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Reconstructing traditional Inuit house forms using three-dimensional interactive computer modelling

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Virtual heritage environments provide researchers and the general public with a tool for exploring archaeological data in a dynamic and interactive fashion. This paper discusses recent attempts by the authors to construct a prototype three-dimensional interactive computer model of an Inuvialuit sod house based on archaeological, ethnohistoric and ethnographic data from the outer Mackenzie Delta area in Arctic Canada. Such computer models have the potential to provide significant insights into the design principles used in traditional Inuit architecture. They can also be integrated with three-dimensional scans of cultural artifacts and other recorded media to create an interactive virtual heritage environment. In addition to providing an armature for the collection of oral histories and traditional knowledge, these web-based virtual environments allow members of the general public to experience cultural sites in inaccessible areas like the Canadian Arctic. Virtual environments may also provide archaeologists with new insights into the role that human senses may have played in the design of small-scale dwellings. This paper will focus on how the computer model was constructed, and presents examples of how the model can be used both as a research and education tool.

INTRODUCTION

The objective of this paper is to outline recent efforts to construct a three-dimensional virtual reality model of a traditional Inuvialuit winter house, using archaeological, ethnographic and ethnohistoric data. The inspiration for this project stems, in part, from recent uses of virtual reality (VR) modelling in archaeology, and from reconstructions of Thule Inuit architecture by Robert McGhee at the M1 site, located near Resolute Bay on Cornwallis Island, Nunavut. The use of VR modelling in archaeology is presented as a collaborative process between the archaeologist and the computer modeller. While both parties can bring unique insights to the computer reconstruction process, archaeological and ethnohistoric data gaps and technological limitations create challenges that can affect the creation of a plausible reconstruction. In this paper, we discuss how the model was constructed and how we addressed various challenges that emerged during the project. In addition, we also examine potential uses of the model as a tool for both education and research.

WHY CONSTRUCT VIRTUAL REALITY MODELS OF TRADITIONAL INUIT ARCHITECTURE?

While virtual reality models are becoming increasingly commonplace in archaeology, the use of computer graphics to reconstruct prehistoric and historic architecture actually dates back to the early 1980s. Pioneering projects include John Woodwark's reconstruction of the temple precinct of Roman Bath for the BBC (British Broadcasting Corporation), the reconstruction of the Saxon Minster at Winchester (Colley et al. 1988: 99–106; Heywood et al. 1984: 61–70) and a computer reconstruction of Paris in 1789 (Collins 1993: 14). The accuracy and realism of these early models were constrained by limitations in computing power and software available at the time. Over the past several decades however, advances in computer graphics systems have enabled researchers to render prehistoric and historic architecture in increasingly realistic ways. In addition, buildings can now be placed into virtual environments that allow users to navigate through the structure and explore architectural details, the contents of rooms, and so on. Examples include Levy's recent reconstruction of the Temple site at Phimai, Thailand (2001).

As VR models increase in sophistication, archaeologists have begun to explore their potential as visualization tools for heritage conservation, education and research. A computer reconstruction of the Dresden

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Frauenkirche, destroyed by Allied bombing raids in 1945, provides an example of how VR models have been used to aid national heritage projects (Collins 1993). In addition, many online virtual archaeology sources now present educational VR 'tours' of such archaeological sites as Cerén, Copán and Chavin de Huántar. Peterson et al. (1995) have also used VR models to explore how lighting and architecture might affect the organization of activity areas within pithouse dwellings at the Keatley Creek site in British Columbia.

