Towards Increasing Active Citizen Involvement in Urban Planning through Mixed Reality Technologies

Sam Sabah, Imran Hossain, David Weiss, Alexander Tillmann
Goethe University Frankfurt
studiumdigitale
Eschersheimer Landstr. 155-157, 60323 Frankfurt am Main
{sabah, hossain, weiss, tillmann}@sd.uni-frankfurt.de

Abstract. *Augmented Reality (AR) and Virtual Reality (VR) have the potential to revolutionize urban planning by providing immersive and interactive experiences for visualizing urban spaces. However, citizen participation is hindered by the perceived costs of learning and the technical skills required for AR and VR. Physical models offer a tangible representation of plans, enabling citizens and students to visualize their ideas. Combining physical objects with AR and VR is challenging but holds promise for citizen participation. This paper explores the integration of physical models with AR/VR to create a synergistic effect that fosters citizen engagement in urban planning. We introduce the concept of the 'City Planner,' a mixed-reality application currently being developed, which combines AR/VR, urban planning, and physical objects to transcend traditional participation barriers. The proposed concept aims to make urban planning accessible, intuitive, and inclusive for citizens and students, regardless of their technical expertise.*

Keywords. Social citizenship; Urban Planning; Citizens Participation; Extended Reality (XR); Augmented Reality (AR); Virtual Reality (VR), Mixed Reality (MR); Object detection; Image recognition

1 Introduction

The integration of Extended Reality (XR), which encompasses Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) technologies, has the potential to revolutionize urban planning processes by visualizing the unseen.

XR models of cities can be created to provide a flexible and functional representation of the urban environment, making it easier to visualize the unseen (Thompson et al., 2006). However, ensuring the active participation of civil society in urban planning projects remains a challenge. Citizens often show "rational ignorance" toward urban planning events, and the cost of learning how to participate in such projects often outweighs their perceived potential benefit from taking part (Krek, 2005). XR technology can improve civil society participation in urban planning by creating interactive and immersive experiences that are easily understandable. This, in turn, can increase engagement and participation in planning processes, allowing community needs and opinions to be considered. By involving civil society in planning processes, people can develop a stronger sense of belonging and connection to their community and city. They have the opportunity to participate in decisions that affect their immediate surroundings and daily lives, making them better able to engage in their community (L., 2016; Siembab, 2019).

In school education, developing skills for participation and co-design of urban spaces is crucial (A., 2016; D., 2015). The educational concept of Spatial Citizenship in Geography involves children and adolescents participating in local urban planning processes to promote their socio-spatial perception and understanding of urban spaces. Geomedia, including digital tools like scribble maps and sketching programs, are used to facilitate this process (D., 2015; Kanwischer et al., 2018). Visualizing ideas for public space redesign remains abstract and difficult to imagine how one's plans would look and feel in reality. Digital Geomedia and maps also pose accessibility issues. A solution that provides better visualization and ease of operation is highly desirable for participatory planning processes involving students and citizens. Tangible interfaces can be more inviting and conducive to collaborative interaction (Thompson et al., 2006), therefore combining the allure of something tangible with the advantages of XR technology holds the promise to raise the level of citizen engagement in urban planning.

2 State of the art

A substantial body of academic research emphasizes the significance of employing XR technology in urban planning. Using an AR platform can enhance public familiarity with urban design indicators and effectively promote public participation in evaluating urban design (Wang and Lin, 2023). Similarly, the utilization of Virtual Reality (VR) technology in participatory urban planning also offers numerous advantages, including higher engagement and more vivid memory of the viewed content, which can lead to better-informed decision-making (Van Leeuwen et al., 2018). Within the scope of a participatory design project, a positive social impact on the neighborhood can be observed, reflecting the needs and wishes of the inhabitants and increasing their interest in local urban development (Van Leeuwen et al., 2018). In order for VR to effectively support urban planning, factors such as 3D visualization, simulating real-world scenes, user-friendliness, interactivity, inspiring enthusiasm, and inspiring creative thinking should be considered (Jiang et al., 2023).

VR has significant potential in urban design, offering real-time testing, effective communication, and improved designs. However, challenges include computational costs, limited accessibility, technical shortcomings, and the need for further research. Overcoming these challenges will enable VR to enhance the urban design and increase public participation (El Araby, 2002). The use of 3D data, therefore, seems to be beneficial for urban planning, and XR technologies can help predict the look and impact of new architectural objects on the surrounding environment (Cirulis and Brigmanis, 2013). The use of XR technologies in urban planning can increase citizen participation, particularly among young people, through its ability to provide spatial and contextual cues that enhance creativity and interactivity. The use of haptic 3D tools enabled collaboration in teams and provided an option for user engagement (Saßmannshausen et al., 2021).

For architecture students, including new interactive and gamified visualization systems can have a positive impact on the development of urban projects as an educational tool. These systems can improve students' academic and competence development, which is linked to their motivation (Fonseca et al., 2017). Integrating Service Learning (SL) into geography lessons effectively encourages interest in participating in urban planning processes among children and adolescents. By incorporating SL activities into the curriculum, students gain new perspectives and multi-perspectives on the daily actions of children and adolescents in the context of urban planning (Schulze et al., 2015).

