8-2014

Urban planning process: Can technology enhance participatory communication?

Rojin VISHKAIE

Richard LEVY

Anthony TANG
Singapore Management University, tonyt@smu.edu.sg

Urban Planning Process: Can Technology Enhance Participatory Communication?

Rojin Vishkaie[*1], Richard Levy[2], Anthony Tang[3]

Faculty of Environmental Design-Department of Computer Science, University of Calgary
University of Calgary, 2500 University Dr. NW, Calgary, Alberta, Canada, T2N 1N4

[*1]rsalehiv@ucalgary.ca; [2]rmlevy@ucalgary.ca; [3]tonyt@ucalgary.ca

Abstract

Oftentimes, within the urban planning process, urban planners and GIS experts must work together using desktop Computer-Aided Design (CAD) and Geographic Information System (GIS). However, participatory communication and visualization which are important in the urban planning process, are not a central focus in the design of current computer-aided planning technologies. This study tends to provide an understanding of technological challenges and complexities urban planners and GIS experts encounter while engaging in a participatory environment during the urban planning process. This study also explores the perceptions of urban planners and GIS experts about the potential impact and usefulness of interactive surfaces in their practice. Participants including ten urban planners and GIS experts are interviewed. From the analysis of the interviews, five main categories emerge that offer a snapshot of urban planners' and GIS experts' current urban planning work practices and expectations while interacting with CAD and GIS when provided with interactive surfaces.

Keywords

Urban Planning Process; Participatory Communication; Visualization; Technology; Qualitative Studies

Introduction

The urban planning process involves communicative and technical activities. Conventional technologies such as Computer-Aided Design (CAD) and Geographic Information System (GIS) are used within this process, however, these computer applications do not support the participatory communication and visualization of the urban planning process. Participatory communication refers to creating shared understanding, perception, and knowledge between urban planning stakeholders within a collective decision-making environment of the urban planning process which should empower their voice through simple visualization, thus discovering solutions to their complex problems. Furthermore, most existing desktop CAD and GIS technologies are designed with the idea that urban planners and GIS experts are at their desks. However, such conventional systems do not fully fulfil the mobility and participatory communication needs required in the work of urban planners and GIS experts (Forester, 1989 and Bellotti and Bly, 1996 and Luff and Heath, 1998 and Tufte and Mefalopulos, 2009).

Consequently, much more effort needs to be directed towards the development of new technologies that support both mobility needs and participatory communication and visualization as compared to current desktop workstations in the work settings of urban planners and GIS experts. Additionally, although there is a perception that interactive surfaces are useful in enhancing participation between urban planners and GIS experts within the urban planning process, there is insufficient understanding about the specific communicative needs of urban planners and their stakeholders in these contexts (Fernquist, 2013 and Su, 2013 and Murray, 2012 and Rogers and Lindley, 2004).

For this reason, this study provided an understanding of technological challenges and complexities that urban planners and GIS experts encounter while engaging in a participatory environment during the urban planning process. This study also explored the perceptions of urban planners and GIS experts about the potential impact and usefulness of interactive surfaces in their practices. Thus, a series of semi-structured interviews was conducted with urban planners and GIS experts involved in the urban planning process. The analysis of the interviews revealed urban planners' and GIS experts' experiences and expectations of participatory and interactive future technologies that could potentially enhance the urban planning process. Finally, this study demonstrated that participatory communication, visualization, and computation within the design review process could potentially be supported by using interactive surfaces.

Scope of the Study. This study had the following objectives:

1. Investigate the types of tools and technologies that are needed to support the work of urban planners and GIS experts using interactive surfaces.

2. Develop an understanding of how urban planners and GIS experts currently use desktop CAD and GIS computer applications.

3. Explore what urban planners and GIS experts envision as potential uses for interactive surfaces.

Related Work

Technology for the Urban Planning Process

The urban planning process involves considerable technical and communicative activities. Often, the urban planning process require participation of a diverse group of stakeholders such as urban planners and GIS experts to discuss the subtleties of the design and decisions, and then to create alternative solutions. Furthermore, desktop CAD and GIS computer applications are useful socio-technical tools that can support the end product of this participation as plans to respects the aesthetics, economic, social, and political context of a proposed development project (Innes, 1998 and Innes and Booher, 1999 and Brail and Klosterman, 2001 and Longley, et al., 2011).

Moreover, micro-mobility refers to mobilizing and manipulating tools and technologies within the organizational setting, where various activities occur. Studying the urban planning process shows the micro-mobility of tools and technologies are critical to the work and communication amongst urban planning stakeholders. It is widely recognized that the access to real-time information, and the need for immediate participation with others, are essential parts of the urban planning process. However, the urban planning process still depends highly on the use of traditional tools and technologies such paper and text-based documents, as well as desktop CAD and GIS computer application (Brail and Klosterman, 2001 and Luff and Heath, 1998).

Urban planning has recently been involved with computer-supported techniques that try to maximize collaboration. These techniques include groupware, computer supported cooperative work (CSCW), and cooperative and participatory design. Furthermore, "Groupware is an umbrella term for the technologies that support person-to-person collaboration; groupware can be anything from email to electronic meeting systems to workflow." Groupware also includes shared drawing, group decision support and scheduling and project management. As well, groupware allows urban planning activities within groups to negotiate spatially while designing plans and sketches and writing documents (Laurini, 2001).

