INTERPRETING ARCHITECTURAL SPACE THROUGH CAMERA MOVEMENT

Abstract. This paper examines how camera movement interprets architectural space and describes a navigation system that is designed to facilitate real time path planning and control of camera movement. The navigation system also allows people to save and retrieve walkthrough paths and thus enables different interpretations of the space by different observers to coexist in the same space. With case studies, we demonstrate that whether a space appears intelligible or unintelligible may be manipulated in the way how the space is interpreted through camera movement.

1. Introduction

In studying architectural space, walking through the space inherits a tremendous difference from looking at a model of the space. In the former case, space embodies experience, while, in the latter case, space becomes an object to be looked at from outside. Moreover, experiences within a space vary widely depending on how the space is walked through or looked at, although certain obvious attributes of the space remain. For example, the Barcelona Pavilion by Mies van der Rohe would appear to be composed of linear wall elements no matter how the space is perceived. However, whether the space appears confusing or not depends on how the space is experienced. The experience of space is similar to the performance of a music score. While the score determines the structure and components of a piece of music how the music is played would lead to different versions of musical interpretations, some of which can be extremely unlike in terms of how the music sounds. Same in the spatial interpretation of architectural space, although certain elements are so strong that they almost lead to identical experience, some are much dependent on how the space is walked through and looked at. The same space may have various, if not opposite, renditions. We call this phenomenon spatial interpretation through camera movement.

Experiments have been done in using digital models with virtual cameras and recording the walkthrough into video clips to study the spaces, e.g. a John Hejduk's un-built project, the Diamond Museum (Author's reference omitted for anonymity). In that experiment, individual walkthrough animations were made in order to use camera movement as a tool to test architectural concepts in space. Hejduk's original argument of how the diamond space becomes flat was examined. The method of using camera movement to test architectural ideas was convincing.

To further explore the research of interpreting architectural space through camera movement, an architecture-specific navigation system is desired. Ideally, it would allow interactive walkthrough in a space for richer experiences than that obtained through video, and more importantly, enable different interpretations of the space by different observers to coexist in the same space. Our recently developed architecture specific navigation system is used for this further exploration of interpreting architectural spaces. The system has the following features that facilitate the exploration. It integrates a perspective view and a map view. In the perspective view, route knowledge enables navigation from point to point using landmarks, and is based on an egocentric reference frame. In the map view, survey knowledge enables interactive and efficient planning of journeys, and is based on an exocentric reference frame. The observers' paths with related information, including coordinates and viewing directions, can be saved in real-time over a network and can be loaded and replayed later by other observers. That way, observers can experience the same walkthrough made by any other observer, e.g. the space's designer who wants to present the design through his/her preferred paths. This enables different interpretations of the space by different observers to coexist in the same space.

With the help of the new system, a series of experiments are conducted. Barcelona Pavilion, which is commonly regarded intelligible space, is compared to the Diamond Museum, which is commonly regarded unintelligible space. By manipulating the camera angles and paths, the space of Barcelona Pavilion appears unintelligible while the Diamond Museum appears intelligible. We pushed the study of the interpretation of architectural space to an extreme that a space may appear the opposite to its objective architectural characters. In the paper, we describe the implementation of the navigation system and demonstrate its application in examining and proving the subjectivity of spatial cognition. The results of this research can be applied to design studio teaching for analyzing and interpreting designed spaces through camera movement, which utilizes an architecture specific navigation system.

2. Camera Movement in Architectural Space

A camera is a spatial device that interprets the embodiment of space. It not only indicates a hypothetical observer's position within the space but also implies how the observer looks at the space. Therefore, a camera is more than a viewing instrument. It is an extension of the observer's body and hence an experiential instrument. To set up a camera is to unavoidably give answers to the many questions related to the observer's body in space. Is he/she moving fast? Is he/she taking swinging steps? How close is he/she to the boundary of space? Is he/she taking the center of the space or almost touching the walls? In other words, technical parameters of a camera bear variables as to a observer's embodiment of space.

The spatial experience documented by a camera is personal by definition. Subjectivity comes in play whenever there is a choice of camera movement although some personal experience may appear more objective than others. For example, a continuous shot at eye level may look more objective than a continuous shot of a worm's eye view. A continuous shot in which the camera keeps on the same level and in the same direction may appear more objective than a shot with camera rotations. However, no matter how objective the shot may look the route of the camera is a complete subjective choice. Therefore, to examine a space, one has to determine a route first.

