MANAGING COMPUTER-BASED ENVIRONMENTAL INFORMATION

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I. Introduction

Recently, environmental issues in architecture have drawn increasing attention internationally. This is shown by various publications and research that present issues and design approaches aimed at environmental integration. Since the 1950s, concerns about both industrial pollution and energy supply were reflected in a greater and wider interest in the life cycle of nature and renewable resources. Olgyay, McHarg, and other researchers pioneered the study of arcology, a design theory and method based on architectural implementation of the environment. Their revolutionary principles emphasize the basic aspects of the natural environment, including climate, physiography, hydrology, vegetation, and the lives of the inhabitants, in addition to traditional aesthetics (fig. 1).

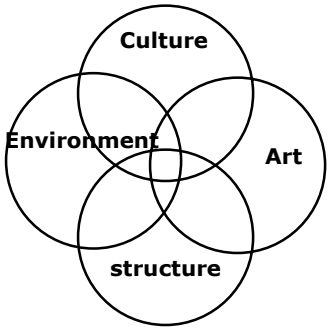


Figure 1. Design integration

As both an alternative and complement to contemporary environmental design, feng-shui is a Chinese geomancy that examined the sites of cities and determines the desirable layouts of buildings. Currently, architects of many major projects in Western societies have relied on input from the feng-shui experts before construction begins. But even Chinese, who are familiar with ancient eastern literature and philosophy, often have difficulty understanding the basic feng-shui concepts and methods of application. Feng-shui is based on a set of values different from current technology and lifestyles; they are approved historically by the ancient examples in Asia, Africa, and the Middle East.

As the result of a need to include ecological principles in the design process, many computer tools are now available that allow climatic factors, such as temperature, solar radiation, and wind to be analyzed, and provide guidance for their proper utilization. Other computer tools analyze the physical environment. However, it is often difficult to balance the many considerations for the climatic and physical factors. On the other hand, land information such as zoning and utility maps, aerial

photographs and topography maps are now available for many locations in electronic format. More and more often this information can be accessed over the Internet. This creates an opportunity for these information sources to be downloaded and combined into a digitized format for viewing and comprehensive analysis.

This paper presents a framework and approach for managing both contemporary and traditional environmental information with a computer-based tool (fig. 2). This tool will be focused on the site evaluation process. There are three major components of the tool: the graphical user interaction (GUI) component, the environmental analysis component, and the conversion component. The graphic module will act as a preprocessor and postprocessor for the analysis component. The environmental analysis module is actually the integration of several software packages. By applying the feng-shui principles, results from those packages are converged to derive the conclusion. The conversion component allows inputs from GUI to be converted into formats recognized by the analysis software packages. Meanwhile it allows the outputs from the analysis packages to be converted into formats displayable on the GUI.

