TourAR – Augmented Reality and Tourism

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ABSTRACT

TourAR is an augmented reality application built with WebXR frameworks to improve user experience in tourism. It provides users with features: 1) displaying target locations' names and Google ratings as labels floating or attached to the target locations based on their geolocations; 2) highlighting target locations by dimming the background and displaying the target locations with green highlight or normal lighting; 3) summoning a virtual tour guide to commentate on the target locations; 4) navigating to a target location. Furthermore, we conducted user studies to improve the design and user experience of TourAR.

Author Keywords

Augmented reality; tourism; mixed reality; mobile application; WebXR.

CSS Concepts

• **Human-centered computing~Human computer interaction (HCI)**; *Augmented reality*; User studies;

INTRODUCTION

When people visit new places and need information about such places, they must search on multiple platforms to obtain business information, Google ratings, GPS navigation, etc. TourAR addresses this issue by displaying multiple sources of information in one application.

With the help of augmented reality, TourAR conveys tourism information intuitively with its four main features:

1. Label. Desired locations' names and Google ratings are displayed in floating labels or attached labels based on whether the user is located in an open area, a populated area, or a hybrid area. The categorization of different areas is based on predefined geofences.
2. Highlight. When the user presses the highlight button, the background is dimmed, and the desired location is highlighted with a green filter or normal lighting.
3. Tour guide. The user has an option to summon a virtual tour guide to commentate on the desired location.
4. Navigation. When the user presses the navigation button, a dotted line appears leading to the target location.

CONCEPT AND RELATED WORK

As we were exploring concept and design, we were inspired by two design concept images on the internet and some feedback and suggestions provided by our instructor, Dr. Ryo Suzuki.

Concept 1 - UI and floating labels

Figures 1 and 2 are design concept images about AR and Tourism, which inspired us to design the feature of displaying floating labels. Figure 2 also inspired us to have three buttons in the main UI for camera, highlight and navigation. Figure 3 is a design concept we made to display floating labels to identify mountain tops, which later transitioned to the feature of displaying floating labels in open areas.

Figure 1. Concept image of the label feature (Morozova, n.d.).

Figure 2. Concept image of the label feature and app UI (Zumoko, 2018).

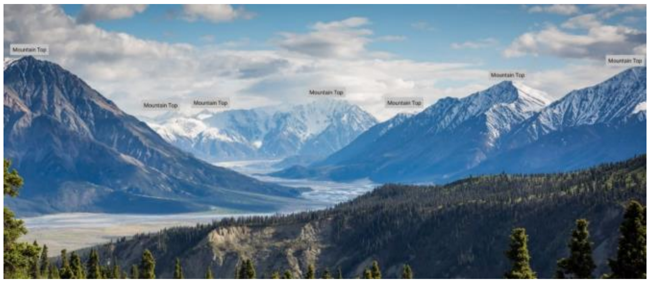

Figure 3. Concept image of label feature edited based on (Emsley, 2016).

Concept 2 – Highlight

This feature was suggested by Dr. Suzuki. Figure 4 is a generic photo based on his suggestion on the highlighting feature that changes the background to monochrome and displays the location with a layer of bright colour. This concept later transitioned to the highlighting feature that dims the background and display the location with a green layer or with normal lighting (a transparent layer).

Figure 4. Concept image of the highlight feature (Fotor, n.d.).

Novelty

Based on our user study, we design TourAR to use the user's current geolocation to determine the best way to display labels. We implemented geofences to achieve this; if the user is located in an open area, floating labels are displayed; if the user is located in a populated area, attached labels are displayed. In addition, the tour guide feature can provide an immersive AR experience by letting the user to watch a virtual tour guide's commentary with voice. Furthermore, TourAR's highlighting feature can be toggled on to lock on a desired location.

SYSTEM

TourAR is an augmented reality application built with a WebXR framework, 8th Wall and an open-source library supporting GPS-related features, AR.js. It is cross-platform and runs on mobile web browsers. Many virtual objects in TourAR are positioned based on their GPS coordinates, so the user's permissions to access GPS, motion sensor, and camera are required to allow TourAR to function properly.