To date, however, most applications of VR modelling in archaeology have tended to focus primarily on the architecture of complex societies rather than small-scale societies such as hunter-gatherers. This is unfortunate because the types of building materials used to construct the dwellings of small-scale societies are often easier to model, and can therefore function as test cases for examining how the arrangement of architectural elements might reflect decision-making in the past. Furthermore, a great deal of ethnographic information on hunter-gatherer dwellings exists throughout the world, which, when combined with archaeological information, can result in a VR model that is a closer approximation of reality than one based on archaeological data alone. The fact that these types of structures can be modelled with a greater level of realism than larger, more complex ones suggests that we might be able to use them to examine human sensory experiences in the archaeological record. This unique approach examines the role played by sight and sound in mediating human–environment relationships. It is based on the premise that different cultural groups through time may have placed greater emphasis on certain senses than others. The acoustic properties of a particular setting, for example, may have been considered more important in determining the location of a site than its visual surroundings. Illustrations of this approach include research into the acoustic properties of underground ossuaries in Neolithic Malta (Devereaux and Jahn 1996) and prehistoric rock art sites in Australia, North America and Europe (Dayton 1992). Elsewhere, viewshed analysis in Geographic Information Systems (GIS) has been used to examine how the placement of Neolithic cultural features is influenced by what is seen as one moves across the undulating landscape of the area (Llobera 1996). Similarly, virtual environments may provide archaeologists with new insights into the role that human senses may have played in the design of small-scale structures. For example, they provide a means of simulating how the placement of natural and artificial light sources might affect one's perception of the dimensions of the interior space, or how light could be used strategically to draw attention to certain areas/spaces in a dwelling, while concealing others through shadow. This line of research may provide new insights into how humans use the built environment to manipulate social relationships through sensory perception. The application of such an approach using the Mackenzie Inuit VR house model is discussed later in this paper.

CRITICISMS OF VR MODELS IN ARCHAEOLOGY

While VR modelling has great potential in archaeology, it is important to acknowledge recent concerns regarding its usage. One of the major catalysts for VR modelling in archaeology has been the demand for interesting and exciting public presentation. This can dictate the look and content of the virtual experience and result in the addition of features that may be incongruous with the archaeological reconstruction. In such cases, virtual constructs may take on a life of their own, potentially misrepresenting the history and content of a site to future generations (Miller and Richards 1995; Purcell 1996). Archaeological data can also be distorted when models are divorced from their theoretical and methodological contexts (Miller and Richards 1995: 21). For example, how does the archaeologist draw the viewer's attention to the types of data that were used to create the model, and the data gaps that had to be overcome? This problem is of particular significance because the visual images generated by computer modellers are often so convincing and realistic that they convey authority where none might exist. Members of the general public accept the premise that computers make research more accurate and precise. Consequently, VR modelling in archaeology can create the impression that archaeologists know more about the past than they actually do. Though a justifiable concern, reconstruction based on incomplete data has been part of architectural interpretation since the Renaissance. As in the past, drawings and models were important vehicles for considering how the ancients built their monuments. Like the drawings of Roman ruins by Renaissance architects (e.g. Bramante, Serlio, Palladio and Vignola), virtual constructions can be used to kindle similar excitement and interest in archaeology among contemporary audiences. This makes them potentially powerful tools for soliciting public support for the preservation and investigation of archaeological sites. Regardless, methods need to be explored for indicating uncertainty, such as the hazy shading of architectural details, or hot linking areas of the model directly to data. By implementing such mechanisms, the line separating realism from conjecture is brought into sharper focus by the archaeologist.

A second concern with VR models is that the ability to display architectural detail is occasionally hindered by the limitations of real-time rendering. In these situations, the use of static images of the model is often preferable. This is less of a concern with small-scale structures, such as the one presented here, as the architectural elements used in their assembly generate a level of detail that is far easier to render than that associated with a contemporary Western European building. While specific aspects of any archaeological feature might be best represented in static images, VR modelling is still essential because it provides the archaeologist with an interactive space for conducting experiments on the possible arrangements of architectural elements. This is particularly difficult using two-dimensional drawings. For example, understanding the construction of a complex joint can be problematic from static images. Having the ability to rotate the object in real-time can add a level of understanding not possible with elevation, plan and section. Thus, false assumptions concerning the reconstruction of the site can be minimized. The combined use of static images and real-time models can result in new hypotheses that guide archaeological fieldwork in ways that would never have been possible otherwise.

THE CONSTRUCTION OF THE VR MODEL

For the purposes of our project, the *igluryuaq* or winter house of the Inuvialuit of the Western Canadian Arctic was selected as a VR case study for the use of virtual reconstruction for several reasons. First, the Inuvialuit built their houses out of sod, stone and driftwood, which were abundant materials along river banks and in coastal areas. Consequently, the shapes and textures of these building materials were relatively easy to model using computer graphics. Second, a critical component of all VR reconstruction efforts is availability of data, and a relatively rich database of information on traditional Inuvialuit life exists. Much of these data are derived from archaeological excavations, especially those sponsored by the Prince of Wales Northern Heritage Center and the Northern Oil and Gas Action Program (NOGAP), historic accounts by explorers such as Sir John Franklin, missionaries such as Emile Petitot (Savoie 1970) and various oral history projects (Hart 1994). From this information, it was possible to formulate a detailed idea of how a classic *igluryuaq* or Mackenzie Inuit winter house would have been constructed.

