REMOTE STUDIO SITE EXPERIENCES: INVESTIGATING THE POTENTIAL TO DEVELOP THE IMMERSIVE SITE VISIT

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Abstract. Immersive technologies are now enabling better and more affordable immersive experiences, offering the opportunity to revisit their use in the architectural and landscape studio to gain site information. Considering when travel to a site is limited or not possible, immersive experiences can help with conveying site information by overcoming issues faced in earlier virtual studios. We focused on developing three applications to understand the workflow for incorporating site information to generate an immersive site experience. The applications were implemented in a semester-long joint architecture and landscape architecture studio focused on remotely designing for the Santa Marta informal settlement in Rio, Brazil. Preliminary results of implementing the applications indicate a positive outlook towards using immersive experiences for site information particularly when a site is remote.

Keywords. Immersive experience; site visit; virtual reality.

1. Introduction

Immersive technologies are becoming more mainstream, improving in quality, accessibility and becoming more affordable through immersive experiences (IE). This transition allows spatial disciplines, like architecture and landscape architecture, to revisit possibilities for using such technology in the design process. Over the years, studios have attempted to incorporate IE to transform practice by using such technology to complement or replace traditional media. This thinking had limited results due to a number of barriers which impeded widespread adoption. As many of these barriers have been resolved by modern technology, we can revisit the possibility of reintroducing IE into the studio. Specifically, we capitalize on IE's ability to generate site experiences and use it to address issues in design education, particularly concerning remote locations. This idea falls in line with original considerations for the virtual design studio, giving access to remote locations and cultures (Kvan 2001). We broadly hypothesize that IE can promote understanding certain aspects of a site; that computer visualizations can help communicate site information (Wergles and Muhar 2009). IE can convey remote sites when an actual visit may not be possible (George 2016).

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Our research objectives for the scope of this study focus first on developing a workflow with three different IE applications, addressing earlier barriers to implementing IE into studios, and integrating those applications into a studio to see student's user experiences. We present a brief background of IE for studios, a description of modern IE technology and user experience, our workflow for developing three modern IE applications, and a discussion with rationale on implementing the applications into a studio with preliminary results from an informal exploration. We conclude with implications and future directions to address our main hypothesis.

2. Background

The history of immersive experiences (IE), including virtual and augmented reality, in architectural education is vast, spanning from the 90s to the present. Despite this relatively long history, IE have not been genuinely accepted as a means of conveying sites and designs in the studio. The benefits of IE for design education are often discussed with positive outlooks but have long been overshadowed by the barriers of earlier IE. Experiencing a site is a fundamental part of the design process where designers immerse themselves in the locale of a project. With design occurring at an increasingly global scale, original ideas that studios should investigate more geographically distant locations is coming to the forefront of design education needs.

The traditional design studio incorporates site visits to place students into the potentially unknown (Leach 2002) for critical exploration. The need to place students into an actual environment presents a challenge when sites are geographically distant from a studio location. IE has been considered a solution for this issue by enabling students to develop an understanding of geographically distant environments and cultures through interactive collaboration. This idea formed as the virtual design studio, where a group of designers could come together through technology mediation to share site, culture, and design ideas (Wojtowicz 1995; Duarte, Bento, and Mitchell 1999). Maher, Simoff, and Cicognani (2000) explain that virtual design studios enable "sharing design information and supporting interaction regardless of place and time" (pg. 3). In these virtual collaborations, designers considered 'local' would physically visit the site to "get a 'feel' for the place" (pg. 6). The remote designers then rely on site analysis information from traditional media communicated through technology. Similarly, this concept occurs in in-person studios where only a few students can visit a site; where site characteristics are filtered through the lens of those who actually visited (George 2016).

