IMAGE MORPHING FOR ARCHITECTURAL VISUAL STUDIES

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Abstract. The purpose of this paper is to suggest and demonstrate how image interpolation, as a tool, can facilitate architectural illustration of design content and process. This study emphasizes a design-oriented image transition process that is distinguished by two types of morphing: process and source. A morph model is presented with components of input, function, output, and constraints. Based on a model's definition, a matrix is used to illustrate the relationship between the two source images by referring to origin, reference plan, configuration, time, etc. Morphing contents emphasizes changes of pixel, outline (2D or 3D), and order. Possible applications in architectural visual studies include morphology study, comparison building renovation before and after, dynamic adjustment, quantitative measurement, dynamic image simulation, and model and image combination.

1. Introduction

The purpose of this paper is to suggest and demonstrate how image interpolation can facilitate architectural illustration of design content and process. This study emphasizes a design-oriented image transition process. A morphing function, considered as a software tool, is applied to interpolate images derived from design content to explain contextual issues. The function was applied in a computer-aided architectural design (CAAD) course and design studio of graduate level to exemplifies its usefulness as a medium in architectural visual studies.

Most design graphic processes are conducted as "cause-effect" manipulations. In other words, designers present problems and solutions in graphic form as a black box. Interpolation processes by a designer can hardly be formulated, since it starts as mainly a type of internal communication (communication with oneself) (Schon, 1983). The transition between problems and solutions most likely comes from a graphic process, with limited assistance of verbal interpolation or communication. For example, a cartoonist's comment on Loos's Goldman and Salatsch facade

(see Fig. 1) had a strong resemblance on Steiner's facade too (also see the section of Morph Matrix). The resemblance in architecture frequently is interpreted as metaphors. It depends on a reader's interpretation.

Figure 1. A cartoonist's comment on Loos’s Goldman and Salatsch facade (Frampton, 1982)

Many architectural examples can be interpreted by graphic interpolation, as a tool, to present or contrast design intentions to a more clear level. For example, a form or proportion study of building elements is often made within a certain tolerance. After adjustment and manipulation of contents, designers compare the difference between source (original contents) and result (modified contents) to fulfill design evaluation or interpretation (Herbert, 1990; Lawrence, 1993). A graphic interpolation tool can make a "cause-effect" manipulation more conceivable. Graphic processes can play a role as aids to record design contents or as stimuli for further design development. Morphing is a type of interpolation. This manipulation is manually achieved by a designer's definition of source and goal. The interpretation process is as important as retrieving solutions to problems.

The design interpolation process is an animating process. The media presented in traditional design interpretation is more like a cause-effect interpolation. Problem-solving presentation is similar to a key-framed illustration to contrast or interpret design contents. An interpolation process is also a calculation for retrieving specific frames under manipulation constraints. An automatically executed interpolation process can be helpful in conducting design process. Not only can illustration be made easily, but it can be executed or rendered as digital media - a movie. Each frame can be selected from a recorded process for further manipulation.

Animation can be made by many methods (Badler and Glassner: 1993; Fléjy, van Dam, Feiner, Hughes: 1990). Image morphing is used to handle 2D media for various types of design contents. 2D images, instead of 3D volume, are used in this study. Graphic interpolation is conducted through
an application allowing a user to define constraints (like control points or lines) for linear motion.

2. Morph Emphasis

Morphing emphasize process or source, depending on which part of morphing is viewed (see Fig. 2). Linear interpolation is morphed along an axis. Sources are the images located at two ends. The process-emphasized morphing has source given at each end, and the purpose of the interpolation is to record and illustrate process. The source-emphasized morph has subsourse given at each end, and the purpose of the interpolation is to retrieve another source image located in between. Different emphasis results in different parts of the axis sampled to find design contents.

![Figure 2. Two types of morphing](image)

A morphing map presents the process of how a desired image frame is interpolated from a series of existing or morphed images. Inside the map, images that are highlighted are sources. Those sources are numbered in sequence. Source images can also be interpolated from other images. A morphed image of a map can be used to as a source image for other layers of the map. Therefore, a morphing map contains a number of related layers (see Fig. 3) and presents a record of the operational procedure and manipulated result.
3. Morphing Model

The morphing process can be described by Mmorph, which is used to suggest and demonstrate image interpolation, as follows.

\[ \text{Mmorph} = (\text{input}, \text{function}, \text{output}, \text{constraints}) \]

- **input**: source image. Two images are required as endpoints for a linear interpolation. Images are in a bitmap format and are usually similar.

- **morphing function**: This function linearly interpolates the pixel values of the two input images at corresponding locations or within a predefined boundary. Interpolation is calculated with reference to control points; or lines that are assigned in one source image will appear at the same place on the other. Points and lines can be relocated afterward, since comparing the different contents of two images is the main concern. Control points can be connected with a line or a closed polygon. An image located closer to a control point has a larger transformation level. If no control points are assigned, pixels are morphed by brightness and color.

- **output**: morphing result. Output is either morphed images or sources located along the interpolation axis. Images are often presented as an animation with a predefined number of frames. The animation can be played back and forth or frame by frame to inspect changes in detail. Source images can also be output.

- **morphing constraints**: Constraints include number of frames, transformation level, file format, and image size. If number of frames of an animation is reduced to zero, no change will occur. The frame number constraint is related to the level of change between adjacent morphed images. File format is restricted to bitmap image in this study.
4. Morphing Matrix

The morphing matrix illustrates changes and references on separate axes (see Fig. 4). Changes are presented visually.