THE *IGLURYUAQ* OR MACKENZIE INUIT WINTER HOUSE

Until the early years of the 20th century, the Inuvialuit of the western Canadian Arctic spent the winter at places that were close to beluga hunting areas, or where other food was abundant (Friesen and Arnold 1995). At those locations they built winter dwellings from driftwood, which they covered with blocks of sod and earth for insulation (Arnold and Hart 1991: 199–200). This type of *iglu* is called an *igluryuaq* (plural = *igluyuaruit*). One entered an *igluryuaq* through a porch (called a *silaliq panga*) made of snow blocks, which led into a long tunnel (called a *tuqsuuq*) (Arnold and Hart 1991: 199–200). Inside the house, at the far end of the tunnel, there was a door (*katak*). The tunnel was lower than the floor of the dwelling, and because cold air is denser and heavier than warm air, it was ‘trapped’ inside the tunnel. The *igluryuaq* often had three rooms or platforms, one at the back and one on either side (Arnold and Hart 1991: 199–200). Each was enclosed on three sides and opened up into a central area. These platforms were raised above the level of the floor so that people could sit and sleep in the higher, warmer air. Oil burning lamps, called *qulliq*, were usually placed in front of each platform for light, heat and cooking. A window in the roof (called an *igalik*) provided additional light. The roof also had a vent (called a *qingaq*) to let out stale air. Archaeological evidence from western Arctic sites like Cache Point, Pond and Kuukpak indicate that small, one-roomed structures were gradually replaced by larger multi-family dwellings through time (Arnold and Hart 1991: 199–200).

BUILDING A VIRTUAL MODEL: THE SCIENCE AND ART OF COMPUTER VISUALIZATION USING THREE-DIMENSIONAL MODELLING AND VISUALIZATION TOOLS

The case study approach to archaeological modelling can provide insights into the computer reconstruction process. Ideally, computer reconstructions involve an iterative collaboration between the archaeologist and computer modeller. Both bring unique insights and understandings from the evidence and technology required in these reconstructions. For the archaeologist, arriving at a plausible solution based on the existing historical and archaeological record is key (Bocchi 1999; Davis 1997; Forte and Alberta 1997; Novistki 1998). For this task, an environment that can test alternative hypotheses is required (Miller and Richards 1995). Each stage in the design process can reveal new inconsistencies and possible solutions for re-constructing architecture of the past. For example, changing the size and proportions of a roof beam can have consequences throughout a structure, resulting in a completely new design construct. For the modeller, this process may include a series of design concepts, each accommodating a different interpretation of the archaeological evidence. An iterative design process that incorporates the archaeologist's knowledge of traditional construction techniques is necessary in order for computer models to help answer questions about the form of simple and complex architecture from the past.

This case study aims to offer guidance to those interested in computer reconstruction and visualization of architecture based on archaeological evidence. Technology should be considered a moving target; what was true a year ago will not be true a year from now. As such, any case study provides a benchmark in the evolution of technology applied to specific problems, in this example, to archaeological reconstruction and computer visualization. Discussion here focuses on the quality of the product that can be produced from computer models and the constraints on model size and detail. This paper also discusses issues in planning an archaeological reconstruction for various audiences and venues. Today, virtual representations of archaeological and historic buildings are of interest to the general public. Museum displays, tour operators, educational websites, video and CD-rom's take full advantage of virtual materials for public education and tourism (Boland and Johnson 1996; Hower and Parmley 1996; Purcell 1996). The Inuit sod house showcases how computer model output can be used for museum and public education programmes and research.

