

History of Architecture 101

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This paper documents research in the field of virtual archaeology as an assist in teaching history of architecture. Virtual archaeology or re-creating ancient worlds digitally is not a new item. While the virtual reconstructions of Cahokia on the Mississippi or the Royal Cemetery at Ur in Iraq have provided us with glimpses of how those ancient sites might have looked, the ‘quality’ of the digital end product has been lacking and not well used within the structure of traditional history of architecture classes. This is because virtual archaeology is in its infant stages. And, architectural historians are just beginning to use digital tools. This paper makes the point that in order to truly develop the bases of a new cognitive science, virtual archaeology has to incorporate a willingness to achieve higher digital modeling and rendering qualities. And, it has to be well integrated into history of architecture classes. In other words, our ability to explore, to interpret and to appropriately use digital tools needs to aspire to greater and more penetrating abilities to reconstruct the past.

This paper presents the theoretical reconstruction of the Aztec Templo Mayor in Mexico and how this research project was integrated into the course ‘Pre-Columbian Architecture’. Students in this class have been fascinated not only by the use of animated sections, visualizations and animations, but how these new digital approaches helped them grasp and appreciate the very significant architectural contributions of the early inhabitants of the Americas.

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Figure 1

Introduction

“Don’t take History of Architecture 101. It’s a boring class. You won’t learn anything. Besides, you have to memorize all these words that don’t mean a thing and are hard to spell. You also have to read these thick volumes that cost a lot of money. They have hundreds of pages with small print talking a lot about all these places and buildings, but don’t really tell you how those spaces looked like. The professor is OK, but shows all these old slides in the dark auditorium, and you can’t help but to fall asleep. The worst part is that I don’t see the use of going through all this old stuff. Not only it’s dull, but I just don’t see the point in relation to what I plan on doing in the future...”

History of Architecture Student

A typical student that at age three began to be immersed in a variety of media, from electronic toys and devices to a barrage of television and cinematic imagery, by the time he or she reaches college has become a media saturated creature. He or she finds that many of the instructional approaches that have not kept the pace with the times are dry, dreary and devoid of purpose. While such negative attitude and perspective is debatable, it nevertheless raises questions on using new digital technologies in the classroom, especially in history of architecture courses. Why? Because unlike other courses within the architectural curriculum, history courses provide a unique window of opportunity to integrate theoretical reconstructions, animations of ancient sites, as well as many other pioneering approaches. This paper is not intended to argue that a history class has to be ‘flashy’ and use all kinds of pyrotechnics in order to be first-rate. Instead, it presents a range of tactics that can easily be integrated to history of architecture courses.

Approaches

While there are many visual aids that can assist in understanding, interpreting and projecting the value of history of architecture studies, none of those traditional assists compares with the power and capabilities derived from using virtual explorations of the past. The reason for this assertion comes from the wide range of tactics now available to enhance education. Not only a professor can discuss heretofore unknown qualities of places or buildings using theoretical reconstructions, but the presentations themselves, the messages, can be easy to comprehend and astonishingly attractive.

From a wider perspective, the assists that virtual reconstructions of the past provide fall into the following categories:

1. Planar representation
2. Three-dimensional visualization
3. Static and animated representation
4. User interface and immersive technology

