EXPLORING IMMERSIVE DIGITAL ENVIRONMENTS

Developing alternative design tools for Urban Interaction Designers

DANNY D. NGUYEN¹ and M. HANK HAEUSLER²
University of New South Wales, Sydney, Australia
Computation and Spatial Design. Research [C+SD.R]
¹ danny.nguyen@unsw.edu.au
² m.haeusler@unsw.edu.au

Abstract. In contemporary architecture firms, most design drawings are done via use of 3D modelling software. This method requires advanced knowledge of the software in order to produce an accurate representation of space into the digital environment. The paper argues that conventional 3D visualization methods to design and analyse are restrictive to how well the user understands the space on a computer, as drawings are done ex-situ and without testing the design concept in-situ, hence there might be a level of disparity between the design and final fabrication. This is particularly a challenge when designing Urban Interaction Design concepts, as combinations of variables play a role in how the design will be received by the audience. Observing the design challenges for Urban Interaction Design and applying knowledge to architectural representation, potentially an alternative sketching process can be developed to alleviate the disparity between the conceptual design and post fabrication. This paper discusses an experimental process of using wireless spatial sensing devices to digitize physical spaces in real-time and to use on-the-spot analysis. In its conclusion the paper argues that this method enables the designer to gain advanced conceptual understandings of the intended space and thus make more informed decisions.

Keywords. Spatial Design; Human-Computing Interfacing; Urban Interaction Design; Spatial 3D Visualization; Wireless Sensor Technology.
1. Introduction

1.1. DOCUMENTING SPACE

Current methods to document physical space for use in analysis studies consist of specialized 3D modelling programs that give users the ability to input accurate dimensions or data. Manually modelling a space can take time and the benefits can greatly impact a designer’s way of thinking or design decisions. However, though the processes introduced give a designer the ability to visualize space and the intended use, digital 3D models are only able to envisage limited information and is a testament to how well a person without perspective can imagine a space they have not been in, hence why being physically or mentally immersed in a space can achieve a richer experience for the designer or user (Hannington et al. 2002).

The aforementioned tools used to document space looked at giving a designer a starting foundation to develop concepts that can utilize space effectively. The distinction between documenting a space using tools, and physically having the final "product" situated in the intended space can have a profound impact on the conceptual idea that the designer is trying to demonstrate with the design. This disparity can arise from discrepancies from observing the design in a closed workspace, and then embedding it into the intended space (Boring et al. 2011).

Indifferences between ex-situ and in-situ are most notable in Urban Interaction Design projects, where the uses of such design concepts are defined by the interaction of its users. Commonly to test these designs, prototypes are constructed to give designers insight of the proposed final physical form or design (Trifonova et al. 2008), the prototype either resemble the final product on a smaller scale or segments of the designed product is fabricated for testing in the intended space. Despite the positive benefits for prototyping models prior to final fabrication, this method can become as well cost intensive and time consuming, for those involved.

1.2. EXAMPLES OF DISCREPANCIES IN URBAN INTERACTION DESIGN

Designing interactive installations for public spaces is riddled with obstacles, in particular satisfying and encouraging human interaction as changes in ethnographic records and environmental surroundings can create an increasingly difficult task in designing engaging interactive experiences for each individual (Smyth et al. 2011). The records pertaining to data of human behaviour is constantly changing with each trending cycle, to which an inter-
An interesting idea can become stale quite fast due to the desensitizing environment we live in, where technology and grand displays are lacking innovation.

An example of the uncertainty pertaining to Urban Interactive Design Installations, Jennifer Steinkamp (2001) is an artist that specializes in the use of media and light projections to create interactive installations that incorporates public user interaction by placing image projectors in areas where the light produced will directly be disrupted an individual, causing their shadow to become part of the vivid images being displayed. The use of human shadows are meant to create erratic and dismay in the projection, however what was unnoticed not until the exhibition, is that only children were influenced to "play" and be a part of the work, whilst adults took an analytical approach by standing in one spot trying to understand the concept which was not the intention of the interactive design (Steinkamp, 2001).

As the research has discussed, the challenge of designing for Urban Interaction design installations without in-situ testing can manifest latent issues that are not seen until exhibition, thus a solution to this problem is to enable urban interaction designers a means to test design concepts within the intended space by using digital simulation techniques to produce immersive digital environments that can be developed to produce similar in-situ testing results.

