Public Eye - Exploring Augmented Reality Solutions To Encourage Citizen Participation in Urban Planning

ABSTRACT

Public Eye is a concept of a device that will act as a platform to host a shared discussion space between municipal planners and citizens, to help encourage and enhance civic engagement in urban planning. This device uses the metaphor of coin operated binoculars - that can be found at typical POIs - but is enhanced with augmented reality. We present a detailed overview of a prototype demonstrating this concept, which is conceived using modern easy-to-use toolkits such as *PointCloud* and *Untiy3D* running on an iOS device. Emphasis is given to solving challenges such as occlusion of real objects and realistic shadows and reflections to strengthen realism and maximize immersion of the user.

Author Keywords

Augmented reality; citizen participation; urban planning; tangible interaction.

ACM Classification Keywords

H.5.1 Information Interfaces and Presentation (e.g. HCI): Artificial, augmented, and virtual realities

General Terms

Design, Human Factors; Prototyping.

INTRODUCTION

Augmented reality with tangible artefacts is a research topic that has posed many interesting research challenges over the years, and there are now an impressive number of works that have generated useful and applicable solutions for e.g. marker detection, occlusion and feasible visual rendering techniques with easy-to-use game engines [9, 3, 15], running on a variety of physical platforms. Recently, a number of off-the-shelf toolkits and applications have appeared (e.g. PointCloud or Qualcomm Vuforia), which can be tailored and run on ordinary smartphones, and it is now possible to envision a broad variety of commercial, educational and public solutions where these techniques might be taken into popular use in the near future.

One such area is the use of augmented reality solutions for civic engagement in urban planning projects, e.g. construction sites. Such projects often generate curiosity from bypassing citizens who often feel inadequately informed or may further even be ignoring the urban planning process due to high costs of participation and little personal reward [8]. Along with larger projects there are sometimes also public debates regarding different alternative routes that a project might take and the promise of being able to illustrate, from the physical location of the construction site, the different alternative designs makes augmented reality solutions especially interesting for such projects (as also suggested by e.g. [2], [12] or [13]). In this paper, we present an exploration of some available toolkits for generating 3D visualizations that could be useful for this scenario, and point to some current challenges that still exist in terms of object/people occlusion when implementing such a system in an actual construction site in the real world. We illustrate these challenges through a tangible demonstration along with rendered three-dimensional animation.

BACKGROUND AND RELATED WORK

Urban planning is a topic that has been heavily explored in research within the domain of tangible interaction. Several of the early systems showcased by the tangible media group at MIT were related to the visualization of alternatives in the built environment, presented in a variety of forms, e.g. the URP system and the Tangible Geospace/metaDESK [14]. These systems were all based on physical tables with a sophisticated setup using projection and physical artefacts, and were presented indoors and away from the actual construction site. They were addressing the challenges of the urban planners alone, without considering the potential of using it to instigate citizen dialogue. Several later projects, (e.g. Korn et al., the Danish project) instead used mobile devices to gather locally situated input and feedback from citizens on a landscape architecture project [4]. A general challenge in such projects has been to get the citizens to know that there is a project going on, and through physical signage etc. encourage people to download the required app or visit the projects website. There have been a number of attempts to include citizens in the urban planning process using augmented reality, e.g. Allen et al. describe a concept allowing citizens to participate in the urban planning process [2] where they come to the conclusion that augmented reality is commonly accepted and appreciated by younger generations, although this effect is not as strong with older generations. Recently, utilizing augmented reality or especially virtual reality tech-

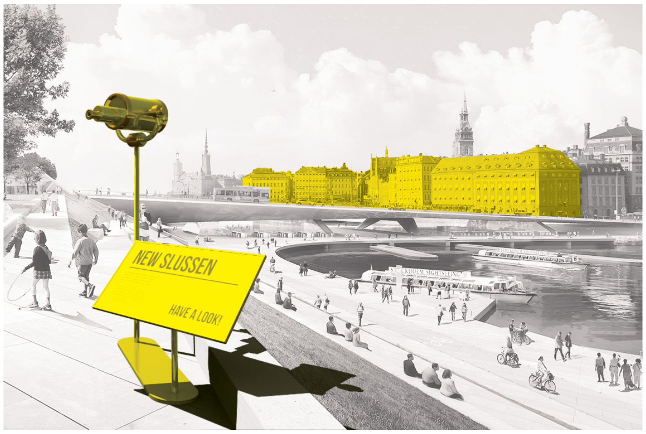

Figure 1. Illustration of a public installation.

niques meant high costs. However, utilizing low-cost devices, such as the Hasbro My3D devices is an affordable way to realize virtual reality with a smartphone, as achieved by [6]. Also wearable technologies are emerging, such as interactive glasses allowing novel ways of interaction. Lucero et al. are exploring the design space of these technologies [11].