As mentioned previously, building a computer model of a small-scale structure such as an Inuit winter house has certain advantages over the construction of larger, more complex buildings. For example, a small structure can be built as in reality, piece by piece. For modelling larger architectural complexes, form must be reduced to simple primitives, as dictated by the rendering limitations of today's computer technology. The demand of rendering objects in real-time at 30 frames per second restricts the level of realism that can be achieved in these more complex models. For example, in VR and web environments, a wall is commonly modelled as a single rectangular prismoid rather than as a series of stone blocks. However, these problems are minimized in less complex architectural configurations which can be modelled at the detailed level of individual building elements. The Inuvialuit winter house model therefore fell well within the current limitations of real-time rendering in computer modelling.

THE COMPUTER RECONSTRUCTION OF A TRADITIONAL INUIT HOUSE

As part of the initial exploration, a detailed model was built from a plan for the Kuukpak site in the outer Mackenzie Delta area using 3D Studio VIZ, a popular computer application used in architectural modelling (Arnold and Hart 1992: 199–200). Scale drawings of the site provided the basic dimensions and locations of the main structural and architectural features including the major support posts, walls, sleeping platforms and entrance. Published drawings and accounts, including Franklin (1828) and Petitot (Hohn 1981), and various Inuvialuit oral histories (Hart 1994) provided information on possible configurations for the architectural form. From the beginning of the project, it was decided that elements would be unique objects, rather than modelled as a collection of objects. In the reconstruction of the Inuvialuit sod house, the exploration of possible design alternatives resulted in a series of models detailed to the level of individual elements. Then, the completed models created in 3D Studio VIZ were loaded individually into a VR environment (WorldUp, Sense8), allowing the geometric details of assembly to be explored from any angle. To understand the value of this approach, the design history of two reconstruction details are presented: (1) the placement of the pony walls; and (2) the entrance to the structure.

The first version of the model was largely centred on a 1990s' physical reconstruction based on ethnographic data (Figure 1, left). In this reconstruction the side-walls appear distinctly separate from the roof structure over each sleeping platform. A comparison of this first model with historic drawings and photographs posed some interesting contradictions. Rather than a back

FIGURE 1. Left: first version of the computer reconstruction. Right: final reconstruction.

