Experiencing an Ancient Assyrian Palace: Methods for a Reconstruction

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Abstract
The various forms of two and three-dimensional applications of Computer-Aided Design provide methods for analyzing, seeing, and presenting newly realized design work. It can be used to re-create building spaces unseen since their collapse centuries ago. In our project we blur the lines between the design of new architectural spaces and the re-conception of ancient spaces, thus merging the fields of architecture and archaeology using digital technology. Archaeologists and Architects are interested in similar goals concerning the depiction of space and form but archaeologists must deduce from historical, cultural and social comparisons as well as actual excavated remains.

Our project is reconstructing the 9th-century BCE Palace of Ashurnasirpal II situated in Iraq. Though much of the palace has been excavated its architecture and full artistic program will never again be fully realized. Attempting to visualize partially preserved archaeological sites depends upon deductive reasoning, empirical wisdom and sound research. By modeling digitally and using “real-time” Java-based programming, the researchers have learned more quickly about the building than through traditional flat plans, cross-sections, drawn perspectives and constructed models. We are able to “inhabit” specific interior and exterior spaces in ways not possible before. Using the tools of digital archaeology allows a myriad of educational possibilities for the scholar, student or layperson.

Keywords
Architecture, Archaeology; Reconstruction; Web, VR
1. Introduction: From Excavation to Paper to New Experience

The usage of Computer-Aided Design (CAD) along with modeling programs and Java-based technologies have become widespread, globally, in academia, in fieldwork, and in professional and industry practices, with the most popular place for the dissemination of research results on the World Wide Web (Forte and Silliioti 1997; Novitski 1997; Barcello, Forte and Sanders 2000; Dabney, Wright and Sanders 1999; Forte 1997; Gay 1996; Grady 1998). The various forms of two and three-dimensional applications of CAD provide methods for analyzing, seeing, testing and presenting newly realized design work. It also can be used to create reconstructions of building spaces and places that have not been seen since their destruction or collapse centuries ago. In our project, we are combining various CAD applications with Java-based and virtual reality technologies to present combinations of different data with more precise and realistic spatial models. We are interested in these results and we are particularly enamoured of what the process of making the models is teaching us.

In the study and practice of architecture, a full building or creative design is usually drawn and modeled in a variety of ways to convince the client or user of the project viability and hopefully unique spaces that will be built to harmonize with the site. The archaeologist is interested in similar goals concerning the depiction of space and form but must deduce the usage and success from historical, cultural and social comparative research and actual excavated remains. In our project we are blurring the lines between the design of new architectural spaces with the concept of re-conceiving ancient spaces thus merging the fields of architecture and archaeology with the aid of digital technology.

Our multi-faceted project is reconstructing the 9th-Century BCE Northwest Palace of Ashurnasirpal II situated in modern day Iraq (Figure 1). Much of the colossal palace has been excavated but the architecture and full artistic program will never again be fully realized. Attempting to visualize an archaeological site that only partially exists depends upon a certain amount of deductive reasoning, empirical wisdom and sound research. By collaborating with architects and scholars in other disciplines as well as researching other related sites and their finds, the entire picture of social life, spatial character and possible symbolism becomes more clear.

We are using digital technology to aid us in adding significantly to the documentation that has been amassed over the last 150 years. This method allows us to see and deduce differently and, more importantly, to “test” our decisions. Over the last decade we have moved from photo and paper-based documentation to the creation of an in-depth virtual-reality publication of what we “know” about this palace. It is our intention to provide access to more than a replica of what might have existed in antiquity. There is sometimes a look of “flattening” or an “over-simplification” in digital renderings in comparison to traditional handwork, yet the three-dimensional clarity and the detailed presentation of the spaces rendered with light and shadow are actually more precise. (Figure 2) The team involved in this project has learned more quickly with this three-dimensional-technology medium about the architecture of the building than through what more traditional flat plans, cross-sections, drawn perspectives and constructed models provide. Also, information is much more malleable, allowing us to discuss and change the model more quickly than with traditional methods of drawing and re-drawing.