Location data collection and geofencing

Floating labels and highlighting filters are positioned based on their GPS coordinates. The user's current location is also categorized as a part of an open area, a populated area, or a hybrid area based on predefined geofences. Therefore, TourAR collects the user's current location on each frame. The collected GPS coordinates are compared to the predefined geofences (see Figure 5) so that certain virtual objects are shown or hidden based on which type of area the user is located in. Geofences are defined based on the latitude-longitude coordinates (obtained from Google Maps. See Figure 6) of the vertices of rectangles representing populated areas and hybrid areas.

```
let isFar1 = true
AFRAME.registerComponent('hiddenfar1', {
  init() {

  },
  tick() {
    let latitude1 = 0
    let longitude1 = 0
    navigator.geolocation.getCurrentPosition((position) => {
      latitude1 = position.coords.latitude
      longitude1 = position.coords.longitude
      // console.log(latitude1);
      // console.log(longitude1);
      if (latitude1 >= 51.08 && latitude1 <= 51.09 &&
      longitude1 >= -114.145 && longitude1 <= -114.135) {
      // if (latitude1 != 51.08723170868223 || longitude1 != 114.13805922292853) {
        isFar1 = true
        // Smart:   latitude: 51.08723170868223;  longitude: -114.13805922292853
        // Current: Latitude: 51.085311999999995, Longitude: -114.1407744
      }
      if (isFar1) {
        document.getElementById('textSmart').setAttribute('visible', false)
      }
    })
  },
})
```

Figure 5. Code snippet of GPS coordinates collection and geofencing.

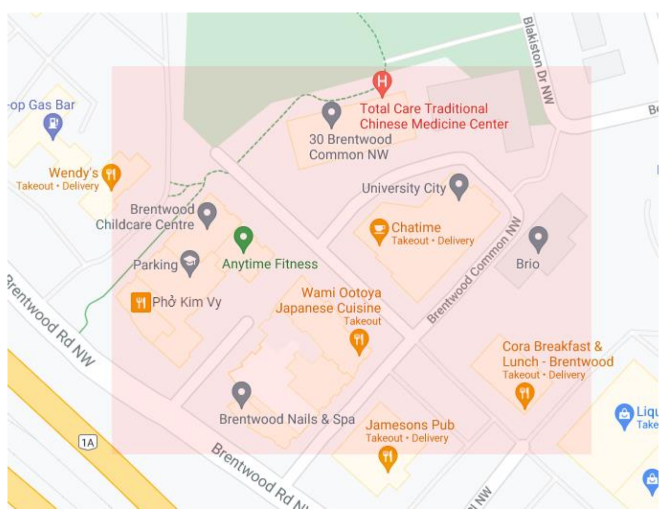

Figure 6. Geofences of a populated area edited based on (Google Maps, 2021).

Feature 1 – Labels

Based on the user study, we made two types of labels, floating labels and attached labels, in three types of areas based on the user's current location and geofences we implemented, open area, populated area, and hybrid area. Floating labels are labels positioned based on their GPS coordinates shared by their physical counterparts, such as buildings as the target locations in the real world, so these labels visually appear to be floating over the target locations. Attached labels are labels positioned on a surface of the target locations, such as signs, windows, and doors, so these labels visually appear to be attached to the target locations.

Open area

An open area is an area with lots of surrounding open space, such as parks and parking lots. There is less interference for GPS signal due to the lack of obstruction from high-rise buildings, and the user tends to be far from the target locations; therefore, this is the best environment for floating labels. Since most of the areas are open areas, there is no geofencing for open areas. Floating labels are demonstrated in Figures 7 and 8.