XR technology offers promising improvements to urban planning processes by increasing comprehensibility, interactivity, and accessibility and enabling earlier citizen participation in the planning process. However, further systematic development and analysis of XR applications in urban planning are required (Wolf et al., 2020). The utilization of such an approach can lead to more informed and collaborative decision-making (Seichter, 2007).

3 Research objective

The state of the art shows that there is a growing body of scientific evidence that supports the benefits of combining tangible elements and XR technology in urban planning to increase citizen participation.

A City Planner that combines planning with tangible and XR technology is being developed to explore the efficacy of actively involving citizens in urban planning and helping students develop spatial citizenship skills. The application creates a Mixed Reality environment that utilizes physical objects to plan the construction of a virtual space. The aim is to gain insights into the potential benefits of XR technology in urban planning and increase citizen participation in the planning process. It is essential to clarify that, at this stage, the City Planner is purely a conceptual idea under development and not a fully developed or commercially available product.

3.1 Methodology

Utilizing XR technology with 3D rendering in urban planning has been found to offer numerous benefits, including higher engagement and more vivid memory compared to traditional 2D presentation technologies (Van Leeuwen et al., 2018). By immersing users in a realistic virtual environment, VR enhances their spatial understanding and enables them to interact with urban spaces in a more immersive and intuitive manner. However, despite the potential advantages, the development of XR applications for urban planning still presents significant obstacles for many individuals (Ashtari et al., 2020). Challenges such as technical complexity, high costs, and the requirement of specialized skills hinder widespread adoption and limit the accessibility of these technologies.

To address these challenges, there is a growing need to create more compelling and meaningful user experiences in XR that can help overcome the barriers to adoption (Ashtari et al., 2020). The focus is shifting towards developing user-friendly tools and platforms that simplify the process of creating XR applications and empower users to harness the full potential of these technologies.

In line with this objective, our proposed approach is the City Planner, which aims to streamline the development process of XR experiences in urban planning. By automating various technical aspects and providing pre-designed templates and tools, the City Planner aims to alleviate the burden on users and facilitate the creation of immersive and interactive XR experiences. This approach empowers urban planners, designers, and citizens with limited technical expertise to actively participate in the urban planning process and make informed decisions.

The City Planner serves as a bridge between the complexities of XR development and the need for accessible and user-friendly tools. It empowers users to create engaging and realistic virtual simulations of urban spaces, allowing stakeholders to visualize and evaluate proposed designs, make more informed decisions, and actively contribute to the planning process. By providing an intuitive and streamlined user experience, the City Planner aims to democratize the use of XR in urban planning and foster greater public engagement and collaboration.

3.2 Design and Development

City Planner consists of six key components that work together. These components interact with each other to create a tool that allows different stakeholders to explore various planning scenarios, understand the potential impacts of different strategies, and make informed decisions.

Figure (1) illustrates the different component of The City Planner.

1. Gameboard Component: This component is a portable surface that represents a piece of real-world land where the Physical Objects can be placed to create a virtual model of the city or land to be planned.
2. Physical Objects Component: These are elementary abstract tangible 3D objects that represent real-world objects, such as trees, buildings, roads, cars, and other urban infrastructure elements. These customizable 3D objects allow users to recreate and experiment with different layouts, designs, and arrangements of various urban elements.
3. Stakeholders Component: This aspect of City Planner includes all individuals and groups involved in the urban planning process, such as citizens, decision-makers, and other interested parties. City Planner can be integrated into the classroom as a part of Service Learning, making students a part of the Stakeholders Component. By incorporating the perspectives and opinions of a diverse range of stakeholders, the planning process becomes more inclusive and informed.
4. Monitoring System: This component is responsible for observing and directing the changes made by users on the Gameboard and sending this information to the Authoring component. It ensures that all modifications and arrangements made on the Gameboard are accurately tracked and recorded in real time.
5. Authoring Component: This Component of City Planner constructs the XR (extended reality) experience. It processes the information collected by the Monitoring System and translates it into a VR, MR, or AR experience that users can engage with.
6. Viewing device: This can be an XR-capable device, usually a VR/MR Headset or an AR-capable smartphone, that allows users to view the city planning experience. This device enables users to immerse themselves in a virtual model of the city using VR technology or use it for Realworld Mapping via an AR device by overlaying AR virtual objects on a real-world location. This enables the users to explore various planning scenarios and understand the potential impacts of different urban planning strategies.

These six components work together to create a powerful tool that simplifies urban planning. To ensure the effectiveness of the Object Detection module in observing and monitoring any changes made, the 3D objects produced must be distinguishable from one another. This is necessary to facilitate the process of monitoring and tracking any changes or modifications made to the objects on the Gameboard.

The Gameboard itself is intelligently segmented into distinct sections, each of which can be readily identified by the Monitoring System.

