Abstract. It may be impossible in physical reality, due to implementation costs involved, for prospective users to preview future urban projects as life-sized 3D models at actual locations, but in augmented reality it is. Besides this feature, the idea of harnessing geo-located augmented reality (GAR) technology as a platform for citizen engagement includes a future possibility of users submitting their feedback in the form of full-scale 3D virtual sketches, also geo-tagged to the site in question. Following is a brief description of an academic research project undertaken to explore this idea by harnessing the GAR interface now available on smartphones, such as the iPhone 3GS/4. An initial prototype web-app was developed and tested for basic functionality, exposing a number of limitations but affirming the overall potential of this idea. It offers a 3D language of communication that is intuitively accessible for professionals and the lay public alike. It also commands a certain mass appeal at a fraction of the cost of popular media, and can therefore increase the influence of citizen deliberations. This potential is introduced via a description of the initial prototype study, to prepare ground for full-fledged development of this idea and subsequent testing within a citizen engagement setting.

Introduction

Geo-located augmented reality (GAR) technology allows virtual 3D models to be viewed as super-imposed images in live video screen views of any given place. Till recently this interface was accessible only by specialized equipment, but it is now offered on compatible smartphones as well as hand-held tablets, via the Layar browser. This technology was identified in the present research project as
bearing potential for application to the context of citizen engagement in public space governance on the basis of three in-built qualities.

Foremost of these is the alternative it offers for addressing the information inaccessibility gap that arises on the side of end-users when they are invited to participate or collaborate in governmental spatial design decision-making processes. This gap is the result of the conventional practice to obligate untrained users to comprehend and comment on two-dimensional representations of what are essentially three-dimensional or four-dimensional spatial design decisions. A shift in approach is visible in recent research and practice, from indirect representation to more direct simulation systems, coupled with the use of internet-based social and crowd-sourcing media, as a more intuitive platform for three-dimensional decision-making. GAR technology replaces the cumbersome coding and decoding required by indirect representational systems and the physically detached displays of simulation systems with a direct in-situ three-dimensional walk-around experiential system.

In addition to this, by virtue of this technology now being available on portable devices such as smartphones and hand-held tablets, the experiential system that it offers can be deployed with equal if not more ease in an outdoor setting as well. This translates into opportunities for collective social encounters based on actual in-person presence of all stakeholders at the site of in question, instead of the constrained virtual presence possibilities provided by social media interfaces.

A third quality is that GAR technology at present commands a certain public charm and mass appeal, which elevates related content to a competitive position against popular media at a fractional access cost. This combination of popularity plus low cost opens the possibility for long-term research-driven citizens’ interests to exert an equitable influence in comparison to media-propelled profit-driven interests of commercial stakeholders.

These qualities were explored in practical terms through a scaled-down implementation of GAR technology in the form of an iPhone web-app. Development and evaluation of the initial prototype is described here, beginning with a brief review of the research context of this project, namely published work on alternative technological tools for citizen engagement.

Research Context

Published work on the development of technological support tools for citizen engagement in governmental decision-making processes, specially concerning public space issues, has already been reviewed in detail by a number of authors, including Hanzl (2007), and with reference to cultural considerations in particular, by Foni, Papagiannakis, and Magnenat-Thalmann (2010). Those that relate specifically to the use of GAR technology to facilitate participative design of public spaces are more recent and relatively few (Hii, Zhou, Karlekar,
Schneider, & Lu, 2009), while a larger number of previous works deal with the broader spectrum of underlying issues, bound at both ends by two mutually convergent directions of research: development of IT-based alternatives for improvement of public consultation processes; and, technological innovations for achieving dimensional consistency in the representation of spatial design through realistic life-sized 3D in-situ outdoor imagery. Since an exhaustive discussion of the whole expanse of available literature is beyond the scope of the present discussion, an indicative selection of most relevant and recent sources is presented here, divided into four key sub-categories: issues of perception of three-dimensional information by the lay public; engagement of users by invitation into the spatial design studio; usage of online discussion forums and social media; and, usage of simulation or augmented reality based interfaces.

