PAPER

Empowering through Extended Reality

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Keywords: extended reality, immersive experience, scenario planning, civic engagement

Immersive visualization technologies, such as Extended Reality (XR) go beyond passive methods of civic engagement with community members. They offer a variety of interactive methods to expand visualization techniques in participatory planning and design. This paper discusses an experimental XR platform developed by collaboration between an academic research unit and a private software developer. This XR platform supports an on-going comprehensive planning process aimed at enabling public participation with a goal of increasing awareness of future development alternatives through 3D immersive experiences.

INTRODUCTION

It is argued that the practice of community planning not only requires individual participation in the profession, but also requires active civic engagement. Samuel Mockbee once stressed the importance of a deeper democratic purpose of inclusion in energizing one's community. Many methods for public participation have been introduced in urban design and its allied fields such as architecture and landscape design. This type of community-based practice has its root in the field of participatory planning and design, which is a response to the demand to have voices heard and ideas taken from those who are involved in the process. It sees community members as citizen designers who play an active role in shaping the formulation of both the design process and its ultimate results. One of many issues facing this type of participatory approach has to do with the challenge of making the process comprehensible, relevant, and interesting to the potential participants in order for them to willingly participate in the process. Extended Reality (XR) apps on personal mobile devices, such as smart phones or tablets, may offer some solutions. Immersive visualization technologies, such as Virtual Reality and Augmented Reality, are powerful tools to facilitate participatory processes in community planning and design. As a visualization apparatus, XR goes beyond passive methods of engagement and their one-way communication with the public. XR offers an interactive method to expand both non-computerized and computerized visualization techniques in community planning and design. Moreover, XR promotes civic engagement by providing comprehensible information to citizens and assisting them to express their preferences in an intuitive way [1].

This paper discusses the "Transforming City of Charlotte with Immersive Visual Data" project, funded by Knight Foundation's Smart Cities initiative to foster public participation through XR. An XR platform is being developed to assist in two critical planning and design activities: 1) using immersive visual effects to reveal and communicate planning intentions and goals, 2) engaging community members in decision-making roles. The proposed platform will leverage XR technologies and scenario-based methods to create a new user interface to support critical community outreach activities for the on-going Charlotte Future 2040 Comprehensive Plan. Community members who are concerned with the future of Charlotte will be able to use the XR platform to learn about how the resulting Comprehensive Plan may (re)shape the physical fabric of their communities, see the future urban form via this immersive experience offered by the platform, and in turn share their ideas with the City.

IMMERSIVE TECHNOLOGIES IN CIVIC ENGAGEMENT

One of the key factors to successful community planning and design is for urban planners and designers to work together with community members and empower them to play a key role in this community building and transformation process. Together urban planners and community members work to envision the future of their communities [2]. However, it is inevitable that people hold different views of their communities and often have different scenarios about the future. To bring together these diverse viewpoints and further come to a unified vision of the future in this community planning and design process, neutral information is needed to build a foundation for informed decision-making. To meet this need, urban planners and designers must employ proper tools to acquire and analyze data, help people gain insights into the conditions of their environments, and in turn develop common understandings of issues facing their communities [3, 4].

Immersive visualization technologies present an opportunity for data visualizations and information sharing. Over the past years, much attention has been turned to Extended Reality (XR). XR is a universal term inclusive to immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR). These technologies create immersive experiences with a perception of being physically present in a non-physical world. VR creates an artificial world where a user can interact and reach out to various virtual objects through a headset with specialized software

and sensors. AR, on the other hand, through mobile devices or smart glasses, takes a user's view of the real world and superimposes virtual objects onto the physical environment.

XR is a new way of seeing. A viewer's own visual perception can be enhanced through computer-generated digital contents. This can be achieved in a variety of ways by see-through devices, head-mounted displays, or mobile devices amongst others. The common features of all these systems are that virtual contents generated by these digital devices and the real-world physical reality are combined and overlaid. These systems operate interactively in real time and three-dimensional (3D) information is provided [5, 6].

Initial research on XR and its related technologies, such as Augmented Reality (AR), can date back to the 1950s [7]. However, the first definition of AR was provided in 1997 by Azuma: An AR environment has the following three characteristics: "1) combines real and virtual environments; 2) is interactive in real-time; 3) is registered in 3D." While AR has been in use since the 1990s, this has mainly been in research projects, and only a few specific projects have been developed. Only in recent years have mobile XR applications enjoyed an increased presence due to the development and use of XR-enabled game engines or browsers. Because of the current distribution of suitable mobile devices equipped with high-resolution cameras, data connection and improved computing power, XR applications have become of interest to general end users.

