DIGITAL METHOD FOR LANDSCAPE EVALUATION: The Lesser Three Gorges

JIXI AI, SHIKE LI AND GEBING WEI
Professor in City GIS, Faculty of Architecture & City Planning, Chongqing University,
Chongqing, China 400045.
aijixi@cqu.edu.cn or aijixi@yahoo.com.cn

Abstract: Landscape in the narrow sense means a set of multiple features about topography, landforms, scenery, etc., and it is in accord with general people, especially their visual experience and psychological cognition, and also acceptable to architects and planners. This paper presents a digital method aimed at the type of river valley landscape and several key quantitative indexes. The writers have taken the Lesser Three Gorges as an example to evaluate its value in landscape, and shown this method available and useful.

1. Introduction

In recent years, landscape evaluation and its digital methods have become a hot point. However, it should be indicated that the definition of landscape has many representations. Landscape in the narrow sense means a set of multiple features about topography, landforms, scenery, etc. in a geographic region with a scale range from several hundred metres to several ten kilometres. And landscape in the broad sense indicates many geographic units with different materiality or nature, which are made up of different types of ecology systems and have a duplicate pattern in a scale range from several ten kilometres to several hundred kilometres (Forman and Godron, 1986; Forman, 1995). The former is in accord with general people, especially their visual experience and psychological cognition, and also acceptable to architects and planners. The latter is used often by ecologists and is somewhat apart from us. Furthermore, the digital methods used by the latter are mainly 2D approaches, especially 2D top-view of RS. But visual experience and psychological cognition means more 3D approaches, or at least there may be different 2D views from some particular directions.

Landscape evaluation has different ways because of diverse landscape definitions. In this paper we deal only with those digital methods for landscape evaluation from commonsense and based on GIS.

From 2001 to 2004, we undertook a project, one of China's national key

projects of science and technology. We were asked to build an information system for supervising and protecting national parks in China. Originally, we drafted a large target including formulation of index system for landscape evaluation available to all the 151 national parks. However, the difference in landscape among these parks was so great that we found our early target was unreal. While one park presents scenery of lakes and inlands; another reflects scenery of beautiful peaks and strange rocks; and there is even a park with desert scenery. Could we draw up a uniform system of evaluation indexes for all park landscapes? The difficulty was obvious.

Figure 1. Landscape of Desert.

Figure 1 shows the typical scenery of desert. How to appreciate such strange scenery is one thing and how to describe its characteristics is another. Strong winds often move sands all around and thus dunes may be formed. If we try to suggest some evaluation indices, the research about three main types of dunes as shown in Figure 2 to Figure 4 should be done.

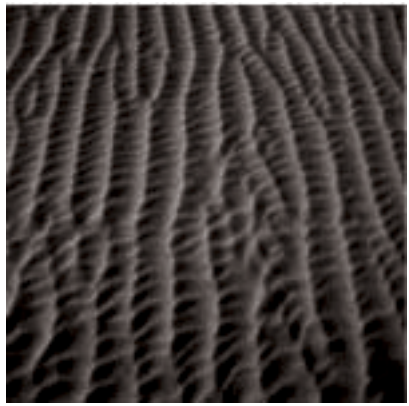

Figure 2. Feather-like Dune.

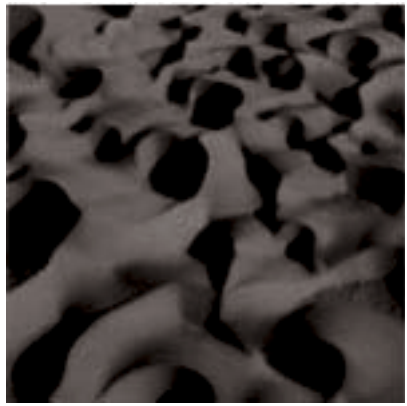

Figure 3. Bicorn-like Dune.

Figure 4. Scale-like Dune.

Finally, we focused on the typical landscape of a river valley because our model base was The Lesser Three Gorges, one of China's national parks and one part of the region at The Three Gorges of Yangtze River.

