CURATING ARCHITECTURAL COLLECTIONS

Interaction with immersive stereoscopic visualisation

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Abstract. We present our research on the use of immersive stereoscopic visualisation in interaction with collections of architectural representations. We investigate the processing and visualisation of multiple model representations from architectural datasets. We develop two models for locating collections of datasets in spatial contexts, namely a realistic gallery and a synthetic landscape. We evaluate and report the qualitative interactive experience with two forms of contextual interaction within a novel stereoscopic immersive visualisation (cylindrical projection) environment. The use of immersive stereoscopic visualisation conveys aspects and dimensions of the collections that would not be possible without the forms of contextual interaction, the gallery metaphor and the synthetic landscape to interact with the architectural collections. The combination of abstract representations with realistic sense of scale and interaction provide the user with an immersive experience to convey the collective form.

Keywords. Digital data acquisition; architectural reconstruction; geometry processing and algorithms; immersive stereoscopic visualisation; human computer interaction.

1. Introduction

The built environment domains of architecture, urban design, city and regional planning produce massive visual datasets at multiple spatial scales and modes of representation. Immersive stereoscopic visualisation techniques offer potentially novel ways for representing and navigating such vir-
tual environments. The realistic graphics of building, precinct and city models (real and unrealised) has now reached a point of perfect virtualization of scale, light, materials and context (Hernández et al, 2006). However, the simulation and immersive of abstract datasets poses a number of challenges for the graphics and visualisation pipeline as well as the structuring and serialization of the data. This paper reports on interaction with model collections using an immersive stereoscopic visualisation environment.

2. Background

Walter Benjamin’s 1936 essay (Benjamin, 1970, edited by Hannah Arendt) on the transformation of cultural experience through photography and film situates the object or experience in space and its dislocation from its context. Malpas (2008, 2009) argues that this loss is also evident in the use of new media in the reproduction of virtual environments. The lack of contextual cues leads to a compression of space and time and is disorienting in the context of virtual reproduction. Recent developments in immersive visualisation using high-resolution large format displays can address these conceptual challenges through combining real and virtual world attributes in a seamless manner. In particular, the examinations of environments that combine realism with abstraction have particular promise in our research.

2.1. IMMERSIVE ENVIRONMENTS

The use of desktop Virtual Environments (VEs) to communicate and present design intentions are now commonly used in the spatial disciplines. Immersive environments such as large interactive touch surfaces (Huang and Chang, 2006) head mounted displays (Schnabel and Kvan, 2003), dome projection systems (Melenbrink and King, 2015) and panorama theatres (Oreinstein et al, 2015) provide a new dimension to the ways in which abstract architectural collections can be perceived, studied and analysed. Visual immersion coupled with stereoscopic interaction supplemented with cues such as audio and event based simulation can approximate real, physical environments (Champion et al, 2003). The major benefit of immersive visualisation is the perceptual shift (Bishop and Dave, 2001) in the viewer’s experience of the information and the environment. Affleck and Kvan (2005) have observed that the majority of virtual environments attempt to create a realistic representation of their subject. Non-realistic virtual models of artefacts and abstractions have received little attention. In our research we combine the characteristics of virtual environments to explore and interact with a collection of architectural abstractions. Just as close-ups or slow motion in film
permit seeing reality in a deeper way (Manovich, 2002), abstract models provide such a mode in the case of understanding architecture.

2.2. INFORMATION ABSTRACTION

Physical artefacts are digitally represented as abstract three-dimensional models through representations comprising geometric entities. The models are composed of geometric primitives comprising point and boundary (edge and surface) representations, wireframe models, surface meshes and solid representations. The multitude of representations and their computational properties reflect the diverse needs of the visualisation, animation, rendering and CAD community. For example, geometric accuracy and modelling precision are emphasised in the CAD community while material properties (e.g. textures) and interactivity are better supported in the visualisation community.

The reconstruction pipeline involves using the digital information generated by acquisition methods to create three dimensional point, surface and solid models (Dave, 2001). Furthermore, the experience of the three dimensional representations are further enhanced with skeletal models of geometry, two dimensional dissections and sectional models that allow the user access to hidden aspects of architecture, not directly experienced through conventional virtual heritage modelling and visualisation (Datta and Beynon, 2014).

2.3. RESEARCH OBJECTIVES

The aim of this research is therefore to investigate how immersive stereoscopic visualisation can facilitate interaction with collections of abstract architectural representations. Our objectives in this research are to:

• Investigate the representation, processing and visualisation of multiple architectural datasets (Model Representation); and
• Develop context models for locating collections of datasets (Scenario or Context); and
• Evaluate the immersive experience of these models in a virtual environment (Narrative or Interaction).