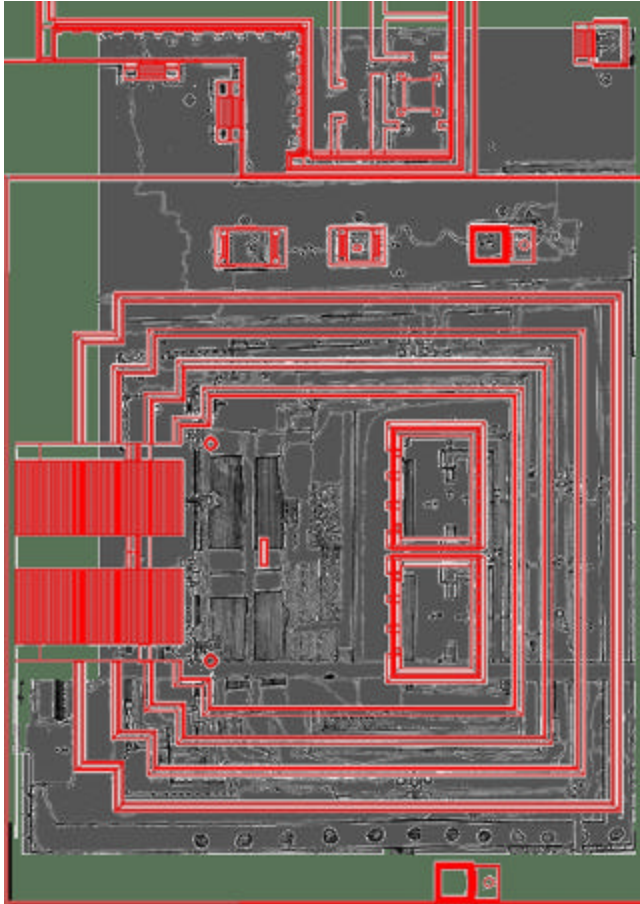


Figure 2

For example, we can illustrate how archaeological data can be used to locate foundations of ancient structures. Figure 2 presents a digital overlay where in gray color one can visualize site plan data coming from archeological mapping via satellite aerial imagery. In red color one can begin to see a potential theoretical reconstruction outlining the foundations of ancient structures. The overlay is from a section of the Aztec Templo Mayor.

Figure 3 presents the superimposed site plans of two Mesoamerican cities: Tula, the capital of the Toltecs, and the theoretical reconstruction of the Aztec Templo Mayor site. In this overlay, it becomes clear that the Aztec designers of the Templo Mayor site in Mexico City used composition principles first developed by Toltec designers several centuries earlier. Even the dimensioning modules appear to be similar. The illustration shows in black color the Aztec scheme. The Toltec city is shown in orange color. Both are drawn at the same scale.

Another way of presenting enhanced architectural information is through the use of photocomposition. This technique basically consists of manipulating graphic elements in a photograph in order to illustrate or highlight a particular argument. Elements can be distorted, scaled, colorized, etc. While this procedure has been available for many years using multi-layer acetate film and other darkroom techniques, it has been cumbersome,

Planar representation

There is no question that traditional orthographic plan, elevation and section drawings of places and spaces are essential components in history of architecture courses. Because these techniques of representation have been easy to draw and reproduce, they have been used for centuries. However, this is where the effort has ended. How can we develop these traditional representation methods further and, for example, connect archaeological mapping of existing remains with potential theoretical virtual reconstruction using graphic overlays? Could we complement the discussion of a site by analyzing the evolution of construction layers? With digital technology, we can now add to the discussion topics that were almost impossible to present some years ago. And, we can do this in very visually attractive ways. For

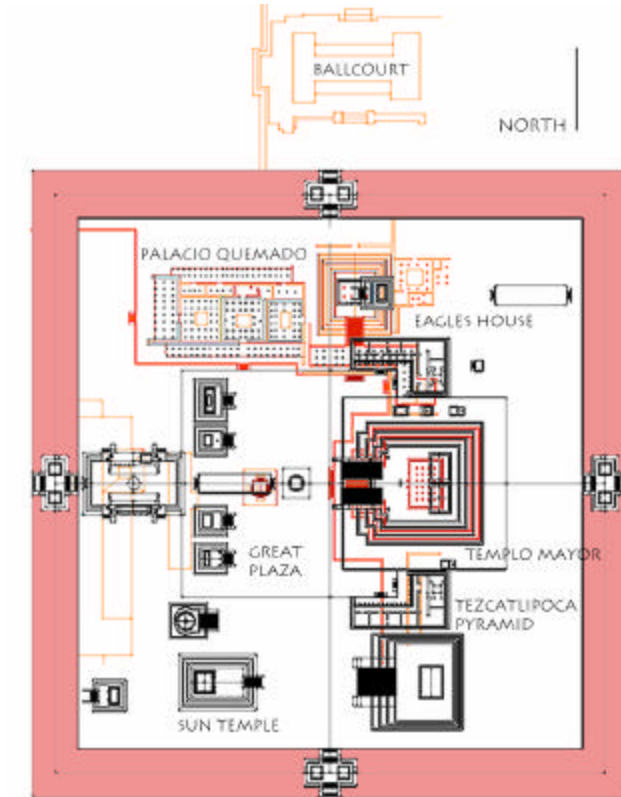


Figure 3

original drawing or photograph using current architectural representation systems in order to recreate theoretically how the original structure may have looked. An ancient pictogram that only a few highly trained specialists could decipher can now become an attractive drawing that all can easily read and interpret.

time consuming, and rather expensive.

