

Animation Techniques to Represent Graphic Analysis of Architecture: A Case Study of Richard Meier's Atheneum

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Abstract. *It is debatable whether design can be taught. Frank Lloyd Wright himself mentioned that architecture should be taught by its principles, discerning the principles underlying in works by various architects. In the absence of thoroughly satisfactory methods of combining various means of digital representation for analysis, this paper investigates the features of 3D computer models; in particular, its animation environment to aid graphic analysis of built forms. Computer 3D animations, which are generated from 3D models, have an unparalleled capability to demonstrate spatial experience. Animations can also manipulate the constituent components of the spatial structure, thus illustrating analytically the composition of a building or object. The most significant aspect of 3D animation is in its flexibility of manipulation of various physical and rendering attributes of a 3D model. For the purpose of case study analysis, Richard Meier's Atheneum in New Harmony, Indiana is chosen for its clarity in design elements and demonstration of applicable principles. Through various animation clips, the basic techniques are illustrated as an effective method of communicating concepts of graphic analysis.*

Keywords. *3D Animation, Analytic Diagram, Form Analysis, Design Principles, 3D Model.*

1. Graphic Analysis & Digital Animation

Analysis for a built physical building inherently leads to the reconstruction of the underlying design principles as a predicted hypothesis. By definition, an analysis is an abstract process of simplification that reduces a total work into its essential elements. In architecture, the primary goal of design analysis and its representation is to expose the underlying

concept, organizational pattern, design characteristics, and 'tectonics' through simplified diagrams. Both the process and product of an analysis can be a valuable learning experience.

This paper highlights the techniques of 3D-computer animation environments that take into account parametric changes to help enhance representation of analytic animations and their related models. The power of 3D animation lies in its

ability to respond to every event within a defined timeline where each event is recognized by the application software, and events occur each time an object is changed in terms of its position, orientation, scale, shape, and rendering characteristics. Usually every event that has happened to every object is tracked, and a final animation is created incorporating changes of all objects.

2. Atheneum Animation

This case study animation is composed to offer a clear understanding of architectural components of the Atheneum in New Harmony, Indiana by dissecting the building using computer 3D modeling and animation techniques. The Atheneum, designed by Richard Meier in 1979, is an example of contemporary modern architecture, with white enamel panels and overlapping grids. It is structurally and texturally quite different from the historic buildings of New Harmony, and thus forms a striking contrast with them. This animation attempts to graphically explain the function of the Atheneum and the primary concepts of its architecture in the context of its settings in New Harmony.

The animation is mainly composed of two sections: analysis and design principles. The analytical section includes information on the Atheneum site, town grid, structural grid, space, and movement sequence. This section explains Meier's design approach and process, and also use of the building by visitors. The Design principle section includes information on design concept, the building's relationship to the site, and origin of the design. Also, this section includes information on the unbuilt part of the Atheneum located in next to the exterior stair in the original Plans.

3. Formulation of Analytical Diagrams

To formulate the content of an analysis, the first and foremost requirement is to gather all available

information on hand and then review them carefully. This may include a written description of the project, architect's original comments, explanation of the design concept, early sketches by the designer, site and floor plans, building sections, elevations, and three-dimensional views. In addition to this, acquiring information on the architect and his/her theories is needed in order to understand the designer's thought process. Studying all available information and comprehending the form and spaces both in plan and 3-D, is needed in order to interpret, analyze, and represent the specific emphasis of the design. After acquiring and studying all available information, specific aspects of the various design principles and spatial organization need to be analyzed in graphic format using known drawing conventions with modifications (processing techniques) as necessary.

For an effective graphic analysis, all inventoried information should be illustrated graphically. In any illustration, important factors may be abstracted, or isolated and emphasized, to build a firm foundation from which to interrelate all known elements.

The case study analysis of Richard Meier's Atheneum, illustrated in animation clips, takes into account of all the considerations mentioned in this section to formulate its analysis.

