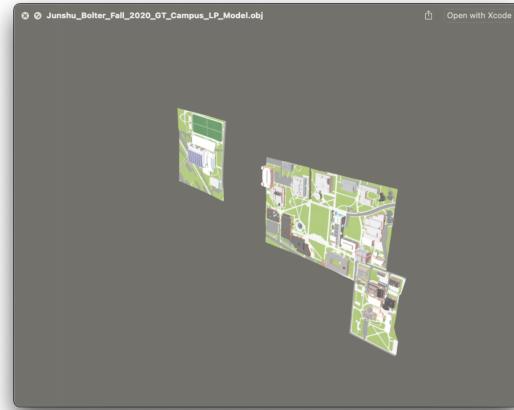


Figure 5. Textured 3D model includes selected areas on campus.

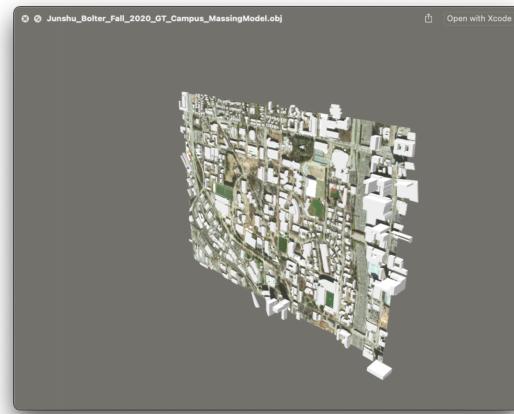


Figure 6. The 3D model with non-textured buildings for the whole GaTech campus, plus surrounding buildings.

2. Information

As shown in the "Design" session, information of each artifact or architecture on campus is shown next to them, for users' convenience to learn about them. Information is in multiple form factors, such as 2D & 3D text, image, or embedded HTML components that support more interactive features, such as multiple pages, and buttons & hyperlinks. Texts and images are originally supported by

A-Frame; and *HTML Embed*, a component created for A-Frame, is developed by GitHub user superreggbert [7], which is using the advantage of A-Frame's support for components.

3. Contents

The purpose of this app is to tell Georgia Tech's story and help people to learn our history and culture. Most of the contents are originally from Georgia Tech's website.

Part 2. A-Frame and 3D Model Implementation

1. A-Frame Prototype

Before the 3D model was delivered, I have built a rapid prototype in A-Frame showing what this app might look like. To represent that I will have texts added around the buildings and places, I used an A-Frame box that represents Clough Undergraduate Commons and a green rectangle for Tech Green.

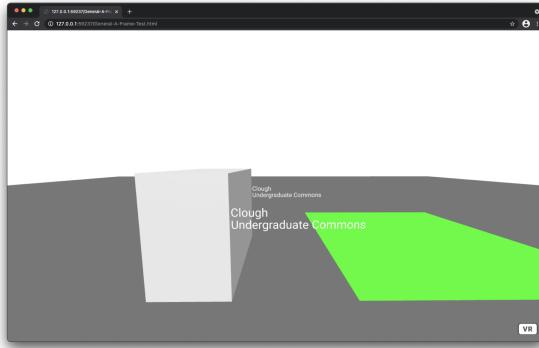


Figure 7. A rapid A-Frame prototype showing my idea of how to build this 3D space. Text "Clough Undergraduate Commons" is showing next to the A-Frame box that represents this building.

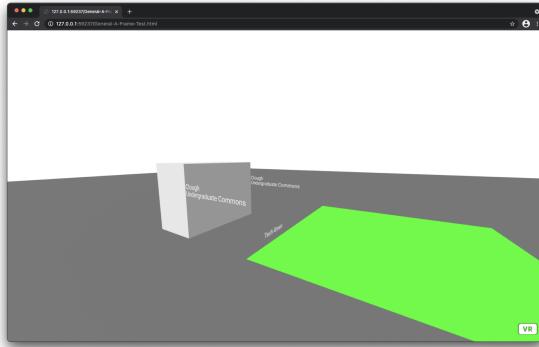


Figure 8. Another angle shows "Tech Green".

2. Modifying 3D Model

The original 3D Model needs to be repositioned, rescaled, rotated, reformatted, and combined, in order to fit the A-Frame virtual space. I've tested on the textured model first. After several testing, the modified textured model works perfectly on A-Frame. The camera moving speed looks just fine with the rescaled size. Besides, these two 3D model files are combined as one full model. Repeated buildings in these two models were solved by deleting these buildings from the non-textured model and replaced those as textured buildings. Finally, the model is reexported in GLTF format, which is recommended by A-Frame.

Part 3. Location Mapping

In order to implement the location feature, the camera position of the A-Frame view should be translated from the user's current location. To implement this, the coordinate of the A-Frame virtual space should be mapped into the geographical coordinates in latitude and longitude.

The mathematical equation for mapping numbers is [5]

$$Y = (X-A)/(B-A) * (D-C) + C$$

It applied for both latitude and longitude mapping. For latitude, the equation is

```
mapped_latitude = (current_latitude - latitude_of_the_first_sample_location) / (latitude_of_the_second_sample_location - latitude_of_the_first_sample_location) * (the_Z-coordinate_value_of_the_second_sample_location_in_this_A-Frame_space - the_Z-coordinate_value_of_the_first_sample_location_in_this_A-Frame_space) + the_Z-coordinate_value_of_the_first_sample_location_in_this_A-Frame_space
```

The same applied to the longitude.