At present, this new technology is mainly used for marketing, navigation, in the game sector, in medicine, as well as for service technicians and in tourism. The field of urban planning is increasingly interested in XR. The assumption is that the use of XR can support quality assurance in planning processes [8]. In particular, architecture and urban and landscape planning could benefit from the use of XR applications. XR has the potential to expand the range of instruments which are offered to support public participation and community engagement. It is expected that computerized tools like XR will change but also increase the quality of public participation.

Reinwald argues that visualizations in planning, especially the digital technologies developed over recent years, can function as a mediator of empowerment in public participation. XR in urban planning and participation processes has the potential to improve civic engagement processes and make them more efficient. To increase the standards and quality of public participation procedures, XR instruments should satisfy requirements such as framework conditions and virtual contents should be clearly and comprehensively communicated or equal chances for different groups to participate and influence the decision-making processes should be guaranteed [9].

CHARLOTTE FUTURE 2040 COMPREHENSIVE PLAN

Overview

The City of Charlotte is a major metropolitan and commercial hub in North Carolina. The City is embarking on its journey to growth and investment over the next 20 years. The City of Charlotte has been partnering with local communities since 2019 to develop the Charlotte Future 2040 Comprehensive Plan, a plan that will guide how the City will invest in itself over the next 20 years. Once adopted, this plan will be the foundation for strategic policy, equitable investment in infrastructure, and new regulatory tools. It will be the blueprint for the City of Charlotte to realize its vision, which is aimed to opening its arms to a diverse and inclusive community of residents, businesses, and visitors alike; a safe family-oriented city where people work together to help everyone thrive. Through the Charlotte Future 2040 Comprehensive Plan, the City visualizes a shared vision of its growth, development, and capital investment in a variety of areas of planning and development, including land use, transportation, housing, economic development, parks, facilities and services, sustainability, etc [10].

Scenario Planning

Scenario planning is a method that tests development alternatives and their influences on achieving community goals. This planning method influences growth policy and development regulations and is useful in communication between different departments in a government and the subsequent tradeoffs are important to be able to communicate with the community at large [11]. The City of Charlotte has adopted scenario planning in their current Charlotte Future 2040 Comprehensive Plan to engage residents and collect inputs for the Comprehensive Plan and for participants to learn about prioritizing and leveraging growth and its impacts. The community inputs collected during this engagement process have been fed into the city's scenario analysis for developing various future growth alternatives for comparisons and negotiations. One key objective of this approach is to ensure that the path to creating complete neighborhoods for all residents in the City is equitable, economically viable and fiscally responsible [12].

Scenario planning that utilizes geographic information mapping to enable data analysis and facilitate communication has been frequently used in land use and transportation planning. However, conventional scenario planning is oftentimes static and two dimensional in external communication. This project is aimed at breaking the barriers of map-literacy and open up access to explore growth options, impacts, and tradeoffs through easy to understand, real-time 3D visualizations, and allow for multi-user interactions.

CHARLOTTE FUTURE XR PROJECT: TRANSFORMING CITY OF CHARLOTTE WITH IMMERSIVE VISUAL DATA

The Charlotte Future XR project, described in this paper, intends to develop a mobile/desktop XR platform that uses 3D immersive technologies (i.e., Virtual Reality, Augmented Reality, and Mixed Reality) to assist in two critical activities needed for successful scenario planning. These activities include: 1) using 3D visualizations to reveal and communicate planning intentions and development goals; 2) engaging stakeholders and community members in meaningful decision-making roles. The proposed platform, which can be used in smartphones, handheld devices, head-mounted displays, and desktop computers, will leverage cutting-edge digital technologies as well as geospatial data analytics and visualizations techniques. This novel method will create a user interface to support these two critical planning and community outreach activities for the Charlotte Future 2040 Comprehensive Plan.

Key Objectives

The Charlotte Future XR project intends to support the Charlotte Future 2040 Comprehensive Plan. The project is aimed at augmenting the City's transformational growth plans through XR technologies. City Building Lab at the University of North Carolina at Charlotte aims to provide a 3D immersive experience of the City's transformed model via a cost-effective, collaborative, and user-friendly XR software solution.

This XR solution will help community stakeholders validate the design, collaborate on design ideas, and leave feedback. In the current phase of the Charlotte Future 2040 Comprehensive Plan, the primary focus is on community outreach. These community outreach activities will focus on the following two primary use cases.

