Form Follows Feng-shui: A Constraint-based Generative System for Housing

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Abstract
Louis Sullivan's dictum "Form follows function" can be changed to "Form follows feng-shui" in Eastern Asia; even today in the 21st century, feng-shui still constrains the design of residential layouts in Taiwan and Korea. In this paper we describe a generative system for form and space planning that supports the schematic design phase of housing through both functional and feng-shui constraints. The functional constraints include the size of each space component, adjacency, etc. The exterior environment of a house and making use of interactive relationship between the five-elements (wu-xing) are feng-shui constraints, which provide geometric information and suggest location and orientation of each component according to the resident's personal information. We have implemented a prototype to illustrate how this works for residential space planning. The prototype augments a conventional CAD software with a knowledge-based system and a set of graphical user interface applications.

Keywords: housing; feng-shui; postmodern; context; generative system

1. Introduction
New design examples in postmodern architecture, reflecting such theories as deconstructionism and digital architecture, are becoming ubiquitous the world over. Yet, in Far East Asia, many believe that good feng-shui – developed by the ancient Chinese to relate people and man-made environments to their natural environment – still makes for good houses, and they choose to arrange their living environment according to these precepts. In this paper, Louis Sullivan's dictum "Form follows function" becomes "Form follows feng-shui," at least, in Taiwan and Korea.

However, modern designers, in these countries, suffer from an inability to acquire good reliable traditional feng-shui information. Sources of feng-shui are of two kinds: common folklore and archaic texts, the latter of which are difficult to understand. The transition from abstract concepts to tangible design solutions requires good planning and a well executed process that takes a correct interpretation from these sources. However, getting a grasp of feng-shui for use as representations of knowledge is made even harder, because information about feng-shui is often interwoven within its own sources.

Despite this, and perhaps, because of it, a constraint-based generative system for form and space planning, to support the schematic design phase of housing, is desirable. Such a system can provide geometric information and suggest location and orientation for each component, based on rules of harmony (or conflict) between resident and house. These very same feng-shui constraints would be interpreted differently according to the personal information of any resident such as their gender, time of birth, and occupation. Given such a system, with an appropriate graphical user interface, through interactive and direct manipulations, designers can effectively and quickly develop adaptable solutions for schematic design problems that satisfy both functional and feng-shui constraints. We describe such a system in this paper.

2. When Postmodern meets Feng-shui
We start with two paradigms: Postmodernism and Feng-shui – one western, the other eastern, one new and the other old – which appear to have nothing in common. Yet, both are deeply rooted in the essence of place, interweaving cultural and social interaction with physical design.

New western paradigm – postmodernism
Discussions on postmodernism, by such philosophers as Gadamer, Derrida, Foucoul, Habermas, etc., visually embodied architecture in the 1980's. Despite the fact that any definition of postmodern architecture will always be controversial, most writers seem to agree that it is characterized by eclecticism and multiplicity. For instance, Jencks (1991) describes 'radical eclecticism' thus: "We can point to three basic justifications for choosing a style, or mixing styles, as the case may be: the context the building fits into, the character of the particular functions which must be enhanced by style and the taste-culture of the inhabitants." Similar sentiments are echoed in Klotz (1988). He adds that
postmodern architecture takes into account a history of architecture and refers to given factors of an entire cultural setting. It is interesting to note that Charles Moore's Piazza d'Italia in New Orleans is mentioned as a good example by both these writers.

One of the foremost proponents of postmodern architecture is Peter Eisenman who admits to being influenced by Derrida. Eisenman's House II, illustrated in Fig.1., exhibits a full set of inspirations for his design. First, there are internal rules to create a form. Second, he uses diagrams that describe the relationships among deep structure, prior conditions, and actual environment. Third, there is a relationship between deep structure and a prior condition in the essence of the architecture (Lao 1999). Deep structure possesses the potential to reveal the spatial experiences, but requires a physical alteration to make them manifest. This manifestation is a prior condition in which the act of shifting creates readable spaces, while the initial platonic form is no longer a singular unit, but a fragment of its original whole.

Eisenman's own works follow this concept. In particular, in working with computers, he employs a vector notion to represent form. For example, in the Virtual House, shown in Fig.2., he expresses each connection as a vector.