Virtual design studios transitioned from quasi-virtual desktop to immersive virtual environments in order to capitalize on the immersive nature of head-mounted displays (Schnabel et al. 2001) and large-scale 3D screens (Kalisperis et al. 2002) to present scale and movement in the act of design. The true strength of IE comes from conveying architectural representation by presenting perceptual cues through movement and time to help improve comprehension of both space and form (Kalisperis et al. 2002a). IE can perceptually engage users through immersive and interactive means (Bowman and McMahan 2007), resulting in the sense of one's self being located in the simulated space, or sense of presence (Balakrishnan and Kalisperis 2009). Presence relies on a number of factors to occur, starting with attention where focus is allocated on the simulated space. Once attention is allocated towards the simulated space, a user can become cognitively absorbed where they begin to lose track of time (Agarwal and Karahanna 2001). Lastly, a user needs to enjoy the experience which ultimately improves feelings of presence. Once presence is achieved, factors such as memory and cognition are reported to improve (Balakrishnan et al. 2012). The role of presence is alluded to in the history of IE in studios, where it relates to the benefits of incorporation into studio pedagogy. The challenge faced by integration of IE into the studio however stems from a number of barriers. IE was costly to purchase and operate, it typically required special expertise. Utilizing IE was difficult as content integration into an application was not easy and oftentimes not compatible with other digital tools. Lastly, IE has continued to struggle with issues of cybersickness which become more prominent with extended use.

Modern day IE are overcoming many of the issues reported in earlier attempts in the design studio: cost of equipment, content integration, and cybersickness. More affordable and higher fidelity IE can be purchased off the shelf, working with many consumer grade computers. Content can be created with greater ease and incorporated into the growing number of technology from the Google Cardboard to more high-end head-mounted displays (e.g. Oculus Rift, HTC Vive). Real data can be integrated into 3D environments through the use of LiDAR and photogrammetric methods while 360° imagery captures a wide field of view in a high resolution (Zhao et al. 2017). Finally, the entertainment industry has heavily invested in reducing issues of cybersickness, enabling extended use of IE. With these barriers being removed, we can consider how IE can be re-introduced into the design studio.

In summary, we revisited the need for presenting unbiased geographically distant information in the studio, the use of IE for comprehending space through user experience, and how modern day IE is overcoming the original barriers in design studios. With these points in mind, we focus on exploring the potential of developing IE for the studio to satisfy the need for geographically distant experiences, while gaining an understanding of how modern day IE has overcome some of the original barriers. We first focus our efforts on developing a workflow across three types of modern IE: webVR, mobile VR, and head-mounted display (HMD) desktop VR, where each type becomes increasingly more immersive. We follow three goals in our exploration: 1) develop a plan to capture site information that would be relatively unbiased, 2) to develop three individual applications that utilize the same point and click functionality to 360° content, and 3) to implement the applications into a studio as a use case on user experience for continuous improvement.

3. Development of the three applications

We collaborated with a studio course focused on a remote site, the Santa Marta informal settlement in Rio, Brazil. The Rio Studio was a joint architecture and landscape studio aiming to explore the issue of population growth and urbanization in the southern hemisphere, exposing students to a large-scale problem that consists of numerous social, infrastructure, ecological, and urban planning issues. The organic structure of informal settlements proves challenging for designers to comprehend and improve without multiple visits to the site, which in some regions is both costly and dangerous. Informal settlements like Santa Marta are not governed and do not follow conventional policy for forming urban space, leaving documentation of the site limited as residents constantly make changes. Like many Brazilian informal settlements, Santa Marta has high building density and occupies a very steep portion of Dona Marta Hill. The crowded space in Santa Marta has created unsafe living conditions and is representative of the socioeconomic status of the residents. Despite public authority interventions, the quality of life in these informal settlements remains an issue. The Rio Studio provided a means to develop IE for conducting a site visit remotely, not relying only on traditional media (e.g. topographic maps, etc.).

