Smart-Phone Augmented Reality for Public Participation in Urban Planning

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ABSTRACT
We investigate smart-phone based augmented reality architecture as a tool for aiding public participation in urban planning. A smart-phone prototype system was developed which showed 3D virtual representations of proposed architectural designs visualised on top of existing real-world architecture, with an appropriate interface to accommodate user actions and basic feedback. Members of the public participated in a user study where they used the prototype system as part of a simulated urban planning event. The prototype system demonstrated a new application of augmented reality architecture and an accessible way for members of the public to participate in urban planning projects.

Author Keywords
Smart phone, architecture, urban planning, participation, augmented reality, mobile augmented reality

ACM Classification Keywords
H.5.1 Multimedia Information Systems, H.5.2 User Interfaces.

INTRODUCTION

Citizens show “rational ignorance” toward urban planning events (Krek, 2005). The cost of learning how to participate in urban planning projects outweighs their perceived potential benefit from taking part (Krek, 2005). How might we help reduce the cost of learning, and improve the public's perceived benefit from taking part? How can we increase their willingness to participate?

It can be seen from the literature that augmented reality can be used to help enhance the urban planning process (Piekarski and Thomas, 2001; Sareika and Schmalstieg, 2007; Schall et al., 2009). However, the emphasis of research in the field of mobile augmented reality for urban planning is with adding extra functionality to create novel yet applicable systems for expert users and stakeholders, and little has been done in the way of public participation systems for average users (Zhou et al., 2008). As Livingston (2005) suggests, these added functionalities tend to confound the user's experience and ability to perform tasks. There is a need to evaluate high level user tasks such as information identification and representation, as most of the focus in the field is in low-level perceptual tasks (Azuma et al., 2001; Livingston, 2005). Similarly, more work has been done in developing the enabling technologies of augmented reality, like tracking, calibration, and display, than to the areas of mobile augmented reality and augmented reality application evaluation (Zhou et al., 2008).

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The prototype we've developed is a smart-phone-based augmented reality system for supporting public participation in urban planning events. It takes into account the potentially confounding factors from previous research which could hinder public participation and limit the ability for users to evaluate the system's potential benefits. This study used mobile augmented reality to show 3D models of potential new designs of a building within the context of its environment. This was done in the context of public participatory urban planning, and the system allowed its users to vote for their preference in the proposed designs. These votes would be made available to the managers and stakeholders of the urban planning event.

The objective of this study is to determine whether by using a smart-phone augmented reality system both (1) the willingness of the public to participate and (2) the perceived participation in urban planning is increased. A secondary objective of this study is to qualitatively examine the public reaction to this technology. This study not only provides insight into the possible application of smart-phone augmented reality for urban planning projects, but also provides a better understanding of the general public's perception and experiences using a smart-phone based augmented reality system.

This paper will briefly traverse the previous work done in the area of mobile augmented reality for urban planning, and go on to describe the developed prototype system, the research methodology and results and analysis of the obtained data. The results of the research are discussed, and possible future work is considered.

PREVIOUS RESEARCH

Public participatory geographic information systems have been used in the past to try and improve the public's participation in urban planning processes, but little empirical evidence exists to show its success (Krek, 2005). In fact, the effect of “rational ignorance” can be observed among citizens, where the cost of learning how to participate in the planning process can outweigh their perceived potential benefit; the perceived benefit from participating is usually low and the cost of learning how to use a new system and participate in the process is high (Krek, 2005).

Visual information is used for a citizen to understand and act upon the changes proposed in an urban environment (Wang, 2007). Such visual information can be retrieved from a variety of sources, including from original 3D architectural models produced using modelling software, such as CAD drawings (Wang, 2007). By allowing access to this kind of easily interpretable visual information, the non-professionalism barrier can be suppressed (Hanzl, 2007). Among the various information technology tools available for public participation in urban planning is augmented reality.

Augmented Reality

Augmented Reality (AR) "allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore AR supplements reality" (Azuma, 1997). AR can be defined as having three main characteristics: It combines real and virtual elements, in interactive real-time, which are registered in 3-D. There are many enabling technologies that are required to make useful and compelling AR applications, including display devices, tracking technology, calibration techniques, and interfaces and visualisation (Azuma, 1997).

Mobile Augmented Reality and Urban Planning

Mobile augmented reality provides a new way to approach outdoor information tasks. This section describes three major efforts to develop outdoor augmented reality urban planning systems: Tinmith-Metro, Urban Sketcher, and Vidente.