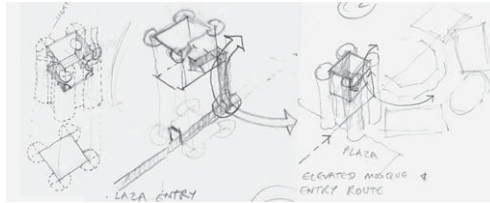
As a process of representation, the following steps may be traced in a work of analytical animation.

- First, decisions need to be made on specific issues that will be illustrated in the analysis. A list of those issues is useful.

- Quick thumbnail sketches need to be drawn to get an overview of the effectiveness/appropriateness of sketches in relation to the issues being analyzed. The same issue may be illustrated several different ways. At this level, drawings do not need to be clear enough to be communicated to others.

- Using thumbnail sketches (figure 1) as the

Figure 1. Schematic thumbnail hand sketches as reference for final computer 3D models



base drawing, newly refined and more developed illustrations need to be drawn emphasizing clearly each specific issue of the analysis. For instance, to show the structure of the building, all support systems may be highlighted showing only the related enclosure. At this level, the drawing should communicate well without the help of extensive text description. The analytic drawing can be drawn either manually or with the help of a computer application.

In the next level, a computer 3D model and a well-planned animation strategy can be brought to add more dimensions to the presentation.

4. Basic Techniques of Architectural Analytical Animation

Computer animation for architectural analysis has three basic stages that affect the final desired output. These are:

- 4.1 3D Modeling Stage
- 4.2 Animation Stage
- 4.3 Visual Effects and Video Editing Stage

4.1 3D Modeling Stage

Constructing and composing objects in a three-dimensional computer environment that have length, width and depth are usually referred to as 3D modeling. A 3D model rarely ends with the modeling process itself. Most three-dimensional models go on to be rendered and then continue through the production process of animation.

Without getting involved into technical details, it could be simply described that there are three

basic factors that determine what a 3D object will look like. The first factor is the modeling/rendering mode, which tells the model how accurately an object is to be drawn and how much surface detail to display. Secondly every object is assigned a surface, which gives the object color and texture. The third factor is the lighting, which provides shading and depth to the model. Although a combination of all of these factors can provide a wide range of rendering options, the use of wireframe variations, surface shades, and surface transparencies are significant ones that help illustrate analytical models quite effectively.

It can be said that all conventions of drawings (plan, section, elevation, axonometric, and perspective) need to be considered in order to represent analysis of form and space. Axonometrics and aerial perspectives (with distant vanishing points, similar to an axonometric) are significantly effective because of their diagrammatic three-dimensional nature in communicating the main idea. The key seems to be in highlighting parts or segments within the 3D diagram.

The focus of all general purpose modeling applications is to draw and render physical objects and render their material characteristics. It should be noted that in analysis, representation of non-physical objects is as important as the representation of physical objects. At present, the alternative solution for such a differentiation is the combination and variation of shades of color, transparency, and options of wireframe variations, all within a rendering mode.

A 3D model in a computer environment is created with lines, rather than dots or broken lines. Some of the improvised and unique features, like a dashed line or a thicker profile line in the periphery, cannot be generated in the default modeling environment. However, if planned at the modeling stage it is possible to modify individual line thickness to create such effects in the final animation.