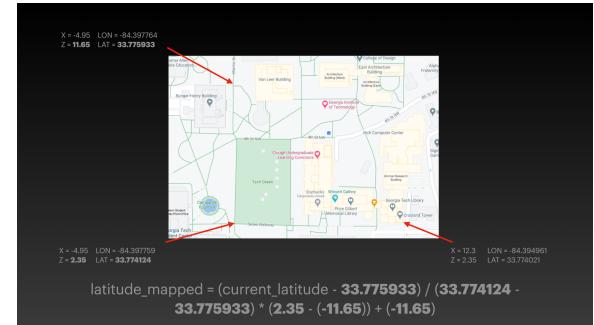


Figure 9. Mapping latitude.

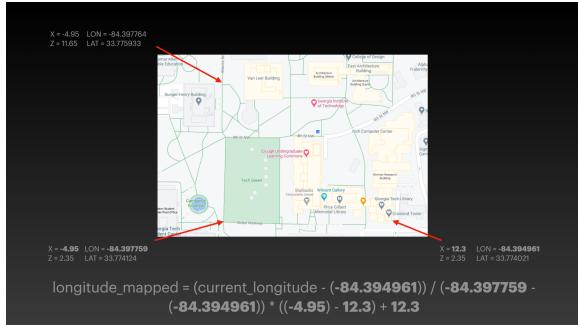


Figure 10. Mapping longitude.

The location mapping is implemented in the index.js file. On the webpage, the “Step 1. Get my location” button linked to the `getLocation()` function, which is to save users’ current location and translate the current geographical coordinate to the A-Frame camera position using the equation mentioned above. The “Step 2. Position me on the virtual map” button is for users to set the camera to the updated camera position that matches users’ current location, by calling `setCamera()` function. After pressing the “Step 1” button, it is recommended to wait for a second or two to update the location in the background, and proceed to “Step 2” for updating the camera view.

Part 4. Virtual Reality UI Development & More Features

At this moment, we now have a framework for a 3D space that is mapped with geographical coordinates. For the rest of the development, we started focusing on updating content following the design guidelines and design goals mentioned above.

Besides, there are additional two hyperlinks for users to customize their camera view. The “Bird View” hyperlink is calling `birdView()` function in index.js to change the height (Y-axis) of the camera view to a higher position, in order to offer a bird view. Same for the “POV” button that called the `povView()` function to lower the camera.

Further Thoughts

This app provides major content for campus tours, while due to the limitation of time and resources, more details need to be added for each building, road, sculpture, etc.

In addition to the location feature, adding real-time orientation support to make the camera position matches the compass orientation could deliver an even better user experience. Currently, users can rotate the camera view with finger swiping

to correct the camera position, in order to locate the building/artifact they want to look at. With compass orientation integrated, the camera view for the virtual world can match what directly in front of them automatically, so users don’t need to locate the building/artifact manually.

Brand Design

We believe that GT VR Tour will be an essential tool for future Yellow Jackets and visitors. The branding of this app should be clearly distinctive and easy to recognize in light of Georgia Tech’s visual identity, from the logo, typeface, to the user interface.

The logo of the GT VR Tour consists of a graphic icon of the Kessler Campanile, a spiraling sculpture that represents the past, present, and future of the Institute [6]. The letter “V” in “VR” is combined with the Kessler Campanile icon. Both the Kessler Campanile and a 3D model of the Yellow Jacket mascot without texture in the background represent that this is an app designed specifically for Georgia Tech. Besides, the lower-left corner has an icon that represents “location”, which highlights that this is a location-based application.

The app’s user interface, for both the embedded HTML components in A-Frame and the general UI elements for the web page, followed GaTech’s official branding guidelines with the use of GaTech’s signature color scheme and typography. The background color is Navy Blue (#003057). For texts on the top of both embedded HTML components on a transparent background and web page on the Navy Blue background, the text color is white with Buzz Gold (#EAA00) glowing effect, in order to make the text easy to read on the screen.

The font used for A-Frame 2D texts, embedded HTML components in A-Frame, and webpage is Roboto, one of Georgia Tech’s official brand typefaces, also a free font offered by Google, Inc.



Figure 11. GT VR Tour’s logo.

Conclusion

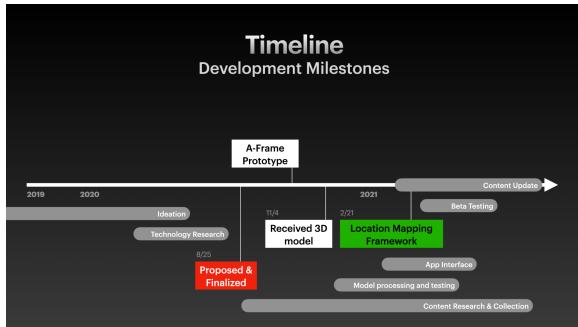


Figure 12. Development Timeline of GT VR Tour.

The development of the GT VR Tour app results in a full, legacy framework of the location-mapped 3D space of the Georgia Tech Atlanta campus and surrounding areas, which provides unlimited possibilities to add information, contents, and stories into this massive virtual 3D space. It has a lot of potentials and rooms for updates in the future.

This is GT VR Tour, the next-generation campus tour experience that offers an interactive, immersive, and informative user experience designed for everyone in everyday use. And our journey has just begun.

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