CONCEPT

In the current project we explored the case of providing a static installation with a binocular-like device through which anyone may look and see what the final result of the construction project will look like, with an added dimension of augmented reality including computer generated 3D objects interspersed with reality. These installations will provide means for citizens to visualize municipal planning in its real environment and create a two-way communication channel between planners and citizens, e.g. by allowing citizens to view multiple potential alternatives to a proposed plan and leave feedback right away. So apart from just delivering information, these installations would thereby also be used as a direct feedback channel from the public back to the city and can be utilized to gather citizens input. Figure 1 shows an overview illustration of the envisioned system as used in the public space. Their aesthetics will be inspired by coin operated binoculars - like those that can be seen at typical POIs. We believe that the familiar design and the fact that they are in situ would increase the probability of interaction by citizens. These installations would be free to use and placed around a future construction site allowing users to view the result from multiple angles, and in the planning phase also allow citizens to select e.g. their favorite design among alternatives and provide feedback. Having multiple installations may awake further interest among citizens and be an invitation to explore the future building from different perspectives. According to Bohj et al., visualizing municipal planning in its real surroundings provides extra stimuli which affects the quality of reflection by the user [4]. Further Ishii mentions that augmented reality is focusing on "visual augmentation" [7], therefore we try to address this issue by enhancing the tangible appearance. Compared to existing solutions (e.g. URP) this concept will integrate into the real environment and still allow sophisticated visualization of e.g. simulating shadow casting, wind simulations, reflections and so on. In the following section we will describe the feasibility of developing the technology of such installations by using state-of-the-art and freely available toolkits. Although the described concept is hypothetical at the moment, we believe these installations will encourage citizen's participation.

THE EXPLORED DESIGN CASE

Based on the above described case, we designed a system running on the *Unity 3D Game Engine* [15], which was extended by the *PointCloud SDK for iOS* [1] and executed on an iPhone 4S. The PointCloud SDK has a very straightforward approach and is easy-to-use within the Unity game engine. Briefly, the PointCloud AR API is looking to find pre-defined patterns from the smartphones camera stream, so called *image targets*, and can therefore derive the virtual camera transformation matrix, position and orientation in the game engine. Image targets are set as a reference to identify the scene through feature detection by the PointCloud SDK. The format of the image target is proprietary and binary, but can be generated through an online service provided by PointCloud. The SDK implements a robust and fast *Simultaneous Localization and Mapping (SLAM)* technique. As our tests with the SDK showed, it recognizes the image targets very fast and extends the map by extracting image features in real-time. In our first iteration, we tested the feasibility of the described approach by using several rendering techniques, such as reflection of the surroundings, and we tested the performance of the image target recognition under several conditions: conventional targets; as printed patterns and photos; and also in a real environment, such as a wall of a house. A major challenge that we found was that in a real scenario the scene is constantly changing and therefore making it difficult to find an appropriate image target caused by e.g. trucks, cars or pedestrians walking by the scene. Further rendering of a realistic scene would be challenging, since common AR strategies dont take obstacles into account and would simply ignore it (e.g. an overlapping building).

Thus our main focus in this part of the project has been to illustrate this challenge and explore a variety of ways that this might be addressed. We developed the software for a working prototype and to demonstrate the physical appearance we utilize the *Hasbro My3D* device [5]. This device is an affordable pair of binoculars that can hold an iOS device (several version of iPhone and iPod Touch). Further it has a split screen view allowing it to render 3D stereoscopic images to enhance the perceived 3D effect by producing a side-by-side view with an image for each eye (although we were not able to use this technique, as explained in Conclusion). We managed to implement several techniques, such as a basic user interface to switch between models and a social like/dislike feature, animations and a masking technique to hide specific objects of an area. As described earlier, this is due to the fact that current AR techniques are rendering 3D scenes on-top of a two-dimensional video layer and ignoring the surrounding. For example if the camera is capturing a scene where an object of the real environment would overlap the 3D model, the model would still be drawn over

(a) Scene in Unity Editor. (b) Screen capture from the device. (c) A person testing the prototype.