2. Research Question

Consequently the objective of this paper and the larger scope of the research are in providing urban interaction designer’s toolsets to translate physical spaces into a 3D environment and perform real-time simulations with digital objects they wish to develop for fabrication prior to implementing the design in its physical spatial context. The research aims to demonstrate via connecting physical interaction with digital systems, one can enrich and clarify the design intention and allow designers to make informed decisions by investigating:

Can a physical environment be recreated as a 3D model in real-time by using wireless spatial sensing devices that replicate interactions to improve urban interaction design concepts?

3. Methodology

Applying action research methods, the paper intends to derive a systematic approach to ensure each progression of the research thoroughly identifies the problematic areas. Drawing upon research conducted in the uses of advanced digital design tools in interactive design (Trifonova et al. 2008) a framework
for experimentation of an alternative system can be approached to enhance user experience with conceptualizing and testing Urban Interactive Designs in the intended space.

The purpose of researching into methods that allow the real-time translation of physical to 3D objects is to keep the entire design process period to a minimum, since an objective to this research is also about making use of available time and to thoroughly test variety of variations in the designer’s conceptual thinking.

In establishing the requirements for the system, a study was conducted to test a range of cameras/system that enabled the translation of physical spaces to digital models. Thorough experimentation of the accuracy of available systems concluded that the Kinect system demonstrated the most positive results to record human movement and stationary objects within an environment and create 3D models from those findings.

4. Background

4.1. URBAN INTERACTION DESIGN

The term Urban Interaction Design denotes the use of public urban spaces becoming a canvas for designers to embed interactive systems and installations to create information rich or enjoyable interactive experiences for the public (Dalsgaard, 2010). This topic of research can come under much scrutiny by the public, as the ideas fabricated by the designers try to utilize public interaction to create an experience in the installation. As described earlier, the intention or purpose of the system during the exhibition may not function as visualized in the conceptual stages (Steinkamp, 2010).

The paper argues that understanding the level of uncertainty that plagues the success of an Interactive design and being able to visualize completed digital concepts in a space prior to costly prototypes being made, may reduce the experimentation phase and cost.

4.2. SOFTWARE AND HARDWARE USED IN PROJECT

The design tool system researched in this paper intends to translate physical spaces into a 3D digital model, also making use of mobile smartphone devices as an interface to control and view actions by the user. Giving options to control the system wirelessly, the interface will allow users to generate the digital space, place digital objects in the space and reset current analysis.

To create a testing environment, the following different components were used and combined:
Xbox Kinect: The Kinect is a type of depth camera that is able to determine the distance of object’s in its field of view, it is also able to record the physical human structure and its movement patterns in real-time.

Mobile Smartphone: Due to the rapid growth of mobile smartphones, the use of this device as an interface was selected due to the ease-of-use with connecting and displaying webpages.

Grasshopper: Visual scripting and 3D modelling software that allows users to import and export data from external programs, which for this project acts as a hub for the entire system, where data can be processed and used.

Website Interface: An interface developed using PHP web coding language. Selected as a simple means to read and write to external text files.

5. Project study: User Defined Spaces

The paper presents follow up research findings previously discussed (Nguyen D. et al. 2013) into the development of a platform that assists urban interaction designers by providing a design-sketching tool using wireless spatial sensing devices. Previous research conducted by Nguyen and Haesler 2013, observed traditional architectural drawing methods used by designers for Urban Interaction Design projects, the research used well documented case studies 2002 sixth Swiss National Exhibition Pavilion, Blur Building by architects Elizabeth Diller and Ricardo Scofidio and 2011 Architectural Festival Sydney Student Studio Installation, Hypersurface Architecture [Redux] coordinated by M. Hank Haesuler, Sally Hsu and Danny D. Nguyen to highlight an area of development to current sketching tools for Interactive designers. It concluded with the establishment for grounds of an experiment to demonstrate an alternative sketching tool, in this paper the experiment and research findings are presented and discussed.

In acknowledging current design processes in Urban Interaction Design, such as storyboarding and real-time gaming environments, the developed system intends to improve the user experience (Buxton, 2007) and design process and enable users to simulate real-time design concepts in suitable digital environments.

Prior to discussing the detailed outline of the system the paper intends to give background information of the system’s principles.

5.1. EXPLANATION OF SYSTEM PRINCIPLES

The system being developed is for the purpose of an alternative design-sketching tool for real-time spatial analysis and/or concept visualization. To translate a physical space into a digital 3D model, the research requires a means to capture the useable space within the physical environment. Taking
into account that not all spaces are either basic rectangular or empty rooms will further refine the system’s ability to conduct real-time analysis, as it takes into account any negative spaces which may affect things such as flow or optimal views calculated from the analysis software. The useable space that is being defined is about areas within an environment that is not blocked by pre-existing elements such as furniture, room shape and/or structures (Shown in Figure 1).