The organization of the information digitally lets us also take these constructed images and mesh them with researched information such as the ancient and modern technology and history of the
A little over 150 years ago, a young British adventurer named Austen Henry Layard began excavations at two sites in northeastern Mesopotamia, in what is today Iraqi Kurdistan: at Kuyunjik, the citadel mound of the ancient city of Nineveh and on the citadel mound of Nimrud, the site of the ancient city of Kalhu. It was at Nimrud that Layard unearthed the best preserved of the ancient palaces of Assyria, the so-called Northwest Palace of King Ashurnasirpal II, an Assyrian monarch who ruled from 883-859 BC. It is called the Northwest Palace because it was found near the northwest corner of Nimrud/Kalhu’s citadel mound. Layard worked for 6 years (1845-1851), excavating and documenting these sites. As at Nineveh, he and his assistants planned, drew and removed from the ruined site of the Northwest Palace the collapsed brick and stone bas-reliefs that decorated the palace’s walls. The technical drawings and sketches of the architectural remains and bas-relief, testimony to the Layard years in Assyrian Mesopotamia, are preserved in the British Museum and the British Library. A series of activities have occurred since this time making the job of documentation and reconstruction extremely difficult—more excavations and then the cutting up and dispersal of the bas-relief decoration originally found in situ.

Over the last 150 years, the bas-relief, whole or in fragments, have come to be found in many parts of the world—some in private collections and some in public. During the course of Layard's excavations and those of his assistant, Hormuzd Rassam, and with Ottoman approval and the approval, support and assistance of Henry Rawlinson, the British government’s representative in the area, the stone bas-relief decoration was distributed to friends, family and the British Museum. Some of the relatives were supporters of Layard’s work in Mesopotamia and its publication.

Visitors came to Nimrud both during and after the concluding years of Layard’s time in Mesopotamia and then in the years during which other excavators, including the British Museum's William K. Loftus and William Boucher (1854-55) worked at Nimrud. These visitors received permission, literally, to mine the site of what were
considered duplicate images, some of them fine examples of 9th Century BCE bas-relief sculpture (Curtis and Reade 1995, pp. 9-16; Larsen 1966)

Examples of bas-relief from the Northwest Palace are now to be found in 65 museums and private collections across the world. Large collections can still be seen today in museums such as the British Museum (London), at the Metropolitan Museum of Art and The Brooklyn Museum of Art (New York), The Louvre (Paris), the Los Angeles County Museum (California) and the Staatliche Museum (Berlin). Every few years, another fragment surfaces, adding to the still incomplete knowledge of their locations. Today we can document the whereabouts of 323 complete and fragmentary examples of Northwest Palace sculpture outside Iraq.

When the British School returned to Nimrud after the Second World War, they re-excavated Layard’s finds and extended their work into parts of the palace that neither Layard nor Rassam had touched. They also began to restore bas-relief to the walls. The principal result of the British excavation work was the realization that the palace was much vaster than Layard’s plans and reports indicated. When the British moved off the citadel to work in the lower town, the Iraqis continued to excavate, ultimately turning the palace into a site museum (Mallowan I, 1966, pp. 103ff.) (Figure 3).

In the 1974 the Polish Center of Mediterranean Archaeology of the University of Warsaw arrived at Nimrud with a contract to excavate the area of the Central Palace of King Tiglath-pileser III which lies to the south of the Northwest Palace. One of the by-products of the Polish time there (1974-76) was the attention that the director of the Polish project, Janusz Meuszynski, paid to the continuing presence of the Iraqi mission. Meuszynski, with permission, had the whole palace site documented in photographs: the restoration work, every fragment of fallen and broken bas-relief, and all the pavement slabs. These were

Figure 3. Existing bas-relief at the Nimrud Site Museum, restoration by the State Organization of Antiquities, Iraq and the British School of Archaeology’s excavation team, directed by Sir Max Mallowan.
added to another set of photographs that Meuszynski had taken in 1971. Meuszynski also arranged with the architect of the Polish excavation, Richard Sobolewski, to re-survey the site and record it in plan and in elevation. This became the first scientific plan and elevation since Layard’s time.

After the accidental death of Meuszynski in the spring of 1976, the Polish work at Nimrud ceased. Sobolewski became the caretaker of all of Meuszynski’s records, finishing Meuszynski’s publication of part of the palace and then turning to Samuel Paley to help with the rest. In 1992, they completed a restoration on paper, published by the German Archaeological Institute, of all the known evidence (Sobolewski 1981, pp. 250-5; Meuszynski 1981; Paley-Sobolewski 1986, 1992.)