Digital photocomposition has addressed these issues and is now quite easy to carry out. The application of this technique proved invaluable in understanding how Mesoamerican architects created their first designs using a very unique system of planar representation. Unlike the symbols we use today to represent buildings that include plans, elevations and sections, Mesoamerican architects used a rather clever system that combined in the same drawing or illustration one or more facades and one or more sections. To the untrained eye this system is quite difficult, if not impossible to comprehend. However, with the assist of digital photocomposition procedures, we can shift and scale elements in the

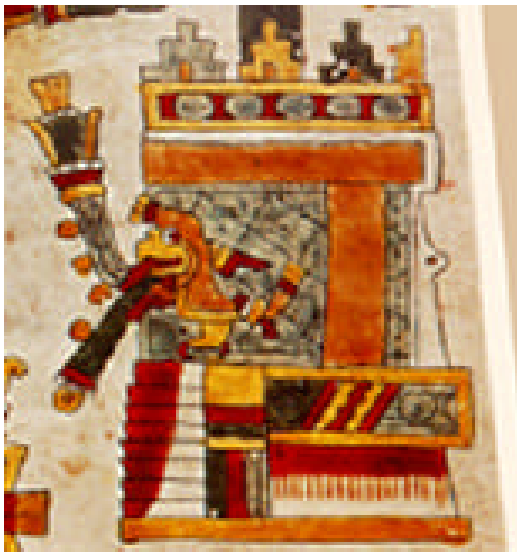


Figure 4

Figure 4 shows a section of the Cospic Codex, a skin screenfold manuscript at the Biblioteca Universitari in Bologna. This particular illustration shows in traditional Mesoamerican fashion how 'tlacuilos' or Indian graphic artists represented buildings. Some elements like the roof termination are illustrated in frontal elevation. Other building components like the base are only partially shown. The outer walls of the structure are illustrated with some elements drawn as elevation while others are sketched out as section. In the classroom, one could show and discuss the original pictogram and verbally attempt to 'reconstruct' it in

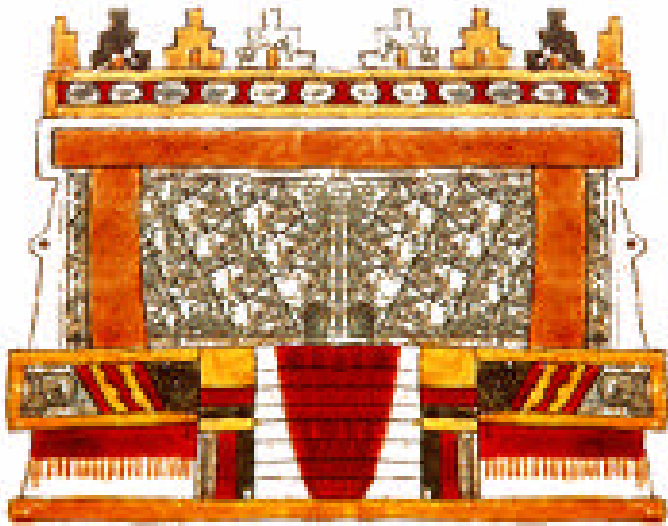


Figure 5

continue to explore issues of building scale, proportions or tectonic qualities.

Many of us have attended presentations where the silver screen revealed poor, almost unreadable material. Mediocre publications containing illegible imagery abound. These conditions can be improved significantly by applying new digital technologies. Better



Figure 6

and more visually attractive depictions of historic drawings, artifacts and buildings are just a few clicks away. A case in point is shown in Figure 6 where new digital graphic techniques have resulted in the re-discovery and enrichment of ancient documents. This particular figure contains a representation of Mictlancihuatl, the female deity of the Mictlan or Mansion of the Dead in Aztec mythology. The original Indian pictogram of this deity is in the Fejervary-Mayer Codex at the Free Public Museum in Liverpool England. It is barely readable. Even the first facsimile edition published by Lord Kingsborough in 1831 has lost most of its colors and textures. In order to arrive at the graphic shown in Figure 6 a high resolution scan of the original pictogram

order to get an idea of how this structure might have looked. On the other hand, it is now a lot less painless to actually perform 'digital surgery' on the original drawing and recompose it. Figure 5 shows a theoretical reconstruction elevation based on the Aztec pictogram shown in figure 4 where all the building elements are drawn using current conventional drawing techniques. In this case the digital photocomposition has only included the relocation of some building components. But, the process could certainly

over the years. Clarity and intelligibility in the representation of the deity slowly began to emerge. Facial features, hand delineation, and other symbolic elements finally came back to life resulting in a brilliant impression of the Aztec goddess. To further enhance the readability, the outline was digitally embossed and placed against a contrasting color background. It should be pointed out that in this case the effort was not meant nor intended to give a different look to the original pictogram. The goal was simply to explore ways to make understandable an otherwise unreadable pictogram.