Figure 2. Demo scene from different perspectives

the object in the foreground. To compensate this problem, we implemented a technique to mask out objects that are modeled in the Unity 3D Editor (see Figure 2a). This is implemented with a custom shader that basically turns off the rendering for the overlapping scene. The following steps are performed to address the occlusion problem and prepare a scene for the resulting app:

Modeling. The scene is modeled in the Unity Editor. A map (e.g. from a mapping service like Google Maps) can be used as reference. In Figure 2a objects to be masked out have a dark-grey color, same as the background color of the scene. These objects are assigned with a material that implements a *Depth Mask Shader*[1] - this prevents the rendering of the object with the assigned material if it is visible in the viewport. The Unity game engine has an hierarchical approach that consists of a scene containing several game objects. Therefore the rendered object and the masked objects are game objects and placed in the scene.

Rendering. Most of the computing workload is done by the SDK. Figure 2b shows a screen capture from the prototype where the masking is shown: the rendered house in the background and the tree are overlapped by the house in the foreground. The Unity game engine ignores the rendering and only makes the background layer visible. Since the PointCloud SDK is drawing the camera footage on the background, the foreground is drawn correctly. Further to enhance the realism the scene has adjustable shadows (simulating a sun light with strength and direction as parameters). As Underkoffler et al. describe, shadow casting is a crucial aspect of the urban planning process [14].

In summary the scene must be prepared precisely as it would be in reality, including all obstacles that would interfere from the viewpoint. There is a tradeoff with the accuracy of the PointCloud API preventing an exact masking of the obstacles. However the results were believable and satisfying, which was also achieved by having further enhancements such as animated cars or shadow casting on the real objects of the scene. Beside the shader techniques, some scripts (in our case C#, although Unity allows other languages such as JavaScript) were responsible for drawing the user interface and handling the user input, e.g. allowing the user to switch through alternative models, setup and calibrate the scene for a demo session or providing a feedback mechanism with a like/dislike button.

DEMO

To showcase our concept we prepared a paper model scene with an abstract map and buildings, as shown in Figure 2c. This scene was modeled in Unity 3D and compiled to run on an iPhone 4S. The scene consists of several paper-crafted buildings (which will be masked out) glued on a paper map. The map was also used as reference for the image target and could be identified by the prototype. Although the map was partly covered by the paper buildings, the image detection worked quickly and robust from different angles. The 3D scene consisted of changeable 3D buildings, animated cars driving on the roads and a tree. To show the concept of the binoculars metaphor we use the Hasbro My3D device, as it can be seen in Figure 2c. Further to illustrate the citizens' interaction the app has some a basic UI for user feedback. This demo was presented at our university in May 2013.

During the demo session we asked the people trying our prototype to fill out a short survey on their opinion of the citizen involvement in the urban planning process. In summary our prototype was perceived well and the interest of the need to involve citizens more seriously seems promising. Our participants agreed that it is important to involve citizens in the urban planning process and they would be excited to see attempts to allow citizen to participate as our demo showed The qualitative feedback of our demo was continuously positive and filled with excitement.

CONCLUSION

We have presented a short analysis of core challenges for the design case of augmented reality applications on the scale of the built environment, which we illustrate in the form of a tangible demonstrator.

Although our tests with the PointCloud SDK worked in real environments, it is difficult to adapt this concept to more complex scenarios, such as construction sites and more advanced techniques are required. The scenario is by nature

[1] `http://answers.unity3d.com/questions/243371/depthmask-shader-receive-shadows.html`

very messy and complex and therefore it may be hard to find suitable image targets. Finding suitable image targets, that are more static (e.g. the top of a building) may improve the results.

Further we utilize the My3D binoculars for the demo. It is possible to render 3D stereoscopic images and perceive real 3D, however the limitation of one camera on the phone prohibits the use of this technique since two cameras are needed to get depth information. To solve this attempt it would be possible to operate two cameras, or make use of special optics to split the image for a single camera, like *Poppy*, a recent project on Kickstarter is trying to raise money for [10].

To address the challenges of the complex modeling of the environment, we can imagine some techniques to simplify the process. For our first attempt to realize this concept in a real environment we made use of the 3D models visible in Google Earth. These can be downloaded in the Sketchup Warehouse and afterwards be imported into the Unity Editor. A reference map will help to align these models in the scene. Another, more future-oriented, solution might be utilizing 3D pointcloud scans (e.g. with laser techniques) of an environment to derive exact models.

Building on-top of existing industry-standard frameworks has the benefit of a wide community support and makes it easy to address particular problems. The Unity game engine has a very large community and therefore provides a lot of extra add-ons to extend the capabilities. Utilizing these techniques is a very feasible way of creating prototypes for complex scenarios.

By providing an easy-to-use installation with a familiar appearance, as opposed to e.g. require the download of an app to a smartphone (which is more time consuming), we believe that the amount of effort needed to participate will be less; thus facilitating citizen involvement in urban planning.

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