2.1 ROUTE

A space embeds certain attributes, some of which can be quantified while some can only be qualified. Taking a route in a space is in fact crossing areas with various attributes. A route not only implies which areas are shown and which are not, or the sequence in which individual areas of a space appear but also, more importantly, implies if certain spatial attributes are shown, if so, in what way.

2.2 CAMERA ANGLE

At each point of the route, a camera may take various shots with different settings, such as distance, focal length of lens, camera height, camera pan and zoom. These settings compose a camera angle. These technical factors indicate experiential aspects of space.

2.2.1 Distance and Focal Length of lens

The distance of seeing is how far a camera is to the subject, which determines if the texture or the structure of the subject will be perceived. Looking closely at the subject tends to foreground its texture, an extremely local attribute of space. Looking from a distance at the subject, the relationship among parts of the subject becomes obvious. A wide focal length of lens may compromise the local view resulted in a close distance. By using a wide angle focal length, the camera view is no longer about the texture of an object but about how one object is related to another.

2.2.2 Camera Height and Subject Angle

Camera heights differ dramatically how space appears in a photo or a movie. Normally, an eye-level shot is less dynamic than other camera heights, such as a high angle, a low angle, or tilted "Dutch" angles, and thus less interesting in terms of the composition of each individual image. However an eye-level shot is the closest to a normal view of a observer in space among all camera heights. A high angle or a low angle shot limits what can be seen through the camera while tilted "Dutch" angles aggressively challenge the normal orientation of gravity.

Besides camera height, subject angle also plays an important role in depicting a space. Subject angle determines the appearance of flatness or depth of a space. Whenever an object presents only a single surface to the camera it appears to be flat. When the object presents two or more surfaces to the camera its depth becomes apparent.

2.2.3 A Pan or Dolly Shot

A pan or dolly shot happens when a camera itself rotates. If a camera revolves along horizontal or vertical axes, which is to follow the orientation system defined by gravity, the pan or dolly shots help extend the limited view of a still shot. For example, by using a horizontal pan shot, the camera may provide a wider view of space. The observer may see not only what in front of him/her but also what behind him/her so that an overall understanding of the space starts to form in the observer's mind. In real life, a pan or dolly shot is to look around.

2.2.4 A Zoom Shot

A zoom shot depicts space across distance. For example, when zooming in, the camera captures an overall view first and gradually changes to a close-up view. The camera or the hypothetical observer from the camera does not travel across the space to achieve the change of views. What has been changed in the zooming process is the subject that the camera depicts. Therefore, the indication of a zoom shot is the change of focus of the observer.

2.3 DURATION AND TRAVEL SPEED

Along the route, a camera may travel in various speed and duration. The appearance of space may be different in a time dimension. They indicate how long the observer stares in the same direction, how frequently the observer changes views, how fast the observer relocate him/herself in space. Whether a space appears intelligible or not may be resulted in by whether enough time is given for the spectator to capture and understand the visual information through camera.

3. Our Navigation and Camera Control System

For the purpose of interpreting architectural space through camera movement, we examined the current available tools and found the problems of current camera control and navigation systems, such as: (1) Difficulty in path finding makes users often get lost because of the nature of complex environments and the lack of cues for path finding. (2) Excessive freedom of movement makes users difficult to have natural paths as in the real world, e.g. users often bump into walls or make unnatural sharp turns. (3) Designers or users of virtual spaces often have preferred paths for others to visit in order to present their design or interests, but they have no control of where others will go, unless the paths can be stored and retrieved in real time.

3.1 PREVIOUS WORK AND OUR SOLUTION

Previous research work has addressed some of these issues separately, e.g. adding global maps in addition to local views (Elvins, et al, 1998; Fukatsu, et al, 1998) or adding various landmarks (Darken, et al, 1996; Vinson, 1999) to help path finding; using the "river analogy" (Galyean, 1995) or "StyleCam" (Burtnyk, et al, 2002) to guide users and enable users to deviate from the guided paths. However, each of these methods alone cannot provide a satisfactory solution, e.g. adding maps or landmarks cannot solve the natural path and the guided tour problems; the "river analogy" or "StyleCam" does not provide map knowledge thus users are still lacking context for path finding and lacking capability for path planning. Also, none of them addresses the problems of real-time path saving and retrieving.

Our solution of a navigation system addresses the above problems comprehensively. It includes the following aspects.