2. Features of River Valley Landscape

There are many similar scenes of river valleys all over the world. The features of these river valley landscapes, however, are generally described only by characters (words and statements) or directly presented through pictures. Also, the feeling people get on looking at the pictures can only be described in language, such as "a precipitous gorge", "a wriggling river", 'a complete series of tense and loose feeling with close and open space alternately", and so on. What are the typical features of a river valley landscape? What are the necessary quantitative indices to evaluate these features?

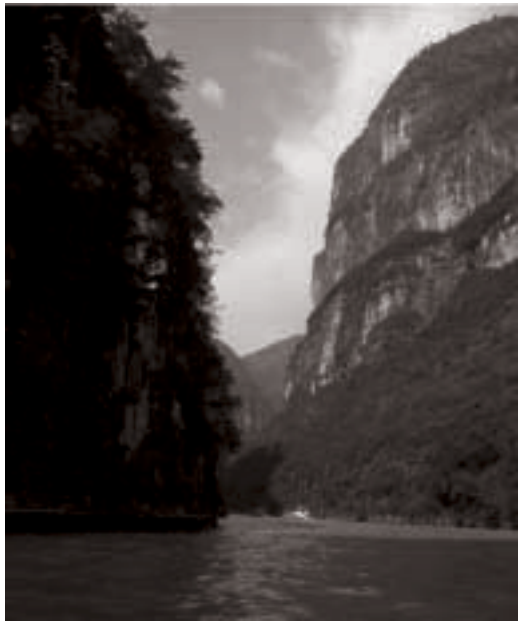

Figure 5. A Scene of Lesser Three Gorges.

Figure 6. The Angle Indicating Narrow Passage with Steep Rocky Sides.

Now let us try to introduce several features from different aspects. First, a gorge generally means that there always exists a deep and narrow passage with steep rocky sides. So we can take the angle in Figure 6 as an important feature.

Figure 7. Daning River Among the Lesser Three Gorges.

Figure 8. Wriggle Yellow River through Fields.

Second, excluding the clear water, one of the key features of a river that can catch people's eye is its wriggle form through mountains or fields.

Thus we can introduce an index in future, which may be taken as the measurement of this wriggle feature.

Figure 9. Wriggle Yellow River through mountains.

Third, if a river valley varies a little with a long and long narrow passage, the travellers looking around will soon be weary with pent-up emotions. This is like the sensation of passing through a long tunnel, seemingly endless. An impressive river valley would give people a complete series of tense feelings by continuous and alternate close and open spaces. This remittent visual experience is a type of three-dimensional spatial feature.

Besides the above three typical features about a river valley landscape, there is another feature which may only exist in The Lesser Three Gorges. Daning River among The Lesser Three Gorges is one of the branches of Yangtze River and its outfall to Yangtze River is located at the entrance of Wuxia Gorge, the middle one of The Three Gorges of Yangtze River. A strong contrast between The Three Gorges and The Lesser Three Gorges makes the word "lesser" more direct, conveying a meaning of "graceful and restrained". Especially when someone happens to enter Daning River from Yangtze River, he or she will have a real cognition that The

Lesser Three Gorges are “graceful and restrained”. This directly materializes in size and volume of the rocky sides and two rivers.

3. Quantitative Indices for Evaluation

According to four main features of river valley landscape, we defined 4 relative quantitative indices that can be calculated through spatial analysis methods in GIS. They are: gorge index, tortuous frequency index, remittent frequency index and glory / pretty index.

GORGE INDEX

As shown in Figure 6, we defined the gorge index as the following:

$$g = \frac{1+\cos\alpha}{2}$$

Here, g ---- the gorge index;

α ---- the angle indicating narrow passage with steep rocky sides.

The range of g is from 0 to 1. When g = 0.5, it indicates this is a gorge. The more g is close to 1, the more the rocky sides are steep, even an appearance of “line-sky”.

