NOT JUST ANOTHER PRETTY FACE
Exploring the Analytical and Educational Possibilities of Virtual Reconstructions and New Media Applications in the Heritage Architecture of the United Arab Emirates

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Abstract. Digital Heritage has gained popularity recently as means of dynamically representing and reconstructing historic buildings and cityscapes. Simultaneously this new medium of visualization affords another approach to examine human-virtual environment interaction and offers possibilities of exploiting virtual environments as educational tools. At Zayed University, a federal university primarily for women citizens of the United Arab Emirates, we have integrated student-faculty research and documented and reconstructed a number of historical buildings within the curriculum of the Department of Art and Design. We have further collaborated with the animation program at Winston Salem State University in North Carolina, utilizing the motion capture laboratory at The Human Performance and Biodynamics Laboratory between Wake Forest University School of Medicine’s Department of Orthopaedic Surgery and Winston-Salem State University’s Department of Physical Therapy. The primary idea is to contribute to the ongoing documentation of the country’s heritage through creating “responsive virtual heritage environments” where the spectator is actively engaged in exploring the digital space and gain certain degrees of control over the course and scheme of the dynamic experience.
1. Introduction

We seek to analyze the social and spatial dimensions of traditional architecture in the United Arab Emirates both as individual objects and as part of a larger architectural ecosystem using a combination of GIS and CAD software. This paper reviews three projects utilizing different applications, thereby demonstrating a range of analytical and educational possibilities through the integration of CAD programs with other statistical, geographic, and visualization software. In these projects, we integrated student-faculty research and documented and reconstructed a number of historical buildings in the United Arab Emirates. The idea is to contribute to the documentation of the country’s heritage through creating “responsive virtual heritage environments” where the spectator is actively engaged in exploring the digital space. While these are works in progress, our aim is to combine the efforts of designers from different disciplines with a historian’s perspective to create applied research learning opportunities for our undergraduate design students. In the process, we contribute to the documentation and analysis of traditional architecture in the Gulf and, hopefully, bridge what Anne Kelly Knowles describes as the “epistemological divide between geography and history” where “history is the study of when, geography the study of where.” (Knowles, 2008)

In his forward to Jennifer Whyte’s Virtual Reality and the Built Environment, David Gann writes: “The way in which we visualize buildings – their component parts, how they work and how they might be used – has a strong bearing on the built environment we create and inhabit.” (Whyte, 2002) Whyte and Gann emphasize virtual reality as a tool in the design of contemporary buildings. Gann explains that “[e]merging tools for design visualization are changing the practice of design itself. They provide opportunities as designers no longer need to be temporally or spatially constrained by previous limitations of sequential decision making processes.” (Whyte, 2002)

Digital Heritage has gained popularity for dynamically representing historic buildings. We seek to demonstrate that it can exercise as strong an impact on historical research as virtual reality has had on contemporary design. This new medium affords another approach to examine human-virtual environment interaction and offers possibilities of exploiting virtual environments both as educational and research tools, not only through its offering of new viewing perspectives and navigational modes, but also through its ability to re-present the material and ephemeral qualities of the building and its spatial context. Furthermore, in partnership with more conventional ethnographic, geographic and historical research, it can further demonstrate cultural design elements.
2. Literature Review and Context

The project synthesizes the concepts of key writings across several discourses, beginning with the architectural history of the Persian/Arabian Gulf. The most notable works are by Coles and Jackson (1975, 2007), who originally documented a single windtower house in Dubai in the early 1970s and then later expanded the work to include the surrounding city quarter. In addition, Damluji’s survey (2006) includes both traditional and key examples of modern architecture in the UAE. All three works examine the morphology of the buildings with attention paid to construction techniques and passive cooling technology. Coles and Jackson’s latter work additionally focuses on a single house type that they identify as originating in Bastak in southern Iran and attempts to sketch out the historical context for the movement of this style to the Arabian peninsula. The windtower house is an iconic house type with examples in all of the key ports of the Arabian coast, but is still only one of many types constructed prior to industrialization. It has, however, been the focus of several works that seek to define the physical elements of this style. (Al Rostomani, 1991; Dubai Municipality, 2006)