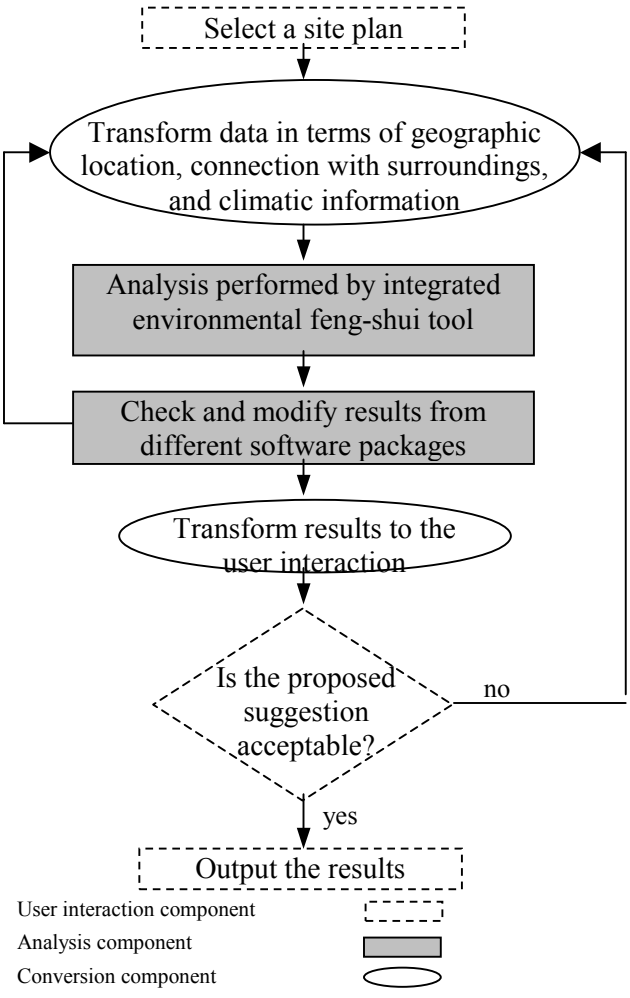


Figure 2. Flow chart of the integrated environmental information management tool.

Using feng-shui principles, the first phase of the research seeks to establish a combined analysis approach that may lead to a better understanding of the relation between humankind and the natural environment, and create harmony and equilibrium between them. The implementation strategy can be found in the concept of a rule-based information system -- a computational information representation system based on a structured database -- where each rule is established based on both western and eastern principles.

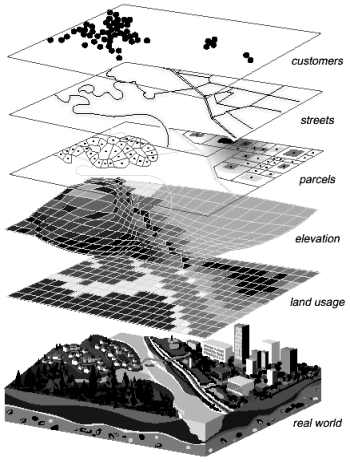
II. Design Rule-based System

Rule-based systems emphasize reasoning based on certain hypothesized rules. Archetype analysis, style characterization, shape grammar, and expert systems are new developments regarding design by rules. Combination of rules can be further used to support case-based design, knowledge-based design and more sophisticated expert systems.

There are three steps to establish a rule-based system. The first step is system design. The nature of the rules used by McHarg and Hendler indicates both sequential and hierarchical organization could be applied in establishing a rule-based system. Next step is to identify the rules. In our research, each rule is established based on both western and eastern principles. The third step is to apply these rules to a layered information structure. The methods used by McHarg and the application of GIS tools has already shown the possibility of integration of the rule-based approach with the design process. McHarg

demonstrated the result from each analysis in a transparency and attached them together to get the summary. Similar concepts can be seen from the design of computer tools: ArcView GIS from ESRI separates the information in layers and supports the users to apply rules in its analytical functions (Fig. 3).

a) Maps for analyzing the factors in McHarg's research (McHarg, 1969)



b) In ArcView GIS, rules can be applied to one layer or several layers simultaneously (http://www.esri.com/software/arcview)

Figure 3. Similar concepts to apply rules in layered information structure

However, many issues still need to be considered to apply the rule-based approach with the digitally represented information. Research about the functions supported by the computer tools is also very important. Then the implementation of the rules may combine several existing functions together or new functions should be developed.

III. Transform Feng-shui Methods into Computerized Components

Basic Theory of Feng-shui

Literally, Feng-shui means wind and water. It is the Chinese geomancy that examines the sites of cities and towns, and determines the layouts of buildings and graves. It has been used by Chinese since the Zhou dynasty (1066-771 B.C.).

The basic theories of feng-shui include the Yin-yang theory, the energy flow (Qi), the five characteristics, and the eight trigrams. Each of these is highly related to others and could be interpreted flexibly if conflicts exist. A brief interpretation of each characteristic is listed as follows:

Yin-yang theory is the fundamental principle presented in Qi, five characteristics, and the eight trigrams in feng-shui. Based on the observation of the universal energy of the earth, the ancient Chinese believed that everything in the universe was produced by changes, the results of yin and yang balance. Yin (- -) symbolizes the moon, the female, the dark, and the stillness; while yang (—) symbolizes the sun, the male, the brightness, and motion.