The house, initially, stems from an interaction of nine cubes that constitute a potential field of internal relations and interconnections. A field of influence is attributed to each vector, which updates its virtual movement through time. The visualized lines, together with their geometric properties, become moving forces. These correlated movements produce a mechanical system capable of generating forms influenced by the position and orientation of the vectors (Galofaro 1999).

Recently, another architect, Greg Lynn (1999) has depended heavily on computers to present his work process, which he terms animate form. An example of this can be found in his house prototype on Long Island (Fig.3.). He assigns various elements to the existing site forces of attraction and repulsion, then, maps the resulting behavior patterns. The shapes are determined by forces with linear, vortex, or radial directions and include various parameters for decay, acceleration and turbulence (Lynn 1999).

**Old eastern paradigm – feng-shui**

The ancients assessed all probable consequences, of erecting a structure, on a balance of nature; they designed for a relationship between building and the cosmos (Bramble 2003). Feng-shui has application to a wide variety of areas; what we explore here is that part of it that applies to the form and arrangement of residential spaces. The cycle of five-elements (wu-xing), namely, metal, wood, water, fire, and earth, is the central, and perhaps its most important concept in feng-shui. The relationship between the five-elements is shown in Fig.4.

It was believed that everything belongs to the five-elements so that one had to follow the rules of producing and destroying the five-elements in order to bring good fortune or provide for the protection of energy (qi) (Chiou 1996). The five-elements relate to the exterior environment, which, in turn, has an influence on houses and the residents therein. In the sequel, we explain first, the relationship between the exterior environment and the five-elements, and then, the relationship between housing layout and the latter.

**3. The Relationship between the Exterior Environment and Wu-xing**

Each of the five-elements has its own concept of shape. Feng-shui experts classify the nine-stars – the seven stars of the Great Bear constellation and two other smaller stars near Polaris – as corresponding to the shapes of the five-elements (Chiou 1996). The shapes of the nine-stars are shown in Fig.5.

Traditionally and historically, the nine-stars have been used to determine the shape of the mountain surrounding
the houses. However, in considering modern housing environments in cities, the mountain is often obstructed by high-rise buildings; as a result, a number of feng-shui experts have had to adapt and redefine traditional knowledge to fit in with current situations. In this case, the shape of the mountain can be replaced by the shape of the building surrounding the house.

4. The Relationship between Housing Layout and Wu-xing

The nine-stars correspond to the orientation of a house; since the house is at the center, the remaining eight stars correspond to eight orthogonal and semi-orthogonal orientations, giving rise to the 'eight trigrams.' The eight trigrams are divided into two parts: the East Four Fates, which indicate the north, east, southeast, and south directions, and the West Four Fates, which indicate the northeast, southwest, west, and northwest directions. Fig.6. illustrates the eight trigrams. The colored areas represent the east four fates and the white areas the west four fates.

Based on the relationships of the eight trigrams, the eight different kinds of Fates are specified by an individual's gender and year of birth. That is, each individual belongs to one kind of the Fate according to their personal information. The nine-stars are classified into eight 'fortune classes' which are assigned to the trigrams. Of these, vitality (生氣) is considered to be the most fortunate. Three others in decreasing rank of good fortune are: longevity (延年); heavenly doctor (天醫); and essence (伏位). The remaining four are unconsidered as ill-fortunate — disaster (禍害); six goblins (六煞); five ghosts (五鬼); and death (絕命) (Chiou 1996).

Fig.6. The Eight Trigrams (Later Heaven)

Discussion

Norberg-Schultz (1985) describes the concept of dwelling in these terms: "To dwell implies the establishment of a meaningful relationship between man and a given environment. This relationship consists in an act of experiencing a total environment as meaningful, that is, in a sense of belonging to a certain place." Context is reality as defined by the "natural and cultural history" of place. Context, as planners and designers use it, is a spatial representation of the metabolic processes in motion in space and time. It becomes a four-dimensional construct composed of culture-based organizational and structural relationships (Kasprisin and Pettinari 1995). This is in exact correspondence with Carr's (1961) definition of history in that it "consists essentially in seeing the past through the eyes of the present and in the light of its problems," and this is the reason why some postmodernists focus on transferring historical contexts into their design problems.