Furthermore, CommunityViz is a commercial, modelling and scenario evaluation planning and decision support system with visual and interactive components for community planning and design. This software is based on Esri's ArcView GIS that integrates words, numbers, maps, diagrams and images in an interactive real-time and multidimensional environment (Walker and Daniels, 2011). Moreover, Esri CityEngine is a commercial, 3D modelling software that uses GIS for geo-design based on 2D and 3D data. Furthermore, CityEngine is used for 3D city modelling in a virtual urban and architectural environment, simulation, game development, and film production (esri, 2014).

However, tangible User Interfaces (TUIs) developed by the computer science research community have been explored within the context of GIS, where a tactile user interface combined with numerical simulations allow the user to interact with the tangible objects. These interfaces suggest a more effective use of GIS by non-experts in distributed decision-making processes (Ratti, et al., 2004). The computer science research community has also developed a luminous-tangible workbench for urban planning and design (URP) that facilitate the manipulation and exploration of factors related to physical objects in urban planning including shadows, distance measurements, reflections, wind effects and site views. It employs several luminous-tangible interactions to present visual information and 3D model related to physical architectural objects (Underkoffler and Ishii, 1999).

In addition, Mixed Reality that is used for a bimanual handheld urban planning interface supports searching, inserting and creating contents (Sareika and Schmalstieg, 2010). The Urban Sketcher is also designed to improve real-time communication amongst urban planning stakeholders (Sareika and Schmalstieg, 2007). Further, augmented and mixed reality and interactive tangible tabletop and 3D printed models of buildings are used to improve participation in urban planning through the communication of digital models (Välkkynen, et al., 2013). On a commercial level, CommunityViz, in combination with fixed interactive surfaces, provides regional information through the collective use of digital maps (Placeways, 2013).

Study Methodology

To address the guiding research questions of this study, methodology of ethnography and contextual design were employed to allow gathering rich data and developing a descriptive understanding of problem context, and generating facts that emerge from the user unanticipated data. Furthermore, during the course of this study, semi-structured interviews and demonstrations lasted approximately one and half-hour for each participant (Beyer and Holtzblatt, 1998 and Creswell, 2007 and Rogers, et al., 2011).

Interview Method. The first step in this study was semi-structured interviews that aimed to discover how the participants use CAD and GIS in their work practices, and how they could see interactive surfaces enhancing their work. The interview questions were designed to be sufficiently open to allow shifts in explorations. Each interview began with the same set of demographic questions followed by a series of open-ended questions. The interview session lasted one hour for each participant.

Demonstrations. The second step in this study was demonstration sessions that showed the participants CAD and GIS computer applications combined with the use of interactive surfaces. For the purpose of the demonstration, a mock-up was employed to present a participatory environment for viewing and manipulating CAD drawings and models, and GIS maps using Microsoft digital tabletop and iPad. During the demonstration session, participants were asked about their understanding, needs, perception, and suggestions pertaining to the use of the mock-up. The demonstration session varied between fifteen to thirty minutes for different participants.

Participants

Ten participants including six urban planners and four GIS experts are recruited for this research study. Purposeful sampling strategy was used to select the participants (Creswell, 2007). Using a snowball sampling technique and an email distribution list, participants were recruited from urban planning and GIS disciplines, as shown in Table 1.

TABLE 1 PARTICIPANTS' BIOGRAPHICAL INFORMATION

Participants	Urban Planners	GIS Experts	CAD-Experience-Yrs	GIS-Experience-Yrs
P1	N	Y	N/A	N/A
P2	Y	N	N/A	20
P3	Y	N	12	12
P4	Y	N	N/A	8
P5	Y	N	15	15
P6	Y	N	19	19
P7	Y	N	N/A	19
P8	N	Y	N/A	N/A
P9	N	Y	N/A	25
P10	N	Y	N/A	15
Total	6	4		

Research Limitations

In this research study, ethnographic studies were conducted that take a qualitative approach. These studies are time-consuming for both data collection and analysis. In the absence of quantitative data, it is difficult to check the validity of the research conclusion. An ethnographic approach can provide an understanding of concepts and context. In addition, the sampling strategy employed in this research study can discover detail about a specific context. In this research study, small samples of experts were interviewed. Even small samples will generate a large quantity of data. The vast majority of the interviewees are currently employed in industry and/or academia in the Calgary. Only one of the participants was employed in the UK. It would have been better if more participants from other cities. A larger sample size would have provided measures that can be expressed with greater confidence. Furthermore, interviews were conducted and the collected data was analysed by the primary researcher. Researcher's personal thoughts and feelings concerning the overall research process might bias the thoughts, feelings and ideas of the participants and hypotheses generated from the research study.

Data Collection and Analysis

All the interviews including the demonstrations were audio recorded. Audio recordings were transcribed manually. In this research study, affinity-diagramming technique is used for analyzing the data. This approach enables the researcher to organize ideas and statements gathered during the interviews and demonstrations (Beyer and Holtzblatt, 1998 and Rogers, et al., 2011). Five categories were developed as a first step in analysing the data, including: General practices with CAD and GIS; CAD and GIS operations, and software; CAD and GIS, and interactive surfaces; Desktop computers and interactive surfaces; and

Perceptions of users.

Each category was divided into more detailed categories in a meaningful way determined by the goal of the research study. The main categories below are organized manually. However, in the next steps Microsoft Excel was used to computerize the categorizing and analyzing the data, Fig. 1-5. In the results sections, representative quotes along with participants' number are presented.