To prepare the first comprehensive excavation publication in the 20th century, Meuszynski, Sobolewski and Paley adopted the following complicated and time-consuming “paper” process (Figure 4): Motifs in each room were traced from the photographs taken for and by Meuszynski. For instance, in room I, seen in three registers, kneeling human-headed geniuses are alternating with trees on the upper register, a summary historical and building inscription on the middle register and eagle-headed geniuses alternating with trees on the lower register. An elevation drawing was prepared, which showed what was in situ and what was missing. A hypothetical scheme, which took into account the direction in which each figure stood relative to the trees, was developed. The next step was to assemble all the pieces that could be found belonging to this room according to the schematic, matching inscription fragments, iconographic details, sizes and shapes of the cut and broken stone. Then scaled photographs of each piece were pasted-up on a drawing of the hypothetical scheme. This paste-up was then given to an artist, who made the publication drawings. Finally, the room where these slabs existed could then be visualized as a whole, approximating what Layard described when the same room and its partly fallen bas-relief were first uncovered. But, the whole room was really only visualized from the ground up to the top of the bas-relief slabs and no more. So, what did a room, or indeed the palace as a whole look like?

3. Developing the Project

One of the primary reasons for doing this project was to create a way that one could not only view the architectural remains of the palace but also see the bas-relief art in virtual situ, thereby gathering and reuniting all of the bas-relief into a virtual museum. This has never been attempted for this palace or any other Assyrian site. Not only was it rare for archaeologists to think this way but also it was important to find a way to make this work more accessible to our colleagues, students and the public.
There are several difficulties with access to the remains of the palace:

- the actual site is nearly impossible to get to because of the present political conditions;
- the fragments of the decoration of its walls are distributed far and wide;
- there is continued danger to the palace's existing preserved remains from the natural environment, pollution and robbery.

New computer-based methods of publication and presentation, which are increasingly available for educational purposes, made it possible and indeed necessary to “re-create” this great monument so that it would survive as part of our heritage. Almost a decade ago, Alison B. Snyder (University of Oregon), joined the original team of Samuel Paley (University at Buffalo) and Richard Sobolewski (Warsaw) to begin to do some of the first reconstruction work since their 1992 publication on the palace (see our later description of architectural reconstruction rationale). An alliance with Dr. Donald Sanders and his company, Learning Sites Incorporated, was forged at a meeting of the Archaeological Institute of America six years ago. And in the last year this team has expanded to include Thenkurussi Kesavadas (also at the University at Buffalo). Most of the last four years have been spent working on our CAD-oriented goals by building the research into the model for the PC and supercomputers with an emphasis on important parts of the palace such as the Great Northern Courtyard and Throne Room suite, which comprise the north wing of the palace.

Primary in our minds was the fact that, in over a century and a half since its excavation, there had been virtually no attempts to visualize the remains of the Northwest Palace of King Ashurnasirpal II of Assyria except through discussions, including our own, of its architecture and decoration. Most textbooks still reproduce Layard’s commissioned drawing of 1849, in which he envisioned the Throne Room from the vantage point of somewhere near the middle of the room, looking west toward an anteroom. That visualization has a distinctly Victorian aesthetic regarding the scale and representation of the structure, the décor and wall patterning, all of which many have become used to: coffered ceiling, large light well, pastel shades of color and mixed patterns and borders (Figure 5).

Our study first through paper and now more precisely in CAD has enabled us to interpret the remains in the context of other excavated palatial settings and has led us to different conclusions. The new technologies we are using, including Virtual Reality, allow us much more latitude, both in testing our decisions quickly and in our ability to move around the “environments” almost as if we were actually at the site. So we can now “experience” the reconstruction and have at our fingertips a vast amount of information that will be more useful and accessible than in a traditional book format. We can include in one place (i.e. WWW, CD-ROM, etc.) the drawings made by Layard on the site during the excavation, the records and illustrations prepared by the later British excavations, the Polish documentation and the Iraqi excavations along with our own scholarly surmise. Our virtual reconstruction is actually based on a mixture of drawings, photographs of the bas-relief, re-constructed spaces, décor patterns, and even furniture replications with a series of applied textures and colors. The multi-faceted applications of CAD have been realized for years, yet all of our work points to very new information for the architect and archaeologist (and for other scholars and lay people) interested in learning a great deal more about an ancient structure. The ability to act as a discoverer and a scholar able to amass many levels of information all at once has just began to be a powerful and experi-
ential educational tool for us. The final effect is somewhat like a smart montage that simulates what the original palace might have looked and felt like.