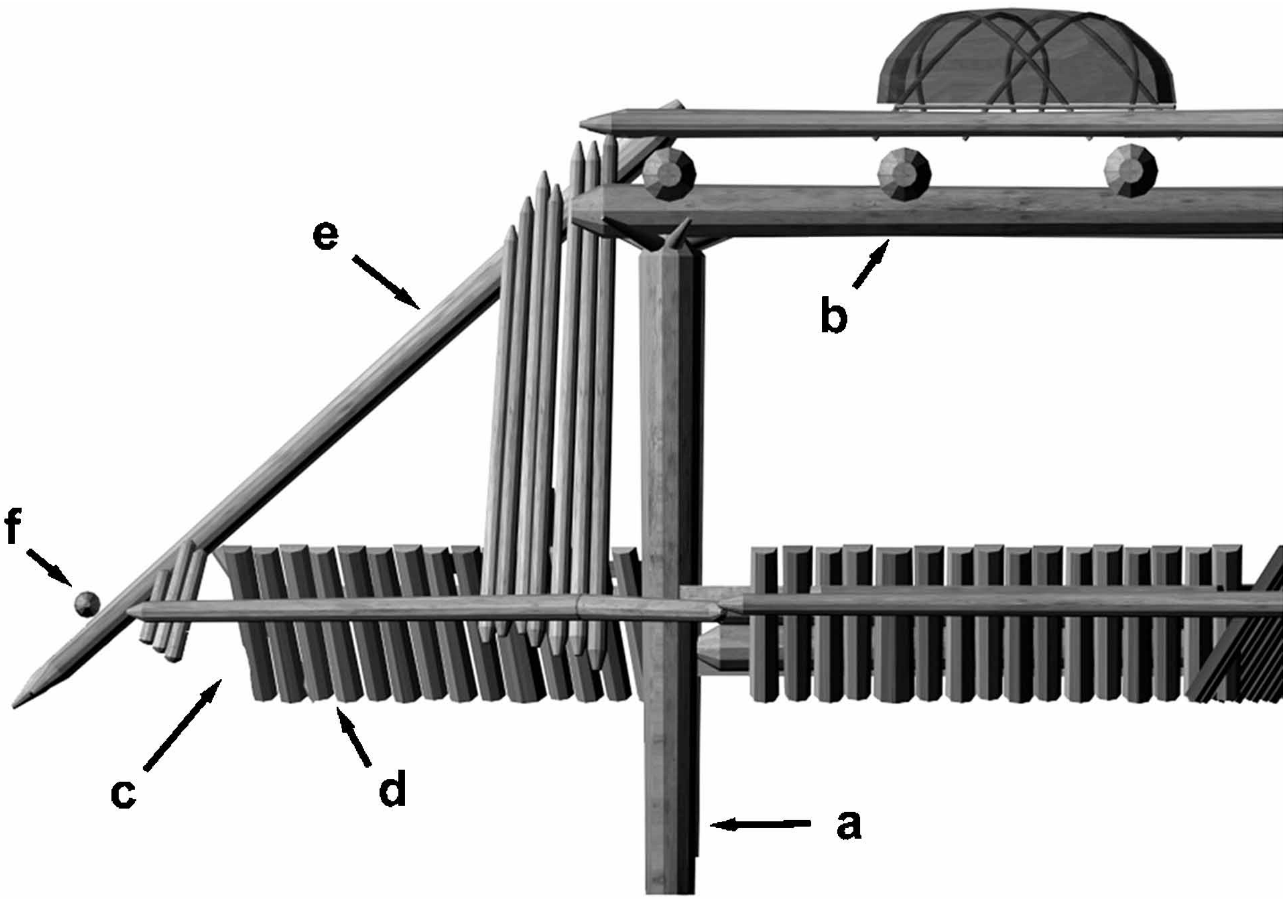

FIGURE 2. Section, final computer reconstruction: a, main supporting post; b, roof beam; c, pit; d, pony wall; e, log (abutment support); f, lean-to roof.

FIGURE 3. Post and beam construction, computer reconstruction.

wall, a short pony wall appears in the account by Franklin (Franklin 1828). In Emile Petitot's drawing (Hohn 1981: 40), wall logs were placed in a fan-like pattern at the rear of the sleeping platform. Also, the existence of a trench at the Pond Site excavation, Cache Point and Kuukpak (Arnold and Hart 1992: 199–200) is suggestive of a lean-to structure over each sleeping platform instead of a framed structure. In the second model (Figure 1, right), the elements of support posts and beams, pony wall and roof worked together, establishing a simple but effective structural system (Figures 2 and 3). In this latter reconstruction, the main structural supports and beams would have formed the major supports for the centre roof of the structure. A series of sloping trenches would have formed the perimeter of the structure. Logs placed close together would form the basis of a pony wall providing support for the roof structure by leaning against the main support beam at ground level (Figure 2). Thus, the pony wall served two purposes. First, it enclosed the perimeter of the interior space for each of the sleeping platforms. Second, because it is buried deep into the ground, a foundation is provided for the roof structure, which provides resistance to possible settlement of the roof from sod and snow loads. A log placed against the roof at the base ensured that the ground point of the roof beams would be stable and immovable (Figure 2). In addition to having greater stability over the first reconstruction model, the pony wall configuration could be constructed without the use of lashing or pegs. In addition, this solution could be built easily without the need for notching or shaping the ends of beams, purlins and roof supports; a more simplified construction process than required for the alternative model.

The virtual modelling approach also helped to establish a plausible solution to the architectural form of the entrance into the structure (Figure 1, right). The entrance is composed of a porch (a *silaliq panga*), a long tunnel (*tuqsuuq*) and a hatch-like structure (*katak*) that provide an air lock against cold air. In the first attempt at a computer model of the entrance structure, a change in elevation of approximately 3 feet from entrance to the main platform required a sharply sloping ramp into the *tuqsuuq*. Archaeological data and photographs from the last century revealed that many of the Inuit sod houses were often built into hills or sloping terrain. Experimentation with the computer model revealed that if the sod house was placed into a hill with a modest slope of 7%, the entrance structure could be built without a series of steps or ramps (Figure 1, right).

CREATING A GRAMMAR

Ultimately, by experimenting with the computer model, a set of architectural rules or a grammar was established that could be useful in the reconstruction of other archaeological sites. These rules are based on a set of assumptions. For example, to simplify the process of building a post and beam structure, logs with root structures are placed in an inverted position in a post hole (Figures 2 and 3). This technique of assembly minimizes the need for intricate joinery technology, while reducing the need for large oversized post holes. A future research project that makes use of such grammar is the creation of a virtual environment that gives users an opportunity to build an Inuit sod house from given elements. With a kit of parts and a set of principles the user will be guided by rules towards their own reconstruction of an actual archaeological site. A simplified structural analysis of the form would then be used to test the success of the design in supporting dead loads on the structure, such as sod and snow (Figure 4).