On-site Community Engagement

XR has the power to show community members the full scale, real world implications of various urban planning designs. The XR platform allows community members to stand in the physical world and align the "digital twin" of various design options as a spatial digital overlay. This will enable participants to "teleport to the future" and walk through a fully realized and built design option. In addition to viewing different designs, participants will have the ability to leave spatial notes with their thoughts and comments about each design option. These notes will be spatially tied to the physical and digital site, as well as persistent over time, allowing researchers to access the information at any time. Content will be "anchored" to the physical world through either manual placement or QR codes placed on site.

Hybrid Community Workshops (In-person and Virtual)

In addition to on-site design evaluations, City Building Lab in collaboration with planning staff from the City plan to lead a series of community workshops to solicit ideas from community members about the various design proposals. Using a scaled "dollhouse model" of a neighborhood, participants will be able to view the content at both a miniaturized scaled view, as well as the full-scale world. Participants do not need to be in the same physical location to participate in the meeting. Participants may use customized avatars and connect with one another using the XR platform. Using the function of dollhouse models, participants can find and virtually "walk" their neighborhood at full scale using the XR platform's AR system for navigation.

SOFTWARE FRAMEWORK

City Building Lab has partnered with a third party software developer to design the proposed XR software platform to empower virtual collaboration.

Overview of Charlotte Future XR Platform

The XR software platform designed by the partner is a cloud based XR platform built on a robust and scalable technology stack. It supports multi-users with multiple devices (iOS, Android, Windows, HoloLens2), which makes it a collaborative, device agnostic platform. End users of the software do not need to write any code. This software solution is deployable into a public or private cloud tenant for additional manageability. Users can connect through a web-based interface from any part of the world.

This software XR platform is composed of the following three layers (Figure 1):

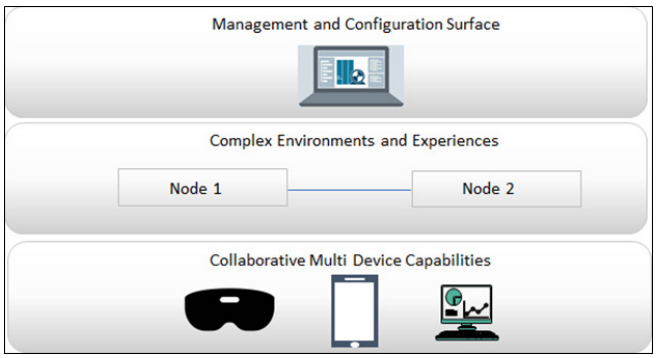

Figure 1. Software Layered Architecture. Source: Altoura.

At the base level, the XR platform supports multiple device types available today, such as HoloLens2, personal computers, and both iOS and Android mobile devices. The platform enables multiple users across different devices and locations to be in the same AR/VR environment and synchronously experience the same XR experiences.

For the next layer, this platform can show complex 3D environments at scale in a photorealistic manner and within these