Qi can be translated as vital energy flow. It is the most important concept in feng-shui as well as in other forms of traditional Chinese culture. The simplest feng-shui concepts consists of Qi arrangement. In housing design, when Qi is abundant, the site will bring health and strength to those who live there. Qi could be influenced by orientation, land form, wind, water, and the surrounding environment of the site.

The five characteristics include metal, wood, water, fire, and earth. The ancient Chinese believed that everything has an attribute regarding the five

characteristics, which influence each other within a certain order: a creative order and a control order.

The eight trigrams -- heaven, water, mountain, thunder, wind, fire, earth, and lake -- are derived from the changes of yin and yang. They also represent the eight directions, four seasons, and times of the day. Figure 4 shows the ba-gua, a feng-shui diagram made up of the eight trigrams combined with feng-shui numbers and eight directions. Ba-gua is the central part of the feng-shui compass, and is the basis for both the form school and the compass school.

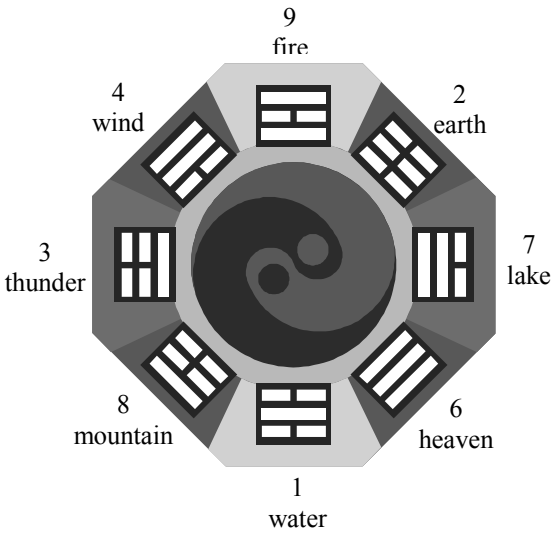


Figure 4. Eight trigrams in ba-gua

Practicing Feng-shui

The selected rules are mostly derived from Yang house of feng-shui, which is for buildings, towns, and cities. Only limited principles from the Yin house of feng-shui, which is applied to tombs, are selected as the supplemental material. The selected rules are also derived from two feng-shui schools: the form school, based on the land form and the Qi related to these forms; the compass school, based on astronomical changes and calculations with a feng-shui compass.

The feng-shui methods of the selection of housing sites in a countryside can be summarized in the following four principles:

1. The principle of systematic analysis is the foundation for the selection of other principles. Every factor within the environmental system is related with others. Some of them may have conflicts at one moment, but they can be transformed to others in certain conditions. The goal of using feng-shui principles is to find an optimized balance of all major factors.
2. The site should be supported by vital Qi. For example, a favorable site should be surrounded by good hills and water. Topographic analysis, dealing with forms of land, for a specific site should be considered in addition to the regional information.
3. A favorable site should have a good orientation, such as facing south for those located in China.
4. Geologic and hydrologic data can provide more detailed information sets to perform the physiographic analysis.

The above rules are interpreted based on several assumptions, such as 1) topographic factors are the most important when evaluating mountains and hills, 2) water-flow patterns are the most important factors when evaluating the influence of a body of water, and 3) the orientation is directed by the feng-shui compass used in the form school. It should be also noted that conflicts and debates exist when applying feng-shui rules because of the flexible practices and ambiguous literature. In this research, the most commonly used texts are selected to support the interpretation.

Interpret Rules in GIS

Literature shows that the ancient Chinese summarized the basic feng-shui principles into illustrated patterns from the form school. Figure 5 shows two patterns with the same contents: the left

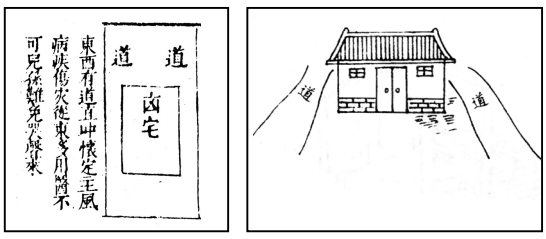


Figure 5. Two patterns show the same contents -- straight roads on both side of the house will bring too strong wind onto the site.

was first published in the Ming dynasty (1368-1644) (Wang 1985), and the right was a new interpretation (Wang 2000). After more than three hundred years, the patterns are still used today, but with no certain sequence and no connection with current technology.