USING THE VIRTUAL MODEL AS A TEACHING AND RESEARCH TOOL

One of the challenges in this project was the need to produce a variety of media useful in both research and teaching. Ultimately, images, QTVR, animations and interactive environments of the Inuvialuit sod house would be needed for web-based instruction. The Prince of Wales Northern Heritage Center and the Inuvialuit Cultural Resource Center are currently developing a

FIGURE 4. Computer reconstruction: frame (left), view with sod (middle), view with snow (right).

web-based learning programme on Inuvialuit culture and history, to be titled *Journey with Nuligak*. This learning programme forms one of the modules of a larger project called 'Lessons from the Land'. The goal of this project is to make the Prince of Wales Northern Heritage Center's museum and archives collections, as well as related cultural and heritage information from other sources, available to schools and communities throughout the Canadian Arctic. One component of the *Journey with Nuligak* programme will feature the VR model of the Inuvialuit sod house, or *igluryuaq*. Using Virtools, a developer's application for creating web-based interactive environments, students will be able to navigate around the exterior and interior of the house where they will view and manipulate virtual copies of actual artifacts recovered from archaeological sites in the Mackenzie Delta region. To create these virtual objects, a three-dimensional laser scanner was used at the University of Calgary to capture surface data that were then transformed into digital versions of the artifacts, accurate to a fraction of a millimetre. Taking this approach to presentation ensures that visitors to the website will experience a plausible reconstruction of what life would have been like in the outer Mackenzie Delta in the past.

Virtools was selected for this project because of its high-quality rendering capability. Virtools with dynamic lighting stencil mapped shadows, fog and texture mapping, can be used to create visually engaging environments. In addition, a 'drop and drag' set of behaviours gives the developers a tool for prototyping VR environments. By interacting with the model, students will learn how sod houses were built, how they were heated and illuminated, and what types of activities occurred within them. This, in turn, may encourage younger Inuvialuit learners to ask elders about traditional dwellings, as well as encourage older learners to do additional research to learn more about traditional forms of dwellings. In building this virtual environment, a simplified version of computer reconstruction was used to permit real-time rendering on a home computer. A more elaborate version will also be available from an FTP Internet site to teachers and museums for research, instruction and teaching.

MODELLING SENSORY EXPERIENCES IN VIRTUAL REALITY

Virtual reconstructions also have real value as research tools because they provide new methods for visualizing archaeological data. In archaeology, two-dimensional graphics systems such as GIS have been used extensively as a means of visually representing the relationships between data and interior/exterior surfaces. VR models allow one to explore these relationships within a three-dimensional environment, where light paths and architectural attributes such as ceiling heights might affect the location of specific types of activities, as well as mediate other forms of human–environment relationships.

Contemporary architects often strategically distribute light sources within buildings as a means of supporting the behavioural needs of individuals (Manav and Yener 1998; Veitch 2001). Different lighting arrangements can affect such things as task performance, as well as impressions of spaciousness, relaxation, privacy, pleasantness and order (Manav and Yener 1998: 45). Robert Baron (1990) has even suggested that appropriate lighting conditions can contribute to social and psychological well-being by reducing interpersonal conflict and promoting greater willingness to help others. This is known as Affect Theory (Veitch 2001: 126). In one study completed by Manav and Yener (1998), human subjects were asked to rate how different lighting arrangements affected their perception of an interior space. Results indicated that feelings of privacy, relaxation and interior spaciousness were enhanced through the use of wall-washing, in which the walls of the space are illuminated, and uplighting, in