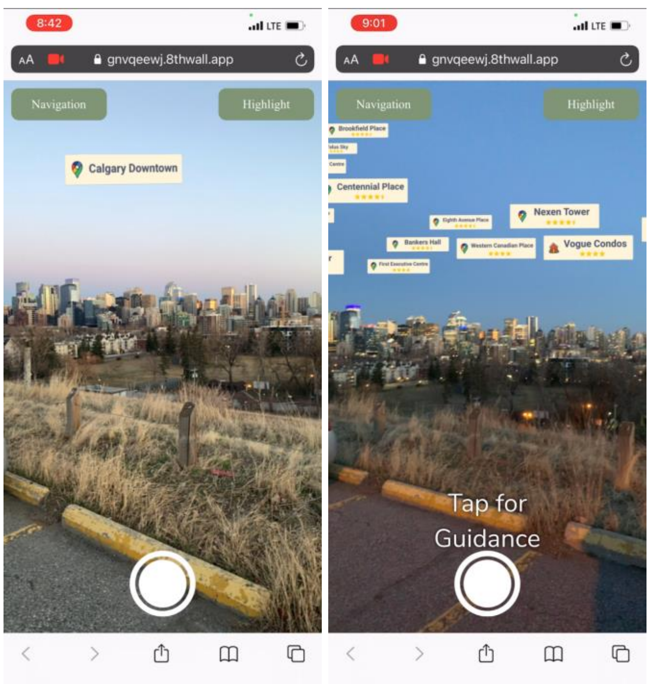

Figure 7 and Figure 8. Screenshots of floating labels in an open area.

Populated area

A populated area is an area surrounded by high-rise buildings, such as downtown districts and apartment complexes. There is more interference for GPS signal due to the surrounding high-rise buildings, and the user tends to be close to the target locations; therefore, this is the best environment for attached labels. Geofencing is implemented for areas surrounded by high-rise buildings. Floating labels are demonstrated in Figures 9 and 10.

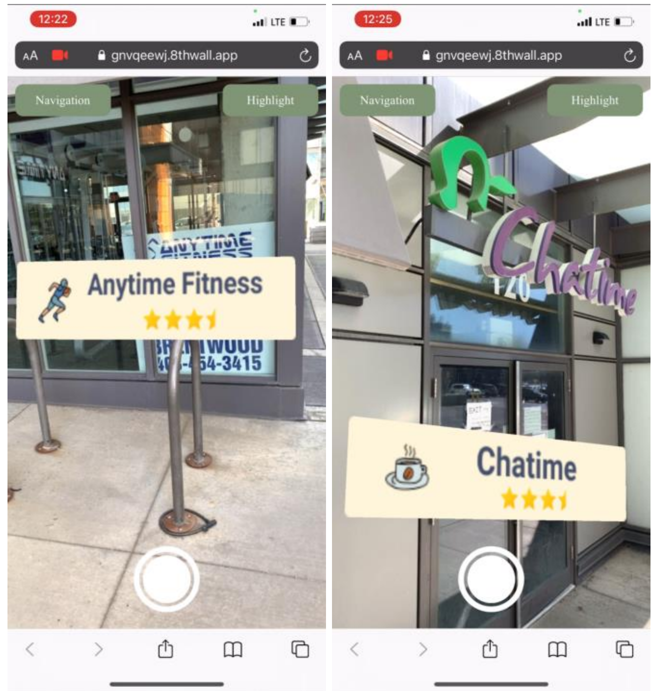

Figure 9 and Figure 10. Screenshots of attached labels in a populated area.

Hybrid Area

A hybrid area is an area surrounded by some open space and some high-rise buildings, such as university campuses. There is more interference for GPS signal near the buildings and less interference in the open space, and the user can be close or far from the target locations; therefore, floating labels are displayed when the user is far from the buildings, and attached labels are displayed when the user is close to the buildings. Geofences are implemented for both open space and buildings' surrounding areas within the hybrid areas. When the user is in the open space of the hybrid area, floating labels are displayed (see Figures 11 and 12); when the user is near the buildings of the hybrid area, attached labels are displayed based on object tracking (see Figures 13 and 14).

Feature 2 – Highlight

When the highlight button is toggled on, the background of the camera feed is dimmed from the addition and colour adjustment of <a-sky> primitive. The target locations are displayed with normal lighting (a transparent layer. See Figures 15 and 16) or a layer of green highlight (see Figure 17 and 18). Floating labels are displayed at the highlighted locations. Based on the feedback from the second user study, highlighting with a green layer can be potentially helpful in a low-light environment, so we tested this use case (see Figure 22).