1. It integrates a perspective view and an interactive map. In the perspective view, Route Knowledge (Edward and Hand, 1997) enables navigation from point to point using landmarks, and is based on an egocentric reference frame. In the map, Survey Knowledge (Edward and Hand, 1997) enables efficient planning of journeys, and is based on an exocentric reference frame.

2. Employing a 2D map, our system enables users to draw paths and improves path planning in a Web-based environment. In addition, the system can generate natural paths with a curve-fitting algorithm. It also can indicate users' position and orientation on the map.

3. Path control is merged into users' interactive walkthrough seamlessly and intuitively. Users take a walkthrough by following the pre-defined paths and by simultaneously and interactively controlling their orientation in a control panel. The walkthrough is partially guided by the pre-defined paths and partially controlled by users' real-time input. This integrates and balances freedom and control in walkthrough.

4. Further more, the paths with related information, including coordinates and orientations, can be saved in real-time over a network by a user and can be loaded and replayed later by other users. That way, users can experience the same walkthrough made by any other user, e.g. the space's designer who wants to present the design through his/her preferred paths.

3.2 USER INTERFACE OF OUR SYSTEM

Our system consists of a 3D perspective view that allows users to walk through, a 2D map view that enables users to draw paths and see their locations and directions, and a control panel that allows users to control their camera parameters, e.g. turning left, right, up or down, increasing or decreasing the field of view (FOV), and increasing or decreasing travel speed, during the journey in real time. The system is implemented through embedding VRML and Java in a web page. A user can first set up the height of the camera in the web page and load a VRML 3D model and its 2D rendering of the top view for creating the user interface of the navigation system. The navigation interface consists of a VRML browser for the perspective view and a Java applet for both the map and the control panel. The communication between VRML and Java is achieved through EAI (External Authoring Interface). The viewpoint in the perspective view is controlled by a path planned in the map view. The control panel controls the camera parameters and results in view change in the perspective view and camera location and orientation changes in the map view. Paths with related information, e.g. coordinates, can be saved by a user and can be loaded and replayed later by other users (Figure 1).

For path planning, the map enables users to click and create control points of a path. We applied B-Spline algorithm to curve-fit the initial paths (polylines) using a user’s input as control points. In addition to creating paths, the user can also load pre-recorded paths. Once a path has been created or loaded, the user can start the walkthrough. During walkthrough the user can use the control panel to change the viewing direction, the field of view, and the travel speed while following the path.