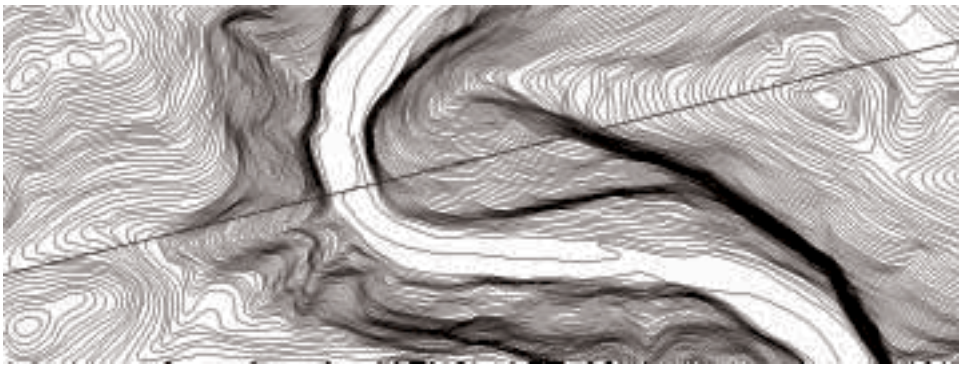

Figure 10. A Cutaway Line through a Point of River-route.

To calculate angles, we can draw cutaway lines through points of the river-route one by one, and then find the most steep connecting line from river-route to the set of intersections with contour lines along two sides of the coast (refer to Figure 10).

3.1.1. Tortuous Frequency Index

According to a set of angles to turn round along a river, a curve can be formed. It should be pointed out that such a curve does not change because of river's location (refer to Figure 11). Then Fourier progression can be used to decompose the curve. Those frequencies having larger amplitude suggest the range of keenness to zigzag. The tortuous frequency index of a wriggle river can be measured by time per hundred kilometres.

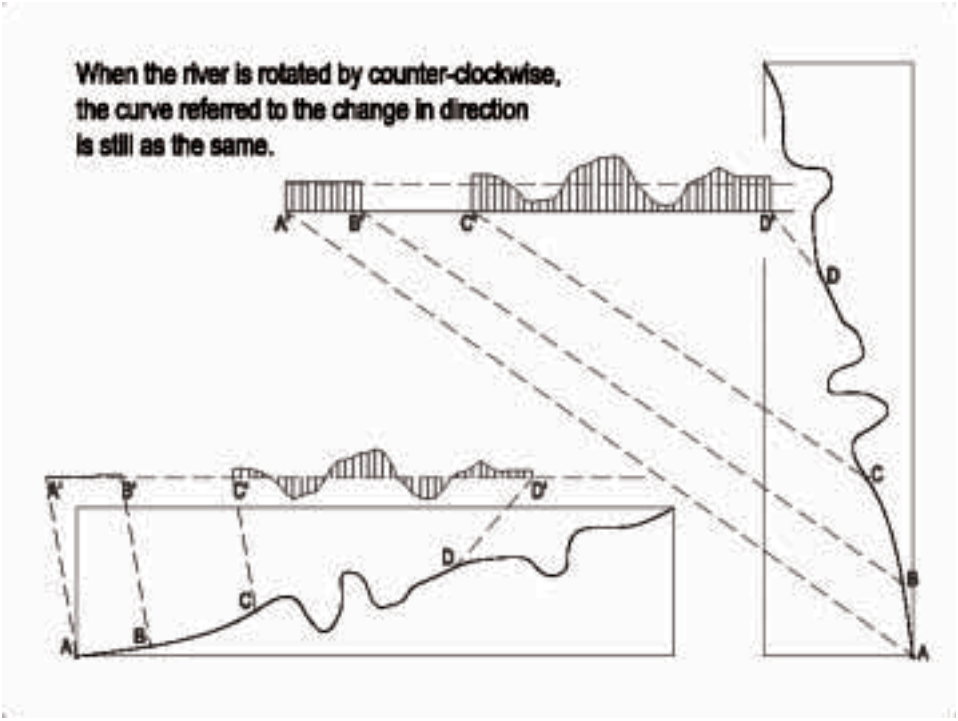

Figure 11. The Curve Refers to the Change in Direction.

3.2. REMITTENT FREQUENCY INDEX

The feature of close and open space alternately in three-dimension can be represented by a set of changes in visual angle. However, such a visual angle has a corresponding relative to the angle shown as Figure 6 (also refer to Figure 12). Thus remittent changes in 3D space can be measured by the set of the gorge indices along a river. Like tortuous frequency index, we can use Fourier progression decomposition approach to gain the remittent frequency index.