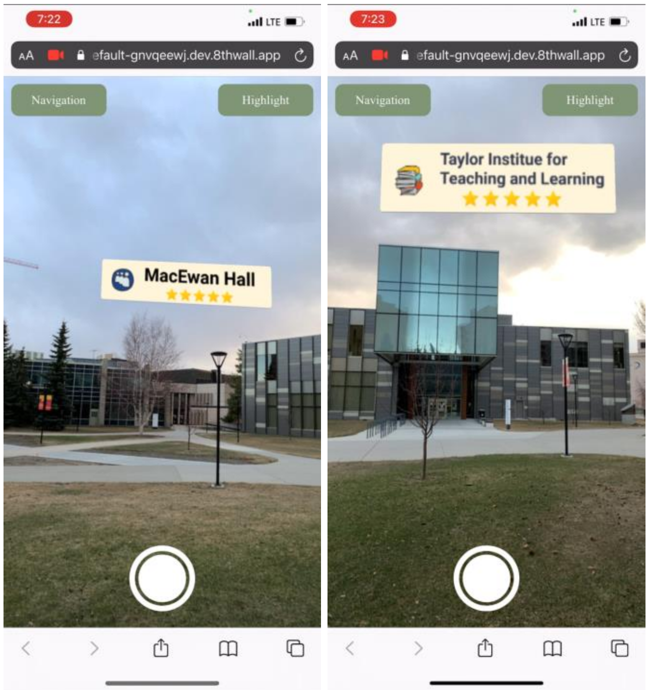

Figure 11 and Figure 12. Screenshots of floating labels in the open space of a hybrid area.

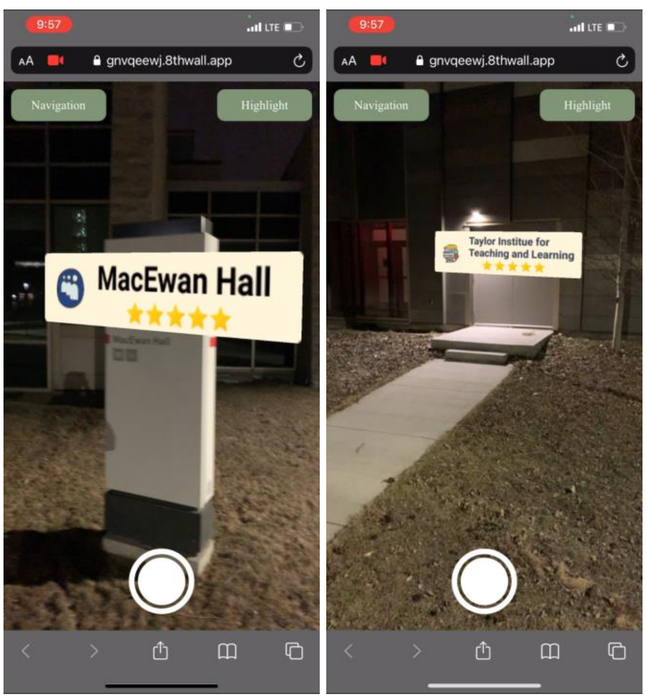

Figure 13 and Figure 14. Screenshots of attached labels near buildings in a hybrid area.