Practically, these patterns can be transformed into computerized diagrams. For example, two roads and a house in figure 5 can be interpreted in GIS as the adjacent relation between road and house objects. More examples can be seen in figure 6. Arcview GIS is a mapping software that links information in layers. The digital map created by GIS has points, lines, and small areas, representing features such as cities, roads, and lakes, respectively. The information database stores data on layers and users can activate layers based on their needs.

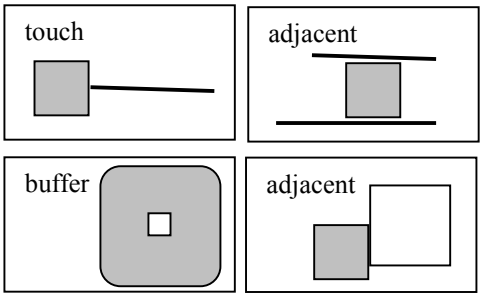


Figure 6. Relations between objects

The following maps show the detailed analysis of possible housing sites in Blacksburg, VA with general feng-shui rules.

- South facing site is favorable. With a digital elevation map (DEM) (Fig. 7), it is easy to compute the change in elevation and slope by assigning a numerical value between 0-255 to each cell, corresponding to a shade of gray (Fig. 8). The favorable site can be located as the dark portion on the map.
- An ideal site should not be on a steep slop, nor at the lowest point in the area for avoiding potential flooding and drainage problems (Fig. 9). The top of the mountain or a ridge should not become an option because of lack of protection (Fig. 10).

When applying these constraints together, the final results in Figure 11 show the possible solutions.