Three-dimensional Representation

Before the advent of three-dimensional digital modeling tools, architectural historians had to rely on existing photographs, sketches and relatively few three-dimensional illustrations to complement their texts or presentations. Many of these sources were in obscure inaccessible locations. New illustrations were difficult and time consuming to generate. Older illustrations suffered from a variety of ills. Perspective deformation, wrong placement of elements, incorrect scale and proportion problems were just some of the problems encountered. While three-dimensional digital modeling is still a difficult tool to use not because it is too intense, but because it requires a high level of precision and complete data sets, it nonetheless addresses and solves many if not most of the previously listed problems. In fact, three-dimensional modeling tools are great assists in solving mysteries related to building placement and delineation. They too can debunk myths that have plagued historical accounts for centuries. A case in point is the architectural delineation of shrines within the Aztec Templo Mayor archaeological site in Mexico City. For many decades architectural historians had relied on sketches and drawings based on Aztec clay models. These very small clay models were found during archaeological excavations done in and around the Templo Mayor site. It is not known if these models were actually used by the Aztecs for design and construction purposes. Perhaps they were simply decorative objects and had other symbolic meaning attached to them. Even though historians were not sure if these models were actual small scale representations of the real temples, they were nevertheless used as the base for theoretical reconstructions. Numerous historians fell in the trap and produced works that envisioned and depicted Aztec temples as very tall structures. Some even introduced imagery that combined stylistic features from Mayan architecture and Aztec production!

Figure 7 shows on the upper left corner a photograph of an Aztec clay model perhaps representing a shrine resting on a pyramid base with an attached staircase. Immediately on the right is a computer model that adheres to the clay model form and proportion qualities. While studying this particular model it quickly becomes apparent that this structure could not have been built with this particular physical delineation. The Aztecs simply did not have the necessary structural or engineering expertise at the time to build such svelte temple. Its shrine at the top can certainly be made out of clay in a small model, but to use the same proportions at full scale is not possible. Below the image of the clay model is another digital model based on sketches produced in the 1960's. For those not familiar with the stylistic building characteristics of Aztec architecture, such delineation would be entirely acceptable. However on close scrutiny, this image contains a long list of problems that the length of this paper cannot afford to enumerate. Suffice to point out that it is the bottom image that most likely paints the reality of the actual Aztec temple. This image was derived from recent archaeological evidence uncovered by the