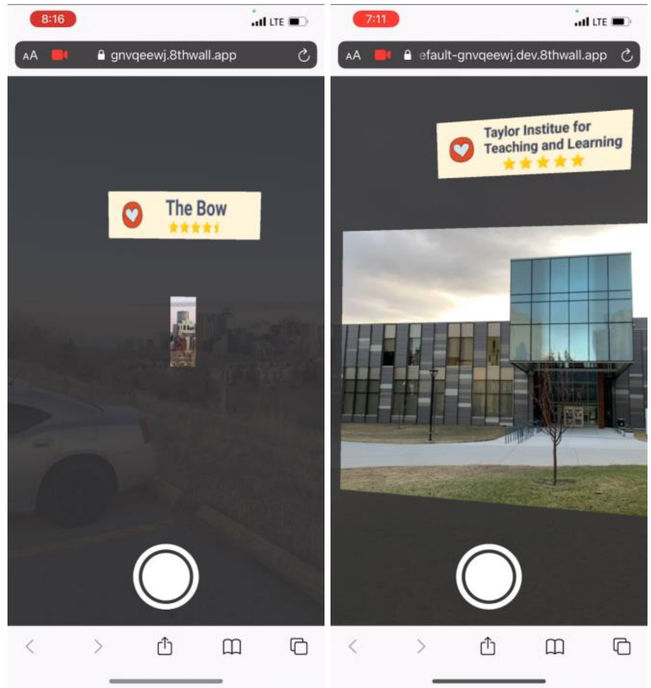

Figure 15 and Figure 16. Screenshots of highlight with normal lighting (a transparent layer).

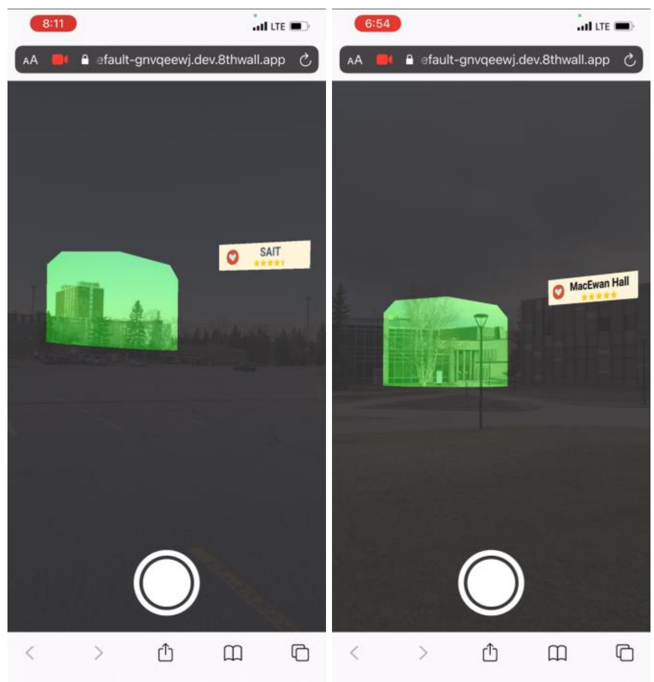

Figure 17 and Figure 18. Screenshots of highlight with a green layer.

Feature 3 – Tour guide

"Tap for guidance" is displayed on the lower half of the screen to remind the user of the option to summon a virtual tour guide to commentate on the target location. The user can tap on the screen to summon a virtual tour guide on the ground, which corresponds to the location on the screen (see Figures 19 and 20). Ideally, the virtual tour guide can provide guidance with customized voices and gestures based on the target locations. Due to the time constraint, a .hcap 3D model from 8th Wall is used for this prototype.

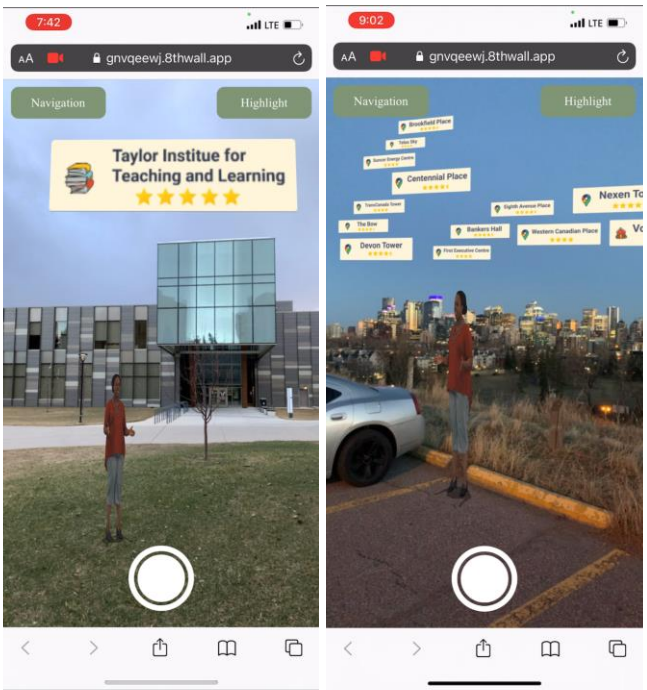

Figure 19 and Figure 20. Screenshots of the virtual tour guide.