Tinmith-Metro

In (Piekarski et al., 2001; Thomas, Piekarski, and Gunther, 1999) the Tinmith-Metro mobile augmented reality platform was developed to examine possible answers to the question: "How does one visualise a design for a building, modification to a building, or extension to an existing building relative to its physical surroundings?" They suggest that in the past a customer or stakeholder in the design process would need to be in the design studio to propose changes to a Computer Aided Design built 3D model, viewed on a graphics workstation. Piekarski et al. used augmented reality to allow the visualisation of designed buildings, or building extensions and modifications, to be displayed and viewed by the user in the real environment where the target end-users were architects, designers, engineers and clients.

The system uses a wearable computer in conjunction with a see-through optical head mounted display to allow the user freedom of movement to interact with and view their environment. The system used GPS and an electronic compass to perform object tracking and registration. A miniature keyboard was used to provide user input and facilitate interaction with the system (Piekarski et al., 2001).

They concluded that their system provided users with a sense of space and "feeling" for the size and location of the virtual objects.

While the Tinmith system provides a comprehensive set of functionalities for viewing and manipulating augmented 3D architecture it was (a) not designed to allow for a degree of realism suitable for a general, public audience and (b) requires substantial instrumentation of the user.

Urban Sketcher

As part of the broader IPCity research project, Sareika and Schmalstieg (2007) developed the Urban Sketcher application to "encourage and improve communication on urban design among stakeholders." The system provides multi-modal interface devices for interaction and collaboration among many users. Visual feedback is provided on a single projected display containing live footage of the augmented scene. The system is housed in a tent on site at the planning event and allows for conventional planning activities as well as the mixed reality approach.

With the Urban Sketcher application, users can directly alter the real scene by sketching 2D images which are then applied to the 3D surfaces of the augmented scene. This sketching provides an intuitive method for collaboration and interaction, even for inexperienced people.

Urban Sketcher demonstrated that the use of AR technology is suitable for public participation. However, it requires a substantial instrumentation of the environment.

Vidente

Schall, Mendez et al. (2009) developed a mobile AR system to provide an alternative to traditional printed plans for field work carried out by utility companies. Using customised hand-held devices, Vidente has been developed, tested and evaluated for demonstrating underground infrastructure virtualisation in the field.

Features and abstract attributes of a geographic information system (GIS) were transcoded into 3D scenes via a multi-stage pipeline. GIS features were converted to Geography Mark-up Language, annotated using real-time data uploaded from the device in the field, and visualised on the device using a 3D rendering engine. The visualisation could have filters applied to reduce the amount of information on screen (Schall, Mendez et al., 2009).

Vidente incorporates various spatial interaction tools. An excavation tool overlays hidden underground infrastructure on top of real-world objects. A labelling tool visualises meta-information from the original GIS on objects selected with a cross-hair. A filtering tool removes unwanted clutter from the visualisation (a feature which proved to be too complicated to use, so the system was reduced to a selectable set of predefined 3D features.

The hardware used was an ultra-mobile PC implementing a version of Studierstube (Schmalstieg et al., 2002), a GPS antenna and a camera, housed in a custom-made base with handles. Three factors were recognised for a system of practical value: it must have sufficient computing power, it must be ergonomic, and it must have six degrees of freedom (i.e. able to be moved in the three perpendicular axes, along with pitch, yaw, and roll rotations) (Schall, Mendez et al., 2009).

RESEARCH FOCUS

It can be seen from these major studies that the technology used in the designed systems, such as head mounted displays, wearable computers, and stationary tools within a tent, while providing appropriate accessibility and functionality to select stakeholders at prearranged meetings, are not likely to be as accessible to the public as other possible platforms such as smart-phones. Smart-phones are becoming an increasingly used platform for augmented reality (Wagner and Schmalstieg, 2009) and based on the increasing sale figures, the popularity of smart-phones is increasing (Wagner, 2009).

This research focussed on using smart phones and augmented reality to provide the general public with an accessible and user friendly way to participate in urban planning events. With our prototype system, users would be able to view new urban designs accurately in the context of their environment, reducing the non-professionalism barrier, and increasing the proliferation and potential of better informed feedback from members of the public.

Compared with the previous augmented reality urban planning case studies mentioned in this paper, our prototype system would seek to give anybody with access to a smart phone the ability to participate in urban planning events, in their own time, and without the need to attend formal or prearranged meetings or presentations. It would serve as a front end to the urban development process, allowing members of the public to view easily interpretable augmented reality visualisations of proposed urban developments, and to conveniently provide feedback to event organisers.

Hypotheses

Hypothesis One: The use of smart-phone augmented reality in a public urban planning event increases public willingness to participate in the urban planning process.

Hypothesis Two: The users of the proposed system are satisfied with the level of their perceived participation in the planning process.

Research variables

The independent variable of this study is the presence of the proposed smart phone augmented reality system, including its components.

The dependent variables of the study are:

- User perceived participation: the degree to which users perceive that their contribution and participation in the urban planning event is significant towards the outcome of the event.
- User willingness to participate in urban planning projects: the extent to which the user has been willing, or is willing, to participate in urban planning events.