With regards to the topic of perception of spatial ideas by untrained users of public space through representation systems, there are two main prevailing viewpoints. One group of authors that have conducted an empirical study report that 2D representations supported by rich supplementary information are a more effective medium than 3D visualizations (Smallman et al, 2001), while others have reported benefits of one option over the other to be associated with the nature of the task in question (Nowell, Schulman, & Hix, 2002; Marchak, Cleveland, Rogowitz, & Wickens, 1993). This later view supports the usage of 3D visualizations as best suited for representation of 3D data, as in the context of spatial design decision-making processes. Most recent arguments on this topic include the view that ‘complex problems can be recognized faster with the aid of an interactive adjustment of suitable viewpoints’ (Pantförd & Vogel-Heuser, 2009), which points in favour of real-time responsive 3D simulations, while another argument is that stronger user engagement is associated with the extent of realism captured by a given medium (Neto, 2006). It is on the basis of similar reasons that a comprehensive review by Hanzl (2007), on research and practice related to the usage of IT tools in participatory spatial design maintains that 3D augmented reality systems hold the most potential as the future direction of this field.

This idea has been adopted in a number of ways in research and practice, including involvement of users by inviting them into the governmental decision-making setting itself (Ismail & Sunar, 2009; Bullinger, Bauer, Wenzel, & Blach, 2010). This approach is imminent to be overtaken however, by the emergent practice of online collaboration, due to increased flexibility it offers in terms of contact timings and reduction of travel overheads (Bourdakis, 2004).

Numerous specific techniques for engaging users through web technologies are beginning to be used, researched and taught widely, including: collaborative environments (Barton, Plume, & Parolin, 2005); and, custom-adjusted gaming environments (Donath & Bohme, 2008). Whereas on one hand this form of citizen engagement enables quantitative enhancement due to flexible access times
and close to nil travel costs, its impact in terms of qualitatively affecting the extent to which users are able to perceive crucial spatial information in their own lay terms is nevertheless limited to screen viewing at best, indicating the need for research into even more realistic outdoor formats (Estrin, 2010).

It is this qualitative gap which outdoor or indoor augmented reality (AR) experiential interfaces have the potential to address. Specific techniques that have been explored so far in research and practice include: camera-tracking based life-sized outdoor AR simulations (Papagiannakis, Schertenleib, & O’Kennedy, 2005); indoor, super-imposition of colors on surfaces (Tonn, Petzold, Bimber, Grundhofer, & Donath, 2008); projects similar in concept to the present one but relying on custom-built set-ups (Hii, Zhou, Karlekar, Schneider, & Lu, 2009; Santos, Acri, Gierlinger, Schmedt, & Stork, 2010; Vlahakis, et al., 2001; gaming virtual environments used for art projects, but using custom-built network (Torpus, 2010). Majority of these works however, are based on custom-configured equipment, leaving room for the use of more ubiquitously available devices, such as GAR-capable mobile phones.

In summing up it can be said that out of all these four directions of previous work, outdoor AR simulation appears to create a visualization that is qualitatively closest to end-user experience (Estrin, 2010), while in quantitative terms on-line discussion forums offer a maximum catchment of end-user feedback (Barton, Plume, & Parolin, 2005). A combination of these two technologies therefore holds promise for the most conducive interface for public engagement in architectural or urban design processes. This idea has already been implemented and tested at an experimental level, albeit involving specialized equipment (Hii, Zhou, Karlekar, Schneider, & Lu, 2009; Santos, Acri, Gierlinger, Schmedt, & Stork, 2010; Vlahakis, et al., 2001). There is room for advancement of this idea through the introduction of devices that are less restrictive in terms of simultaneous usage by larger number of users, availability timings and security issues. Accessibility could be improved significantly if equipment or devices already in the possession of users could be used (Estrin, 2010). This could introduce a model for decision-making processes that could significantly shift the economies of scale of public space design processes in favor of common everyday users who are intimately attached to these places. These users otherwise stand largely excluded in the prevalent model of practice, by which design decisions are influenced by the media-popularized interests of commercially-driven developers or government bureaucrats and their chosen consultants, who may have marginal or nil contact with the context in question (Minton, 2009). It is in this overall perspective that the present project offers an alternative idea to use mobile phone handsets that bear GAR capability. Though such devices are yet to be available at prices that could ensure complete proliferation, a move in this direction nevertheless holds significance as a conceptual shift and a possible avenue of future growth.
A Promising Alternative

Drawing on the above thinking, the basic concept underlying this project was to use the iPhone iOS4.0 platform to harness GAR technology offered by the Layar browser [14], to create a more lucrative interface for spontaneous inclusion of users in public space design processes. GAR technology is expected to have a significant future popularity, as indicated by the estimation of its projected market value by Cheng (2010), in turn reporting on Juniper Research: usage of AR services is ‘expected to reach USD 732 million by 2014’ (Cheng 2010). A decision was therefore taken to develop an initial prototype in the form of a specially formatted website dedicated for use on iPhones, termed as a web-app in the iPhone user and developer community.