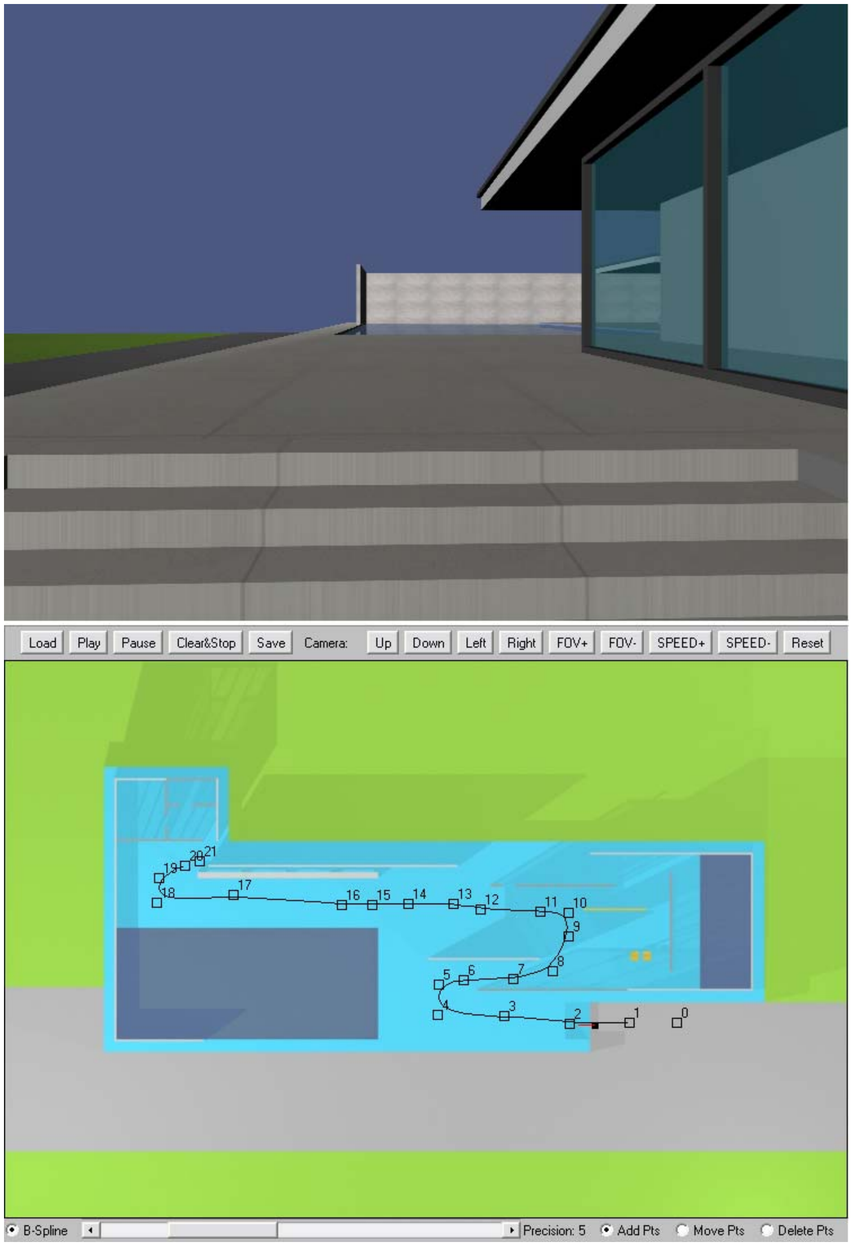


Figure 1. User interface of the navigation system. Top: perspective view; Middle: control panel; Bottom: 2D map with paths and the indicator of the camera location and orientation (Sample VRML source model of the Barcelona Pavilion: Emdanat 1999)

4. Experiments: Exchanging Roles between the Barcelona Pavilion and the Diamond Museum

A series of experiments are conducted to test both our navigation system and our hypothesis: camera movement can interpret space in a subjective manner. We choose the Diamond Museum by John Hejduk (Hejduk, 1985) and the Barcelona Pavilion by Mies van der Rohe (Sola-Morales, 1993) as two samples for comparison.

Although both being modern architecture with free-standing walls, the space of the Diamond Museum and the space of the Barcelona Pavilion appear to be different in terms of intelligibility. However, through manipulation of camera movement the intelligible may become unintelligible and vice versa.

4.1 AT THE CENTER

It is widely accepted that because of the open plan the space of the Barcelona Pavilion is clear (intelligible) rather than confusing (unintelligible). As opposed to the Barcelona Pavilion, the Diamond Museum is much bigger in scale. In addition, the partition walls at the center of the Diamond Museum are curvilinear, which forms a confusing core of the space.

Two identical pan shots at the eye-level with 45 degree FOV are set at the centers of both buildings. On one hand, having much less partitioning elements, Barcelona Pavilion appears to be the interplay among solid surfaces, transparent surfaces as well as gaps between them (Figure 2, first row). The straight edges of the surfaces perfectly match the observer’s expectation. A coordinate system is easily formed in the observer’s mind. On the other hand, at the center of the Diamond Museum, one is surrounded by curved walls so that his/her orientation is completely lost. Therefore, by the first comparison, the space of the Barcelona Pavilion is more intelligible than that of the Diamond Museum. (Figure 3)

Turning the camera downwards, the space of the Barcelona Pavilion becomes confusing. Only the floor surface and a small part of the vertical surfaces are captured in the camera. Comparing this shot and the original shot at the center of the Diamond Museum, it is hard to conclude which space is clearer to understand than the other. The more limited the view is the more confusing the interpretation of the space is (Figure 2, second row).