The prototype mobile AR system

The system, as referred to in this article, consists of a smart-phone and the software and content required for performing the urban planning augmented reality visualisation task used in this study. A graphical user interface was implemented as the front end to the StudierStubeES software (Schmalstieg and Wagner, 2007), an augmented reality platform for embedded systems. The StudierStubeES (StbES) software provides the augmented reality tracking and visualisation framework that this project required. A panorama tracker (Langlotz, 2011) was implemented as the tracking method for the system, where the camera is used to sweep the scene of interest, thereby creating a panoramic image of the scene to which the visualisations are calibrated. A requirement of this tracking method is that the user remains stationary during system use. 3D architectural models were designed by students of the DESI313 Environmental Design course at the University of Otago, and used as the visualisation content of the system. A heuristic evaluation of the system was performed to assess its usability before being used in the field user study.

Toshiba TG01 Smart-Phone

The Toshiba TG01 smart-phone was chosen for this project. It has a 1GHz SnapDragon processor, 256 MB RAM and 512 MB ROM, a large touch-screen, a camera capable of taking reasonable quality stills and videos (3.15 MP, 2048x1536 pixels, with autofocus; VGA video at 30 frames per second), and its Windows Mobile 6.1 operating system is supported by the StbES framework.

System Content: 3D Architectural Models

The 3D architectural models had to be processed and calibrated for use in the system. This required following a strict process pipeline to successfully convert the models from their original 3D Studio Max formats into the Virtual Reality Mark-up Language format supported by StbES conversion software, and also to realign the models in virtual space to have them correctly aligned with the real architecture.

Firstly, the models had to be loaded into the Deep Exploration 3D model conversion software. Using this software, each model could be repositioned and scaled in order to overlay with the real architecture. These output files were then converted to the StbES XML format using the VRML To StbES Converter software. Finally, the XML files could be added to the data directory of the StbES application and viewed upon running the application. The working models were tested against a scale model of the real architecture to be augmented (Westpac building in Dunedin, see Figure 1).

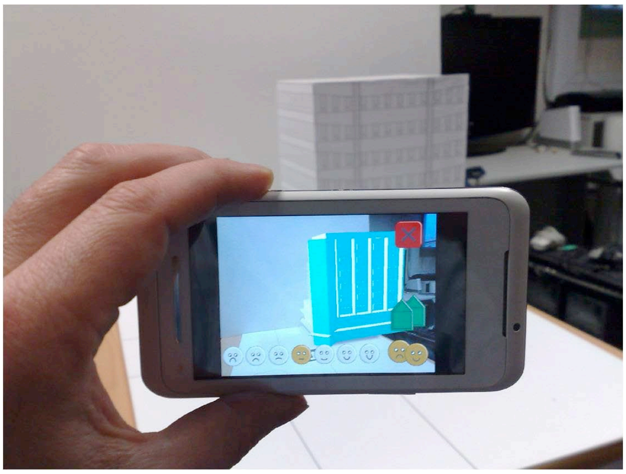


Figure 1. Overlay on scale model

System Interface

The functionality of the system is limited to being able to view the available 3D models and vote for the models according to personal preference. The idea is to keep the functionality to a minimum in order to limit any confounding factors in the user experience of the system. As such, the graphical user interface (GUI) had to accommodate these functions in the most direct, user friendly way possible. As depicted in Figure 2 only the following functions have been implemented:

- a button to switch between the different virtual 3D models (green, MODELS)
- a voting button switching on a row of "smiley" buttons (yellow, VOTE)
- buttons to calibrate (operator) and exit the application (red, EXIT, RESET)

Figure 2. The Graphical User Interface

Heuristic Evaluation of the User Interface

A heuristic evaluation was performed to discover usability issues with the system and to determine what changes would need to be made to reduce potentially confounding interface issues before the final user study in the field. Eight students from post-graduate Information Science and Computer Science courses volunteered to participate in the heuristic evaluation of the system. All participants were experienced computer users and were familiar with smart-phone technology. The number of participants to take part in the heuristic evaluation was suggested by Hwang and Salvendy (2010). The participants recorded usability issues which violated Nielsen's ten heuristics for usability design (Nielsen, 1994), and noted them as being one of four levels of severity: critical, high, medium or low.

The problems discovered during the heuristic evaluation were considered and amendments were made to the system accordingly before its use in the field user study. The changes made to the user interface can be seen between Figure 1 and Figure 2.

USER STUDY AND METHODOLOGY

A user study was designed to formally record quantitative and qualitative data from members of the public using the system. The study took place on the opposite corner to the Westpac building on George Street, Dunedin, NZ, in a position where the panorama tracker could be calibrated by the researcher to overlay the 3D models onto the Westpac building.