4. Further Digital Implications for a Palace Architecture and Archaeology

To re-emphasize our focus first on paper and the transition to digital forms, an important step from codex-based archaeology to digital archaeology is the use of visualization and presentation techniques that take advantage of what cannot be done on paper, such as the use of moving images, sounds, and hyperlinks. Digital archaeology, especially one that takes full advantage of the World Wide Web, need not depend upon the visualization tools, linear format, or two-dimensional display methods of past archaeological reporting. Java, virtual reality, and computer animations can all be seamlessly integrated into the basic methods of disseminating archaeological data. In the paper archaeological report there are: limits on the number of images; limits on the types of images; limits on the sizes of images; prescriptive, static, and linear presentations. There are also the difficulties of continually updating the data and images as well as reporting new ideas. Traditional publishing has expensive packaging costs, mailing costs, warehousing costs, as well as the expense of production per unit of data published.

Electronic reporting integrating the Internet can overcome these and other profession-wide barriers to information because it can reduce the long time lag between data gathering and data dissemination. It can also provide more information more creatively to more people, increase vastly the amount of data that can be included in a publication, increase the options for visual presentation of the data, and provide hyper-linked presentations and customizable search and retrieval formats. And, as we add more information or reconstruction decisions are made, the user can access and learn from the data faster and more effectively than many book publications allow.

One of the most impressive and powerful possibilities using these existing technologies is that dynamic virtual worlds will make it possible for users to visualize alternative solutions to design problems by interacting dynamically and directly with the geometry of the virtual world. We intend to demonstrate some of those advantages through the creation of what we call a Virtual Site Museum that is an outgrowth of the original work currently documented at http://www.learningsites.com/NWPalace/NWPalhome.html. To view the virtual museum, a new website has been created at http://www.classics.buffalo/projects (link to UBVirtualSiteMuseum). Our team is now creating massive research resources based on virtual reality re-creations of the palace. The virtual models have links to drawings, photographs, descriptive and analytical text, and high-resolution renderings of the building complexes (Figure 6). The project is using as intermediaries avatars coming from outside the system and intelligent agents virtual Assyrians — acting as virtual site interpreters, who will be able to answer user’s questions about the palace from the knowledge base, artifacts and locations within the virtual spatial environment. (Figure 7) We will include haptic devices, which add the sensation of touch to the experience and create a more intuitive way of understanding the artifacts and environment. A virtual examination toolkit will enhance the experience of being immersed in a virtual environment through the use of surrogate instruments that can be handled by visitors to the virtual environment in order to carry out some specific task without overloading the computer. We will give the user a ‘virtual binocular’ for viewing across large architectural spaces to extract very high-resolution images from a distance. There will be a ‘virtual magnifier’ to examine details on 3D artifacts and of decoration and extract fine levels of detail without overloading the rendering engines. A ‘virtual ruler’ has already been developed for measuring architectural details and objects in the virtual environment. And finally, a visitor will be able to change the virtual world on command (by voice or menu-driven command) and in real time. This will allow for users to alter and experiment with the geometry of certain spaces and areas and to suggest specific alternative hypotheses about the heights of ceilings or widths of doors. The dynamism of our architectural project represents a new
way of learning and is precisely what a static book publication can not do.

At present some of these tools are in test mode and others already have been successfully demonstrated. A series of these tests are accessible to the viewer on our websites. Eventually, the results will be published both on DVD and on the Internet so that live updates can be integrated, and distance education features and links to new information can be integrated into the existing virtual world as they arise. Access to Internet2 and the technologies of the ImmersaDesk™ and CAVE™ have been successfully integrated into the project.