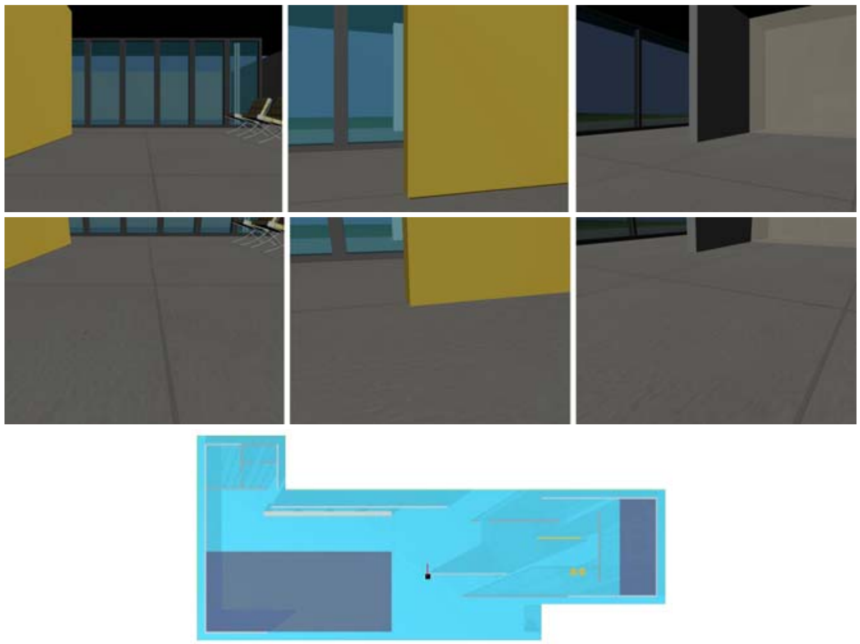
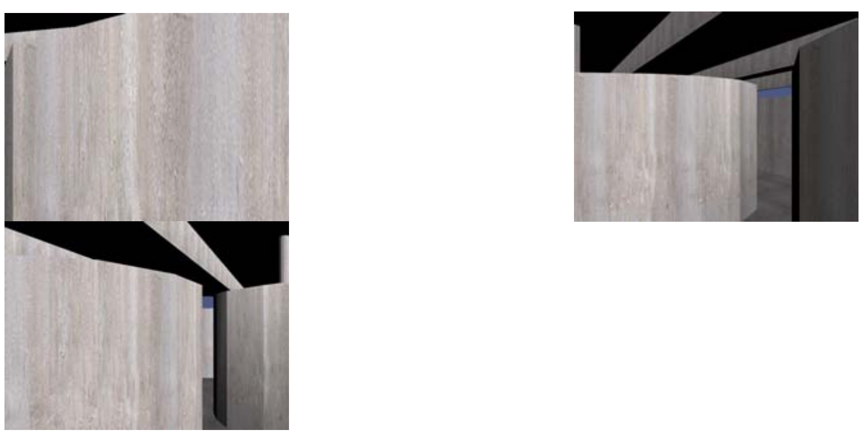


Figure 2. Center views of the Barcelona Pavilion. First and second rows: screenshots of the perspective views; Third row: map view.



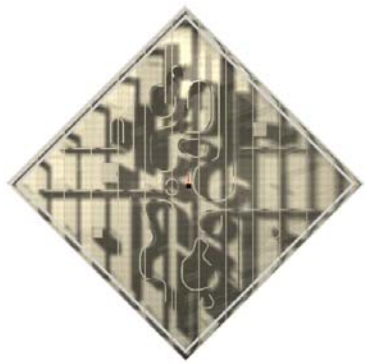


Figure 3. Center views of the Diamond Museum. First row: screenshots of the perspective views; Second row: map view.

4.2 ON THE PERIPHERY

Interestingly, the shot at the periphery of the Diamond Museum seems to be more intelligible than that at the periphery of the Barcelona Pavilion. Along the periphery of the Diamond Museum, the observer is set in a logical system with straight lines that are clear and definite on one side of his/her body while a complex with straight and curvilinear elements on the other. This situation is consistent throughout the route on the diamond shaped periphery (Figure 4). In the case of the Barcelona Pavilion, an eye-level shot is taken along the accessible edge of the building. The direction of the camera is always forward with 45 degree FOV. Throughout the path, there is not much visual consistency. In other words, the observer cannot predict what to be seen through the camera (Figure 5, first row). The space of the periphery of the Diamond Museum appears more intelligible than that of the Barcelona Pavilion.

The appearance of the Barcelona Pavilion can be changed through one single camera setup. We turn the target of the camera towards the wall at the center of the space and take the same route again. The wall becomes the consistent reference of the space. The local visual changes in the space are related to the unchanging visual element, the wall, and thus can be understood in relation to the wall. The space becomes easier to comprehend (Figure 5, second row).