Members of the public at the site were approached without discrimination and individually asked to participate in a brief research study. Upon agreeing to participate, they were given an information sheet regarding the research and the user study, and asked to complete a consent form.

Each participant was initially asked a series of demographic questions regarding their familiarity with mobile devices and their applications, their previous experiences with urban planning events, as well as basic demographic information such as age and gender. All questions of the questionnaire were asked in an interview style by the researcher, where participants could respond verbally. After completing the initial questionnaire, participants had a simulated urban planning scenario explained to them by the researcher, which they were told was a fake event designed for the purposes of the research.

The smart-phone system was then calibrated by the researcher to overlay the visualisations correctly on the Westpac building, and participants then used the system in the context of the simulated urban planning event (Figure 3).

Participants would toggle through and view each virtual model as it would appear at the Westpac building site, and voted on each of the proposed designs by selecting the appropriate "smiley" vote button. They were asked a series of questions about their experience when they had finished using the system. The questions included 7-point Likert-like scale responses and general feedback. The questionnaire questions are described, along with the user responses, in the results section of this paper. Upon completing the study, participants were offered a small chocolate bar as reward for their participation.

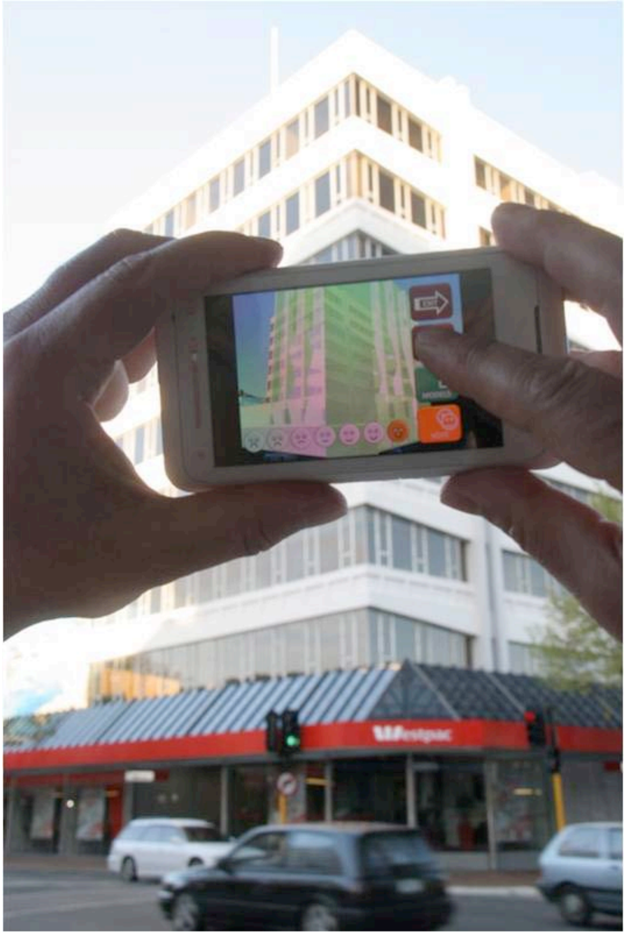


Figure 3. User's View during study

Assumptions

It is assumed that in order for the study to have achieved validity:

- participants in the user study are representative of the general public
- the smart-phone system adequately demonstrates the augmented reality technology in question
- participants will provide genuine, considered responses to survey questions
- the questionnaire will adequately extract useful data during the user study
- the urban planning scenario used is typical of usual urban planning events

Potentially Limiting Factors

Participants

The participants who volunteer to participate in a field survey may vary greatly, and these variations will affect the outcome of the study. Their mood, level of technical capability and familiarity with the technology, the amount of free time they have, and other possible factors such as age and gender and could affect their experience when using the system.

The age and gender of each participant, as well as their familiarity with cell phone and smart phone technology, would be recorded as part of a demographic questionnaire. Participants would be asked if they have enough time to comfortably complete the survey.

Field conditions

During any single use of the system, field conditions may change which could affect the quality of the augmented reality tracking, and therefore potentially disrupt the overlay effect. Care would be taken to ensure that the panorama tracker was correctly calibrated before each trial, and that the quality of the overlay was observed and recorded during the trials.

Interface design

It is possible that the designed interface would not meet satisfactory levels of usability by the time the field study is scheduled to commence, or that the expert users of the pilot study heuristic evaluations consider some aspects of interface design to be acceptable where members of the public may not. It was assumed that any further problems would be observed during the user study, and could be explained by the researcher where necessary.