5. Reconstruction Rationale: Architecture and Representation
Once again, what follows is an overview of the detail and complexity of undertaking a new model of the palace piece by piece. Several modes of testing were needed and are now also afforded by the digital database. Paper has merged and informed our more precise CAD model. The basis for all
of this work is the palace architectural floor plan by architect Sobolewski [Figure 8] and the information that exists from analysis of the excavated and documented bas-relief both facing the exterior and those set within the Throne Room. (Meuszynski 1981, Paley and Sobolewski 1986, 1992) To begin the reconstruction beyond this initial documentation, creative yet formal architectural and archaeological analysis was combined with the very specific evidence. In 1992, when Snyder teamed up with Paley to work on the original reconstruction, it was decided that we would begin with envisioning the mass of the entire palace in 3D axonometric views and then concentrate on the Great Northern Courtyard and the connected throne room to begin to generate methods for reconstruction and analysis at various levels of detail. We began working out the imperfections of what we knew from excavation and what we could begin to imagine from our research study. First interior and exterior elevation sketches were drawn with some consultation with Sobolewski. Then exterior and interior perspective renderings were made for other articles and museum collections. (Paley 1999; see fig. 2—a perspective by A. B. Snyder.)

To achieve this, given the height differential between the interior and exterior relief, Paley and Snyder first surmised that the building’s height, perhaps for the whole northern wing, was probably governed by the exterior facade of the throne room with the interior adjoining rooms and spaces following suit, according to need and assumed hierarchy of importance. A hierarchy of importance and usage led to the assigning of heights of spaces and elements such as doors and niches within them and was based on room size and location within the palace. Because we have the bas-relief and can read the inscriptions we can weigh the importance not only of the size differential but also of the quality of the artwork, to help us presume interior and exterior sizes. This theory of assigning “importance” generally holds true in other extant Eastern and Western monumental architecture and in modern planning and architectural design and we therefore feel comfortable with the assumptions we have made.

Paley and Snyder, in consultation with Sobolewski, first considered the three entrances to the throne room. Next, we had to determine how high and what shape the arched doorways were and then what sort of proportions were to be used as precedents for this building. We chose to make archways with straight sides at the base of the openings which then begin to taper to a parabola or ellipse that spring from the top of the doorway slabs, above the shoulders of the flanking exterior entranceway figures. Our shaping precedent after searching through several paper reconstructions and in situ examples of earlier, roughly the same period and later entrances, is based upon the glazed and painted brick panel from above a doorway dated to the period of Shalmaneser III, Ashurnasirpal’s son and successor. The British excavation in “Fort Shalmaneser” at Nimrud discovered this panel. This is not the shape many would presume from ubiquitous classical roman architecture nor later Islamic pointed arches. Further examples found in preserved Mesopotamian architecture confirm that other tapered archways existed though of different heights and widths (Damerji 1973). All the examples of doorways depicted on Assyrian bas-relief were also reviewed.

The brick panel of Shalmaneser III, which was reconstructed by J.E. Reade (Mallowan II 1966, pp. 454-5 and figure 373) allowed us to formulate a proportional system of the bas-relief to the arched opening (Figure 9). From the increased size of the relief in the central section of the throne room facade and from the standpoint of setting up a strong and regal-like symmetry, we surmised that the central doorway was tallest. We also pre-

![Figure 8. Plan of the Northwest Palace drawn by Richard P. Sobolewski.](http://example.com/figure8.jpg)
sumed a path for suitors/visitors to be received by the king. With this in mind, we concluded that the westernmost door (furthest from where the king's throne sat) was used as the entrance and the eastern doorway was most probably the exit—as Max Mallowan once suggested (Mallowan I 1966, p 103.) Perhaps the king used the center doorway for state occasions, as it faces a prominent set of bas-relief slabs, which depict him celebrating ritual. Path and promenade have been central to many ancient and in fact contemporary sacred rituals. Our surmising cannot be far off base, as the king's colossal architecture was surely designed with this in mind (Figure 10).

Once we set the height of the central (8.00m) and flanking (6.00 m) doorways, we set the height of the roof of the Throne Room facade so as to include room for the exposed interior roof structure over the North Wing of the palace's public audience halls. We surmised a parapet with typical canted crenellations at the top of the wall as depicted in many Near Eastern renderings, with the height of the facade from the courtyard paving surface (mud brick pavers measured in situ at ca. 40 x 40 cm) to the top of the crenellations measuring 12 meters.

Decorative banding above the bas-relief panels and along the front of the archways and below the parapet is suggested by aesthetic and structural considerations. In the case of the bas-relief panels, for example, a border between stone wall decoration and the plastered-brick wall façade was needed to accentuate and separate the relief panels from the wall surface above. There were also fragments of glazed and painted brick remnants found on site during excavations in the doorways. The glazed brick panel from Fort Shalmaneser and an archway, preserved at the time of excavation at Khorsabad, confirm that these types of
banding existed (Sobolewski, 1992, p. 244, Figure 6 —after M. Pillet, *Un pionnier d’assyrologie*, pl. VII).