Figure 1. Immersive Visualisation framework (This figure shows how the information flows from the model to the system e.g. pipeline flow from representations -> scenario context -> interaction)
Figure 1 shows the framework of our research and in the following sections we will present the representation of models, the development of context and interactive visualisation in an immersive environment.

3. Model representation

![Model representations](image)

Figure 2. Model representations. Point cloud, textured mesh, and voxel models (top) and wireframe geometry, solid models and sectional dissections (bottom).

We have addressed interoperability by bringing model representations into a single open interface provided by the Unity platform, a gaming engine widely used in immersive visualisation research (Hoon, Jabi and Goldman, 2003). While primarily targeted at gaming and simulation applications, Unity provides a scripting interface suitable for importing and manipulating data from multiple representations. In this section we present architectural collections derived from Asian temple research repository (Datta and Beynon, 2014) models using three abstract representations, point and voxel models, surface models and solid massing models. Each representation and its abstraction properties are described below.

3.1. POINT CLOUD

A point cloud is a set of discrete points within a three-dimensional coordinate system. 3D Point clouds in architecture are most commonly obtained from laser scanning and image processing software. Such point clouds typically represent the visible surfaces of a building. Point clouds are useful for capturing architectural surface geometry, particularly the boundary of complex artefacts (e.g. ornamental carvings in historic buildings). Secondly point clouds are naturally multi-resolution and can be controlled using measures of
point density. Finally, each point is able to carry scalar field information for visualisation using colour hues. We exploit each of these properties to visually display point cloud representations.

Unity is an interactive visualisation tool and is not optimised for spatial point processing. We utilise a custom import tool (developed at the HIVE) that reads the PLY file into Unity. The point datasets can be controlled through a process of brute force decimation by reading every $N^{th}$ point in the point set. A custom Unity shader is then used to visualise the resultant point cloud. The results are shown in Figure 2 (top).

3.2. VOXEL MODELS

Voxels (3D pixels) can efficiently display dense point cloud data. Octrees provide a hierarchical tree data structure for efficient partitioning, downsampling and search operations on point set data. We have created an import tool that reads point datasets and converts them into an octree representation. A Unity custom script is used to visualise the voxel bounding boxes of each octree node. Figure 2 (top) shows a view of a simplified set of voxels that simplify the dense point cloud data automatically and allows a viewer to interact with the model intuitively.

4. Immersive visualisation of model collections

Interaction with model representations is to a large extent designed for desktop or head mounted displays (e.g. Oculus Rift). Using large-scale environments aids the perception of higher fidelity and resolution in details (Hunag and Chang, 2006, Melenbrink and King, 2015). In this section we describe a large format cylindrical panorama system implemented at the HIVE (Figure 3). Two forms of contextual interaction are tested and a qualitative evaluation of stereoscopic 3D for visualisation (cylindrical projection) is presented.

4.1. HIVE CYLINDER

The HIVE cylinder permits multiple forms of interaction with virtual environments. This display is composed of a half cylinder screen 8 meters in diameter and 3 meters high. Three 1920x1200 projectors at 120 Hz create a continuous image across the entire screen. Stereoscopic 3D functionality is handled with dual K6000 graphics cards and active shutter glasses. The half-cylindrical interactive projection system accommodates 20 to 30 people. Three hardware warp/blend units operate between the graphics cards and the projectors to rectify the image for cylindrical projection (Woods et al, in preparation).
Figure 3. The HIVE Cylindrical visualisation system shows the various parts of the generic cylinder (right), and the warp-blend projection (left). The display permits infrared marker based interaction between users and the model as well as Kinect-based gestural interaction.

Unity (www.unity3d.com: Jan 2016) is used both as a content development platform and for the display of immersive experiences. A generic immersive virtual reality plugin called MiddleVR (www.middleVR.com: Jan 2016) handles interaction with trackers, display architectures and stereoscopic projection in conjunction with custom scripts in Unity. For single users head tracking is possible using a set of OptiTrak cameras placed around the screen edge. These infrared cameras are used for tracking motion and gestures based on detection of markers. This allows the perspective of the viewer to be updated as they move around, allowing a natural interaction with the environment.

Larger scale movements are then controlled with one or more of a standard keyboard and mouse setup, a SpaceMouse for 6 degrees of freedom (DOF) movement. A Microsoft Kinect provides marker-less tracking and user interaction through sensing of gestural motions.
4.2. VIRTUAL GALLERY CONTEXT

![Figure 4. Virtual Gallery Context. Scale models are displayed in an internal gallery context with a high level of detail in texture, lighting and materiality. The scale model representations are augmented by interactive “wall” displays showing supportive representations.]