Complexity of task

A basic requirement of using a smart phone based augmented reality system is to understand, even vaguely, the relationship between the technologies and how they interact and operate. For instance, the phone camera needs to be pointed at the augmented reality marker or correct position of the panorama scene, either of which needs to be kept in view for the visualisation to be correctly rendered. The users' experience of the system may largely be affected by their ability to quickly understand these principles. This potentially confounding variable is of course to be expected when introducing members of the public to a new technology, and would be managed and observed.

Questionnaire

No suitable questionnaire regarding people's willingness and perceived participation was found for use in this study. The questionnaire used was developed by the researcher, and could be a potential confounding variable in this study. There is the possibility that it could introduce bias into the results.

RESULTS AND ANALYSIS

The demographic data were analysed first. 18 members of the public participated in the field user study. Seven of the participants were female and eleven were male. Ten were aged between 18 and 25 and eight were 26 and older. After initial analysis of the data, it was decided that the results should be split into the aforementioned age groups to determine whether age was a factor in the results. The results from the quantitative aspects of the questionnaire are shown below. "7" is always the positive end of the scale, and "1" is the most negative possible response. They are accompanied by descriptions of the formal observations made by the researcher as well as the verbal feedback from the subjects. The data analysis is split into four categories: mobile device familiarity, user experience, perceived participation and willingness to participate.

Mobile Device Familiarity

It was found that subjects in general were less familiar with touch-screen smart-phones than regular cell phones. The 18-25 age group showed a higher level of familiarity with smart-phone technology (mean=5.2, stdev=1.75) than the 26-plus age group (mean=2.375, stdev=2.2). The 26-plus age group showed a greater difference in familiarity between cell-phones and smart-phones.

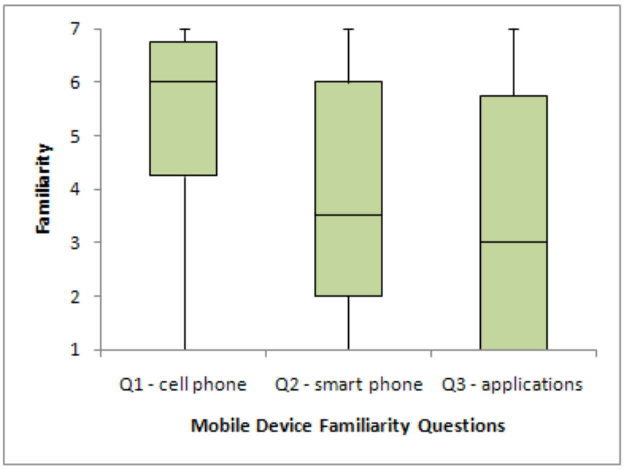


Figure 4. Mobile device familiarity results for all participants.

Figure 4 shows the responses from all subjects to these first three questions of the questionnaire. The variance in the results was quite large (3.04 and 4.87 for Question 1 and Question 2 respectively), so the median value for these responses was used for comparison. This can be seen in Figure 4 where the median value for cell-phone familiarity was 6 and the median value for smart-phone familiarity was 3.5. Although this comparison shows a rather significant drop in the participant's familiarity with smart-phones compared to cell-phones (Q1 mean=5.28, stdev=1.74; Q2 mean=3.95, stdev=2.2; p=0.024), the rather large range in the upper and lower quartiles of the responses suggest the presence of some underlying contributing factor to these responses. It was anticipated that one possible factor was the age difference between the participants, where it was assumed that the younger participants would be more familiar with mobile device technology. The following figures, Figure 5 and Figure 6, show the responses from the 18-25 year old group and the 26-plus age group respectively.

Figure 5 shows a much closer level of familiarity with cell-phones and smart-phones in the 18-25 year old age group ('18-25' Q1 median=6, Q2 median=5.5) than the overall response. Figure 6 shows that the 26-plus age group are not only less familiar with cell-phones than the 18-25 age group, they were far less familiar still with smart-phone technology and mobile device applications. The median response to Q3, pertaining to the participants familiarity with mobile device applications, was very low on the Likert-scale (Q3 median=0.5).

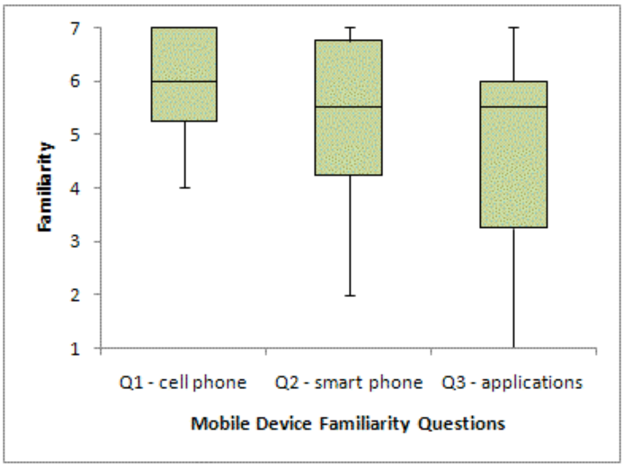


Figure 5. Mobile device familiarity results for 18-25 age group.