Our first objective was to reduce issues of subjectivity in presenting site information, particularly through visual information. Similar solutions utilizing IE for remote site analysis incorporated 360° video captured from drones presented on both a Google Cardboard and laptop along with a basic map showing structure locations (George 2016). The results of student's abilities to conduct site analysis was promising but issues related to video resolution impacted exploration of small details. To overcome this issue, we considered a mix of 360° videos and images which would allow for capturing movement, sound and, small details such as materiality of structures without directional bias found in standard photos. Unlike the work presented in George (2016), the site itself presented challenges with gathering aerial data as it resided close to an airport restricting drone use and was highly dense in most areas making it difficult to obtain exact GPS coordinates. The settlement is also not well mapped in most mapping services (e.g. Google Maps, OpenStreetMaps) because it constantly changes. Our plan was to follow the most documented routes of the site, attempting to capture major areas from the entrance to the uppermost region, collecting the 360° content from a first person perspective. An attempt to use a balloon for a semi-aerial perspective did not succeed due to weather. We collected 93 different 360° images and 34 360° videos the summer before using a Ricoh Theta S camera, an affordable consumer grade 360° camera, which was portable enough to travel and provide decent resolution. Additional content included a number of high resolution images and videos as well as a base map provided by the government in Rio, Brazil.

The second objective was to develop a workflow to create IE that capitalized on easy content generation while considering how commercial experiential mapping programs currently work (e.g. Google Earth for HTC Vive). Three immersive applications (WebVR, HTC Vive, and Cardboard with Android phones) were developed using the 360° content collected from Santa Marta. The 360° content was mapped to the provided base map in all three applications, creating an overview page. A point and click interaction was added to enable 'entering' the 360° content. The WebVR website used a combination of HTML, CSS, JavaScript, JQuery and A-Frame to make the images viewable while linking videos streamed through YouTube (Figure 1). On the overview page, clicking any point on the map would open up a side window with the 360° image and the photo name for easy reference. Clicking the 360° image would change it to full screen view with rotational navigation to explore each image. Clicking the escape button would return users to the overview page. Similarly, on the 360° video overview, clicking a route would open up a side panel with the embedded YouTube 360° video. While the least immersive when running from a laptop or desktop computer, the website was capable of working in stereo 3D in the Immersive Environments Lab (IEL) (Figure 1), a large screen 3D capable presentation space. It was possible to inspect the different images/videos by looking around, from either an individual or a collaborative perspective in the IEL.

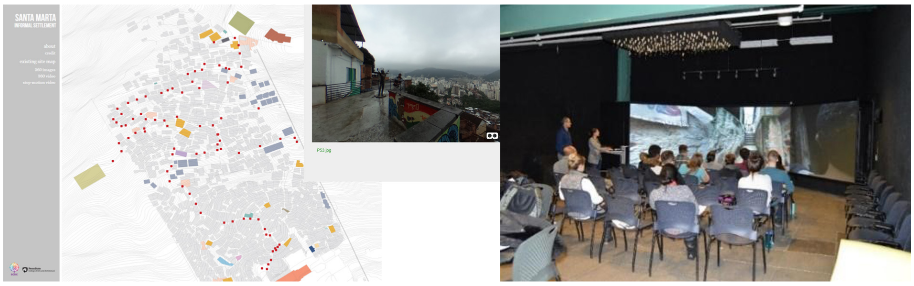

Figure 1. WebVR website with the 360° images and display in the IEL.

The other two applications, the HTC Vive and Android Cardboard, used Unity3D, placing the user inside an image textured sphere to experience each 360° image. While development through Unity3D was the same, different interfaces using the same overview map point and click model from the website were incorporated. The HTC Vive application used an HMD and one of the two hand controllers for interacting with the scene. Controllers and HMD are tracked allowing the user to move around in the scene, the overview map or a 360° image/video in this case. Figure 2 shows the overview map perspective with the locations for the images/videos using the HTC Vive. The one-to-one correspondence between points/paths on the map and 360° images/videos enables multi-scale spatial learning by the user. In the 360° image perspective, a minimized overview map is available for navigation with a zoom-in map attached to the backside of the controller. Specifically, the user's current position and visited places are marked in different colors to afford spatial awareness. The user can navigate between different images or go back to the overview map to select other points, similar functionality found in Google Maps which allows for navigating through different 360° images. Similarly, users can select paths on the map to watch videos. An animated point on the minimap continuously tracks the user's position in each video's playback progress including pausing or replaying.