Feature 4 – Navigation

When the navigation button is toggled, a dotted line is displayed on the ground leading to the target location. The dotted line consists of many small 3D arrows as "dots" pointing at the target location. A floating label is displayed at the target location (see Figure 21). At the same time, the highlight button can also be toggled to highlight the target location with a green layer (see Figure 22).

Supplemental feature – Photo capture

When the photo capture button (circular button at the bottom of the screen) is pressed, a photo of the current screen view is captured (see Figure 23), including the camera feed and virtual objects. The user has the option to press the download button (see Figure 24) to save the photo or press the exit button to return to the main interface.

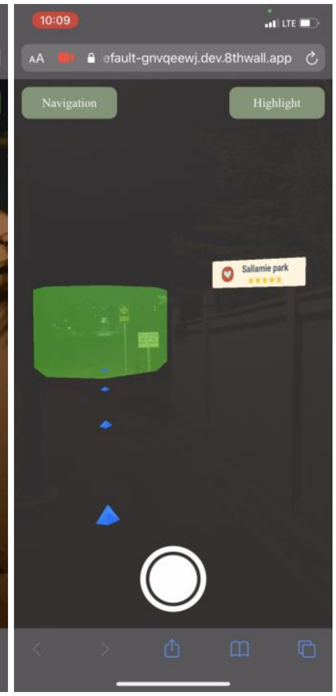

Figure 21 (left). Screenshot of the navigation feature.

Figure 22 (right). Screenshot of navigation feature with location highlight toggled on.

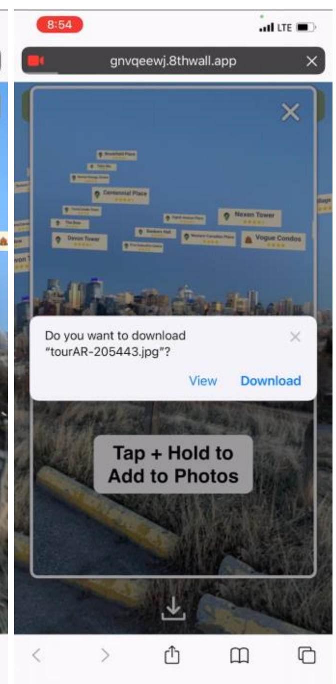

Figure 23 (left). Screenshot of captured photo.

Figure 24 (right). Screenshot of captured photo download.

USER STUDY

Due to the restrictions of social gathering, time conflicts, and time constraints, we were only able to survey five people mostly remotely by presenting our design concepts

and our demo clips. All five participants (three males and two females) are between the age of 20 and 30. They all have some experience with mobile AR apps and consider themselves to have good digital literacy.

Part 1 – Labels

We showed participants three demo video clips from our early experiments on the label feature, including floating labels in an open area and a populated area, as well as attached labels in a populated area. We also explained the limitation of GPS discovered in our early experiments and asked them two questions:

1. Where and how do you think the labels should be displayed near the locations?
2. Can you think of any other designs or use cases for this feature?

Feedback

Floating labels should be raised to the upper part of the screen. Both attached labels and floating labels can be displayed if possible.

Action

We added a third area category, the hybrid area, which is surrounded by some open space and some high-rise buildings, such as university campuses. Based on geofences, when the user is in the open space of the area, GPS-positioned floating labels are displayed; when the user is near the buildings in the area, attached labels are displayed based on object tracking.

Part 2 – Highlight

We showed participants four demo video clips about the highlighting feature and asked them three questions:

1. Do you consider the design of background dimming as useful and effective?
2. Do you prefer the green layer or the transparent layer?
3. Can you think of any other designs or use cases for this feature?

