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Utilizing Fractal Dimensions as Indicators to Detect Elements of Visual Attraction: A Case Study of the Greenway along Lake Taihu, China

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Abstract: It is widely acknowledged that the quality of greenway landscape resources enhances the visual appeal of people. While most studies have evaluated visual perception and preference, few have considered the relationship between the distribution of greenways in relation to the proximity of water bodies such as lakes and rivers. Such an investigation requires an in-depth analysis of how to plan and design greenways in order to better enhance people's willingness to access and utilize them. In this research we propose specific color brightness and contour visual attraction elements to further discuss the quality of greenway landscape resources in the rapidly urbanizing Lake Taihu region of China. Specifically, we utilize a common method in fractal theory analysis called counting box dimension to calculate and analyze the sample images. The method generates data on fractal dimension (FD) values of two elements; the optimal fractal dimension threshold range; the characteristics exhibited by the maximum and minimum fractal dimension values in the greenway landscape; and the relationship between the two visual attraction elements allowing us to derive distribution of the greenway and water bodies. The results reveal that greenway segments with high values of the visual attraction element of color brightness fractal dimension (FD) are significantly closer to the lake than those subject to high values of the visual attraction element. Some segments are even close to the lake surface, which is because the glare from the direct sunlight and the reflection from the lake surface superimposed on each other, so that the greenway near the lake surface is also affected by the brightness and shows the result of high color brightness values. However, the greenway segments with high values of contour element FD are clearly more influenced by plants and other landscape elements. This is due to the rich self-similarity of the plants themselves. Most of the greenway segments dominated by contour elements are distant from the lake surface. Both color brightness and contour elements are important indicators of the quality of the visual resources of the Lake Taihu Greenway landscape. This reveals that the determination of the sub-dimensional values of color brightness (1.7608, 1.9337) and contour (1.7230, 1.9006) visual attraction elements and the optimal threshold range (1.7608, 1.9006) can provide theoretical implications for the landscape planning and design of lake-ring type greenways and practical implications for assessing the quality of visual resources in greenway landscapes.

Keywords: color brightness; contour; visual attraction; fractal dimension (FD); boxplot; Lake Taihu

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1. Introduction

An important type of linear landscape space, the greenway plays an important role in connecting various nodes between regions [1]. Designed with green planting configurations, they often link regional scenic spots, human heritage sites, ecological reserves, towns and villages, wetland parks, urban parks, and healing resorts [2], and carry a variety of functions such as ecological restoration [3], transportation [4], cultural heritage [5], heritage protection [6], fitness landscape [7], and tourism [8]. They are of great importance in promoting a regional perspective on the construction of eco-towns. As a result, the planning and actual construction of greenways is currently receiving unprecedented attention in many areas and some countries have undertaken the construction of greenway systems. Since the 1980s, China's greenways have ranged from localized neighborhood greenways, urban greenways, suburban greenways, and regional greenways to the planning and construction of national greenway networks, with several thousand greenway projects planned and constructed. Greenway construction is gradually becoming an international movement providing an effective means of improving the quality of life of regional habitat through the application of environmental restoration and conservation efforts [9].

It is worth noting that the visual resources of the Lake Taihu Greenway (LTG) landscape are under consistent threat of impact by rapid urbanization [10,11] and human activity [12]. These visual resources are made up of different landscape elements, in order to achieve the purpose of restoring the landscape visual resources of the LTG. This study began with a basic cataloguing of all visual elements in the greenway. Through an extensive literature review process, we were unable to identify little emphasis on research into the visual attractiveness of greenway analysis. The basic elements of landscape visual design are points, lines, planes, solid volumes, and open volumes. The classification of these elements is often conducted at a macro-level and does not specifically evaluate the elements of visual attractiveness in the landscape [13]. In addition, the elements of visual attraction in landscape have a clear classification and focus on the human eye being attracted to the elements of the landscape. The visual appeal elements of the landscape are spatial scale and distance, solids, boundaries, colors, lines, shapes, ephemeral natural phenomena, vegetation, textures, bodies of water, dynamic scenes, and sunlight [14] (Table 1). Landscape visual design elements are classified from a design perspective, while landscape visual attraction elements are classified from a human perception perspective.

Table 1. Comparison of the two element types.

Type	Elements
landscape visual elements	point, line, plane, solid volume, and open volume
landscape visual attraction elements	spatial scale and distance, solid, boundary, color, line, shape, transitory natural phenomenon, vegetation, texture, waterbody, dynamic scene, sunlight

Previous research has found that color brightness and contour elements are elements of visual attraction in landscapes [15]. The visual attraction test was carried out with reference to experiments in the discipline of psychology. It is very clear that locations with high color brightness are more likely to be picked up by the human eye (Figure 1). Rich and varied contour lines are more visually appealing than less varied contour lines, significantly different from other graphics (Figure 2) [16]. However, when these two elements are commonly tested separately, the intensity of visual attraction in the landscape may not be significant.