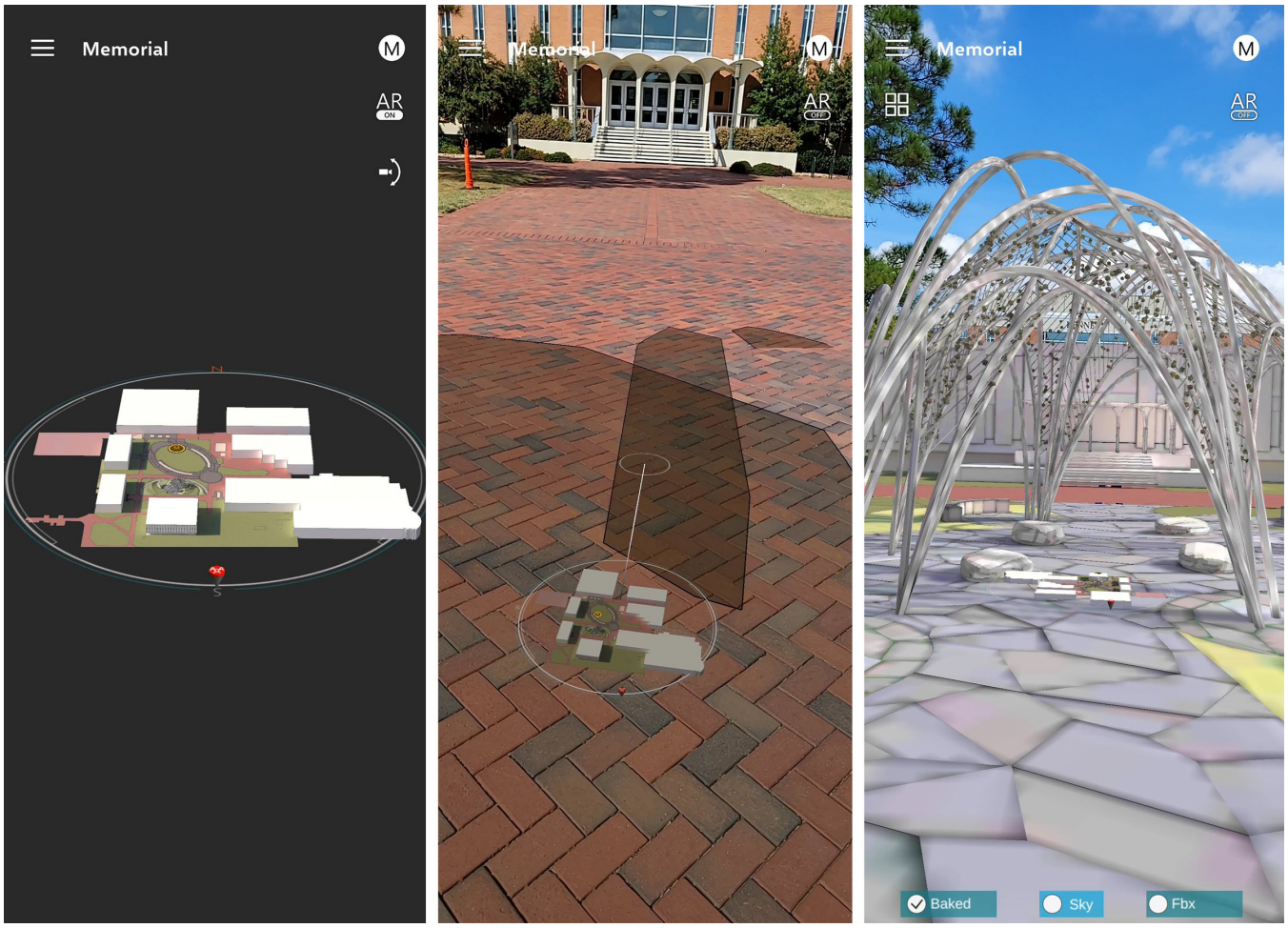

Figure 2. The XR module for Use Case One. Source: the author.

environments the platform can also support complex immersive experiences created on the XR platform.

The final layer is a management and configuration interface, which allows users to build custom experiences to address a wide variety of needs. This layer has two primary modules. The first one is based on Unity asset bundles that contain 3D models as well as step-by-step animations. Unity is the defacto standard gaming engine for cross-platform immersive experiences. The second module is a content management web portal, which allows users to configure their contents and create events and transitions that result in animations and a wide range of immersive experiences.

PROJECT IMPLEMENTATION: EARLY PILOT PROTOTYPE TESTING

The XR platform enables the research team from City Building Lab to create immersive, interactive, and collaborative engagements with the community using content sourced from various 3D programs. As discussed earlier, the research team has identified two use cases where the XR platform can be implemented.

Use Case One

The platform should allow users to physically walk in a city street and see potential urban development scenarios on site. For this use case, the research team has built a prototype module to include a set of future development scenarios, called place types. Users can choose one of the place types from the XR platform user interface to visualize the entire 3D buildout of the selected place type.

Users have two options to interact with these 3D buildout models. Users can choose any location in the model to teleport virtually to this location and see the surrounding of the location as a Virtual Reality experience. When being outdoors in a city street, users can also “anchor” the 3D model into their real physical environment and walk inside the model as an Augmented Reality experience. This is done by manually place their XR model via a 2-step process using a holographic bulls-eye target. The first target locates the position of the model; the second target determines the rotation/orientation of the model (Figure 2).

Figure 3. The XR module for Use Case Two. Source: the author.

This use case should allow users to engage with the urban context in a full scale, realistic, spatial manner and thereby have a better ability to understand implications of zoning, streetscape, building form, etc.

Use Case Two

The XR platform should allow users in a community meeting to see an overview 3D model of proposed future development scenarios. It should also enable users to teleport to any given locations in the overview model and virtually walk through in the model as a first-person VR experience. The platform should enable multi-user experience to encourage collaborative actions during a workshop.

Similar to the first use case, the research team has built a prototype module for this second use case to include a set of future development scenarios. Users can choose one of the models from the XR platform to visualize the selected place type models (Figure 3).