As one passes through the elliptical archway from the courtyard, it becomes a flat arch on the interior, currently measuring ca. 6.40 m high. Our reasoning for this was predicated on the remnants of rectilinear door elements found at Balawat and the hypothesis that rectilinear, decorative, fired-brick panels could have been located above the doorways. An alternative suggestion also led us to an interior flat bottom arched doorway if an arched brick panel that still had a flat bottom such as at Fort Shalmaneser existed above the opening. Our experimentation also brought us to the tall exterior arch and flat interior arch that allows for a height transition that works well with the lower height of the smaller interior bas-relief panels (Figure 11).

The Throne Room measures ca. 9.80m wide by ca. 45.70m long. In studying the proportions of the room and connecting them to the rationale used for the exterior courtyard facade, we realized we had the possibility for a 10.00m high by almost 10.00m wide room. Inclusive in the room are the wood beams (0.6m x 0.6m with part of the beam buried in the ceiling) spanning this width and set every 3 meters along the length of the room. The beams are bracketed by decorative corbels in the shape of upturned hands, which were also found in the debris of the excavation and have precedence of use in other structures such as Assyrian temples and palaces, though none have been found definitively in situ (Curtis and Reade 1995, p. 104, and figures 53-55; Frame 1981. Assyrian hands embedded in a wall at Assur are difficult to interpret.).

To begin to suggest and enhance the grandeur of the Throne Room, a series of decorative, painted motifs have been selected and placed along the tops of the bas-relief. They equal approximately the height of the bas-relief below it, or roughly a 1:1 ratio. We have adopted as a working hypotheses, the height, the motifs and layout as seen in a throne room at Fort Shalmaneser, which was repainted in the time of King Essarhaddon (Mallowan II 1966, pp. 379-80 and figures 307 and 308); glazed and painted wall plaques (Curtis and Reade 1995, pp. 102-3 and figures 50-52) round and shield-shaped; and decorative elements from fragments of painted wall plaster and brick found by Layard and during the Iraqi and British work in the palace (Layard, 1849, plates 84, 86, 97; and from the Mallowan and Iraqi excavations, information courtesy of Julian Reade with reference to Agha and al-Iraqi 1976, pls. 17-19) and by R. Campbell Thompson in Ashurnasirpal’s palace at Nineveh (Thompson 1931, pp. 55ff., and plates XLVIff.; Russell and Hendrix 1999). The modification of the motifs in the present renditions to include figurative elements (human and animal), original to the decoration, is still in the planning stages.

The idea of painted rafters with rosettes and circles with dots comes from the remains of the throne room at Khorsabad, the Assyrian capital of King Sargon II (721-705 BC) (Loud 1936, pp. 67-71, and Plates II and III). At this stage of our work, we decided on a simple geometric decoration, which could be replicated easily, so that we could see what decoration would look like on the walls of our model. We are now considering how to include figural decoration for which there is evidence. Therefore, it is thought that Ashurnasirpal’s throne room and room C, the anteroom at its western end (Figure 2), as well as room F, a staging room to the south (Figure 12), perhaps all the audience halls of the palace, would have been highly painted as opposed to a monochromatic scheme.

![Figure 11. Section through the Throne Room façade wall, Northwest Palace. Reproduced courtesy of Learning Sites, Inc. Williamstown, MA USA](image-url)
Our CAD study has led us to new and different conclusions and a critique of Layard’s original reconstruction (not to mention the décor) which may be compared with our renderings from other viewpoints (Figures 3 and 2, 12). Among the problems we see in Layard’s reconstruction are:

- the major beams cantilevered from the walls to support the light well would most likely collapse, given that the opening seems to span the entire length of the throne room;
- the light well, covering so much of the room, would seem to let in too much rain, sand, and blinding sunlight, damaging to the bas-reliefs, the people, and the mud brick; and
- the people depicted are either too small or the bas-relief too big, at least compared to our current measurements.

Thus, in the Layard drawing, the room’s proportions are incorrectly shown: if the width is correct, then the bas-relief is too large and the roof too low; if the bas-relief is correct, then the room’s width is wrong.