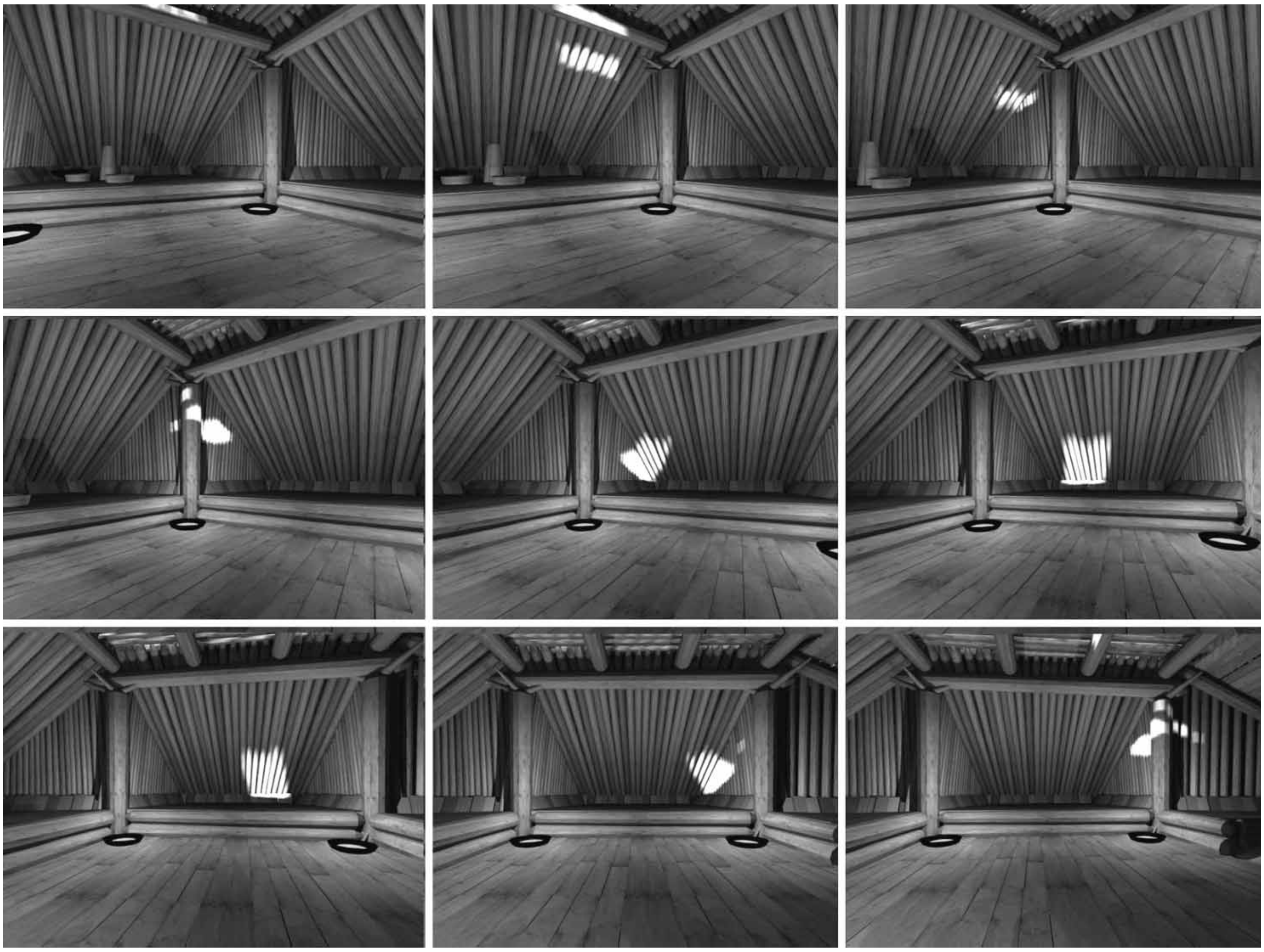

FIGURE 5. Path of the sun on 1 September. Top: 10:00, 11:00, 12:00. Middle: 13:00, 14:00, 15:00. Bottom: 16:00, 17:00. 18:00.

FIGURE 6. Lighting study. Right: single light source bottom centre. Middle: single light source from roof opening. Left: two light sources (lamps located on the left and right of the back sleeping platform).

which light sources are placed low and in the corners of the interior space (Manav and Yener 1999: 43–47).