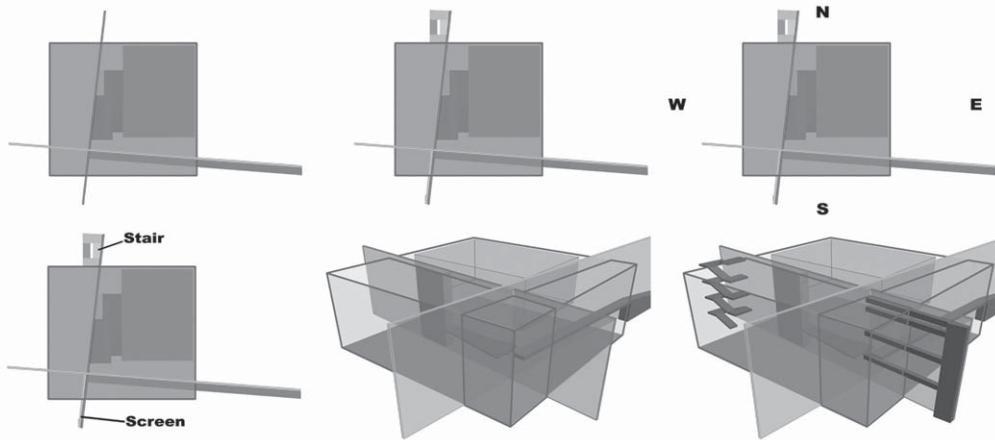


Figure 2. Various modes and combination of wireframe and rendering techniques in the modeling environment for the Atheneum Animation

4.2 Animation Stage

Computer motion models, also known as animations, which are generated from 3D models, have an unparalleled capability to demonstrate spatial experience. Animations can also manipulate the constitute components of the spatial structure, thus illustrating analytically the composition of a building or object. Since animated models can be built initially from a plan, it is possible to show both plan and three-dimensional structures in order to illustrate the sequential reading of the three-dimensional space.

A 3D computer animation can respond to a variety of changes within the components of created models in a defined timeline where each event is recognized and changed in terms of its position, orientation, scale, shape, and rendering characteristics. Usually every event that has happened to every object is tracked, and a final animation

is created incorporating changes of all objects. These techniques of animation and following available features can be very useful for analysis:

- Relative movement of objects in relation to each other.
- Introduction of new object/s within existing objects.
- Removal of an object from existing objects.
- Change of scale in an existing object to highlight other objects importance.
- Change of color and rendering effects while movement is taking place to emphasize or de-emphasize object importance.
- Transformation between drawing conventions to illustrate both 2D and 3D spatial features.

In general, the following basic techniques are important for a work of computer animation in an

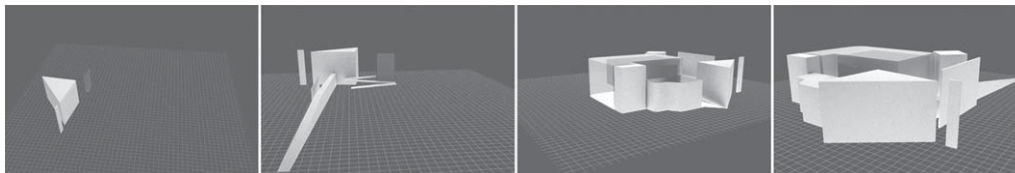


Figure 3. Basic forms of building (Atheneum) appear in sequence using keyframe techniques of animation.

Figure 4. Building (Atheneum) reveals in horizontal section as the cut plane moves upward. Use of slice command in modeling environment as an example of model animation.

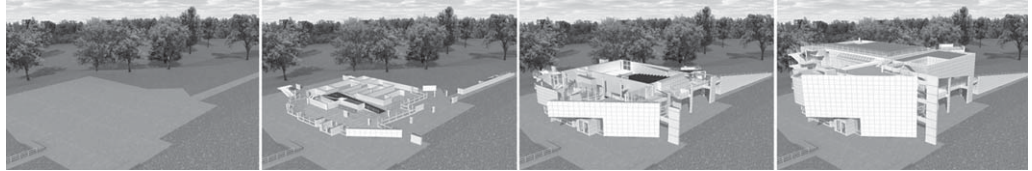
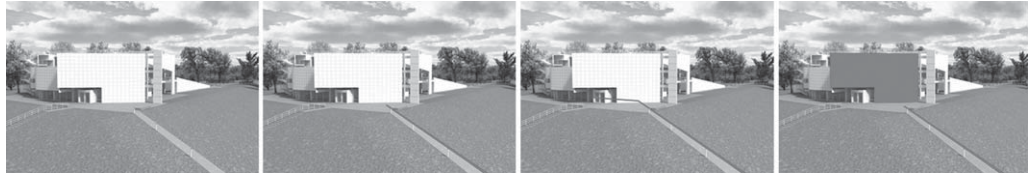


Figure 5. Color animation helps define movement path and wall plane.



architectural analysis.