We are still questioning aspects of the interior and exterior. Some of the items we will study further for this reconstruction are related to structure as well as aesthetic, including building structure, bas-relief attachment, decoration and color, natural light and manufactured lighting, drainage, wall brick sizes and interior and exterior surface materials and decoration. We are experimenting with three-dimensional renderings of furniture (Figure 13) and with the placement of figures in the environment (Figure 14). We have been using our website to show our process and to exhibit the tests as well as so-called final renderings. All of this is now being plugged into the next phase of our project focused on new arenas.

Figure 12. Rendering of Room F from the virtual model of the Northwest Palace. Reproduced courtesy of Learning Sites, Inc. Williamstown, MA USA

Figure 13. Rendering of the throne of King Ashurnasirpal II (883-859 BC), from a bas-relief in Room G, Northwest Palace. Reproduced courtesy of Learning Sites, Inc. Williamstown, MA USA

Figure 14. King Ashurnasirpal on the throne, and walking. Model constructed by Young-Seok Kim, MS, Virtual Reality Laboratory, Department of Aeronautical and Mechanical Engineering
of digital technology to allow for experiencing other rooms as well as other aspects of the palace.

6. The Technological Project and On-going Intentions

The project is working in phases such as research/information collection, modeling, and tools development/navigation at the same time:

- The collecting and organizing of information is proceeding to assemble data sets that can be “mined” by the user. The data sets come from excavation documentation, photo and archival resources, and previous, current and ongoing research. The data sets (texts, 2D and 3D images, sound, voice, video, and computer animations) will be organized into a semantic network (an n-dimensional array structuring the data according to information science and thesaurus principles) that will then be linked to the virtual environment and made accessible to the user either directly via hotspots or through natural language queries to intelligent agents.

- The modeling phase involves three aspects of the design of the virtual environment: building precise and accurate 3D computer models of the palaces, their environs, furnishings and decorations; building precise and accurate 3D “Assyrian” characters to be used as avatars and intelligent agents to make visits to the virtual environments more informative and user-friendly; (back to world links) and defining and creating “nodes”—the hyperlinks and hotspots that connect the virtual world to the research knowledge base.

- The efficient navigation system for visiting and appreciating the virtual environment is being developed to make it more informative and user-friendly for interactive research, distance education, peer-to-peer communication, and public enjoyment. The navigation system will include virtual scaling, natural language parsing, speech recognition, voice activation of avatars and intelligent agents, artificial intelligence, and the building of a semantic network as a way to allow the users as avatars and intelligent agents to interact more naturally with the vast research databanks and educational tools.

7. Conclusion

The final goals of the project will ensure that scholars, students, and the general public will be able to use the virtual environment and its interface for their own work or enjoyment on a wide variety of display systems. We have developed a multi-level virtual environment, which runs on systems from PCs devices to high-end immersive environments, such the Immersadesk™ and a 6-Wall CAVE™. We are working on ideas to adapt it to hand held devices as well. The modeling process, information delivery concepts and user profiles vary for each level of the environment. While a fully immersive environment may be of great advantage to researchers, a PC-based system with auto-stereo may be appropriate for schools and colleges. Hand-held devices may be more appropriate for visits to a site museum or museum exhibition, incorporating sound and virtual contexts that would replace the passive audio systems currently in use. In this research we are investigating the various issues and creating configurations and requirements for multi-tier, intelligent, multi-user virtual reality systems in order to realize fully the potential architectural power of visiting and inhabiting the palace.

To help us we have assembled a research team that includes archaeologists, architects, educators, museum curators, engineers, and computer scientists from both academia and the private sector.

Virtual worlds are an effective means of coordinating and visualizing the disparate data sets of archaeological data—both two and three-dimensional virtual worlds are an effective means of disseminating raw and assimilated architectural and archaeological information. Virtual worlds are an efficient and extremely precise means of publishing archaeological data. Current technologies allow for the creation of natural language person-to-avatar and person-to-agent interrogation within complex and detailed historically accurate virtual environments. Our moving beyond traditional architectural representation techniques enhances our understanding of the palace architecture. Thus, the reconstructed model of this ancient site will be every bit as detailed and “real” as the modeling of an unrealized architectural design, and the inclusion of all facets of related research will be combined in a way that will create a superior educational and visualization tool.

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audiences but have not been ‘published traditionally.’ Some of the technological wording is the same as was published on the Website for the published proceedings of the Salve Regina University conference (Paley and Sanders 2001).

**References**


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