The first form of contextual interaction is the display of scaled representations within a gallery model (Figure 4). In this context, architectural model collections are presented within an interior setting. The model collections are organized into a virtual exhibition of scaled models and drawings embedded within a virtual gallery model. To communicate the rich variation of forms as well as the continuities underlying the corpus, the virtual gallery collapses the realism of each instance and presents them in a unified collective context. The scaled models are arrayed in a grid of plinths. The models can be inspected in greater detail using the camera and interaction model. Each model is a singularity representing a particular spatial and temporal context with a formal and compositional structure. Each model belongs to a collection representing a sampling from a family of related forms.

Head tracking provides an intuitive method of interacting with and inspecting the elements in the environment. In this environment many small models are placed on plinths. This allows the user to inspect the model from many different angles simply by waking around within the confines of the Cylinder display.

4.3. SYNTHETIC LANDSCAPE CONTEXT

The second form of contextual interaction is the display of full-scale models (Figure 5). In this context, each architectural model is sited within an abstract landscape. The full scale model collections are organized in the synthetic landscape to provide a unified context for model exploration. The models can be explored by walking in or flying through the landscape using the gestural interaction described above (Figure 5).

The exploration of these larger spaces, especially landscapes (Figure 5), often benefits from interaction controls provided in the Microsoft Kinect. A
form of gestural control has been implemented that allows a user to move around in large environments. The user can control pitch and yaw by moving their hands in the desired direction; lifting one hand above the other controls roll. The distance between the hands controls speed, i.e. a faster speed is achieved by holding the hands further apart. This allows large environments to be explored in short periods of time and the layout of an area to be quickly understood.

![Figure 5. Immersive interaction with full-scale models in the cylinder and multi-user immersive experience of a synthetic landscape context.](image)

4.4 RESULTS

Immersive environments offer a different mode in which to access and experience places and cultures that may not easily accessible. The advantage of being immersed in the experience and thereby approximating the real experience is a definite advantage. The characteristics, benefits and weaknesses of the interaction parameters are summarised in Table 1. The immersive experiences described above have been tested in the form of guided tours for a collection of people.
TABLE 1. Results matrix based on the framework described in Figure 1

<table>
<thead>
<tr>
<th>Model Representation</th>
<th>Immersive Scenario</th>
<th>Characteristics</th>
<th>Benefits/Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Gallery</td>
<td>- 3D reconstruction models</td>
<td></td>
<td>Seamless presentation of both raw data from point cloud, surface meshes as well as wireframes, voxels and solids can be imported and displayed.</td>
</tr>
<tr>
<td>- 2D surface data</td>
<td>- Emphasis on abstraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Landscape</td>
<td>- 3D Solid Models</td>
<td></td>
<td>Presentation of abstract data requires extensive manual preprocessing such as for immersive visualisation.</td>
</tr>
<tr>
<td>- Emphasis on textures, renders, lighting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td>Virtual Gallery</td>
<td>- Realistic model of gallery</td>
<td>The highly realistic gallery context provides an effective stage within which to view abstract models.</td>
</tr>
<tr>
<td>- High LOD (4 or 5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Landscape</td>
<td>- Abstract computer generated landscape</td>
<td>The synthetic landscape provides an expansive space with a horizon and orientation.</td>
<td></td>
</tr>
<tr>
<td>- Low LOD (1-2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>Virtual Gallery</td>
<td>- The primary narrative is walking through a gallery</td>
<td>Models can be viewed and inspected. Models are supported by information on gallery walls such as drawings, site and interactive display.</td>
</tr>
<tr>
<td>Synthetic Landscape</td>
<td>- The primary narrative is gliding through a computer generated landscape</td>
<td>Glding through the landscape based on gestural interaction provides the primary immersive experience of full-scale models.</td>
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Due to this display immersion, adding interactive elements such as head tracking increases the level of immersion and many people suggest that it is just like being there. When larger environments are being displayed the Kinect provides a natural way of navigating around. Interestingly younger people generally find this more intuitive while older people generally require more detail instruction on how to control the interaction. Having said that nearly everyone agrees that this method of control is very effective at navigating around large environments and understanding the wider context of the objects within.

5. Discussion

The abstraction of scaled models and materiality (monochrome grey scale) are used to provide the user with a gallery experience to convey the collective form. The purpose of immersive virtual experience is not to challenge or displace the authenticity of the physical object or the faithful accuracy of the photographic record. Instead, the aim is to develop “unobtrusive mediations” that permit connections and interpretations that permit scholars and the public to assess and experience the significance of architecture as a collection.
Acknowledgements

Nicholas Oliver and the HIVE at Curtin University are acknowledged for providing the basis for the Unity point cloud import scripts and implementation of the gestural gliding interaction with synthetic environments. Rob Cameron and Andrei Smolik, PhD Candidates at Curtin University developed the Virtual Gallery Unity scene used to display the collections.

References


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