- a. Keyframing and In-Between
- b. Model, Light, Color, & Texture Animation
- c. Camera Animation
- d. Two- and Three-Dimensional Integration Animation

a. **Keyframing and In-Between:** The most significant aspect of 3D animation representation is in its flexibility of manipulation of various physical and rendering attributes to illustrate the idea of the analysis. In an animation, the keyframe interpolation technique is used to calculate the position of objects in space, as well as their shapes and other modeling and rendering attributes. Keyframe interpolation provides as many needed in-between frames calculated by the computer depending on the time length of the sequence. The spacing of the in-between frames depends on the type of interpolations used. The two common types include linear interpolation and curve interpolation. Since each event and relative changes in terms of objects' position, orientation, scale, shape, and rendering characteristics are recorded in the final ani-

mation, this technique can be a very powerful tool for architectural analysis.

b. **Model, Light, Color, & Texture Animation:** With keyframe interpolation techniques, a 3D modeled object can be changed and controlled in its position, shape, and other attributes. Geometric transformation of individual architectural elements in relation to the entire building could be a very effective representation of model animation technique for analysis. Three-dimensional morphing, movement along a path, and surface characteristic changes can also be useful in this regard. Similarly, Light, color, and texture can be animated with keyframe interpolation.

c. **Camera Animation:** The camera is a useful tool because of its motion capability and ability to change some of its attributes. In particular, the motion path of a virtual camera is limitless. Unlike a physical camera, virtual cameras can run through a solid wall or can be placed at a very high altitude. A camera can run from a fixed location or on a specified geometric path. Appropriate motion can be adjusted as needed for the desired animation. Focal length of the camera lens can also be ad-

Figure 6. Camera animates on a line path to upward direction and then downward to illustrate building segments.



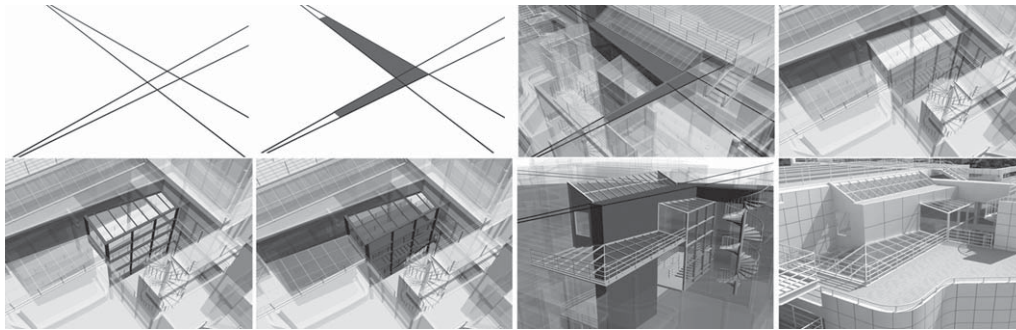


Figure 7. Combination of animation clip and still image. Moving lines change color in the middle section and then highlight the ramp and skylight segment of the Athenium building.

justed to cover appropriate object or space types. Flexibility in having an independent camera path and an independent target path allows a camera to have unlimited options of highlighting desired elements in an architectural animation.

d. Two- and Three-Dimensional Integration Animation: Combining and matching a two-dimensional drawing or image with three-dimensional computer renderings is a technique that can be availed in an animation environment. There are a few variations of this integration technique. Usually, a two dimensional image is placed as the background of an animation environment and three-dimensional objects are animated over the two-dimensional background to get the desired effect. A 3D architectural model growing from a floor or site plan drawing can be a good example of such a technique.