Feedback

The transparent layer is enough for highlighting because the background is dimmed. The transparent layer is better for the environment with normal lighting. The green layer may affect the visibility of the location in normal lighting, but it can be potentially helpful for the low-light environment where the target location may not be clearly visible and can become more noticeable with the help of the green layer.

Action

We tested highlighting with a green layer in a low-light environment (see Figure 22). As a result, we consider the green layer can benefit the location highlight in the low-light environment. In Figure 22, we combined this feature with navigation.

POSSIBLE APPLICATION SCENARIOS

TourAR can be modified to be used for promoting and introducing districts of any size. It can be used as a city's tourism promoting tool, a university's campus touring tool, a newly developed residential area's introducing tool, etc. Since 8th Wall applications are web apps, any user can access TourAR on her/his smartphone's browser.

When AR glasses become common consumer products, tourism and location-based services can be improved with AR technologies. Display of certain information, such as establishments' Google ratings and direction, can become more intuitive and effortless, as simulated by TourAR.

LIMITATIONS AND FUTURE WORK

Distance and depth of field are not simulated well for distant virtual objects. TourAR relies on spatial data to properly position most 3D objects. For multiple objects relatively close to each other but together located very far from the user's current location, their relative distances from each other become less significant than their distances from the user. As a result, these distant objects tend to appear in almost the same size, though they should not, since the more distant the object is located, the smaller it appears to be. Furthermore, for close virtual objects that are coupled with close physical objects (for example, floating labels displayed next to nearby buildings), virtual objects' depths of field can be easily assumed by the user based on the virtual objects' positions, sizes, and their physical counterparts' depths of field. However, for distant virtual objects with distant physical counterparts, their physical counterparts' depths of field are not easy to differentiate because of the long-distance and limitation of eyesight; as a result, virtual objects' depths of field can only be determined by their sizes and positions, without their physical counterparts' depths of field. Moreover, we will explore other contributing factors in the simulation and display of distant virtual objects' depths of field. Aside from position and size, we will explore other properties, such as light, shadow, and physics, on another more customizable framework, such as Unity.

GPS is not always accurate. GPS-positioned virtual objects in TourAR may not be placed at the most accurate positions, as the accuracy of GPS can be affected by many factors, such as satellite positions, interference, and obstructions.

8th Wall applications become slow and have a low frame rate when they are packed with many 3D objects. This issue occurred when we added a .hcap 3D model as the tour guide. 8th Wall provides a fast and simple way to prototype with its sample projects, but it may not be the best framework for 3D graphics-heavy projects. We will explore other frameworks, such as Unity, to address this issue. Furthermore, the 3D model of our tour guide is a .hcap 3D model with generic audio and behavioural scripts from an 8th Wall sample project. We will customize new 3D models with suitable audio and behavioural scripts.

TourAR only has features for outdoor settings. We will explore suitable features for indoor settings, such as indoor navigation, object highlight, and introduction upon entries into new rooms.

APPENDIX – TIMELINE AND TASK ASSIGNMENT

In short, the project was split into the following portions, and both Tian and Kai contributed to the project equally (see Table 1).

Assignee	Task	Deadline
Tian, Kai	Brainstorming and initial meetings.	02/22/21
Tian, Kai	Technical research, design, and proposal.	03/01/21
Tian, Kai	Implement and test GPS-positioned labels. Implement and test tour guide.	03/15/21
Tian, Kai	Conduct a user study on ways to display labels.	03/22/21
Tian	Implement and test geofencing and different ways to display labels.	04/09/21
Kai	Implement and test location highlighting feature.	04/09/21
Tian	Conduct a user study on ways to highlight.	04/16/21
Kai	Implement and test optional navigation feature.	04/19/21
Tian, Kai	Make demos, improvement, and final product.	04/20/21

Table 1. Tasks, deadlines, and assignees

ACKNOWLEDGMENTS

We thank all our design concept and inspiration sources, including our instructor, Dr. Ryo Suzuki, and creators of the design concept images from the internet. We also thank all the participants in our user study for taking their time to provide valuable feedback.

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