Figure 2. HTC Vive with user inside the 360° images.

The mobile version for Android smartphones works with a Cardboard viewer. In contrast to the Vive version, only the orientation of the display can be tracked based on the phone's accelerometer. Other limitations include screen space, and the lack of controllers poses additional challenges. Interaction consisted of gaze control based on a reticle placed in the center of the screen that can be clicked with the Cardboard's only button or by tapping the screen (Figure 3). Figure 4 shows the menu available in the image perspective that allows for moving between images, turning the minimap display on and off, and switching back to the overview map.

Figure 3. Overview perspective in the mobile version for the Cardboard. Gaze control to select map points and switch to the corresponding image.

Figure 4. Image perspective in the mobile version. Gaze-controlled menu to navigate between the images, enable/disable the zoom-in map, or switch back to the overview perspective.

4. Implementation into the Rio studio

The Rio Studio was offered to architecture and landscape students. The studio introduced a unique situation where students would not visit the Santa Marta settlement until the end of the semester to present their projects to the local community. We integrated the three applications into the studio, enabling the students to virtually experience the site to help them access information to analyze the underlying structure. We concluded with the students generating their own 360° images of their projects as part of the presentation to the local community.

4.1. EXPLORATION DETAILS

At the beginning of the semester, we introduced the applications while seeking participation in an informal exploration of the user experience with suggestions for improvement. We started by introducing the website then the HTC Vive followed by the Cardboard for Android phones. We received consent from 10 students to collect responses from each use of an application throughout the semester. We collected preliminary data through surveys: demographics, 2-3 minute surveys, and a concluding survey. The demographics and concluding survey provided prior experience and suggestions for future improvements. We used 2-3 minute surveys as informal feedback to not disrupt the actual use of the IE. The students filled out surveys after using any application. The survey consisted of 20 questions that were either scale-based or open-ended. The scale-based items, nine-point scale, were adopted from known measures of losing track of time from cognitive absorption (Agarwal and Karahanna 2001), perceived enjoyment (Davis, Bagozzi and Warshaw 1999), self-location, feeling oneself in the simulated space, from presence (MEC-SPQ) (Vorderer et al. 2004) and, attentional allocation which we refer to as attention capture (Vorderer et al. 2004). The surveys also had open-ended questions focused on the purpose of using the application and any challenges faced.

4.2. PRELIMINARY RESPONSES ON APPLICATION USE

Of the 10 participants, there were 6 females and 4 males with an even split between architecture and landscape architecture, 7 grad and 3 senior students, and an average age of 24.83. Prior to the studio, only four students had used a Cardboard, none had used the HTC Vive or the IEL. The small sample did not support full quantitative analysis but showed an interesting trend. For ongoing user feedback from the semester, we had a total of 23 complete responses where 43.5% of responses were for the website, 26.1% for the Cardboard, 17.4% for the HTC Vive, and 13% for the website in the IEL. The response means show perceptions of user experience were relatively similar across applications, Figure 5, with the IEL showing the greatest potential in presence, self-location. The Cardboard showed the lowest scores in terms of presence but was comparable for enjoyment and attention capture. Overall, the perceptions were positive in terms of user experience.