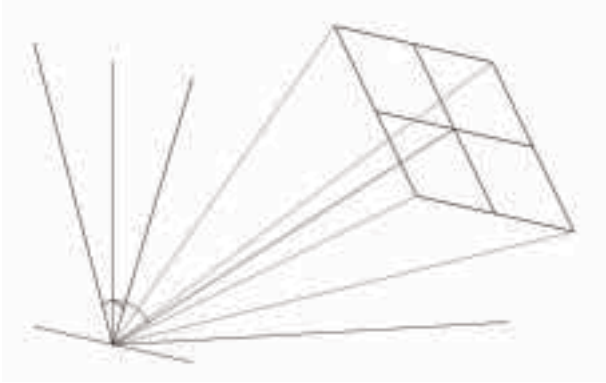

Figure 12. Angle in Vertical Level corresponding to Real Visual Angle.

4. Results of Analysis

Our digital method and several key quantitative indices aimed the type of river valley landscape has been applied in an information system for supervising and protecting national parks in China. Relative algorithms were actualized through secondary development in VB based on a GIS software platform—SuperMap (made in China). The basic space / attribute data come from the Lesser Three Gorges.

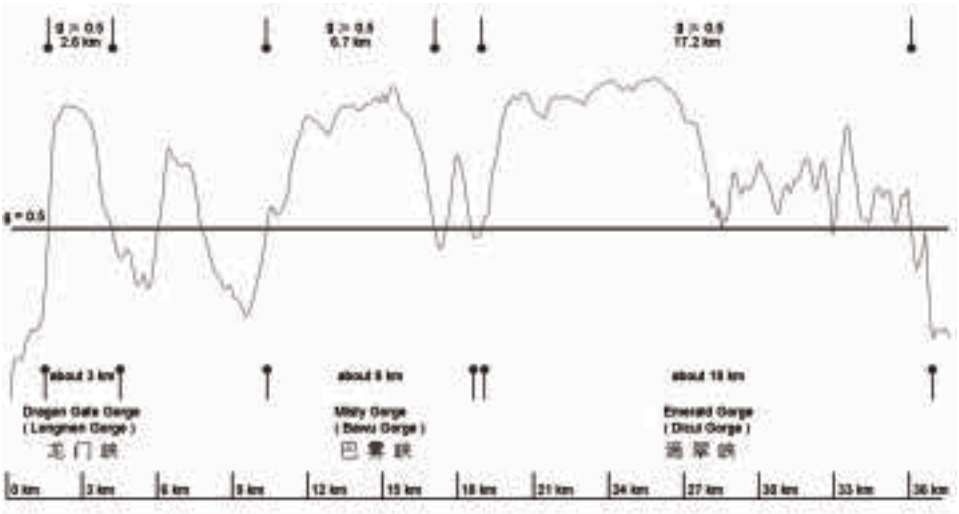

Figure 13. Value Curve of Gorge Index.

We have gained some meaningful results, which suggest that these indices are available to evaluate numerically the landscape quality of a river valley. The following figures are part of our analytical results.

In guidebooks we may find that the lengths of the Lesser Three Gorges are respectively about 3 km, 8 km and 18 km. According to the value of gorge index shown in Figure 13, the gorge lengths that $\boldsymbol{g}$ 0.5 continuously are 2.6, 6.7 and 17.2 km one by one. These values are logical considering the hint reason as in Figure 12. The Emerald Gorge is the longest gorge. Its values of $\boldsymbol{g}$ are all larger than 0.5, and have a fluctuant change. This suggests that its remittent frequency would be high and is one of reasons that enable Emerald Gorge to become the most beautiful gorge.