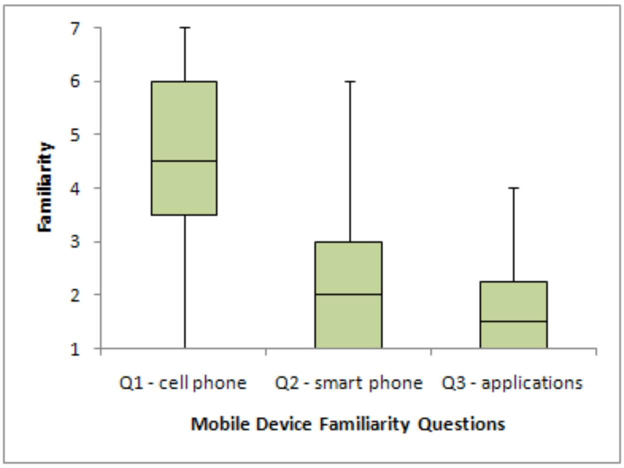


Figure 6. Mobile device familiarity results for 26+ age group.

There was a clear gap in familiarity of mobile device technology between the two age groups. It was anticipated that this gap in familiarity would possibly be a factor in the participant's responses to the user experience questions as well as the questions relating to the hypotheses. For that reason, the results of the remaining questions were also split into the two age groups for further comparison.

User Experience

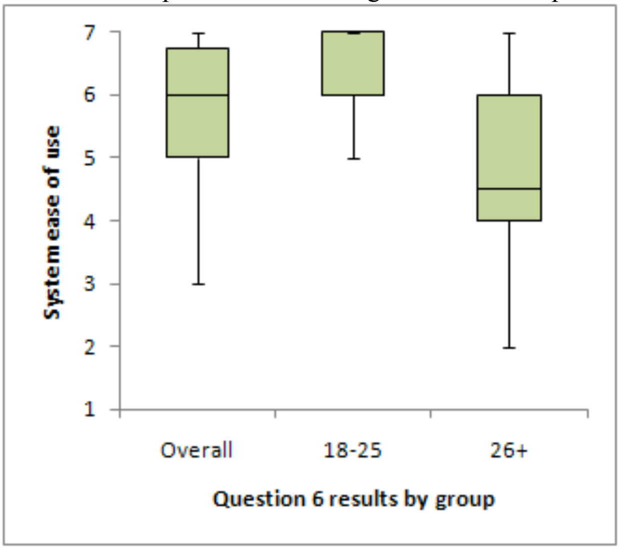
The results of the user experience questions were also split into the two age groups, 18 through 25, and 26 and older. The feedback provided by the subjects for each question give more insight into the Likert-scale responses.

System Ease of Use

Question 6 (Figure 7) asked participants how easy they found the system to use. The median response to the question over all participant's was high (Q6 median=6) although the range of values extended as low as 3 on the seven-point Likert-scale. This can be explained when looking at the responses of the age groups. The 18-25 age group response was very positive (median=6, min=5), whereas the median response from the 26-plus age group was 2.5 points lower (median=4.5), and the minimum value was lower still (min=2).

Figure 7. Perceived system ease of use.

The feedback provided some insight into these responses.



One user of the 26-plus age group found the screen to be too small to use comfortably, and one person found the buttons for voting to be too small. Most people found the system easy to use because of its simplicity.

System Utility

Figure 8 shows the participants' responses when asked to what degree they considered the system useful for participating in the urban planning project. The results to this question were more similar between age groups than in previous questions. This could suggest that it did not require a high level of familiarity of the technology to understand the systems purpose and consider its potential utility.