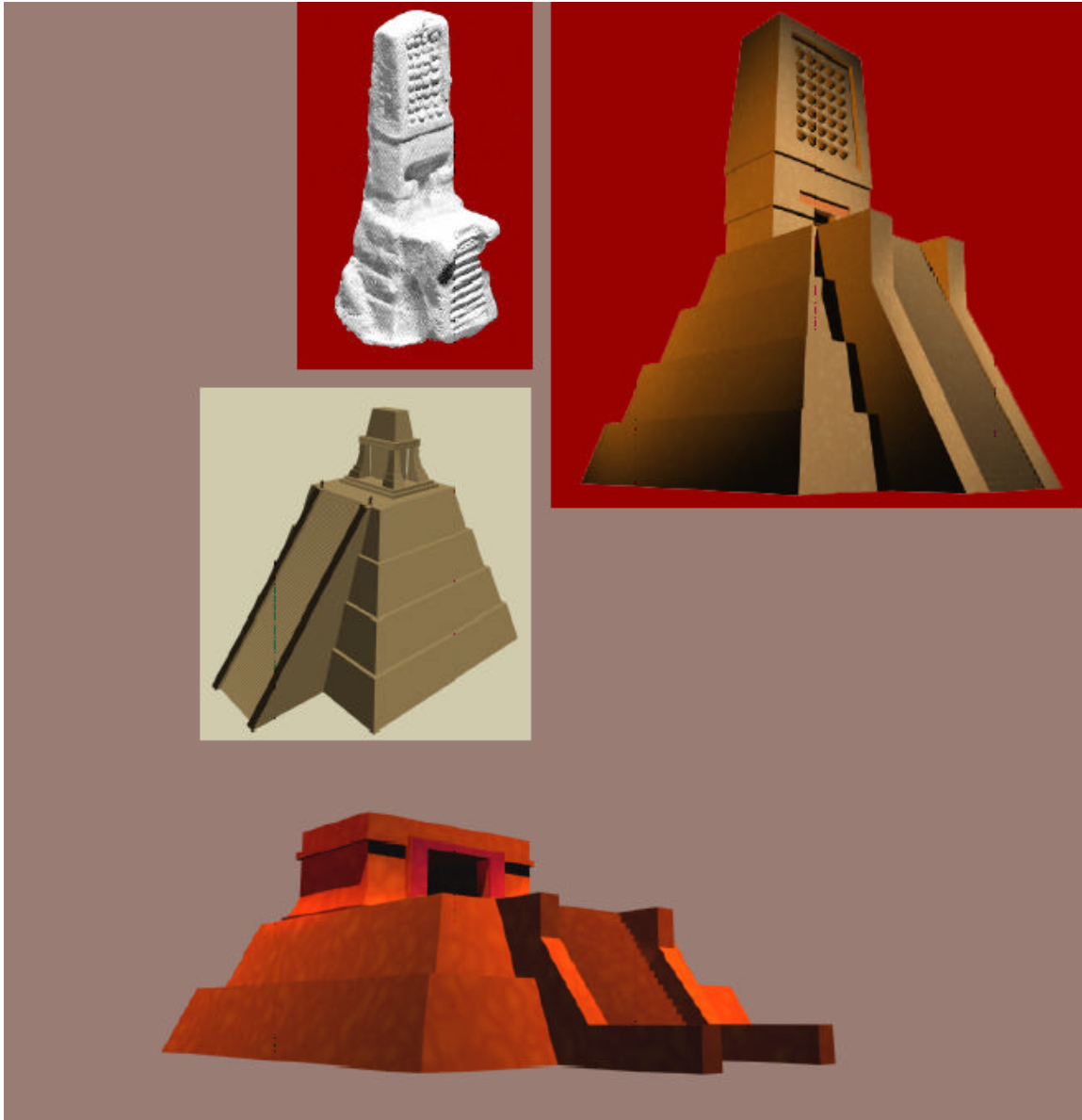


Figure 7

Mexican Institute of Anthropology and History. The temple and its base have correct proportions, and the stylistic attributes pertain to the architectural definition used by the Aztecs just before the arrival of the Spanish.

Digital tools can greatly enhance the teaching and understanding of architectural history in other ways. Their ability to quickly generate a variety of views is truly fascinating. Not only we can now generate isometric, axonometric, and perspective views by pressing a few keys, but it is also possible to generate close-up, eye-level and aerial views that heretofore were not possible. Being able to look at the shrine of Huitzilopochtli atop the Aztec Templo Mayor from the Ytualli or Patio of the Dances in front of the temple and without perspective distortion provides beyond doubt a most direct way of comprehending the synesthetic qualities of Aztec design.

Finally, the ability to explore architectural characteristics that go beyond basic geometric representation is probably the most attention-grabbing innovation made possible by digital technologies. For example, the interface with sites can easily be investigated with terrain modelers. Landscape integration can be studied using fractal generators as shown in Figure 8 visualizing the vegetation characteristics of the Aztec Templo Mayor site.



Figure 8

Also in this category is the ability to explore the expressive qualities of historic sites or buildings. Photographs and drawings of ancient sites usually depict them as bare assemblages of cold stone and rubble. When looking at these images architecture students see them as too removed from today's architecture. For many of them, it is very difficult, if not impossible, to discover the links between a pile of rubble and the actual physical and expressive qualities the ancient site might have had. In the case of the Aztec Templo Mayor, archaeological evidence has documented numerous instances of highly decorated and colorful environments. Added to such physical evidence is the commentary written in the sixteenth century by Spanish friars painting scenes where thousands of individuals danced and sang while hundreds of braziers spilled fire and smoke. With the assist of digital tools we now can recreate such vibrant expressive qualities leading to a much better understanding of not only the basic architectural form qualities, but the total synesthetic feeling and emotion of the place. Figure 9 is a close-up view of the shrines of Tlaloc and Huitzilopochtli atop the Templo Mayor. These two twin temples were placed at the rear of a large platform whose center was the sacrificial slab where thousands of Aztecs had their hearts ripped out as an offering to the deities. This platform most certainly had a dreadful and appalling quality. Cortes, the Spanish conqueror, and other contemporary chroniclers did not sketch out this part of the Templo Mayor site, but wrote extensive accounts describing such frightful space. These accounts formed the base for the theoretical reconstruction.