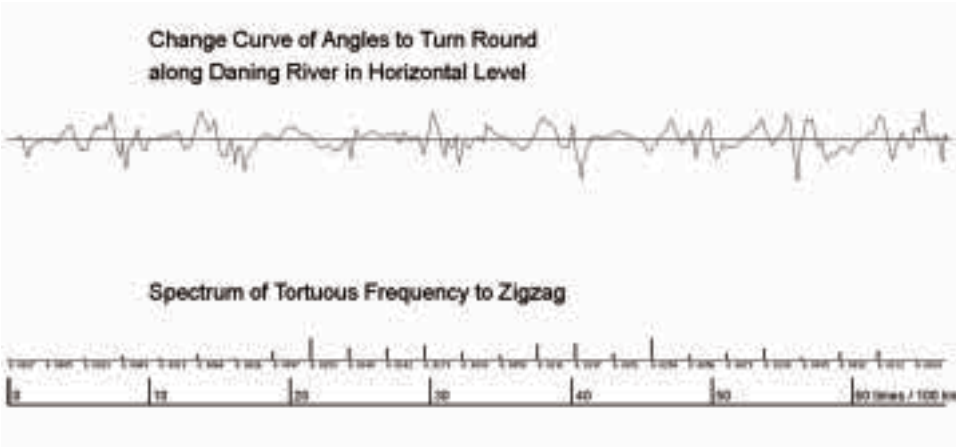

Figure 14. Change Curve of Angles to Turn round along the River and its Frequency Spectrum.

With respect to keenness to zigzag, from Figure 14, we can know that those frequencies behaving higher amplitudes concentrate in a range about from 20 to 50 times per hundred kilometres. This means there will be a lesser keenness almost per 1–2 kilometres, and then a larger one per 4–5 kilometres. In fact, travellers would be zigzaging continuously with imposing scenery of fields, gorges and the river.

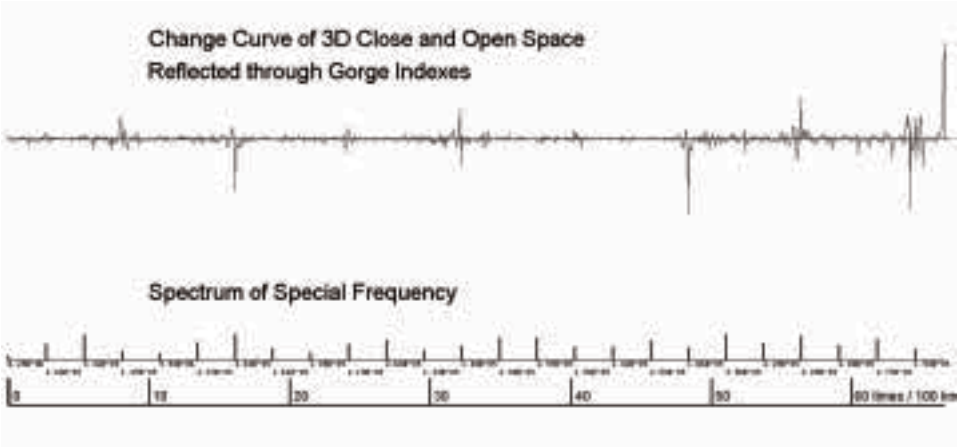

Figure 15. Alternative Change in Close and Open Space and its Frequency Spectrum.

At the same time, the remittent changes in 3D space are frequent. Figure 15 shows that this type of change is mainly relative to higher frequency, especially in Emerald Gorge (tail section of the above curve). After thorough Fourier progression decomposition, we can see the amplitudes are distributed averagely almost in all frequencies, viz. each frequency would play an important role (this is somewhat like a type of "white noise"). It makes people just about to experience a series of tense and loose feelings by close and open space alternately at an interval maybe about 1–2 kilometres. Think about the difference between Daning River and Liliang River at Guilin, Guangxi province. The two rivers are similarly wriggly. However, only the former can give travellers such a remittent feeling. From this point, the remittent frequency index probably is a key index of river valley landscape.

Figure 16. A Picture of Mainly Sketching.

In addition, a picture like Figure 16 would represent the features of a river valley landscape mainly through those contour lines of mountains and the river. Thinking of this, we used Chinese wash painting for reference and developed a program module dynamically to display the view series from the entrance of Dragon Gate Gorge, right at the outfall of Daning Rive, to Dachang, an upriver town.. The module can be used on other occasions. As an additional approach to evaluate landscape resources dynamically, its effect is good and the computer time is also less because of time save in plastering real material texture. The following are some intercept figures.