4.3 Visual Effects and Video Editing Stage

Most architectural animations are a simple

compilation of rendered animation clips that illustrate a building in its total entity. An analytical animation usually goes beyond this norm. Since analytical animations deal with dissecting a building at various levels of details, it does demand use of a wide range of techniques for final compilation. The basic requirement for an analytical animation is to assemble a variety of media types, including diagrams, still images, wireframe models, animated clips, video shots, audio narration, and background music. To get an appropriate professional result, video editing and visual effects become essential techniques in this final stage. All visual effects for analytical animation may be divided in to these four categories:

Matching sources

Combining elements from multiple sources,

Adding or deleting elements

Transforming the source image (morphing)



Figure 8. Three still images dissolve in sequence to illustrate the relationship of the Athenium, the town, and the river.

Figure 9. Rendered image, wireframe image, and text composed in layers along with the mask command to create the effect of a wireframe building turning into a rendered image.

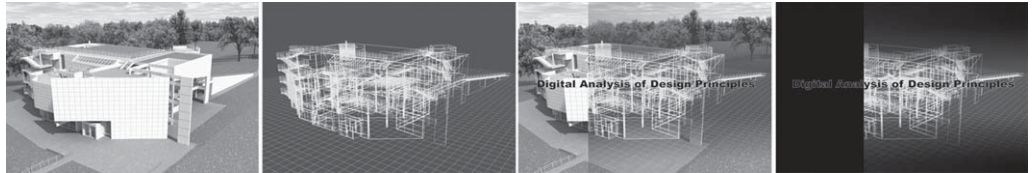


Figure 10. Use of the dissolve technique between two rendered views assigned over a time period to simulate the effect of a day scene turning into a night view.

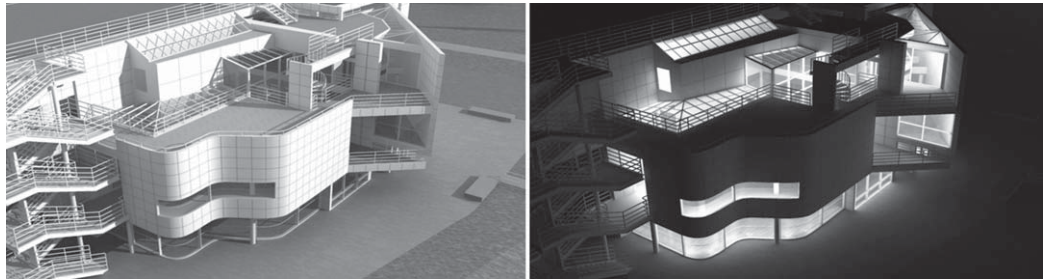


Figure 11. Use of a mask to hide a portion of the screen where credits are superimposed.



Combining elements from multiple sources often uses the technique of compilation in various layers. Effects can be added to highlight particular layers according to its importance. Techniques of Chroma Key or color deletion is often used to superimpose images from two layers. Use of simple dissolves between similar or contrast images are other tools that are effective for analysis. This technique can be used between still and animated clips. Figures 8 through 11 illustrate some of these techniques (including adding transitions, motion, transparency, graphics title, and use of mask) for effective analysis of Richard Meier's Atheneum.

Conclusion

With appropriate 3D modeling and animation

techniques in a computer environment it is possible to create effective means of graphic analysis of form and space that can enhance the representation of analysis in architecture. The animation medium has an edge in representation of form of space analysis because of its ability to create motion models with variations of parametric changes. In addition, visual effects and editing techniques with the combination of animation techniques, make this medium unparallel to other means of analysis for architecture and design teaching.

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