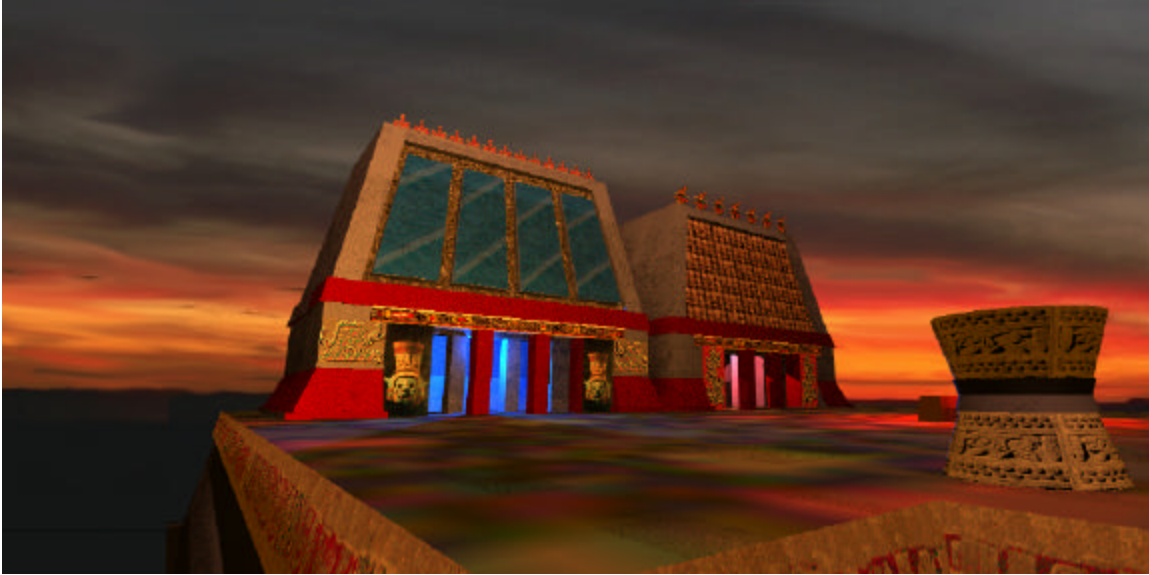


Figure 9

Static and Animated Representation

Animated drawings and ‘walk-through’ or ‘fly-through’ animations can also enrich the study of historic sites. This is particularly true when kinematics reveal how a special quality or attribute was actually achieved. A case in point is an animation showing how ancient sites were assembled in layers. Aztec architecture is the perfect match for this approach because it is a well known fact that every fifty-two years most temples and shrines received a new building layer covering previous construction phases. ‘Walk-through’ films do not hold exclusive rights under this category. More subtle and profound investigations using carefully orchestrated animated sections can reveal qualities not known or perceived previously. For example, we can generate an animation where a series of vertical sections can slowly reveal spatial transitions and hierarchies. Such visualization could demonstrate that a particular sequence of spaces most likely was devised by the designers to inspire awe or admiration. Or, it could also show how designers used spatial sequences of compression and decompression to make the occupants of spaces go about in certain directions. Aztec architecture included many



Figure 10

symbolic associations between mountains and temples. Ultimately, the result was the generation of canyon spatial effects between pyramids. One quickly grasps this valley-ravine outcome by studying an animated series of sections cut through the main axes of key pyramids. Figure 10 shows one frame of an animated vertical series of slices cut through one of the major axis of the Aztec Templo Mayor site. This particular animation clearly illustrates the mountain-temple scheme and

resulting canyon spatial effect. In addition to this mountain-temple association, there also was a directional building quality tied to astronomical observations. Temples not only included physical manifestations or symbolic decoration linking the structure to particular deities but were quite accurately aligned to celestial bodies. With the assist of animated sections both points can easily be appreciated. Visualizing the movement of the sun during the equinox between the twin shrines of Tlaloc and Huitzilopochtli atop the Aztec Templo Mayor is truly a fascinating experience.

Walk-through or fly-through theoretical animations are the most elaborate assists. While their production is currently somewhat problematic, their educational value can oftentimes justify their very demanding and time-consuming attributes. Because the generation of a one-minute animation requires the creation of 1280 individual images on average, the process generally involves a substantial amount of time. It is also complicated by the fact that one has to generate credible imagery based on reliable historic data which sometimes is not readily available. Despite their inherent difficult production, walk-through animations are probably one of the best ways to not only analyze but to ‘feel’ the qualities of ancient places or historic buildings. In the case of the Aztec Templo Mayor, the ability of being able to virtually walk along the side of the Tzompantli where thousands of skulls were strung along wooden poles is an experience that cannot be generated by any other means. Figure 9 is from an animation clip running along the Tzompantli or Aztec skull rack in front of the main temple.



Figure 11

User interface and Immersive Technology – Virtual Reality

Interactivity, or the opportunity that an individual is given to choose or direct the course of study, is probably the most intriguing topic in this presentation. While all the different approaches mentioned above greatly enrich the way we can read and study historic environments and buildings, there is still one element missing. The learning environment is passive: students just listen inactively and look at a variety of visual material. The only opportunity for interaction comes with open discussions or testing. A subject of great debate within academia, the concept of self study and direction, if well implemented, brings stimulating prospects to the study of world architecture. In broader terms, user interface options include instances where a student can: (a) virtually navigate solo or along pre-determined paths through buildings or environments, (b) interact virtually with the environments, and/or (c) be given the opportunity to virtually modify or alter single physical instances such as lighting, or other major changes including scale transformations or modification of tectonic qualities.