General Practices with CAD and GIS

All participants commented on their general practices with CAD and GIS throughout the course of their work, and certain, specific comments are noted in the section below.

Interactive Surfaces. Two participants stated that they had used their personal iPads to interact with CAD and GIS, whereas four participants had never used interactive surfaces; and four participants only had a brief experience using interactive surfaces, such as smart-boards to interact with CAD and GIS in demonstrations.

Experience and Software. Participants had between eight and twenty-five years of experience in academia and industry. They used a variety of combined desktop CAD and GIS computer applications. Out of a total of ten participants eight used CAD and/or GIS software; five used only GIS software; and three used both CAD and GIS software, Table 1.

Participatory Practice. All participants stated that their work requires them to collaborate with technical staff, clients, and researchers. Three participants mentioned that they collaborate with other researchers and students from different disciplines for writing academic papers. Three participants also collaborate with others to improve community engagement. This requires them to work with a diverse group of stakeholders from the public to civil, transportation and geomatics engineers, urban planners, architects, and environmentalists. Furthermore, four participants collaborate with others to find solutions to technical problems. This collaboration includes the Information Technology (IT) departments responsible for customization and optimization of the database, quality control, creating a GIS database and working on data policies and standards.

Experience with CAD and GIS. Participants had a wide variety of experience with CAD and GIS. Two participants had experience in teaching CAD and GIS, as well as industry experience such as managing a GIS team, and have worked in marketing, sold GIS software and implemented large enterprise GIS systems for mobile clients. Four participants also had experience in teaching CAD and GIS university undergraduate and graduate courses. These participants were also involved with research in areas such as applied GIS and wildlife management which involve the use of the GIS to build predictive models for wildlife habitat use. For these participants, CAD and GIS was a tool for mapping, making basic queries, and 3D visualization.

In addition, four participants had experience working in the industrial sector. One of these participants used GIS to determine the location of unexploded bombs. Others used change detection to support decision-making in agriculture and forestry. Mapping was also done to support urban planners and stakeholders in making land use decisions. Property management was another use of GIS for those in industry. Generating risk assessment models for sanitary sewer back up for an insurance company in Canada was an example of how spatial data could be used in industry. One of the participants also conducts research in the use of CAD and GIS for making decisions on visualizing places in 3D virtual environments. As a participant pointed out;

(P5): "If we are going to locate a retail facility … on a site, we want to make sure that it is visible from a number of points, and then we use CAD and GIS 3D to make it possible for the potential investors to make sure they are investing in the right place."

Figure 1 illustrates the affinity diagraming of general practices with CAD and GIS.

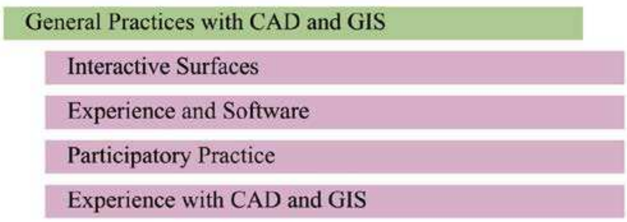

FIG. 1 AFFINITY DIAGRAMING OF GENERAL PRACTICE WITH CAD AND GIS

CAD and GIS Operations, and Software

All participants commented on their experiences with CAD and GIS operations, and software throughout the course of their work and some of these comments are noted in the section below.

CAD and GIS Operations. Only one participant used CAD and GIS in a daily basis. Instead, most of the participants in this study used GIS for analyzing and manipulating data. Four participants used CAD and GIS in their teaching and research. One of the participants used GIS for environmental impact assessments. This participant also uses CAD and GIS for 3D analysis such as visualization studies on cellphone tower location using viewshed analysis.

One of the participants used GIS for different types of spatial analysis in wildlife or the urban planning domain to understand the problem under study. This participant also used CAD and GIS as a community engagement tool to provide input for people in understanding their communities. This participant used the mapping component and CAD and GIS tools to test people's knowledge about the community and space through a digital form.

One of the participants used GIS for teaching cartography, geo-visualization, human computer interaction, spatial cognition, and spatial reasoning and understanding to students. One of the participants also using GIS for spatial analysis, primarily for developing prescriptive or predictive models, used GIS for habitat models in ecology and basic quantifications, species restoration, the area of occupancy or predictive occupancy computation, as well as, exploration of species' habitat. The remaining participants used CAD and GIS for creating maps, modelling, locating new sites within the city, analyzing, managing data, and maintaining the database.

Demanding CAD and GIS Tasks. Participants are asked about the demanding and challenging CAD and GIS tasks in their job. Participants commonly believed that some of the CAD and GIS tasks in their jobs are challenging. Most of the participants mentioned that mapping, data management activities such as data acquisition and assembling data sets and developing modelling tools are the most challenging CAD and GIS tasks in their jobs.

However, data maintenance and data accuracy are the most challenging GIS tasks mentioned by another participant. Also, data accessibility through simple GIS interface is a further challenge for this participant. Another participant stated that manipulating numerous layers and making sure that information is updated in layers over time is a challenging GIS task. This information is critical for effective planning as 3D layers are placed on top of other layers and sites are studied from a visual perspective. One of the participants mentioned that the most challenging CAD and GIS tasks are often related to usability issues of the CAD and GIS applications. This participant is also responsible for teaching the basics of CAD and GIS to employees in the firm.