The interiors of Inuvialuit winter houses were lit by both natural and artificial light sources (Hohn 1981: 36–37). Daylight was emitted into the dwelling through a small window located in the roof of the structure which would have been capped using a semi-translucent cover made of either ice or oiled membrane (Hohn 1981: 36–37). Artificial light was provided by three oil lamps placed beside the sleeping platforms, and secondarily from an open wood fire located near the entrance tunnel (Hohn 1981: 37). Using 3D Studio VIZ, we were able to simulate the daily movement of light across the walls and floor of the structure to assess the relative importance of natural and artificial light in illuminating the interior. Light paths were modelled for the month of September, the earliest time during which these structures would have been inhabited, for a period from 8:00 a.m. to 6:00 p.m. (Figure 5). After running the simulation, it was apparent that the movement of the light path was entirely restricted to the walls of the dwelling. At no time did the light path move across the floor of the house. Similar modelling of light paths in the Keatley Creek pithouse model has revealed that activities requiring visual acuity such as biface retouching occurred more frequently in areas lit by the midday sun (Peterson et al. 1995: 33). Our simulation suggests that natural light in Inuvialuit sod houses would not have played as critical a role mediating the location of activities requiring visual acuity such as sewing and carving. This would have made the choice and placement of artificial light sources much more critical in these dwellings. While open fires were used inside Inuvialuit houses, they were likely used primarily for cooking and only secondarily as sources of illumination. Instead, it would seem as though sea mammal oil lamps were used principally for this purpose. Rather than suspending these lamps centrally from the roof, or placing them in the middle of the floor, archaeological and ethnohistoric evidence indicates that they were placed adjacent to the outer edges of sleeping platforms, low and off to the side.

When these three lighting arrangements – central suspension, middle of floor, to the side – were simulated using 3D Studio VIZ, results indicated that the lighting pattern used by the Inuvialuit produced illumination characteristics consistent with both wall-washing and uplighting (Figure 6). The positioning of sea mammal oil lamps illuminated the surfaces of walls, platforms and floors in a manner that made the interior space appear larger than did the other two lighting arrangements. These observations match those obtained by Manav and Yener (1998: 43–47) in which wall-washing and uplighting created the perception among human subjects that spaces were larger, more relaxing, more private and more pleasing to use. While it is important to acknowledge that different cultural backgrounds can affect emotional or aesthetic responses to lighting systems (Manav and Yesner 1999: 43), these results are nevertheless intriguing because they suggest that sea mammal oil lamps may have been consciously and strategically placed to generate these responses. Given that Mackenzie Inuit winter houses were occupied by three families for protracted periods of the year when daylight was minimal, it is interesting to speculate that Inuvialuit would have been conscious of the effect that lighting arrangements might have had in promoting emotional and psychological well-being. We plan to further explore these 'sensual' aspects of Inuit architecture using three-dimensional virtual models in combination with lighting design and rendering software such as Lightscape and 3D Studio VIZ.

CONCLUSIONS

In conclusion, we have demonstrated that constructing virtual reality models of the structures used by small-scale societies such as Arctic hunter-gatherers can provide a great deal of information that can be used in both research and public archaeology. Access to archaeological, ethnohistoric and ethnographic information provides a rich database of architectural information for the archaeologist and computer modeller to use. Furthermore, the use of raw materials that are easily modelled, coupled with the relatively simple configurations of architectural elements that make up these structures, means that a greater level of realism can be attained through both static images and real-time rendering. These models can serve as valuable visualization tools for both education and research. In particular, the application of virtual environments provides a useful device where both the modeller and the archaeologist can discuss possible design scenarios.

The process of constructing the virtual Inuvialuit winter house reveals a grammar of architectural decision-making that likely reflects attempts to reconcile the spatial requirements of the family with environmental factors that might limit access to building materials such as driftwood. Unlike a set of two-dimensional drawings, the ability to manipulate individual elements in a three-dimensional virtual space provides the researcher with a laboratory for testing possible design scenarios. For example, we were able to assess the relative contributions of natural versus artificial light in illuminating the Mackenzie Inuit winter house, as well as explore the possibility that light was strategically used in these dwellings to alter the occupants' perceptions of the interior space. In addition, the ability to visualize a dwelling in three dimensions provides researchers with new possibilities for contextualizing architectural data in new and exciting ways. Archaeologists can begin to explore how sensual phenomenon such as lighting may have been used to mediate human–environment relationships within a virtual world. The use of VR modelling also benefits students and the public because it offers web visitors interactive materials for exploring cultural sites in inaccessible areas like the Canadian Arctic.

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