Existing community consultation activity was identified as the context for the prototype, and was taken into account via published reviews on this topic (Cuthill 2001), available video recordings of typical community consultations, and also by examining archived/live online discussion forums that simulate or offer an alternative to such sessions. A screenshot of the web-app GAR display is included here (Figure 1).

![Screenshot showing GAR functionality via the Layar browser (16 cubes with superimposed on live video view)](image)

Figure 1. Screenshot showing GAR functionality via the Layar browser (16 cubes with superimposed on live video view)

Evaluation

The scenario selected for an evaluation study was usage of the product by postgraduate students in a university setting. Five tasks were assigned to the voluntary participants: to locate a pre-assigned 3D life-size object and bring into view; and, to recognise and successfully deploy link to the ‘feedback’ webpage. Results revealed areas that needed improvement but were overall positive: participants were impressed by the novelty of the product; and, they invested
more time to understand the navigation system than planned. These indicated the necessity to further streamline the sequence and transition between each function of the prototype.

Analysis of the results revealed that most significant of all the observations was regarding the GPS functionality of iOS4.0. Although issues of inaccuracies and delays were known from beforehand, this study helped identify a certain pattern which could reveal insights for a possible work-around to these issues. This pattern became evident while participants made multiple attempts to view geo-located 3-D images. In the first sweep of the assigned geo-position of the image the browser displayed a distance in the range of hundreds of meters, while in the second sweep it displayed a distance of few tens of meters. The first set of distances happened to coincide with the location of one of the nearest towers for 3G signals, while the latter happened to be closer to the actual distance to the geo-located image. Large amount of the time spent during the operation was in reading the text instructions at various stages. Participants felt burdened by this and the visceral content of the web-app also appeared to have suffered on account of it. A number of positive comments were made by the participants (‘awesome’, ‘cool’, and ‘great’), but appeared to be bogged down by the number of steps involved as well, especially due to non-automated data entry of GPS coordinates.

Among the reflective aspects the most important was the realization that a Java script patch that directly feeds GPS coordinates into a given input form which had already been identified but was saved for later implementation should have been incorporated within the prototype that was used for the current testing exercise. On the whole this evaluation confirmed the envisaged potential of the basic idea of the prototype but at the same time emphasises the need for better performance. Usage of the word performance here underlines the fact that the 3D display of this browser is made possible through the coordination and convergence of a number of technologies and related operative factors, including GPS information exchange, digital compass readings in sync with any change of direction, accelerometer sensitivity, rapid two-way internet communication, and the live video screen display of the device used. These inputs influence the performance of the Layar browser, in terms of time, quality, accuracy, and most of all, reliability.

Conclusion and Future Implications

Overall this study has demonstrated, albeit within certain limitations, the significance of GAR technology available on smart phones as a potential for addressing the information accessibility gap that currently constrains end-users to engage more meaningfully in participatory design processes. Results from the evaluation, though indicating a critical need for several improvements in the prototype design, correspond to the initial research question by providing
evidence for the possibility of using this technology to achieve dimensional consistency between spatial design decisions and their representations as an alternative to overcome the stated gap in participatory design practice. Among the limitations of this study that could be improved upon in future work in this direction, the most significant is the accuracy of geo-positioning offered at present by the Layar browser. Although alleviation of this constraint can be expected with foreseeable improvements in GPS services worldwide, it is nevertheless a serious inhibition for the concept described in this paper at present. In terms of future implications, the 3DPP study offers a ready reference for successive usage of GAR technology for representation of spatial design information. In general this project opens the avenue for further development of the basic concept by transporting it now into the realm of iOS4.0 development. This prospect opens the further possibility of building into this concept a feature for on-the-fly designing of 3D objects as well, as already partially available in the iPhone app called GD3D offered by Google. It would be fortuitous if the time required for this further development could coincide with the availability of better GPS services globally. Furthermore, if decreasing trends in prices of smart phones also continues then this concept could truly serve as a basis for a significant shift in CAAD-enabled end-user involvement in spatial design processes.

Acknowledgments

This project has benefitted during development stages from input of a number of individuals, including foremost: Dr. Martin Tomitch, Dr. Andrew Vande Moere, Dr. Xiangyu Wang, Kazjon Grace, Rui Wang, David Bartollo, Michael Sarroff and Julie Whickers.

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