Preparing CAD and GIS laboratory material for students and working with laboratory technicians to solve the technical problems related to the material are the most demanding job for another participant. A separate participant said that teaching and research involves pushing CAD and GIS beyond the boundaries of current practice. Two other participants said that 3D visualization is the most complex and challenging CAD and GIS task. However, they believed that visualizing CAD and GIS in 3D is a very important aspect of representing the complexities of spatial data. Finally, one participant believed that CAD and GIS tasks that involve visualization and spatial analysis and go beyond implementation of analysis tasks are not particularly demanding. Yet, one participant believed that CAD and GIS tasks are not demanding or even challenging;

(P6): "3D visualization is probably the most demanding of the GIS tasks; being able to visualize in 3D - that is difficult to do with any other application other than a CAD application."

CAD and GIS in Industry. Most of the participants believed that CAD and GIS are mostly used to make models and maps based on images. However, they argue that CAD and GIS could be a very useful tool for every profession that is involved with urban planning, transportation, and health. One of these participants said;

(P7): "A lot of people do not make use of CAD and GIS. In the companies that I have worked with, CAD and GIS are mostly used in a very limited way, primarily for production of maps. I do not think a lot of companies in Alberta use GIS near to its capability; and there are a lot of limitations in terms of the quality of work done by GIS."

One participant stated that GIS is mostly used for detailed environmental impact assessment in urban planning. One participant mentioned that biological applications of GIS including species' risk management, species' habitat and occurrence prediction are common tasks. One participant said that the electrical industry is now using GIS for asset management and analysis, and to optimize the location of future roads. In the electrical industry, GIS was previously used for mapping assets and keeping the database current. One participant said that having access to GIS data via web services has recently been used to amalgamate data from a variety of sources including environmental and water data. Another participant said that, in urban planning, most people use CAD and GIS for land use and transportation planning and employment and housing studies.

Evolution of CAD and GIS Software. All participants thought that CAD and GIS software and practices have changed significantly over the last few years. Participants who work in academia believed that recent technological changes in CAD and GIS computer applications are significant to practice. However, these participants observed that the technological advances used in industry have not been utilized in the academic arena. For instance, all university research projects are still done on desktop CAD and GIS computer applications.

Participants from academia also believed that the biggest change in academia, industry, and everyday life is in the use of simplified and multi-user GIS for sharing information, such as Google Maps. In particular, the integration of intuitive and user-friendly GIS applications such as Google Earth with cellphones, cars, and taxis contributes to public accessibility of GIS interfaces. Moreover, accessibility of open source GIS applications, and GIS cloud and web-based services for mobile devices allows users to interact with GIS with limited or no training. Furthermore, the evolution of line-driven commands of first generation CAD and GIS to Graphical User Interface (GUI) has simplified the interaction with CAD and GIS. Another important change is geo-visualization, which allows people to enhance visualization of geological data.

To some extent, it is now possible to collaborate with others for basic level queries such as navigation and data browsing. However, the primary functions in CAD and GIS have not changed since the inception of CAD and GIS. Working with CAD and GIS still requires intensive education and training. In order to work effectively with others, CAD and GIS software has limitations and requires a high degree of proficiency before becoming an expert user. As one participant noted;

(P10): "When we collaborate, there are still very big difficulties, like if you are in the same or different locations. Interactive surfaces are still designed the same way we already use the desktop computer applications. If you could disengage the database that can be worked on independently and many people work on a distributed database and then bring the data back together, but this is still not actual collaboration."

However, CAD and GIS software are continuously changing. Although, not quite seamless, some components of desktop CAD and GIS computer applications are integrated into a single computer application. However, most GIS users have not changed the way they interact with desktop GIS computer applications since the 1990s, when GIS emerged as a tool for spatial analysis.

Figure 2 illustrates the affinity diagraming of CAD and GIS operations, and software.

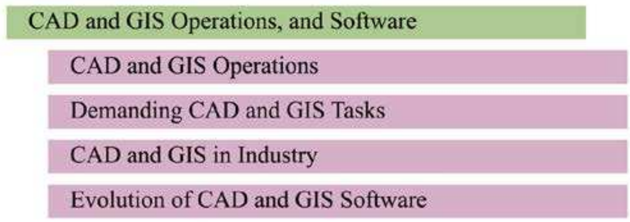

FIG. 2 AFFINITY DIAGRAMING OF CAD AND GIS OPERATIONS, AND SOFTWARE

CAD and GIS, and Interactive Surfaces

All participants commented on their experiences with CAD and GIS, and interactive surfaces throughout the course of their work, and certain, specific comments are noted in the section below.

Mobile, Small Interactive Surfaces. Most participants stated that advances in the development of mobile, small devices such as smartphones and tablets have significantly changed the way people interact with a traditional GIS environment, for instance, paper maps versus Google Maps application for smartphones. Yet, while interacting with Google Earth for way-finding and automatic routing, the user is not aware that they are interacting with GIS. Participants also believed that GIS, GPS, wifi or cell tower positioning are important developments. Participants noted that Google Maps for mobile devices and GPS, combined with GIS mobile field mapping, and data collection using software such as ArcPad Esri, have had a significant impact on the way professionals are able to use mobile GIS applications. This capability coupled with massive simplification of the interface and propagation of mobile, small interactive surfaces for everyday use allows these devices to become mainstream. Participants further believed that mobile, small interface surfaces are appropriate for navigational purposes such as zoom, pan, rotate and tilt, browsing and collecting field data. Nevertheless, mobile, small devices are still limited in terms of their basic functionality.