1) matrix: a matrix of reference and change
2) reference: origin, reference plan, fixed shape, time, or the image itself
3) change: between components or between component and whole configuration. Morphing contents emphasizes changes of pixel, outline, and order.
   - pixel: examples are interpolation between
     - foreground and background
     - solid space and void space
   - outline: examples are interpolation
     - between single element and whole configuration: single element could be a room or a courtyard; whole configuration could be floor plan or site
     - of profile, skyline
   - order: examples are interpolation of
     - arrangement of group of elements
     - urban pattern

![morphing matrix](image)

*Figure 4. Morphing matrix*

A change of pixel is exemplified by two architectural cases. The first originates from the map of plaza Vittorio Emanuele II. This map has buildings colored in black and the plaza colored in white. The black-white representation is inverted into a different solid and void visual emphasis. A gradually morphed sequence is illustrated in Fig. 5. Another example comes from a Japanese architect Kazumasa Yamashita and his project: Obi Second House on 1970 (Yamashita; 1989) (see Fig. 6). The feature-based elevation design concept imitates Yamashita's face. When his face and the house image are used as sources, the morphed result reveals an interesting coherence. No control points or lines are assigned in either case.
Change of order is exemplified by a famous architecture metaphor - the transition of Steiner House and a sewage cover (see Fig. 7). The Steiner House was designed in 1910 by Adolf Loos, who disliked ornament in architecture. A cartoonist of that times commented Goldman and Salatsch facade with a drawing stated a person finally found the type of simplicity he desired - the pattern from a sewage cover (Frampton: 1982). In this study, the cover is compared with another Loos's design - the Steiner House facade. The morphed result presents a transition of size and order between openings in the facade and holes in the sewage cover.
5. Morphing Context of Architecture

Morphing can help explain architectural contexts. Following suggestions are possible uses of morphing in architecture. Some examples are shown in the section of Morphing Matrix.

1) Morphology study: This study investigates contents of a particular morphological interest by applying control points and lines as reference to study configuration shift. This compares changes based on time, origin, or reference plane. Examples are
   • Architect's design style: This study observes style change cross projects by emphasizing a specific design element.
   • Building form's originality: A roof of a traditional Chinese temple consists of components like corner, ridge, and decoration. The configuration of the roof, particularly the skyline, is emphasized due to setback of building below the roof, which is a common design technique. If a roof is observed at a distance, the image of the skyline is considered as a two-dimensional plane. A temple in the northern and southern part of China figures differently in corner and ridge. Control points and lines are assigned accordingly to compare differences.

2) Renovation: This compares changes based on original shape.
   • Style transition: This compares changes between old and new buildings on the same street before and after renovation. Transition is used to contrast the historical feature of a single facade with the whole street image. The changes also refer to different time periods.
   • Construction progress: This illustrates components manipulated by construction or assembly process.
   • Urban image transition:
     • Street image: Old street photo is compared with today's street image to illustrate urban transition.
     • Urban map: Old urban plan is compared with demolished or post-renovated plan to contrast with current city planning.

3) Dynamic adjustment:
- Modules: Modules normally come from structure members, openings, furniture, etc. A co-relation between different dimensions can be achieved by assigning each size as a source image and performs multi-dimensional morphing, as mentioned in morphing map.

- Plans: Boundaries of spaces in a plan are frequently adjusted from early design to final design. Each space constraint can be considered as a source to interpolate possible alternatives.

4) Dynamic image simulation:
- Mental transition of images: This simulates human perception of the environment due to body movement; for example, viewing a street facade from a car driving down a street. Source images come from a collection of individual facades along a moving direction with a given displacement.

5) Model and image combination: Morphing results can be used with other tools or presented in layers.
- Match model with image: This application applies a model-match-image function to seamlessly integrate an additional 3D volume with a selected morphing frame as a short-cut in generating design contents and presenting design concepts.
- Morphing by layers: Foreground, background, and 3D models are separated by layers and morphed to illustrate the influence of different settings on foreground or background. Design alternatives can be generated and selected.

![Figure 8. An operating matrix](image)

6. Applied process, format, and tools

The morphing process is a combinative result of process, format, and tools. The three elements are organized in an operational matrix (see Fig. 8). The process involves four steps. Images are first scanned and then edited. Both control points and lines are used to define either total or a fraction of edited image. Boundaries are adjusted to meet design interest. Tools include applications that can scan, edit, and morph images. The format of each step
depends on user's selection; PICT was used in this study. An animation format like QuickTime® was used to store morphed result.

An application Morph® on a Macintosh® was used to conduct most of the previously mentioned morphing studies. This program is applicable to 2D images only. Combining morphed movies and 3D objects to illustrate design was made by Alias Sketch!® and Strata Studio Pro®, which are also Mac-based applications.

7. Conclusion

In a CAAD course, students discover that this application is very interesting because morphing provides visual study in an animated manner (see Appendix A & B). Many other tests were also conducted as described in the section of Morphing Context of Architecture. Based on the definition of morphing model: Mmorp, image transition can be recorded and analyzed. How to assign control points and lines properly to view design in different morph features is worth studying. Although combinative morphing with a 3D volume is popular in commercial applications, this research emphasizes manipulation of 2D images and exemplifies its usefulness as a medium in architectural visual studies.

Acknowledgments

The credits of the figures go to the students listed as follows.
Figure 6.: Ming-Lan Chen
Figure 7.: Jun-Wey Lu

Appendix A: Heng-Chung Ho
Appendix B: Chi-Chin Lin

References

Appendix A: Morphing between a tree and a building of Le Corbusier's sketches - student's work (Ho, Heng-Chung)

Appendix B: Morphing between human figure's proportion and a plan - student's work (Lin, Chi-Chin)