Figure 1. Explanation of how the proposed system will record room data based on pre-existing elements. Left Image: Space with table; Middle Image: Red defined object to demonstrate unusable area; Right Image: Green defined useable space.

The following points below outline the sequence of actions the user will undertake to document and utilize a digitally generated room with this system.

- **User Input Markers**: The use of the term "Markers" is to define the points that will be generated by the User and to be inputted into a 3D digital space. The location of the points in digital space will reflect the position the user has set.
- **Shell Generated**: Using the markers, a shell is formed with the Markers acting as the vertices of the shell. The shell is generated by a Grasshopper script that reads the Marker location in the 3D environment.
- **Embed Design / Conduct Analysis**: The user is able to then upload and display 3D digital models of their work in the space and/or conduct real-time analysis of the space.

5.2. DETAILED EXPERIMENT

The experiment documented in this paper demonstrates the progression of the system, establishing the thought process of how the physical environment has been translated into a 3D model and details of the first controlled testing environment with an individual being recorded in the physical and digital environments.
To begin developing this system, there needed to be a means to generate digital 3D rooms accurately from physical environments. Using Grasshopper, a script was developed to enable randomly placed points in a 3D environment to automatically generate a shell using the points as the vertices (Shown in Figure 2).

![Image of random points placed and generated shell based on the points]

The points being placed were randomly generated by the Grasshopper script to test the system’s functions; however the intended control and placement of the points requires manually placed points by a user in real-time. Using research conducted prior on devices able to record precise movement and depth, the Kinect device enabled user movement to be recorded by the computer. The data streaming from the Kinect directly feeds into Grasshopper, and generates a skeleton structure of a moving person.

**Defining the User:** When a user stands in front of the Kinect, their body structure is animated in Grasshopper. The visible skeleton structure of the user in Grasshopper is the basic joints such as elbow, knee and neck joints, thus the generated skeleton can accurately mimic the movement of the physical user. Tracking the skeleton in Grasshopper enables the addition of computer scripts to cause pre-define events to occur when certain actions are triggered. In this experiment the user was given a mobile smartphone that displayed a simple interface with a button, each time the user presses the button, the location of their Right Hand was recorded in Grasshopper, such that if they were to press the button in the vertices of a small controlled physical space, a 3D model would be generated (Shown in Figure 4).
Embedding Design: Generating a digital 3D space from points gathered in the physical environment enabled the experimentation of embedding an interactive surface in the digital model, and allowing the user to interact with the digital surface in real-time (Shown in Figure 5).
5.3. RESULTS, EVALUATION AND FUTURE STEPS

The documented experiment discussed in this paper has demonstrated the process in how the research has been conducted. Successfully translating a physical environment into a 3D model and embedding a sample interactive surface the user was able to interact with in real-time has demonstrated the first steps into developing engaging digital environments. However, the drawback to the current system is that the information will need to be displayed on a device such as a monitor, to visually see the 3D models and interactive capacity.

Further application of this system intends to use emerging Virtual Reality goggles, *Oculus Rift*, to enable users to be immersed in the digital environment, rather than having to view the digital model on a monitor (Firth, 2013). The benefits for this direction is it enable head and eye tracking that is displayed on a small screen in the goggles, this allows users to "feel" like they are actually in a predefined space or in front of an interactive wall, as demonstrated in the experiment outline.

6. Conclusion

Research conducted in this paper demonstrates the development of an alternative design tool that can be used to generate and visualize physical spaces within a digital environment. Drawing upon examples of Urban Interaction Designs where installations did not function as intended from the concept stage, such as Steinkamp (2001) light projections, a foundation of proposed research was formed. The significance of this research is to equip Urban Interaction Designers with tools that can create engaging digital environments to experiment with more variations of their conceptual design. Proposing an immersive visualization of digital environments is to help designer connect to their intended space and simulate the behaviour of their interactive design to increase awareness of the final fabrication and exhibition expectations. The success of the experiment documented in this research is to acknowledge the potential and purpose of an alternative design tool in Urban Interaction Design context, as current design tools and methods such as physical prototypes and scaled models are costly and time consuming, and only evaluate fragments of the entire system in the intended space. Further extension of this research will lead into using technology such as the virtual reality goggles, *Oculus Rift*, to create an increased immersive environment for the user.
References

Buxton, W.: 2007, Sketching user experiences: getting the design right and the right design, ed., Morgan Kaufmann


Firth, N.: 2013, First wave of virtual reality games will let you live the dream, New Scientist, 218(2922), 19-20.