This test module enables interaction between all users immersed in the environment and as they move or manipulate objects in the 3D environment, everyone can see the process in real time. Users have the flexibility to experience the project by a laptop, a mobile device or even a head-mounted display (HMD) like HoloLens2.

Charlotte Future 2040 Civic Engagement Events

The Charlotte Future 2040 Planning Team from the City conducted a series of community events between July 24, 2021 and August 13, 2021. The purpose of these civic engagement events was to provide information about the goals and processes for developing the 2040 Policy Map as a component of the Comprehensive Plan. Community participants were asked to identify which place types they would and would not like to live or work near. These preferences served as input in developing the Charlotte Future 2040 Policy Map.

Both two prototype modules in the XR platform were used in these events to allow the participants to visualize different place

Figure 4. The XR platform in use for Charlotte Future 2040 Civic Engagement Events. Source: the author.

types and in turn gain a better understanding of the various characteristics of these place types. The research team attended a total of 10 events and assisted the event participants to use the XR platform. A number of iPads were prepared for the participants to access and try the XR platform (Figure 4). An estimate of 200 participants tested the XR platform and provided brief feedback to the research team. In general, the participants had positive experiences with the platform. However, its effectiveness to convey the underlying ideas of the Comprehensive Plan needs to be further examined.

DISCUSSIONS AND PRELIMINARY CONCLUSION

As discussed earlier, scenario planning seeks to booster the technical efficiency of spatial analysis in urban planning and design as well as to build transparent channels for communication and open platforms for public participation. This socio-technical perspective is important to understand the significance of this particular type of planning, which seeks to integrate social practices of planning with information and communication technologies.

The Charlotte Future XR project, discussed in this paper, is essentially a version of this type of scenario planning practice with advanced visualizations and immersive experiences. It is through this particular socio-technical viewpoint that three key observations about the Charlotte Future XR project are drawn as the follow:

Immersive technologies enable rational inquiry, increases understanding of physical systems

The ability of these XR techniques to conduct visual surveys and to illustrate the results of alternative designs substantially increases planners' ability to engage and educate the public about the rational aspect of various key factors involved in the physical planning process.

Immersive technologies allow collaborative actions, enables quick explorations and performance evaluations on planning alternatives

These XR tools allow community members to generate and compare various future development scenarios that represent different policy alternatives. The Charlotte Future XR project, with its immersive experiences as the canvas, provides the participants a simple viewing interface to quickly visualize different combinations of development alternatives, which can then be tested based on identified parameters that may reflect the consensus among community members in this collaborative process.

Immersive technologies help identify community values, promotes social learning

The continuous public engagement and public education about the potential benefits of alternative growth strategies help build

durable, inclusive consensus within the community over time. Various techniques used in this Charlotte Future XR project, such as place types viewing via VR, walk-through experiences via AR, all afford the participating residents the opportunities to share their ideas and together identify key values that are essential to the future of their communities.

FUTURE WORK: NEXT STEPS

This study is concerned with the factors that are attributed to the implementation of the Charlotte Future XR platform. In other words, this study attempts to unfold what operational issues have an effect on the effectiveness and the ability of this XR platform with immersive technologies to continually engage local communities during the Charlotte Future 2040 Comprehensive Plan process.

To continue this study, the research team will conduct a series of workshops to test and refine the prototype XR platform. Community members from the pilot neighborhoods will be invited to attend a series of meetings and use the pilot XR platform to explore alternative development scenarios as a part of the community outreach efforts of the Charlotte Future 2040 Comprehensive Plan. 3D immersive visual components and other digital data will be displayed through the XR platform to allow community members to visualize how their neighborhoods may look under different future development scenarios. Other workshop activities include: 1) information sessions for community members to learn how to use the XR platform; 2) field testing to allow volunteers to operate the platform at selected locations in the neighborhoods.

This pilot test study will be carried out by the comparative case study research method, which is one of several ways of doing case study research. Four data collection techniques will be employed in this study: 1) documentation review; 2) surveys; 3) interviews; and 4) on-site observations and informal conversations with participants and city planning staff.

FINAL NOTE

Due to the on-going COVID-19 pandemic, the research activities originally planned were disrupted. Those data collection events that may require in-person contact were cancelled, including participant interviews and on-site observations. The author of this paper plans to resume all research activities in the near future once the condition improves and proper authorizations are granted.

ACKNOWLEDGEMENT

The author of this paper thanks the planning staff in the City of Charlotte for their assistance in getting access to some of the materials for this study and for their insight and expertise that greatly assisted the research. This project is supported by the John S. and James L. Knight Foundation.

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