Landscape planning of route-based visibility analysis

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Abstract—**Landscape scenery is an extremely important resource not only for tourism but also for the quality of life. Hence there is a need to classify and manage landscapes. This paper shows how viewshed analysis based on the mobile viewer can be used to evaluate a route and provides a method for assessing the landscape planning of highway. Bresenham algorithm is adopted to select the candidate points to calculate the visibility. This research represents a new method toward the development of geographic information system tools which could provide visual information for making decisions for route-based visibility analysis.**

Keywords—**Visual resources; Viewshed; Spatial analysis; Digital Elevation Model**

I. Introduction

As an essential function in GIS systems, visibility analysis provides the ability to analysis the visible areas or judges the intervisibility between two points. There are plenty of applications in various fields such as optimal path planning [1, 2], determining visual impact of quarries [3], analyzing slow-moving landslide-affected areas [4], wind turbine placement [5, 6] and archaeological landscape research [7, 8].

Landscape design of highway has been abstracted widely attentions in recent years. It is deemed that landscapes are considerably more than just what is seen and perceived. Objective visual analysis could be achieved by viewshed approach which is a widely used technique in the Geographic Information System (GIS) [9].

By means of the quantitative analysis of inter-visibility, Montis and Caschili study the Nuraghes and landscape planning integrating viewshed and complex network analysis [10]. Results show a hierarchical organization and not a random structure in the inter-visibility network, and the inter-visibility among these towers is plausibly connected. Previous work by Castro et al. [11] analyzes the distance visible to a driver on the highway for the highways design and presents a corresponding procedure supported by a GIS. The preliminary experimental results show that sight distance estimation based on GIS has viability which could be similar distances compared with highway design software. In order to link a visibility evaluation to aspects of vision and perception, Chamberlaina et al. recently adopt visual magnitude to calculate the amount of visibility by quantifying the effect of slope, aspect and distance of an area [12]. This composite derivative could be used for route-based applications so that planners can better understand how what is visible may relate to an individual’s judgment and response. Based on this work, we proposed a new descripiton of visibility analysis of mobile viewer and set the Mount Lushan the study area.

In general, as one moves away from the viewpoint a point is visible only if its elevation angle is larger than the largest elevation angle already found between the point and the viewpoint. We adopt the Xdarw algorithm to computer the viewshed [13].

II. Methods

A. Study area

For these considerations of specific location of Mount Lushan and current traffic, this paper selects four routes as linear features for the viewshed analysis of moving points and evaluates the visible landscape on the basis of the distance between routes and the core regions of Lushan. As can be seen in Fig. 1, there are two non-motorized routes and two motorized routes.

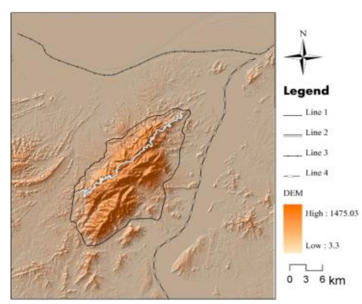

Figure 1. Fours routes of Lushan area for the viewshed analysis of moving points

In order to achieve the evaluation of landscape in road planning, this section selected Mount Lushan area highway as line 1 for visibility analysis. As one only route between Xiufeng Scenic Spot and Jiujiang Jiujiang City, Line 1 is located at the border of Xingzi County, Jiujiang County and Lushan District, and its length is 56.2 km. Line 2 is a mountain road through many important scenic spots of Mount Lushan. For the evaluation of close landscape by visibility analysis, this road is located in the Mount Lushan. Line 3 is a segment shipping line of Changjiang River route from Wuhan City to Anqing City with about 50 km length, where people could visit the northbound Mount Lushan landscape over long distances. Analogously, line 4 is another segment shipping line from Poyang Lake to the confluence of Changjiang River and Poyang Lake, where the water slowly moves and the natural scenery is beautiful. The details of these four lines are shown in Tab. 1. In this table, the average distance is measured from points on each line to Great Hanyang Peak.

TABLE I. DETAILS OF FOUR ROUTES

Route	Name	Length (km)	Average distance (km)	Speed (km/h)
Line 1	circling highway of Mount Lushan	80.7	21.7	50
Line 2	sightseeing route	43.2	10.8	30
Line 3	Changjiang River shipping line	50.9	31.7	25
Line 4	Poyang Lake shipping line	53.8	25.6	15

B. Notation

The moving-point visibility is defined as the viewshed computation from a viewer-point along specific path. After the calculation, we would get all the visible area from the path, which could be served as a reference to some decision support, such as traffic management, environmental planning and visual navigation.

We suppose the complexity of moving viewer is a simple point of DEM, target area is the whole Mount Lushan and around areas. The moving-point visibility issue could be represented as follows:

$$f\left(OSh, OSt, OM, PS, PEf, CTy\right) \tag{1}$$

$$\text{s.t.}\begin{cases} OSh = \sum_{i=1}^{k1} fl + \sum_{j=1}^{k2} fb \\ OSt = 1 \\ OM = f_{ltop}\left(fl\right)/n \\ PS = ax + b \\ PEf = 2 \\ CTy = fvsh\left(OM, PS\right) \end{cases} \tag{2}$$

where *Osh* denotes the geometrical shape, *OSt* is the status of movement, OM is the number mapping of viewer and target points, *PS* is the shape of LOS, *PEf* is the visual effect and the *CTy* is the output mode of current analysis. Because the Landscape planning does not require high-precision visibility, here the value of *PEf* (*PEf* =2) identified low visibility precision.