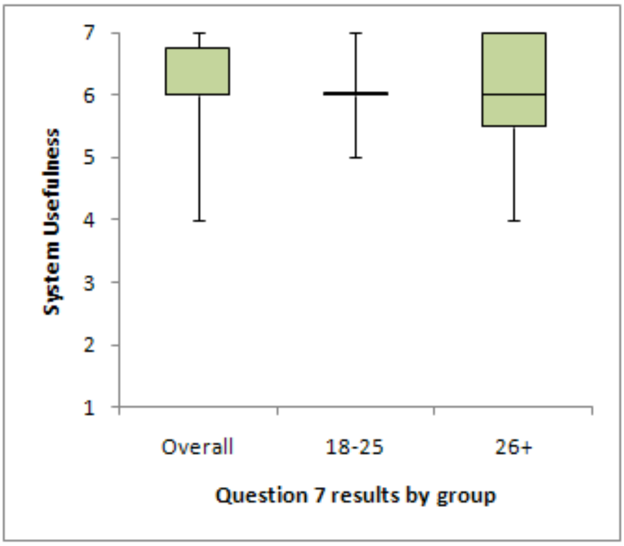


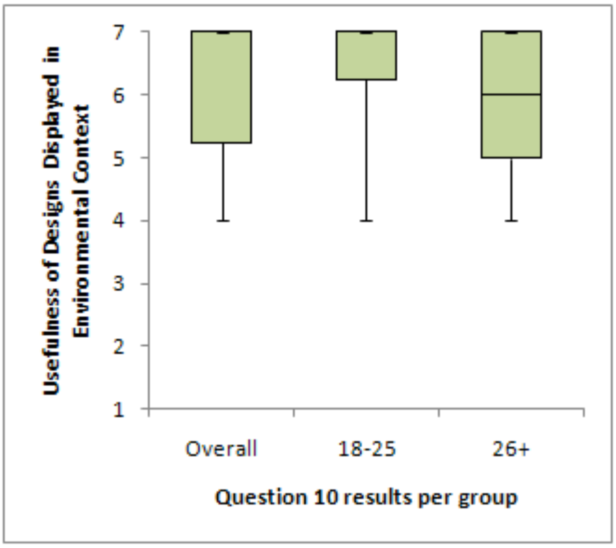
Figure 8. Perceived system utility

According to their feedback, participants thought that the system was a useful visual aid which would motivate people to get involved in the planning process, and that it was good to have an actual perspective of how the designs would look. One participant noted that it would remove the shyness that people often experience in public meetings (during traditional planning events), and that everyone could participate. It was suggested that "multi-voting" would need to be controlled, and that it should have been available for previous planning processes.

Augmented Reality Architecture

Participants were asked how useful they found it to see the new architectural designs superimposed in their actual environmental context. Again, the response was very positive and relatively even across the age groups. The box plot of the results can be seen in Figure 9. Both the overall response and the 18-25 group showed a median of 7, and no response was lower than 4 on the 7-point scale.

Figure 9. Perceived usefulness of seeing architectural



designs in their environmental context

Participants found the augmented reality visualisations useful for a variety of reasons. It was suggested that it would help people visualise the intention of the design better than if they only had access to drawn plans, and that it was good to see a real life model of how the proposed buildings would look. One respondent noted that they were unfamiliar with other methods of public involvement in the design process, so was unsure how these visualisations would compare to more traditional methods. Some participants would have liked a better view of the building and the overlaid model (a shortcoming of the panorama tracking technique that was to be expected), and one would have liked more realistic models to fully understand how they would look in the context of the street.

Perceived Participation

Only two participants had participated in previous urban planning events, making it difficult to gauge any shift in public response in terms of perceived participation. Figure 10 shows the results of the question which asked participants whether they felt that their feedback (in the form of voting) as a result of using the system would be considered and used by the organisers of the event during the decision process. The feedback given by the participants helped explain why the results were fairly neutral, with a large range (between 6 and 2 on the Likert-scale). It was suggested that the voting from the system would only be a significant factor in determining the outcome of the urban planning process if enough people used the system and the results of the voting were made public. A few of the users felt that the organisers would not be likely to consider feedback from the public, and that they were more interested in the views of businesses. A few users appreciated the fact that there were hidden but sensible processes in the planning process that might not accommodate public input.

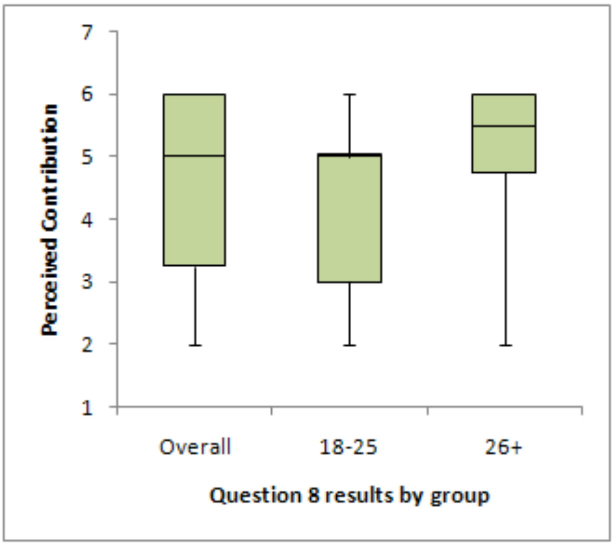


Figure 10. Perceived participation in the simulated urban planning event

Willingness to Participate

Paired two-sample t-tests (with alpha value=0.05) were performed to compare the values of means between the questions relating to the hypothesis. The results of the t-tests can be considered significant, that is, it is highly likely that the difference in means between the two populations did not occur by chance, if the p-value of the test is less than 0.05. P-values between 0.05 and 0.1 can be considered marginally significant (Utts and Heckard, 2005). The two-tailed t-test p-value was used in the analysis of this data as the anticipated difference between the means could be either positive or negative.