Fixed, Large Interactive Surfaces. All participants stated that currently fixed, large interactive surfaces, such as tabletops and large wall displays, are not generally accessible in the workplace. For this reason, they had difficulty in grasping details of the potential use of tabletops and large wall displays. Hence, the advance of such surfaces has not changed the way participants interact with CAD and GIS. In addition, participants said that currently interactive surfaces do not support current CAD and GIS software, which requires the use of a mouse and keyboard. Furthermore, there is no evidence that tabletops will become mainstream with CAD and GIS users. Moreover, participants believed that fixed, large interactive surfaces will not add any new functionality to what already exists. One participant mentioned that these devices are similar to those of an earlier generation of PalmPilots. Interestingly, most participants suggested that fixed, large wall displays and tabletops could replace the paper-based material in the future. As one participant noted;

(P9): "Interactive surfaces have great potential for a big impact. But, they are not particularly intuitive yet. They need a simple and intuitive interface for people who are used to GUI, and mouse and keyboard interactions."

Interface of Interactive Surfaces. All participants agree that a simplified interface would be helpful when using fixed, large interactive surfaces. These surfaces could be helpful in 3D modelling, geo-visualization of population density and buffering, spatial query, and navigation. Participants said that fixed, large interactive surfaces could improve collaboration, access to information, and decision-making in community engagement and emergency management, where there is a highly fragmented work environment. As a participant said;

(P6): "Tabletops and large wall displays could be useful especially for urban planners; they will be able to work with clients, members of the community, put up the data and have easy access to it, but I think it has got a few years off before that happens. These surfaces can be useful for presenting, querying the data, zooming in, zooming out, panning around, and navigating."

Interestingly, most participants mentioned that different functionalities should be created to match the interaction modality of these surfaces. They agreed that different domains such as urban planning and transportation require different sets of tasks, which varies across different disciplines. They also believed that CAD and GIS applications designed for interactive surfaces should focus on particular tasks specific to a single discipline such as transportation planning or urban planning.

CAD and GIS Multi-Modal Interactive Capabilities. Most participants mentioned that audio and video recording and speech recognition should be integrated with CAD and GIS on an interactive surface, because they could then facilitate data collection in the field through a simple data entry or search. Participants noted that high resolution, a high degree of flexibility, fluidity, and size of the screen are the most important features required when interacting with CAD and GIS on interactive surfaces. Specifically, participants pointed out that enabling the exploration of spatial information and easy access to real-time information through an intelligent, intuitive and simple interface are important interactive capabilities that should be supported while interacting with CAD and GIS on interactive surfaces. One participant suggested that augmentation with tangible or haptic features would be useful while interacting with CAD and GIS on interactive surfaces. This would allow for more understanding of the context while interacting with 3D objects such as roads or buildings placed on the interactive surfaces. This participant said;

(P8): "Clarity, lots of ability to display the colours properly, taking photographs, [and] audio recording would be useful too depending what your objectives are and integrating video to link to some sites in space."

All of the participants agreed that interactive surfaces should provide intuitive and fluid interaction with CAD and GIS that could help non-experts with limited computer skills to participate in collaborative activities while performing CAD and GIS tasks. However, one participant believed that interacting with CAD and GIS on interactive surfaces does not improve participation. This participant said that there is no overlap between interactive surfaces and participation, yet people might fight over taking control of the interaction, which defeats the purpose of participation on interactive surfaces. However, interactive surfaces could be useful for participatory tasks such as brainstorming and conceptualizing design ideas.

Similar to Google Maps that focuses on collaboration with geo-spatial data, interactive surfaces provide more control for navigation and browsing purposes for communities, but do not contribute greatly in collaboration. Yet, conventional mouse and keyboard interface provide more control over the interaction.

CAD and GIS Visualization on Interactive Surfaces. Generally, participants agreed that 3D visualization helps people understand the context of a problem. Four participants thought that interactive surfaces would be useful for 2D and 3D visualizations. Half of the participants agree that interactive surfaces provide more intuitive manipulation for interacting with 3D CAD and GIS when viewing a perspective, topography and aerial photography. These participants believed that similar to 3D stereographic projection technology, the capabilities of interactive surfaces for CAD and GIS 3D visualization might not go beyond what already exists today with desktop computer applications. A participant pointed out that;

(P4): "Some people are not visual, but 3D information would allow them to visualize better."

Figure 3 illustrates the affinity diagraming of CAD and GIS, and interactive surfaces.

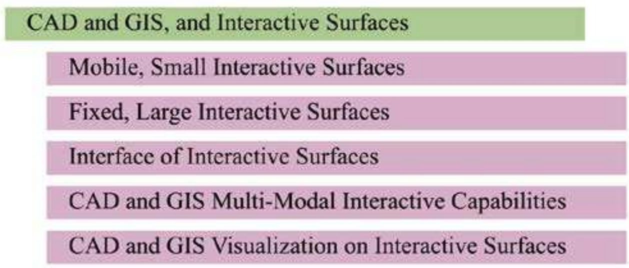

FIG. 3 AFFINITY DIAGRAMING OF CAD AND GIS, AND INTERACTIVE SURFACES

Desktop Computers versus Interactive Surfaces

All participants discussed their experiences with desktop computers versus interactive surfaces throughout the course of their work and some of these comments are noted in the section below.