However, the same feng-shui constraints are interpreted differently according to each resident's personal information. Residential designs evolve constantly in response to changing societal values and needs. As with automobiles, buyers look for specialized products and this has a growing influence on the housing industry; instead of cookie-cutter houses, people want room configurations that reflect and accommodate their particular lifestyle.
Home buyers often have a chance to choose the location of their houses and customize the interior of their units well before the building construction even begins. Whether the designer is western or eastern, postmodernist or subject to feng-shui precepts, customization in architecture is of paramount importance. Traditional architectural design was not just an embodiment of social, cultural and technological factors, it incorporated highly inter-dependent compositional and constructional considerations. It is these latter aspects that make traditional architecture eminently suitable for grammatical analysis. It is the former aspects that endow such rules of composition with meaning (Chiou 1996).

In situations in which it is difficult to acquire appropriate feng-shui information, Eisenman's internal rule concept becomes interesting. Especially, his words 'deep structure' and 'prior condition' correspond to Chiou's former and latter aspects mentioned above. Moreover, Eisenman's diagram concept, originally from Alexander, is able to overcome the difficulties in applying abstract concepts to concrete design. We can see the reasons from Somol's (1999) explanation of Eisenman's diagramming: "Proceeding with halting steps through serial obsessions with form, language, and representation, the diagram has seemingly emerged as the final tool, in both its millennial and desperate guises, for architectural production and discourse."

Communicating perceived relationships in shapes and patterns is greatly facilitated by a graphic or visual language that integrates parts, organization, and structure (Kasprisin and Pettinari 1995). This is shown in Eisenman's projects because for each deformation of diagram Eisenman uses the vector notion to deal with information of context in a parametric way. A vector has density, direction, and force that we cannot draw. A vector cannot be conceptualized, but we can use the computer to represent it (Eisenman 1992). These computer-aided technologies are so versatile that they give us the power to reinterpret knowledge of feng-shui, making it possible for us to create a way of representation by a visualized and parametric mechanism, and help us to store and retrieve a huge amount of interwoven information.

The parameters of the vector may be influenced by external forces. We can see this from Greg Lynn's animate designs. He points out the relationship between external forces and form as: "Instead of a neutral abstract design of space, the context for design becomes an active abstract space that directs form within a current of forces that can be stored as information in the shape of the form" (Lynn 1999). Postmodern space is unlimited or ambiguous in zoning and 'irrational,' or transformational in its relation of parts to whole. The boundaries are often left unclear, the space extended infinitely without apparent edge (Jencks 1991). Similarly, as explained in the previous section, actions of feng-shui correspond to environmental forces. Through the rules of producing and destroying among the five elements in feng-shui, we try to visualize the relationship between environmental forces and the form of an artifact. That is, producing and destroying are interpreted by increasing and decreasing the size of the layout components. This concept corresponds to Lynn's forces of attraction and repulsion. One example of the interactive process between the exterior forces and the layout of the house is shown in Fig.8.

5. Generative System
Constraint handling in a generative system

Most schematic layout systems, SEED-Layout being a seminal example, represent a schematic layout as a collection of room units, each representing a continuous two-dimensional region whose shape and location satisfy the requirements of its associated functions to some degree. The basic idea is that room units are each defined by numbers $x_{lo}, x_{hi}, y_{lo},$ and $y_{hi},$ each representing a coordinate in the Euclidean plane (Fig.9.) (Flemming and Chien 1995).

| New Western Paradigm (Postmodernism) | Old Eastern Paradigm (Feng-shui) |
|--------------------------------------|----------------------------------|
| Context                             | Local Culture (China & Korea)    |
| Customized Housing                  | Individual Information           |
| Deep Structure                      | Meaning (social, cultural, technological factors) |
| Prior conditions                    | Grammatical Analysis (compositional, constructional) |
| Vector (Parametric)                 | Visualized Five-elements         |
| Attraction & Repulsion              | Producing and Destroying         |

Table 1. Summary of Discussions about Two Paradigms

Fig.8. An Example of the Interactive Process

Fig.9. Coordinates of Room Unit (Flemming and Chien 1995)
Unlike SEED-Layout, which creates and maintains constraints automatically, we allow designers to explore a design space by direct manipulation. That is, once discrete parameters are fixed, the designer can, simply by mouse drag-and-drop, rearrange a room on the screen to explore different topological layouts. We explain in section 4, in detail, how this is implemented.