Walter Dostal (1983), among several others active in the UAE (Velde, 2001; Hilal, Velde, and Moellering, 2008; King, 1998) documents several other house types found in northern Ras al-Khaimah, relating them to tribe, geography, and season. Dostal’s interest in the social context for the buildings relates his work to the historic ethnography of Frauke Heard-Bey (1986) and Fidelity and William Lancaster (1999), who describe the social context for the buildings, outlining an economic rhythm of seasonal resource exploitation demanding migration between environmental zones organized within the administrative structure of tribe. The movement between ecosystems creates a varied house typology based on a combination of topology, climate and economic function. While Dostal and Lancaster base their descriptions directly on field work, Heard-Bey utilizes as well J.G. Lorimer’s (1994) Gazetteer of the Persian Gulf, Oman, and Central Arabia, originally published in 1908, as a primary source. Lorimer’s 9 volume set is a comprehensive compendium of geographic, social, and economic data compiled from British agency reports throughout the last quarter of the nineteenth century. Different house types have tribal associations tempered by the specific conditions of the space in which they’re located and the economic activities of their residents. Hawker (2008), referencing studies from elsewhere in the Gulf (Lewcock, 1978; Yarwood, 1988), seeks to extend the discussion of historic architecture beyond the confines of the nation-state and to foreground the tribe as an extra-state structure that contributed to multiple building types symbolizing social affiliation and status (Hawker, Hull and Rouhani, 2005; Hawker, 2006).
It is at this point that we begin to draw on discourses from outside Gulf architectural history and attempt to utilize new technological processes to better define, document and analyse the social and physical conditions that contribute to how buildings were constructed and placed within space. The integration of new mapping technologies inspired by both the availability of GIS browsers like Google Earth and the impact they have had on historical geography (Gregory and Ell, 2007; Knowles, 2008) facilitated thematic mapping of tribes (Sandvik, 2008). The quantitative processing of the spatially-mapped data from Lorimer (1994) has then been related back to the building morphology identified within the discourse of Gulf architectural history and the topology visualized in Google Earth, through the import of xml data into UC/Win Road, or through the generation of GIS survey data imported into Maya.

The ability to create a work flow from 3-d modelling programs like, for example, Google Sketch Up into Google Earth and back facilitates a more specific understanding of spatial arrangements within the topology. Hillier and Hanson’s (1984) ground-breaking work on the quantitative analysis of space and Hillier’s more recent updating of the project (2007) have had an enormous impact on our understanding of the applications of these software packages. In particular, Hillier and Hanson assert that the quantitative analysis of space allows us to “build a theory of how society, through its internal dynamics, produces order in space.” (Hillier and Hanson, 1984:33) Hillier (2007) further defines two kinds of knowledge: social (or non-discursive) knowledge and analytic (or scientific) knowledge, noting that spatial documentation illuminates social knowledge and brings forward the underlying, if unwritten, rules guiding the social dimensions of spatial organization. This is a concept useful in documenting vernacular and traditional architecture and helps bridge Knowles’ epistemological gap between geography and history. Finally, the use of new analytical tools for
analysing the performance of buildings deepens our understanding one additional step. The ephemeral conditions of space - heat, rain, and wind – can also be integrated into this spatial analysis and transcends the analysis of the mere flow of space to a more sophisticated and tangible analysis of how the relationships between the built and natural environments in space function.

Figure 2. A spatial graph of the historic quarter of Bastakiya in Dubai generated using UCL’s Depthmap.

2.1. BARAMA

In the first project, we documented and digitally reconstructed a network of terraced farms in the mountains of the emirate of Ras al-Khaimah used by the Shihuh tribe, renowned for their unique culture (Lancaster and Lancaster, 1999). They are divided into two sections: the Bani Shatair, who dominated the western side of the Hajar mountains, and the Bani Hadiya, who dominated the east (Lorimer, 1994). This particular network is one of the largest in the country and belonged to the Al Mahabeeb subsection of the Bani Shatair (Al Shehhi, 2009).

In 2006, we obtained a grant to complete a GPS survey. The data was transferred into AutoCAD format to create an animated reconstruction of the village. Students constructed simulations of sixty houses, terraces and farm fields in the main quarter, rendered the external facades and added details, such as water pots and weeds. Figures were created to inhabit this virtual space. Costumes were based on historic photographs and facial features came from mapping the faces of male members of the students’ families.
Figure 3. A wire frame model of the farming network of Barama.