Outdoor Environmental Challenges. Participants mentioned that environmental challenges, such as outdoor light reflection, as well as harsh weather condition, such as extreme cold and/or warm temperatures, could affect the functionalities of mobile interactive surfaces.

Ergonomics. Participants mentioned that desktop computers' mouse and keyboard interaction technique is more precise and accurate than touch-based interaction for smartphones, tablets, tabletops and large wall displays. Three participants wanted to have mouse and keyboard desktop functionalities on interactive surfaces while interacting with CAD and GIS. Participants also suggested the use of virtual keyboard, which may include a touchscreen and a desktop computer mouse and keyboard while interacting with CAD and GIS on interactive surfaces. A participant said;

(P6): "What if you could access the keyboard functionality on tabletops? But, I get tired really fast by using a flat display as a keyboard; it hurts my hand and fingers. People do not get a lot of work done with interactive surfaces. I think the real issue is how to replace the keyboard?"

Group Size and Orientation. Participants also mentioned that desktop computers, smartphones, and tablets are single-user devices, however, tabletops and large wall displays could accommodate larger groups of users. Another words, desktop computers, smartphones, tablets and large wall displays have a single orientation, however, tabletops have multiple orientations. Participants agreed that in comparison with smartphones, tablets or large wall displays with one orientation, displaying single orientation geographic information in a collaborative setting on tabletops with multiple orientations is more difficult. Participants also found it difficult to keep up with the multiple orientations of tabletops. They pointed out that manipulating the orientation of the display must be combined with CAD and GIS interaction on interactive surfaces.

Tasks. Participants considered that complex CAD and GIS tasks, such as modelling, data analysis and data management could only be performed on desktop CAD and GIS computer applications. Participates also agreed that tabletops, large wall displays, smartphones, and tablets could not support complex CAD and GIS tasks. Furthermore, participants stated that desktop CAD and GIS computer applications do not support navigation, collaboration and decision-making. Most participants also believed that having interactive surfaces for presenting the outcome of CAD and GIS exploration while instantaneously showing different scenarios could be particularly useful for novices. Moreover, half of the participants mentioned that both modalities of mouse and keyboard interaction of desktop computer applications and touch-based interaction on interactive surfaces have limitations in terms of CAD and GIS 3D visualization.

Figure 4 illustrates the affinity diagraming of desktop computers versus interactive surfaces.

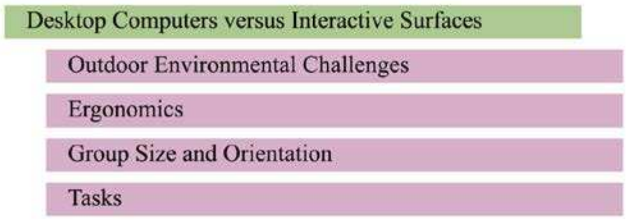

FIG. 4 AFFINITY DIAGRAMING OF DESKTOP COMPUTERS VERSUS INTERACTIVE SURFACES

Perceptions of Users

All participants commented on more specific users' perceptions and certain comments are noted in the section below.

Participation. Participants from academia believed that interactive surfaces have the potential to perform participatory CAD and GIS tasks in classrooms for teaching and learning. Participants from industry said that interactive surfaces could be used for disciplines that require performing participatory CAD and GIS tasks and sharing information. These disciplines include emergency management, community planning, and engagement activities. A participant pointed out;

(P5): "The value of interactive surfaces is in group meetings, because you only have the information on the desktop, which is only installed in certain machines. We never work in isolation; we always interact with people, so it would be very easy to see the interaction on a bigger and more flexible screen."

Also, most participants mentioned that different people use the information in different ways. For example, people working in different industries, such as urban planning, geology, ecology, forestry, and healthcare look for different functionalities in CAD and GIS. A participant argued;

(P7): "In a site selection problem, different people focus on transportation, water, or ecological issues. So, they try to come up with different models to compare. They basically work on the same data, but what each individual does is fundamentally different from the work of others."

Participants stated that having access to a unifying interface where a number of different devices such as smartphones, tablets, tabletops and digital wall displays are linked together could form a shared communication workspace. In this collaborative environment, if each individual has access to an interactive device, each individual device could contribute independently to the workspace. This would create a higher transparency of information and sharing of common knowledge

Interface. All participants agreed that, as opposed to desktop CAD and GIS computer applications, collaboration, decision-making, planning, navigation, and presentation of the outcome of CAD and GIS exploration could be supported better through intuitive interface and interaction design of interactive surfaces. Furthermore, participants believed that adaptation of interactive surfaces and integration of their interface into the desktop CAD and GIS computer applications are the main challenges. They also mentioned that teaching and demonstration requires devices specific to urban planners and GIS experts. A participant observed;

Moreover, participants envisioned that concentrating on interface and interaction design of interactive surfaces, in particular users' spatial cognition, is a high priority component of designing such surfaces. They believed that understanding how people conceptually want to interact with data is a paradigm that should be considered in the design of future versions of such devices. Participants agreed that with interactive surfaces, there are greater opportunities to make the interface simple and intuitive. Participants thought that a simple and intuitive interface for interactive surfaces would be significantly beneficial for CAD and GIS novices and experts. This would create an environment where common knowledge is disseminated amongst a group of users.