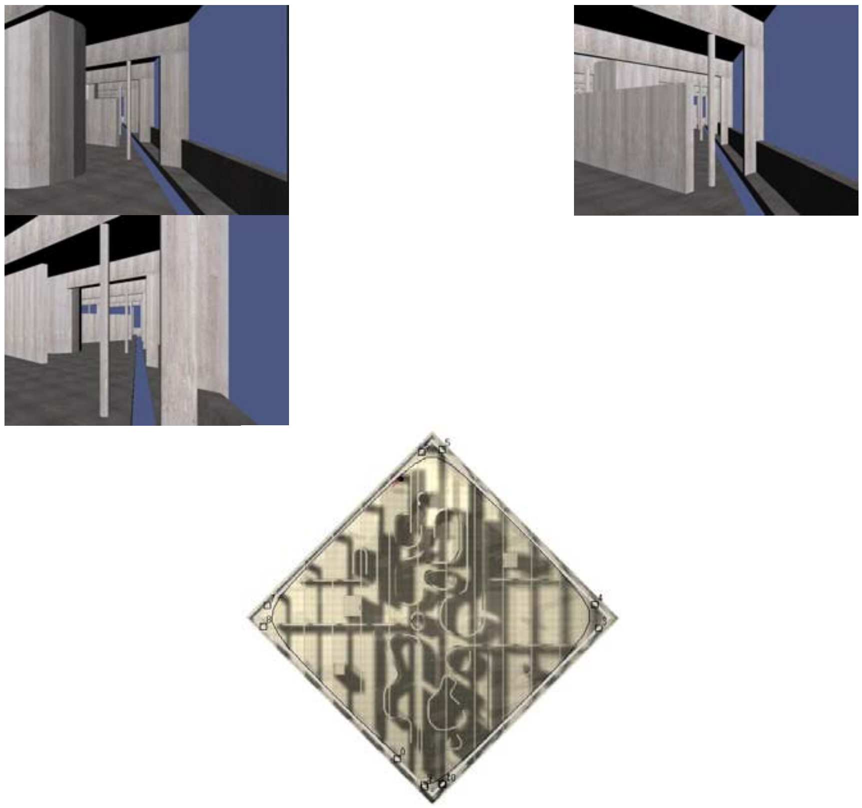
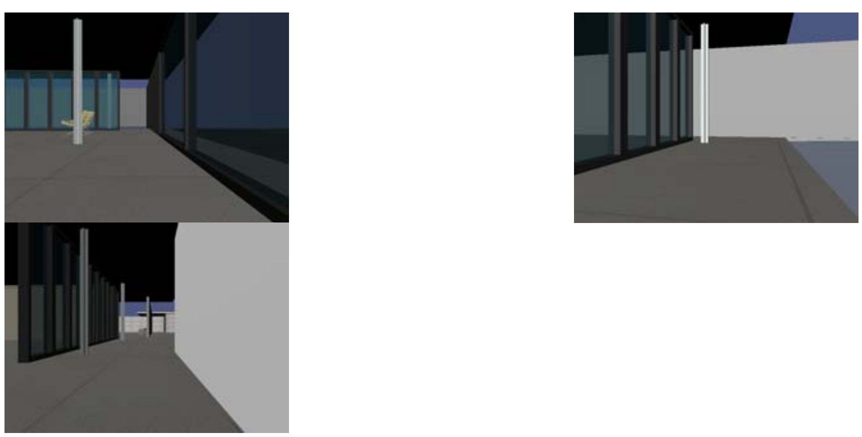


Figure 4. Views at the periphery of the Diamond Museum. Top: Perspective views. Bottom: Route in map view.