This identification is achieved by utilizing Computer Vision (CV) and Artificial Intelligence (AI) techniques through the implementation of two separate AI detection models. The first model is an object recognition model, which serves to identify the specific type of object placed on the Gameboard, while the second model, an object detection model, is responsible for detecting and determining the position of the object relative to the Gameboard.

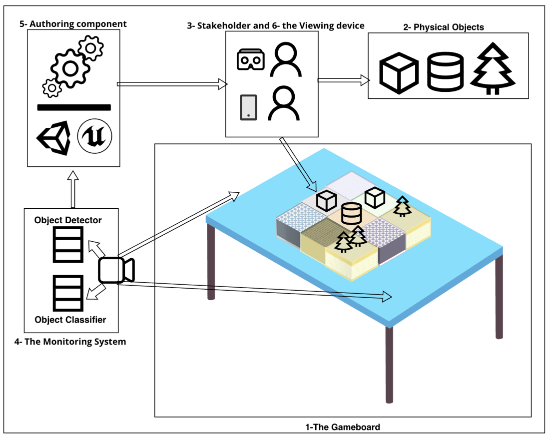

Figure 1: The City Planner Components.

When a stakeholder adds an object to the Gameboard, the Monitoring System detects the change made and recognizes both the type and location of the added object on the Gameboard. This information is then transmitted to the Authoring Tool. Based on the provided information, the Authoring Tool uses UEmbed, a browser-based tool that enables users to map out an area from a top-down perspective and add selective elements like buildings, trees, and characters with various properties. The created map can be exported as a JSON File and imported into a pre-prepared Unreal Engine project with scripts that read the data from the JSON File and build the environment. These functionalities can be used to recreate the world with the data provided by the Monitoring System and pushed to the customized UEmbed Unreal Project.

3.3 Reflection and Improvements

Automated virtual representation creation simplifies the urban planning process, allowing stakeholders to explore the immersive 3D environment and make informed decisions without the burden of manual development. City planners utilize computer vision for object recognition. However, the recognition performance is highly dependent on image quality, which is influenced by factors such as camera sensor, lens quality, illumination, and other camera settings (Kaltenbrunner and Bencina, 2007). Improvements in these aspects can enhance the effectiveness of computer vision in the City Planner.

When considering the redesign of an urban square, it is important to have a clear process in place to ensure that the final design meets the needs of its users. To this end, users can take several steps to guide their decision-making.

1. Identify and preserve surrounding structures or elements: To maintain the character and authenticity of the urban space, it is essential to consider the existing buildings and elements in the area. By preserving these structures, the redesign can seamlessly integrate with the surrounding environment.
2. Arrange new elements and features: Determine the most suitable location and arrangement of new buildings, trees, and other urban elements within the square(Gameboard). This involves carefully considering factors such as functionality, aesthetics, and the preferences of the community. This may include creating open spaces, green zones, and pedestrian-friendly walkways that cater to the needs and preferences of the community.
3. Evaluate different scenarios: Exploring various design options and layouts allows stakeholders to assess the potential impact of each design on the existing urban landscape and the daily lives of its users. This evaluation should consider factors such as sustainability, traffic flow, accessibility, and social dynamics within the community.
4. Gather feedback and incorporate suggestions: Engage with stakeholders, including citizens, urban planners, and decision-makers, to gather feedback on the proposed designs. By incorporating the suggestions and ideas of different stakeholders, the final design can better represent the needs and expectations of all users.
5. Finalize and implement the design: exploring the effect of the design in an XR-capable device to evaluate important factors such as density, relationships between elements, and lines of sight.

4 Summary and Future Work

Urban planning has faced persistent challenges in engaging citizens effectively, limiting decision-making and community involvement. However, recent research highlights the transformative impact of XR technology on urban planning processes. By integrating virtual and augmented reality experiences, citizens can immerse themselves in proposed developments, enabling a deeper understanding of potential changes and their consequences. Additionally, tangible interfaces like gameboards and 3D objects foster collaborative interactions, allowing stakeholders to actively engage, discuss, and work towards consensus, ultimately leading to more inclusive and successful urban planning outcomes.

Using VR technology with 3D rendering in urban planning can provide higher engagement and more vivid memory than 2D presentation technologies (Van Leeuwen et al., 2018).

Despite the promising advantages of XR technology in urban planning, the development of XR applications remains challenging for many. Creating an effective XR application tailored for urban planning purposes involves various difficulties and obstacles that need to be addressed. The City Planner aims to simplify citizen participation in urban planning by automating the development process. This application uses tangible and object detection models to create an immersive 3D environment, which allows users to explore and make informed decisions about the future of their city. Urban planning could be transformed by XR technology integration in terms of decision-making and citizen involvement. Augmenting the XR experience by adding 3D sound can provide an extra layer of information for a more informed decision-making process, but further development and analysis of XR applications are needed.

The integration of XR technology in urban planning and education shows promise to enhance citizen participation, decision-making processes, and community involvement. XR applications offer promising advancements in terms of accessibility and understanding, but additional development and analysis are required to fully realize their benefits.

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