Participants also believed that interactive surfaces have the potential to perform CAD and GIS tasks, such as geo-processing, buffering, simple queries on the fly, and adding layers. They also stated that having access to historical information about the site, and to archaeological and geological information through a simple interface of interactive surfaces, would be highly preferred. However, all participants believed that the current structure of CAD and GIS tasks will not be adapted to the environment of interactive surfaces.

Intelligence. Most participants agreed that automation coupled with artificial intelligence would be needed to accomplish the complexities involved in social institutions and in the cultural divisions of urban planning work. These might be useful for reasoning, planning, learning and communicating perceptual components, and even for manipulating objects involved in the urban planning process. A participant argued;

(P6): "I have to do a lot of commands to get something up on the screen. This is the challenge, because CAD and GIS is never designed to be easy to use. And with [an interactive surface], perhaps simple operations are feasible."

Figure 5 illustrates the affinity diagraming of perceptions of users.

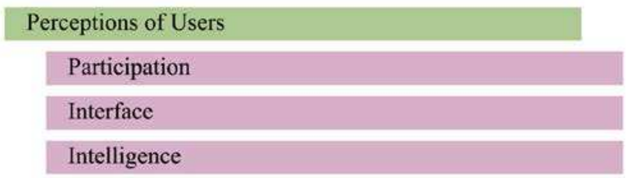

FIG. 5 AFFINITY DIAGRAMING OF PERCEPTIONS OF USERS

Discussion

Typically, urban planners deal with a variety of tasks such as visualizing and calculating the zoning ordinance within the design review process, where participation of the public and the developers is critical to the process (Forester, 1989). Currently, these tasks are performed on conventional paper-based material and desktop CAD and GIS computer applications that do not support participatory communication and visualization.

Furthermore, analysis of the interviews showed that urban planners' expectations and requirements go beyond the existing set of desktop CAD and GIS computer applications used in today's urban planning processes. Hence, the most direct approach to future studies is to further specifically interview urban planners about their software and hardware needs. This study revealed that participatory communication, 3D visualization, and computation are tasks especially within the design review process that could benefit from using interactive surfaces. Moreover, many of these tasks typically involve conflict resolution with a number of different stakeholders, such as urban planners, developers and the public within the design review process. For example, rezoning a parcel of land from residential to commercial can have an impact on adjacent properties, such as need for parking and increased traffic. In particular, visualizing 2D plans and 3D models would allow urban planners and stakeholders to participate in communication around technical issues, and thus potentially resolve future conflicts.

Specifically, six participants who are urban planners mentioned that they would like to use interactive surfaces to perform work conducted within the design review process which are cumbersome and require complex visualization and computation activities. These participants further stated that the design review process always requires transparency in communication, as well as presentation of information. Having access to a technology that can communicate the design review process to both urban planners and stakeholders is a critical need. However, currently, desktop CAD and GIS computer applications are single-user and immobile. Thus, this limits the flow of information and participatory communication during the design review process. Participants also mentioned that the use of mobile interactive surfaces integrated with 3D visualization could be useful for the design review process. This would help urban planners and stakeholders to visualize building proposals, also to communicate around possibilities, which might ultimately lead to more successful outcomes. Two participants argued;

(P6): "Interactive surfaces can be useful for the design review process. They could allow for dragging and dropping 2D drawings and 3D models of buildings or bridges or transportation flow patterns. This then allows them to visualize [what impact different building designs will have in the area?] and what is the community reaction to these changes?"

(P5): "If urban planners have the information available in a more portable format, then it will help us not have to carry lots of drawings and papers to meetings. Working with current desktop CAD and GIS computer applications does not help us communicate or collaborate better in the design review process."

In addition, after further analyzing the interviews three main issues within the design review process have emerged.

Participatory Communication. Ubiquitous interaction of mobile interactive surfaces concerning participatory communication around CAD and GIS operations may provide techniques for urban planners and stakeholders with a wide range of skillset for seamless interactions with CAD and GIS within the design review process. Participatory communication within the design review process, whether together in the same place or separated in space or time, could be further enhanced by using mobile interactive surfaces, supported by synchronous interaction.

Visualization. Simple and intuitive techniques for visualization of the zoning ordinance in conjunction with using interactive surfaces could facilitate the comprehension of plans for urban planners and stakeholders who have poor visual and spatial skills. This could potentially provide a means for the urban planner and stakeholders to visualize the outcomes of their CAD and GIS explorations on the mobile interactive surfaces could potentially reduce the large volume of paper-based documents involved in the design review process.

Computation. Mobile, simple techniques for computation of FAR and other related measurements involved in the design review process would reveal possibilities for the effective use of mobile interactive surfaces. Exploring the feasibility of these new approaches for solving design review problems in an easy and timely fashion could have an impact on the design of future cities.

Conclusions

This study involved the semi-structured interviews that explored the work practices and tools and the technologies of urban planners and GIS experts to help them accomplish their everyday tasks within the urban planning process. It was discovered in this study that the recent convergence between interactive surfaces and desktop CAD and GIS computer applications could introduce a novel, but unexplored interactive arena for enabling participatory communication between urban planners and GIS experts. Thus it was attempted to identify potential CAD and GIS interaction capabilities on interactive surfaces, specifically within the urban planning process. For this reason, this study explored urban planners' and GIS experts' perceived use of interactive surfaces, as opposed to desktop computer applications. As a result, this study provided a platform for urban planners and GIS experts to participate within the urban planning process. Moreover, this study also demonstrated that urban planners and GIS experts using the existing interface and interaction design of desktop CAD and GIS computer applications do not consider the design of these devices to be as effective as they could be. Instead, participants felt that these applications could benefit from more intuitive interaction methods for interactive surfaces.