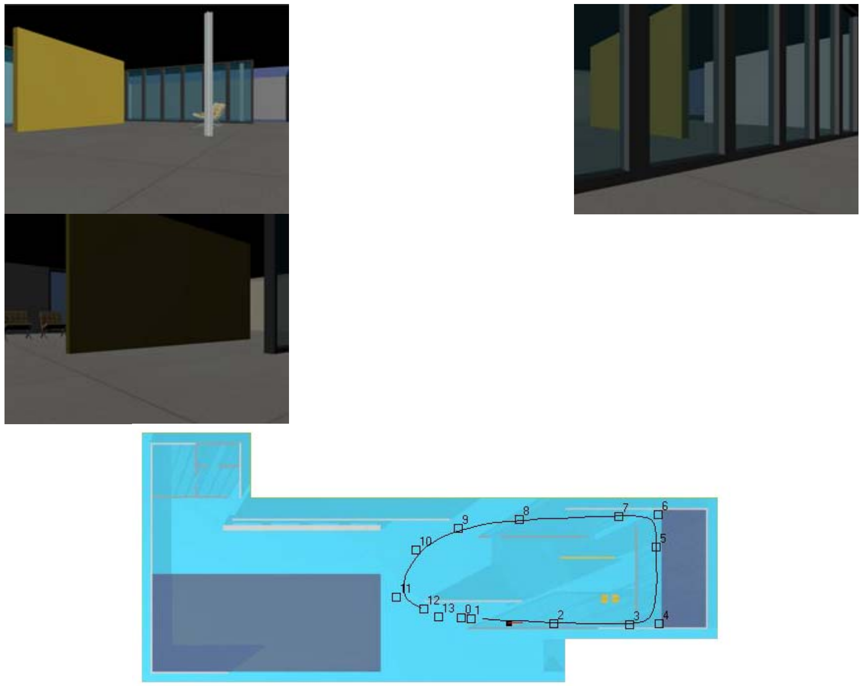


Figure 5. Views at the periphery of the Barcelona Pavilion. First Row: Camera shooting forward; Second Row: Camera shooting the consistent reference of the wall; Bottom: Route in map view.

4.3 CROSSING THE SPACE

Two routes across the space are set both in the Diamond Museum and the Barcelona Pavilion. In the Diamond Museum, the camera is set at eye-level horizontally targeting forward. Moving along the path, the observer is always surrounded by curved walls, except near the ends of the path. These walls force the view to meander around rather than shooting in a consistent direction. The frequent curved turns cause the observer to lose his/her orientation (Figure 6, first row). In the Barcelona Pavilion, similar situation occurs although there are no curved walls. Both spaces appear confusing (Figure 7, first row).

However, in the Diamond Museum, by tilting the camera upwards the space immediately becomes intelligible. Through the camera, the observer sees a consistent system of beams overhead, a way of suggesting the direction towards the other end of the diagonal. Near the end of the path, a straight wall appears, pointing along the direction of the beam system, which confirms the expected orientation (Figure 6, second row). In the Barcelona

Pavilion, tilting up the camera does not improve the intelligibility of the space at all in that there is no consistent reference on the ceiling (Figure 7, second row). The supposed intelligible space of the Barcelona Pavilion changes its role with the supposed unintelligible space of the Diamond Museum.

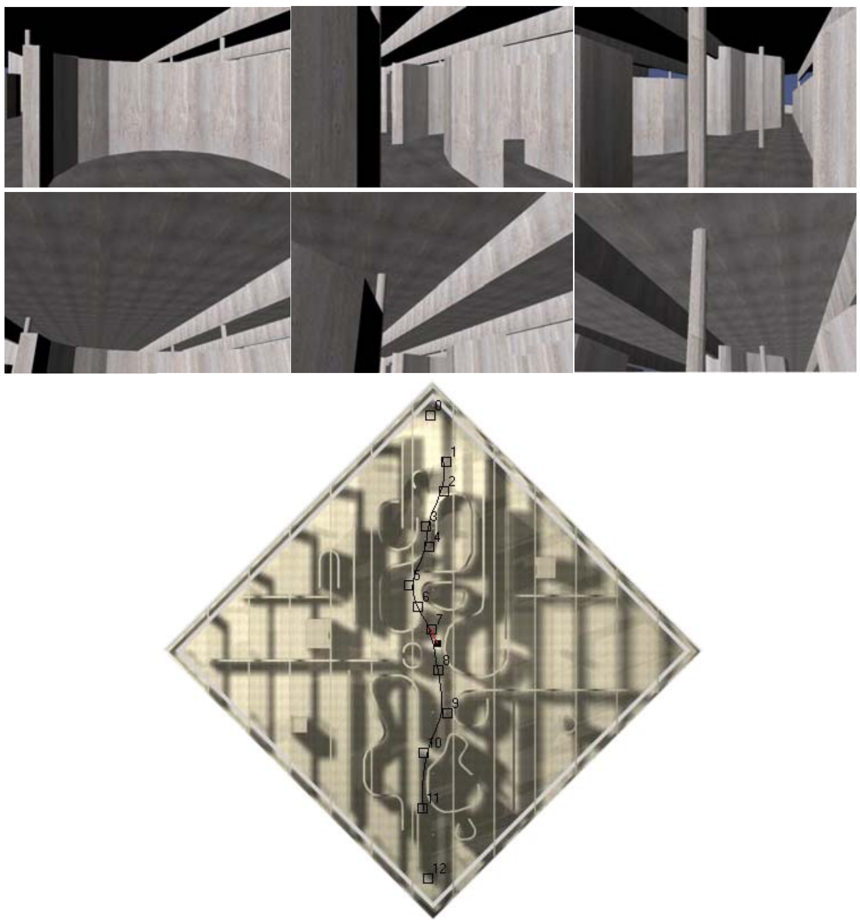


Figure 6. Views across the Diamond Museum. First Row: Camera shooting forward; Second Row: Camera shooting upward; Bottom: Route in map view.