C. Viewshed calculation

The route of visibility analysis will be transformed in to a visibility set by the Bresenham Algorithm (Fig. 2). A problem should be considered is the selection of viewer-points. If the application adopts many viewer-points so as to obtain an approximate simulation of real word, the calculation time of viewshed analysis will be increased rapidly, and vice versa. Hence, an appropriate threshold should be selected to get visibility points. The candidate points should satisfy two conditions:

(1) The Euclidean distance between candidated point and last point should be greader than *CellSize* * *CellSize*/10, where *CellSize* is the resolution of DEM.

(2) If there are at least 3 point in the 3×3 neighborhood, this point might be a turning point of the projection line of route.

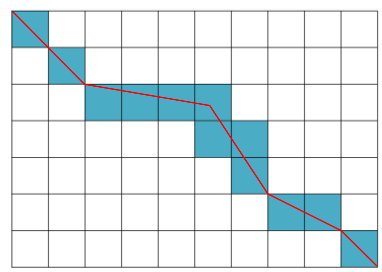

Figure 2. Selection of viewshed points

III. RESULTS

The analysis results of this method discussed above are shown in Fig. 3. The details of the visibility analysis of these four routes are summarized in Tab. 2.

TABLE II. DETAILS OF VISIBILITY ANALYSIS OF FOUR ROUTES

Route	Total visible area (km^2)	Visible area of Mount Lushan (km^2)	Average elevation (m)
Line 1	1145.5	151.2	95.3
Line 2	1656.6	102.0	594.4
Line 3	306.3	87.4	10.4
Line 4	615.3	97.2	11.4

The visibile of Line 1 covers the area around this route and some hillside of Mount Lushan. In the viewshed analysis result of Line 2, it convers almost all the area of Mount Lushan and the around area, as the elevations of this route are high enough. The coverage area of Line 3 is the northern slope of Mount Lushan and the coverage area of Line 4 is mainly the eastern slope.

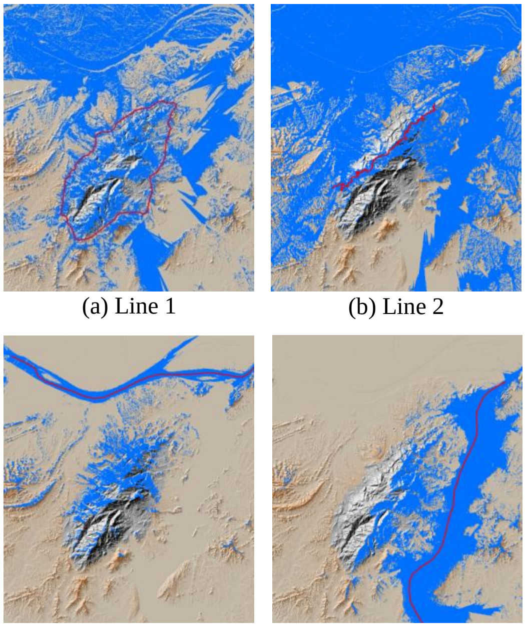

Figure 3. Viewshed analysis of four routes

In order to investage the variation of the visible area upon Mount Lushan, this paper selects fifteen points of these four routes equally (Fig. 4). The visible areas of these points are shown in Fig. 5.

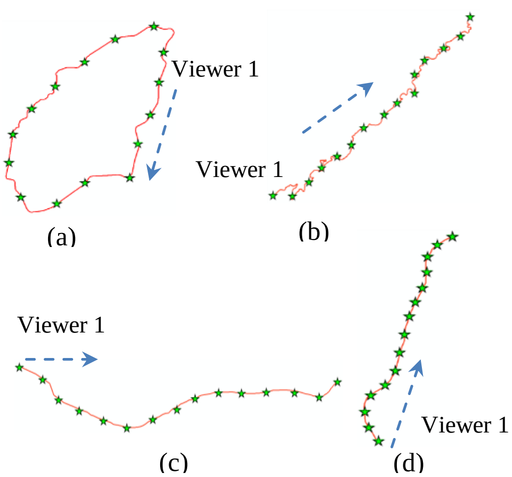

Figure 4. Fifteen view points of four routes

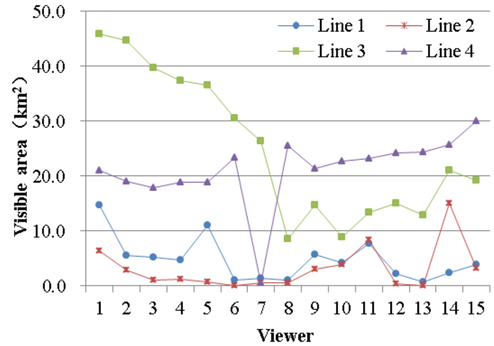

Figure 5. Line chart of fifteen mobile points

IV. CONCLUSIONS

Viewshed analysis provides a quantitative method for the visibility applications, such as landscape design and forestry. This paper proposed a new method to analysis the total visible area of routes and this method could be used in the highway design and tourism planning.

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