Additional data from a 2007 survey was used to reconstruct a self-contained fortified site at the highest altitude of the Barama complex. The subsequent data was converted from an AutoCAD .dwg file into a .obj file and imported into Maya. After importing the .obj file into Maya, we created a polygon mesh over the AutoCAD reference lines. We then used the Maya sculpting tool to push and pull the polygon mesh to fit the AutoCAD lines, selecting polygon faces in very detailed surfaces, such as the canals or trenches, and doubling the polygon count in order to add more surface detail. After finishing the rough polygon surface, the vertices on the object were averaged, the surface of the polygon smoothed and the object triangulated. The Maya file was exported as an .obj file into Z-brush to begin the UV mapping and painting of the surface. This program allowed us to flatten the UV painting surface and export the files into Photoshop and back into Maya. The UV mapping data was exported into Photoshop and the site images were cloned into the final image. This final output was used to create the surface colour and bump mapping in Maya.

Particular attention was paid in both the GPS survey and the ground-level photo-documentation on a network of canals we identified at the site. Particle simulation functions of Maya are to be applied to the resulting rendering from April to September 2008 to demonstrate the complex ways in which the builders used the canal network to enhance the natural flow of topography to feed the flattened terraces. At this point, the reconstruction serves as an important example of how traditional building modified, but did not displace the surrounding environment (Hawker and Tucker, 2008).
2.2. GHALEELAH

The second project was instigated by student research in which students documented the village of Ghaleela in Ras al-Khaimah, identified in British records at the turn of the nineteenth century as a fishing port for the Bani Shatair (Lorimer, 1994). In the early 1970s, Sheikh Rashid bin Saeed Al Maktoum, ruler of Dubai, modernized the port and constructed modern housing. The infrastructure has since fallen into disrepair and the village suffers from power and water shortages. Students completed conventional site documentation using photography, hand drawn elevations, projections and maps, and ethnographic interviews in November 2006 (Malik et al, 2006). These were used for a sustainable re-design proposal. The following year, they completed a three-dimensional model of the town using Google Sketch Up. In 2009, this model was then exported from Sketch Up Pro as an obj. file and imported into Maya, rendered and bitmapped, and then re-exported into UC/Win Road and placed in a reconstructed terrain and populated with simulated figures, fauna and flora constructed from historic photographic sources using Maya models. Motion Capture facilities at Winston-Salem State University and Wake Forest University were used to build a library of movements. The motion capture data was brought into Motionbuilder which was used to attach the data to rigged human models. This allowed for realistic human movements for the simulation in UC/Win Road. We have integrated video pop-ups designed by students to explain cultural practices within the virtual space of the village.
2.3. RESIDENTIAL ARCHITECTURE

Finally, we constructed houses from throughout the country, including complex windtower houses from Dubai, and farming houses, residential complexes, and winter houses in southern Ras al-Khaimah in Google Sketch Up and then placed them in Google Earth. The results reinforce the relationship between the site, orientation and function of the building and demonstrate a clear difference in house typology based on a combination of tribe, status within the tribe, and economic activities of the residents. In addition, we charted settlement and tribe locations in Google Earth, and the houses can be related to a vast array of social and economic data from the early twentieth century. A variety of commercial plug-ins to explore the lighting and surfaces have been in use in the visualizations of the buildings. This has evolved into utilizing plug-ins aimed at analysing the performance of the building according to climatic factors, like sun exposure, shadow casting, wind flow, and building material performance. This is an important exploration, using software intended for contemporary designers to...
dynamically analyse building performance of buildings that no longer exist or no longer exist in their original state. While avoiding the mistaken notion that our virtual reality “...is a replica of reality” (Whyte, 2002), such applications allow us to focus on often ephemeral systems that are nonetheless integral to how a building performs.

Figure 7. A student reconstruction of the Sheikh Saeed House modelled in Sketch Up and subject to performance analysis using Virtual Wind.

3. Conclusion

The primary objective of these projects has been to provide an educational experience for the students creating the reconstructions. In addition the spatial and temporal specificity different computer applications afford has proven useful in highlighting and analysing the buildings’ function within the extreme climate of the country, particularly in visualizing the ephemeral qualities of the architecture as they relate to passive cooling and the inter-relationships between built and natural environments. The ability to mass larger complexes of buildings also illustrates the impact of religious and cultural attributes on building methods. Urban planning strategies developed from the Maliki school of jurisprudence in Sunni Islam and used in Jazirat al-Hamra, for example, regulate wall heights, window orientations, and street paths – something easily demonstrable to students using an interactive model. The accurate reconstruction of the buildings has been dependent on accurate representation of the surrounding terrain. The placement of the structures within the terrain illuminates the dynamic nature of the architecture, with the active characteristics of the VR software allowing for simulations that allow us to define and analyse the performance of the architecture. Recent technical advances and the wider availability of
software designed to assess the performance of modern buildings therefore has enormous implications for the study of vernacular and historic architecture.

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References