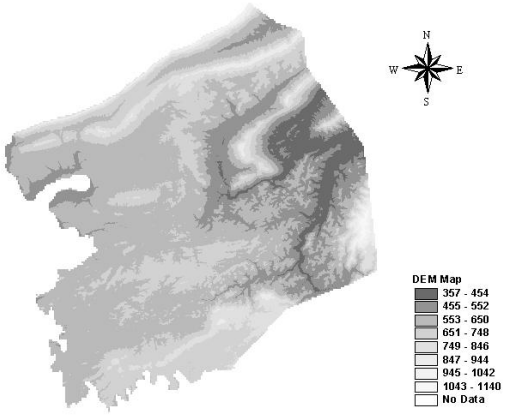


Figure 7. Digital elevation map (DEM) of Montgomery County, VA

Figure 8. Hillshde map shows a relief perspective

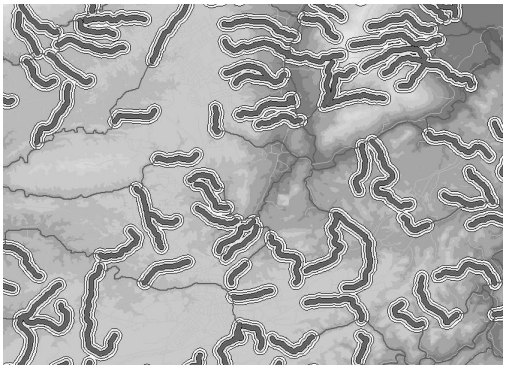


Figure 9. Avoid flooding area

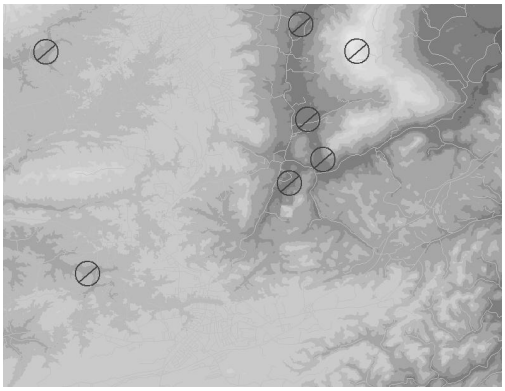


Figure 10. Avoid the lowest point of the surroundings and the top of the hill

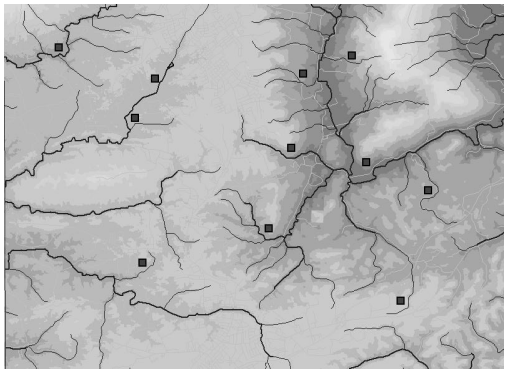
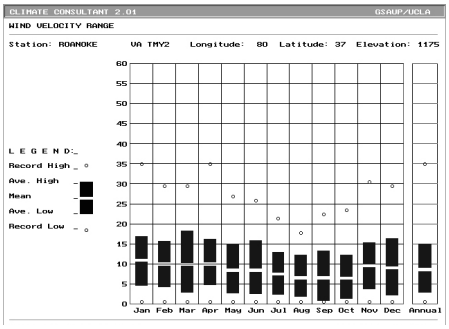


Figure 11. Possible solutions of favorable sites

needs, sun charts and sundials. Based on the passive design strategy as outlined by Givoni (Givoni 1981) and Waston (Waston 1992), it also provides psychrometric analysis that recommends the most appropriate zone.



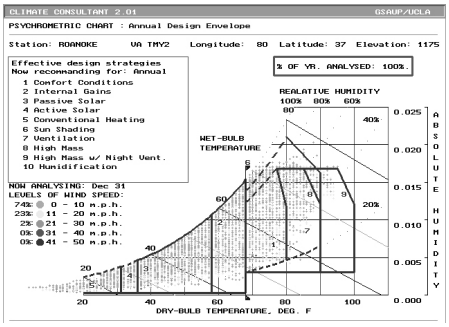


Figure 12. Analysis chart in Climate Consultant

IV. Manage Computer-based Environmental Information

Five groups of data are significantly important in our research: climatic information, topography, geology, hydrology, and vegetation. Managing these information is a two-step process. The first step involves information collection. We need to collect the necessary data, define the research boundary, and set the unit system. Then the data will be converted to a common format. These are adapted to three sequential procedures: converting data, verifying information and correcting data, and deriving new data sets.

Figure 12 shows a weather data chart in Climate Consultant. Climate Consultant was developed by the School of Arts and Architecture of the University of California at Los Angles. It can graphically display climate data, including temperatures, wind velocity, sky coverage, timetable of bioclimatic

However, it lacks a linkage between Climate Consultant and GIS. Figure 13 shows the rainfall map of Curry County, OR. One challenge of the proposed work is to convert data between different computer software packages.

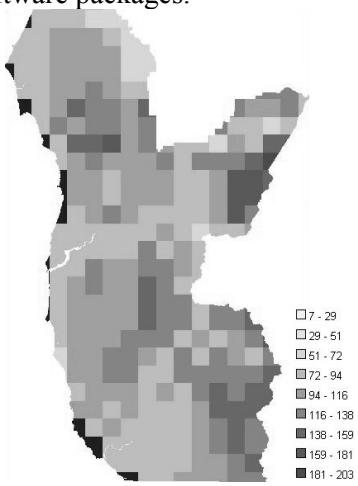


Figure 13. Rainfall map in ArcView GIS

V. Future Development

The managing of environmental information is helpful to enable students and professionals to learn and apply the knowledge in the design process. The concept can also be used to create other architectural related systems such as constructional systems and HVAC systems. Therefore, each information system becomes a component in the whole process, and the incremental expansion of these sub-systems can be further developed into an integrated design decision-making system. This is the first step toward the broadly focused objective.

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