Virtual reality began when the concept of immersion in a simulated world with complete sensory inputs and outputs was first proposed. The idea was to see a screen as a window through which one could see a virtual world that looked real, acted real, sounded real and felt real. The potential of using virtual reality systems in the study of architecture as a more intuitive metaphor for human-machine interaction is enormous because the student can exploit his or her existing cognitive and motor skills for interacting with the world in a range of sensory modalities. For the study of architectural history virtual reality is a lot more than just interacting with historic reconstructions of three dimensional worlds albeit this option is most likely the most important one. By offering presence simulation to students as an interface metaphor, it allows them to potentially perform tasks on historic reconstructions, remote computer generated worlds or any combination of both. The reconstructed environment does not necessarily have to obey certain laws of behavior. The following describes potential application areas where the benefits are more straightforward than others:

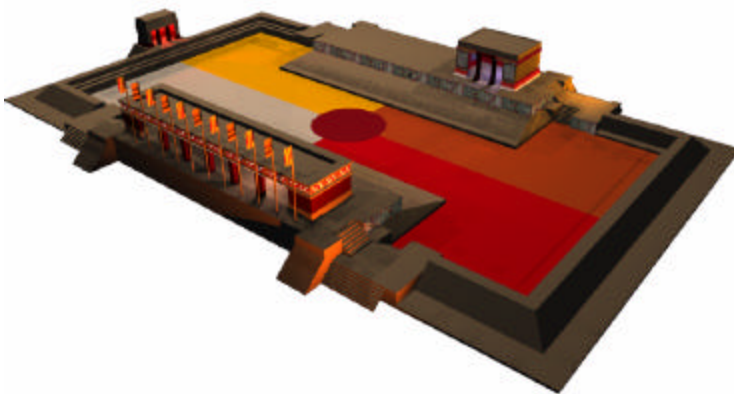


Figure 12

User-Directed Walk-Through

Architectural building or place user-directed walk-throughs have been one of the most successful applications of virtual reality. Figure 12 shows a frame of a fly-through VRML file that models the theoretical reconstruction of an Aztec ball court. In this virtual reconstruction the student can virtually fly around this structure, pan the views and even zoom in on some building details.

Natural interaction using (a) digital panoramas, (b) immersive technologies, or (c) virtual reality modeling systems with digital reconstructions can be important in history of architecture courses because they provide an unlimited number of viewing angle opportunities thereby forming in the viewer a much better and richer mental model of complex objects, buildings and environments. This, in turn, augments the understanding of that object's identity, attributes, functions, and so on. On the market today there are a number of cross platform application packages with the capability to play movies, synthesize music, display animations, view virtual reality worlds and add multimedia options to the computer desktop. These applications are implemented as a set of extensions on the Macintosh platform and a dynamic-link library (DLL) on Windows. They can process video data, still images, animated images (also known as sprites), vector graphics, multiple sound channels, MIDI music, 3D objects, virtual reality objects, panoramas and text. The number of data formats they recognize is impressive. Currently, more than 70 different formats can be imported or exported and as formats are added, applications created today will probably work with them automatically.

Virtual Simulation

How did the shrines atop the Aztec Templo Mayor look like? While the historical record contains a variety of sketches illustrating how these temples might have looked, this question has not been answered satisfactorily. Figures 13-14 are examples where user-directed virtual simulation has helped in determining the most probable architectural configuration for these shrines. Figure 13 is based on the Codex Ixtlilxochitl, an ancient Indian manuscript, whereas figure 14 is based on more recent archaeological data. This particular study demonstrates in a most vivid way to students of architecture that historical interpretations change over time. In other words, what was once considered an absolute truth has now been debunked by new scientific tools and upgraded archaeological data.



Figures 13-14

Virtual simulation is more than only high tech applied to historic buildings or places. When correctly applied to the study of architecture, there is a virtualization of the whole being. We encounter this phenomenon in everyday media worlds. The classical difference between appearance and reality becomes blurred. The simulation, in which students can walk around, is not fictive. It is not pure imagination, but something

realized. It is reality although it is virtual. From this viewpoint, it can potentially become a major determinant or consideration when applied to everyday life.

Telepresence, Teleoperation and Increased Sense of Realism

As we begin to complete the first phase of being able to virtually recreate the past, it is important to pay attention to both the awareness and behavior of the individuals participating in the new technologies. We are now at a crucial moment where the machine-human interface can increase the sense of realism of a virtual experience as well as convey information about a building's identity, qualities, location, function, and so on. We can now increase the range of textural information. We can also examine roughness perception of a set of force feedback generated textures in order to better understand the range and resolution of textural information available through such interaction. We too can add audio stimuli to increase further the potential for conveying more varied and realistic texture percepts through force feedback interaction. With telepresence and teleoperation students can perform actions within virtual environments. They can even generate synthetic characters or avatars to be inserted in models to study their responses to visual, haptic and auditory textural stimuli.