### 6. Platform for a Prototype Implementation

Our system is divided into three parts, which include a conventional CAD software module, a knowledge-based module, and a graphical user interface (GUI) application. Fig. 11. shows the architecture of our system.

AutoCAD is the conventional 2D and 3D design software that serves as the base for our system. The system contains two knowledge bases: a functional generative design knowledge base and a feng-shui knowledge base. The rules are stored in the knowledge bases and the generated results including alternatives are displayed in AutoCAD. As AutoCAD does not provide the functions or deal with drag-and-drop, VBA applications are implemented on the top of AutoCAD as a GUI, to customize it, to seamlessly connect it to the knowledge bases, and to provide an efficient mechanism to communicate between the user and system.

In Figs. 12. through 15., we show the process of our first prototype and illustrate how it works.

A user starts a generative layout system session with the "feng-shui" option (customized by us) from the "Tool" menu in AutoCAD. The initial window is open to input various pieces of information (Fig. 12.). First, the user enters the gender and year of birth, and presses the "Show Fate" button. According to the user's information, our system automatically generates the individual's kind of Fate in the feng-shui View. Then, the user assigns the forms of the exterior environment for the four directions; East, West, South, and North. Whenever the user selects a form for a direction, the nine-square boundaries change instantly, according to the internal feng-shui conditions based on the individual information and the external environmental conditions. If the relationship is "producing", we interpret it as increasing the room size, and if the relationship is "destroying", we interpret it as decreasing the room size.

Once the user finishes the assignments and presses the "Finish Outline" button, the finalized boundary is shown in the View and "Room Layout" part is activated (Fig. 13.).

The next step is arranging all rooms one by one. The user can select desired rooms from the room list appearing in the "Room Layout" area. Each room has its own color to distinguish it from another. The size of the selected room is decided by the user and it is instantly shown on the screen. The user can drag and move the room to any desired position wherever the user wants. Once the user has decided upon a location for the room, the user presses the "Lock" button. Then, the position is evaluated by feng-

### Table 2. Matching between the Fortune Classes and Spaces

| Eight fortune classes | Functional Classes          |
|-----------------------|------------------------------|
| essence (伏位)         | Bedroom                      |
| vitality (生氣)        | main entrance, bedroom      |
| longevity (延年)       | main entrance, bedroom      |
| heavenly doctor (天醫) | main entrance, bedroom      |
| death (絕命)           | bathroom, kitchen            |
| five ghosts (五鬼)    | bathroom, kitchen            |
| six goblins (六煞)     | bathroom, kitchen            |
| disaster (禍者)        | bathroom, kitchen            |

Fig.10. The Decision Process of Functional Spaces
Fig.11. System Architecture

Fig.12. Initial Window of the Feng-shui System

Fig.13. The Results of Assigning the Form of the External Environment

Fig.14. The Result of Some Violations from Evaluation

Fig.15. The Final Layout Shown in AutoCAD

shui and functions such as adjacency or the minimum/maximum room size, in the "Evaluation" frame. Fig.14. shows that the current position is violated by feng-shui and functional constraints at the same time.

The user can choose to accept the recommendation from the computer to change the position, or ignore it entirely and keep the current position. In a similar fashion, the user can iteratively lay out each room in a desired position. When the user is satisfied with a layout, the user presses the "Draw in AutoCAD" button and the result is drawn in AutoCAD (Fig.15.).

Conclusion

This paper proposes a new approach for reinterpreting feng-shui with postmodern architecture, and on the extensibility of architectural CAD software. Through individual information and environmental forces, manipulated by feng-shui as well as functional constraints, our system can provide various combinations of floor plans in housing. The idea needs more development as feng-shui covers areas in architectural design that still remain unexplored.

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