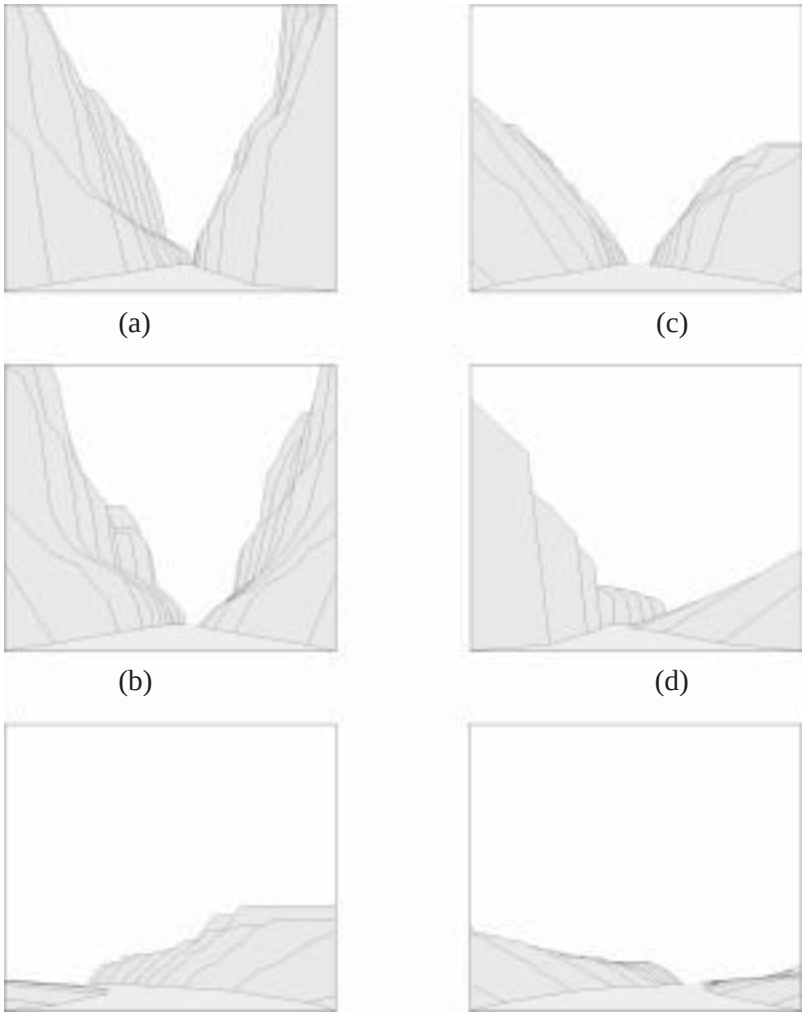

Figure 17. Some intercept figures from our module.

Conclusion and Discussion

We have introduced the digital method aimed at the type of river valley landscape and several key quantitative indices. The approach has been applied in an information system for supervising and protecting national parks in China and shown this method as available and useful. Taking the Lesser Three Gorges as example, we have gained some meaningful results, which suggest that these indices are available to evaluate numerically the landscape quality of a river valley and relative algorithms are verified as being useful.

Nevertheless, there exist several problems. First, we basically considered landscape features from the respect of their special forms and let pass those features expressive mainly in material, lustre and colour, etc. Second, we used GIS only as a tool to manage large quantity of special information and the algorithms deal with its analysis function a little. Third, our research work focused on landscape starting from shape and how to join this to landscape starting from ecology remains a challenge.

Acknowledgements

The work was sponsored by the Chinese national key project of science and technology (2002BA107B-11). Shuang Zhang has made some contribution in formulation of index system as a graduated student for Master in Architecture Science and Technology.

References

Forman, R. T. T. & Godron, M. 1986, Landscape Ecology. New York; John Wiley & Sons.

Forman, R. T. T. 1995, Land Mosaics: The Ecology of Landscapes and Regions. Cambridge; Cambridge University Press.