In particular, this study revealed that there is potential for a much greater use of interactive surfaces that goes beyond merely replicating desktop CAD and GIS computer applications' capabilities on interactive surfaces. By considering the properties of each device included in this study, mobile versus fixed and multi-user versus single-user, it was also revealed that interactive surfaces could be used as supplementary devices in conjunction with desktop computer applications in the design review process. Furthermore, it was speculated that integration of mobile, small interactive surfaces, such as tablets could potentially enhance participatory communication and visualization needs of the design review process.

To sum up, as part of this study, the following questions arose: What user capabilities do urban planners want integrated with CAD and GIS on interactive surfaces within the design review process?; Is what urban planners want to do with CAD and GIS on interactive surfaces within the design review process already possible?; What tasks do urban planners currently complete using CAD and GIS on interactive surfaces within the design review process? Together with the results of this study, these questions guide the future direction of this research study.

REFERENCES

Bellotti, Victoria., and Bly, Sara. "Walking Away from the Desktop Computer: Distributed Collaboration and Mobility in a Product Design Team." *in the CSCW '96 Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work* (1996): 209-218.

Beyer, Hugh., and Holtzblatt, Karen. *Contextual Design-Defining Customer-Cantered Systems.* San Francisco: Morgan Kaufmann Publishers, 1998.

Brail Richard K., and Klosterman, Richard E. Eds., *Planning Support Systems: Integrating Geographic Information Systems, Models, and Visualization Tools.* Redlands, California: ESRI Press, 2001.

Creswell, John W. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches.* California: Sage Publications, 2007.

esri. "City Engine." esri, February21,2014. Accessed February20,2014. http://www.esri.com/software/cityengine.

Fernquist, Jennifer. E. "A Collaborative Planning Support System for a Multi-Touch Tabletop - The Effect of Number of Touch Inputs on Collaboration and Output Quality." 2010.

Forester, John. *Planning in the Face of Power.* California: University of California Press, 1989.

Innes, Judith E. “Information in Communicative Planning.” *Journal of American Planning Association* 64, no. 1 (1998): 52-63.

Innes, Judith E., and Booher, David E. “Consensus Building and Complex Adaptive Systems, A Framework for Evaluating Collaborative Planning.” *Journal of American Planning Association* 65, no. 4 (1999): 412-423.

Laurini, Robert. *Information Systems for Urban Planning: A Hypermedia Cooperative Approach.* New York: Taylor & Francis, 2001.

Longley, Paul A., Goodchild, Mike F., Maguire, David J., and Rhind, David W. *Geographic Information Systems and Science 3e.* New Jersey: John Wiley and Sons, 2011.

Luff, Paul., and Heath, Christian. "Mobility in Collaboration." *in CSCW '98 Proceedings of the 1998 ACM conference on Computer Supported Cooperative Work* (1998): 305-314.

Murray, Janet H. *Inventing the medium: principles of interaction design as a cultural practice.* Cambridge, MA: MIT Press, 2012.

Placeways. “CommunityViz.” Placeways, February 21, 2014. Accessed February 20, 2014. http://placeways.com/communityviz/.

Ratti, Carlo., Wang, Yao., Ishii, Hiroshi., Piper, Ben., and Frenchman, Dennis. “Tangible User Interface (TUIs): A Novel Paradigm for GIS.” *MIT Transactions in GIS* 8, no. 4 (2004): 1361-1682.

Rogers, Yvonne., and Lindley, Siân. "Collaborating around vertical and horizontal large interactive displays: which way is best?." *Interacting with Computers* 16, no. 6 (2004): 1133-1152.

Sareika, Markus., and Schmalstieg, Dieter. "Urban Sketcher: Mixed Reality on Site for Urban Planning and Architecture." *in 6th International Symposium on Mixed and Augmented Reality* (2007): 27-30.

Sareika, Markus., and Schmalstieg, Dieter. "Bimanual Handheld Mixed Reality Interfaces for Urban Planning." *in AVI '10 Proceedings of the International Conference on Advanced Visual Interfaces* (2010): 189-196.

Rogers, Yvonne., Sharp, Helen., and Preece, Jenny. 3rd Eds., *Interaction design: beyond human-computer interaction.* Sussex, UK: John Wiley & Sons, 2011.

Su, Tao. "A Multi-Display Collaborative Urban Planning System with a Federated Architecture." 2011.

Tufte, Thomas., and Mafelopulos, Paolo. *Participatory Communication: A Practical Guide.* Herndon, VA: World Bank Publications, 2009.

Underkoffler, John., and Ishii, Hiroshi. “Urp: a luminous-tangible workbench for urban planning and design. Human Factors in Computing Systems.” *in The Proceedings of CHI ‘99* (1999): 386-393.

Välkkynen, Pasi., Siltanen, Sanni., and Väätänen, Antti., Oksman, Virpi., Honkamaa., Petri., and Ylikauppila, Mari. "Developing Mixed Reality Tools to Support Citizen Participation in Urban Planning." *in 6th International Conference on Communities and Technologies* (2013).

Walker, Doug., and Daniels, Tom. *The Planners Guide to CommunityViz, The Essential Tool for a New Generation of Planning.* Washington: Planners Press, American Planning Association, 2011.