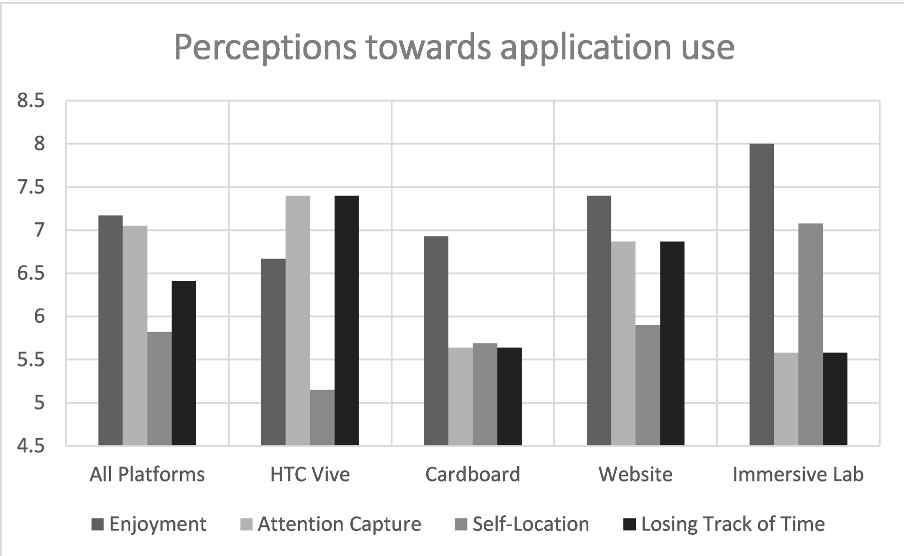

Figure 5. Calculated means for four survey categories of user experience by application.

The majority of responses (74) were open-ended and used to help improve technical and content issues with each application throughout the semester. Responses were grouped across two categories: need for experience and content improvement. Need for experience contained themes that ranged from desired information type, ‘the buildings entrances in road intersections’ and ‘to see the building materials and the feel of the corridor spaces’ to the success of information provided, ‘map-picture reference....when you deal with a complex site, it is easy to forget where you took the picture'. The second category, content improvement, contained themes for general issue reporting, 'images were inverted', and suggestions for improved functionality, 'a pause feature and fast forwarding/rewinding...'. Cumulatively, the responses were increasingly positive as issues were resolved throughout the semester.

4.3. REFLECTIONS FROM PRELIMINARY RESULTS

The studio provided positive results on the potential of IE to supplement site experiences. Responses indicated a sense of presence occurred in all applications. Informal discussions and open-ended responses indicated that immersive applications could be a good alternative over traditional media when actual site visits are not possible. Through the applications, we were able to assist students in addressing issues within the Santa Marta site. The success of the immersive applications was indicated through interaction with the community members. While limitations of the student's proposals were noted by the community, the students indicated the applications helped them form an understanding of key physical characteristics of the site. This understanding was aided by the iterative improvement of each application. Issues were immediately addressed and suggestions were collected for future implementation. Accessibility of the applications was a common issue as there was only one HTC Vive and the Cardboard was only for Android phones. Making all of the applications more available is a future implementation.

Other limitations focused on lack of content where more detailed information and experiences were the most desired. The issue of content is a challenge, particularly when the sites represented are difficult to fully capture. Currently, similar consumer products such as Google StreetView and Google Earth do not have enough content for these settlements, making it difficult to find similar applications. One possible avenue is to consider more modalities (e.g. audio) to create a richer experience of the existing content. Students noted after visiting the community, the largest limitation was the inability to convey the social dimension of the community. The suggestion was to add a dialogue with the community through the applications, a shared experience. The challenge then becomes how existing technology can facilitate this dimension. In short, IE does improve understanding of physical features, an improvement compared to traditional media (e.g. photographs, maps) but still present limitations in capturing social and cultural dimensions.

5. Implications and future outlook

Understanding a site is important as more projects start to occur globally with physically distant sites. The re-vitalization of IE presents an opportunity to utilize experiential benefits to provide an experience of a site. The challenge presented by the Rio Studio was to provide an experience of the current state of the Santa Marta settlement to design students. We developed a workflow for creating three immersive applications to portray the site. Our focus was to consider the implications of IE as a means to communicate the site, enabling studio students to design. We successfully developed and incorporated the applications into the Rio Studio while iteratively refining the workflow through an informal exploration of user experience. Addressing our broad hypothesis, we focused on how to develop applications that overcome past issues with IE then capitalized on identifying trends in user experience as a driving factor for future performance. Our future work includes a full evaluation of the application.

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