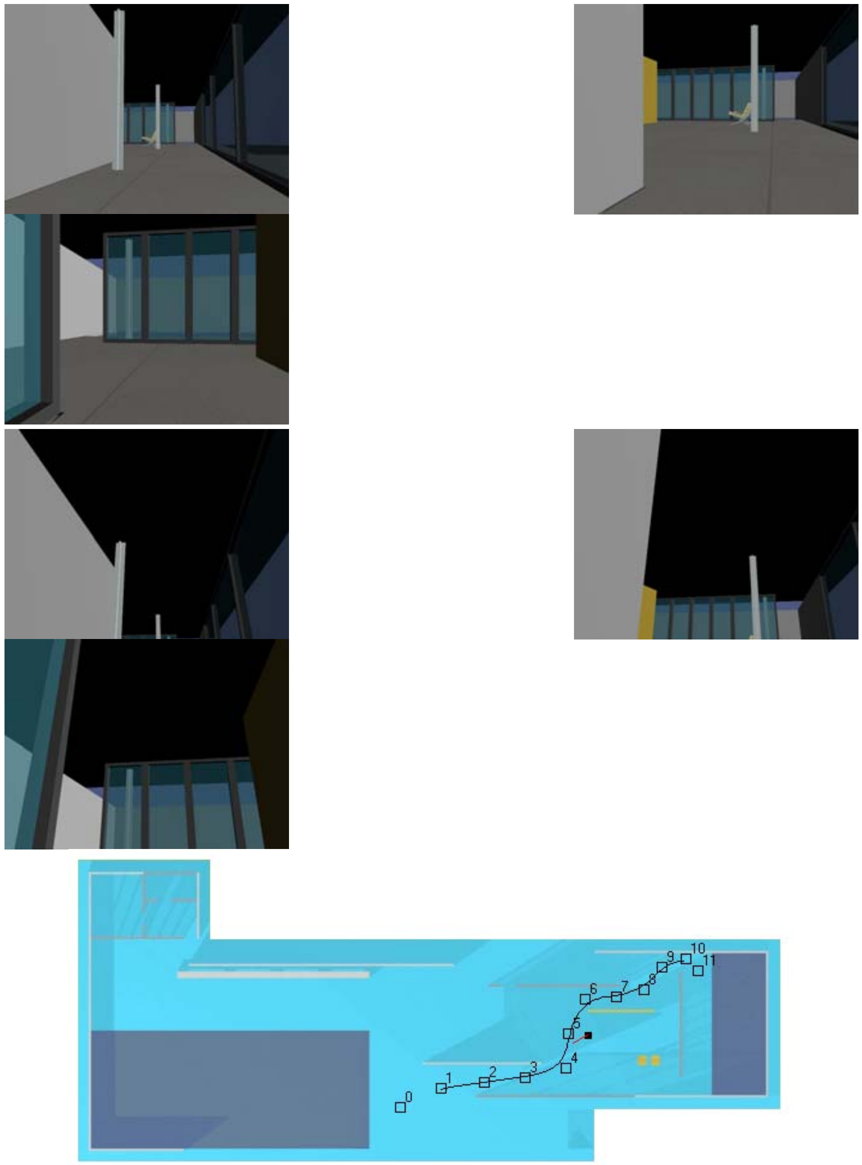


Figure 7. Views across the Barcelona Pavilion. First Row: Camera shooting forward; Second Row: Camera shooting upward; Bottom: Route in map view.

5. Conclusions and Future Work

By using camera movement, we demonstrate that whether a space appears intelligible or unintelligible may be manipulated in the way how the space is interpreted. Our navigation system can assist the interpretation process by providing a proper user interface to facilitate real time path planning and control of camera movement. Therefore, the navigation system is also an analytical tool in addition to a representational tool. Future work will include implementing more features, such as depth of field, in order to achieve a more realistic appearance of space. We expect our research on navigation and interpretation of space will ultimately assist in offering new approaches for the future development of architecture-specific 3D viewers and will assist in architectural design presentation and analyses that employ Virtual Reality technology.

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