The result of the t-test performed on the "willingness" questions ("How willing are you to participate in urban development projects?" asked before using the system and "To what degree would you be willing to participate in urban development projects if you had personal access to this type of system?" asked after using the system) showed a significant increase in willingness recorded for the second question. The mean increased from 4.33 (with standard deviation = 1.74) to 5.33 (standard deviation = 1.71) with a p-value of 0.005 (t-critical=2.11, df=17). This increase in mean can be seen in Figure 11. The increase in mean for the 18-25 age group was significant (Q1 mean=3.9, Q2 mean=5.7, p=0.001, t-crit=2.262, df=9).

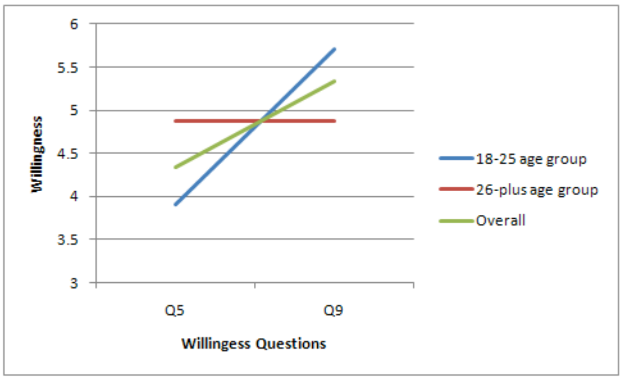


Figure 11. Mean willingness to participate without (Q5) and with (Q9) the system

DISCUSSION

This research aimed to determine whether the public's willingness to participate in urban planning projects and their perceived participation in such events would increase if they had access to a smart-phone augmented reality system. A prototype smart-phone augmented reality system was designed and used to overlay virtual 3D architectural designs over an existing building and to allow users to provide feedback based on their personal preference of the proposed designs. A user study was designed to evaluate the prototype system in the field, using a custom questionnaire which members of the public would complete. The intention was to gather quantitative data in order to support or reject the hypotheses of the research, as well as qualitative data to gather broader insight into the public's perception of mobile augmented reality for urban planning projects.

It could be seen that there was some divide in the results between the younger and older participants. When looking at the results of the mobile device familiarity questions, it could be seen that the younger participants were generally more familiar with mobile technology than the older ones; a result that could have been anticipated. This same divide seemed to appear again when the participants were asked how easy the system was to use; the younger subjects responded more positively than the older group.

The same trend was seen again when inspecting participants' willingness to participate in urban planning events. Here, only the responses from the younger participants (the 18-25 age group) showed an increase in willingness if they were to have access to the kind of system introduced in this study. The overall difference in means between both questions did increase however as the response from the older group remained the same for both questions. The overall mean increase was shown to be significant.

The qualitative feedback gave an impression of how the public reacted to the prototype system. The feedback was generally very positive, especially among the younger participants. They saw the prototype system as a useful tool for visualising proposed architectural designs, although participants would have liked to have had access to more information about the designs. Participants generally showed an understanding of how to view the augmented-reality rendered designs, suggesting that the augmented reality approach to visualising 3D architecture was not too difficult to pick up for new users.

The feedback showed that the participants had a range of reasons to believe that the project planners would not consider their participation in the urban planning event, but thought that if enough people used the system and if the results were made public, then their contribution would be of more importance. That the prototype system was "nice and simple" to use and "easy to understand" suggests that it may help reduce the rational ignorance citizens have towards participating in urban planning projects described by Krek (2005).

Participants in the field study showed an increase in their willingness to participate in urban planning events with the use of a smart-phone augmented reality system. The research could not, however, show the effect such a system would have on the public's perceived participation during planning events. Valuable feedback was obtained which suggested that smart-phone based systems like the one introduced in this research would be valuable for helping the public visualise proposed architectural changes to the urban environment during planning events.

FUTURE WORK

Considering the positive and thoughtful feedback gathered from the public during this research, future work could be done in improving the prototype system used here. This could include designing ways to incorporate extra information about the designs and urban planning events, and allowing users to view higher quality models from multiple viewing angles. In terms of increasing the public's perceived participation in urban planning, the system could be extended to allow for web functionality in order to make the user's feedback public and to allow for a sense of community among the participants of the urban planning event. Further extension could allow users to upload their own design concepts, or modify existing ones, to better share and understand their ideas about their urban environment. This could include a desktop PC version of the system working in conjunction with the mobile version, to extend the functionality beyond the limitations of the smart phone device.

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