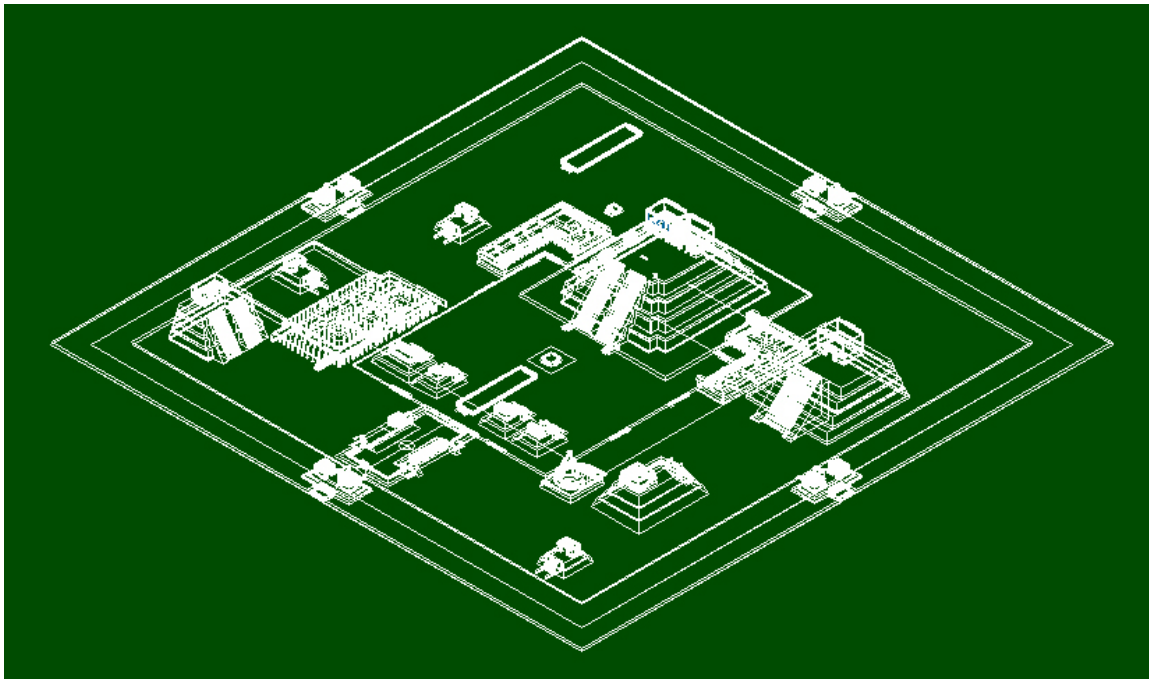


Figure 15

Image 15 is a screen capture of a virtual reality model where students can follow a do-it-yourself tour and navigate freely through the site of the Aztec Templo Mayor. This model includes markers where students can obtain additional information such as a description written from the Aztec point of view about what happened when Moctezuma, the last Aztec ruler, and Cortes first met. There is also the possibility of following a guided tour where students select a viewpoint on a pre-selected position for viewing a scene. In this case each vantage point has a name and students can use a menu to cycle through the viewpoints. The model includes provisions catering to those who wish to see the

reconstruction in full detail. Clicking on other markers activates movement of objects using script nodes, sensors and routes. Special virtual reality modeling elements called billboards can also be activated where messages appear on transparent background layers. At particular nodes students can appreciate the path of sun rays on the spring equinox. On this date as the sun rises, the rays pass between the shrines atop the Templo Mayor. At the intersection of major axis there are nodes that activate 360-degree panoramas of the scene. Finally, there's a fair amount of activity in this virtual reconstruction that students can teleoperate: flames and sparks rising from the braziers, boats sailing around the lake, and birds flying overhead.

Conclusion

Architectural history education has been developing as an island community with few ties to the information technology mainland. It currently lives inside its own structure and is dependent on a limited set of specific educational approaches for authoring and presenting. This paper submits that architectural history education should relocate to the mainland and live and benefit from very exciting new ways to look and study old worlds. Far from suggesting that old educational approaches be abandoned, this paper recommends that those insular approaches pack-up and set sail for the mainland, and integrate into the mainstream. It is cool.

Bibliography

(1) Serrato-Combe, Antonio, The Aztec Templo Mayor, 2001, The University of Utah Press, Salt Lake City.