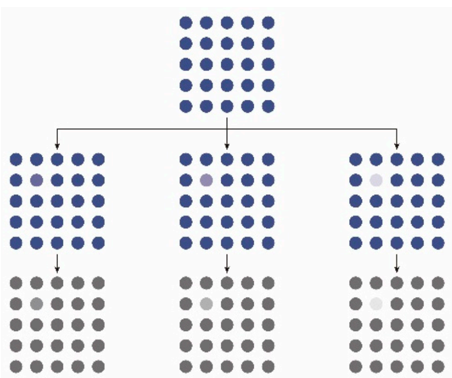

Figure 1. Color brightness experiment.

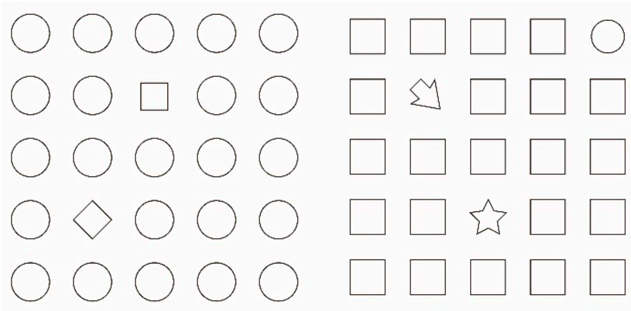

Figure 2. Contour experiment.

Fractal theory suggests that irregular landscape patterns reveal the attractiveness of layered color brightness and contour attraction elements in nature because of the statistical self-similarity [17,18] and complexity [19,20] of fractal elements. Mandelbrot was a renowned mathematician and economist, and the founder of fractal theory. He gave the following definition of self-similarity. When each portion of a shape is geometrically similar to the whole, both the shape and the cascade (the generating mechanism for the details of the shape) that generate it are called self-similar [17,21]. Research over the past decades has shown that the complexity of fractals refers to the variation of the details of the fractal pattern with scale. Complexity can describe problems with a very large number of variables, where each variable has its own unstable behavior or may be completely unknown. The analysis of complexity reveals structural features of fractal meter boxes and produces systematic changes as parameters are varied [22,23]. The algorithm of box counting fractals in fractal number theory can attenuate the influence of subjective factors in the evaluation process, so that the variability of the visual attraction elements of the landscape of the LTG can be objectively reflected. Based on the principles of fractal number theory and the above experimental results, the contour lines have typical irregular shapes and self-similarity. Color brightness can be expressed because of the strength of brightness by means of the black and white binary image analysis of fractional dimensional number theory. Therefore, we hypothesize that these two elements have a significant impact on the visual attractiveness of the Taihu Greenway landscape and be able to assert within what threshold range these two elements can achieve the highest visual attractiveness values.

Specifically, due to the width of Lake Taihu, the human eye cannot see the shoreline on the opposite side of the lake but can see the sky in the distance connecting to the lake along the horizon. The greenway immediately adjacent to the lake is subject to the glare of sunlight reflecting from the lake, producing a stronger light, which is related to the color brightness. Further from the lake the greenway links different landscape elements based on spatial scale and relative position [24], highlighting elements such as vegetation types, road boundaries, physical buildings, landscape structures, dynamic scenery, texture, etc. These elements have a richer contour than the water surface and are all factors in determining the high or low visual attraction value of the landscape [25,26].

For these reasons the LTG was selected as the research site. Building upon our hypothesis that color brightness and visual contours can be measured to reveal visual attractiveness in a landscape, we engage the following research questions: (1) Does the landscape color brightness of the greenway significantly increase immediately adjacent to the lake? (2) Does the landscape contour of the greenway become richer away from the lake? (3) Are the two landscape visual attraction elements important indicators of the quality of the visual resources of the LTG? (4) Do the two landscape visual attraction elements influence the distribution of the greenway in relation to the lake?

2. Data and Methods

2.1. Study Area

The study area for the case study is Lake Taihu (Figure 3) situated in the Yangtze River Delta (30°55′40″~31°32′58″ N and 119°52′32″~120°36′10″ E). Lake Taihu is one of the largest freshwater lakes in China with typical characteristics of a shallow and subtropical lake in the region. Its watershed draws from an area of 36,895 km^2 including 3192 km^2 of open water [27]. It is in one of the most rapidly urbanizing and economically productive regions of Yangtze River Delta and is an important resource for tourism and healthy recreation while also supporting a rich diversity of ecological conditions [28]. In recent years, the continued expansion of urban development in the Yangtze River Delta has had a negative impact on supporting the ecological stability of Lake Taihu. These activities have also affected the visual attractiveness of landscape resources along the Yangtze River Delta, and issues such as damage to visual resources need to be urgently addressed. The LTG is therefore the most appropriate location to study the type of greenway around the lake.

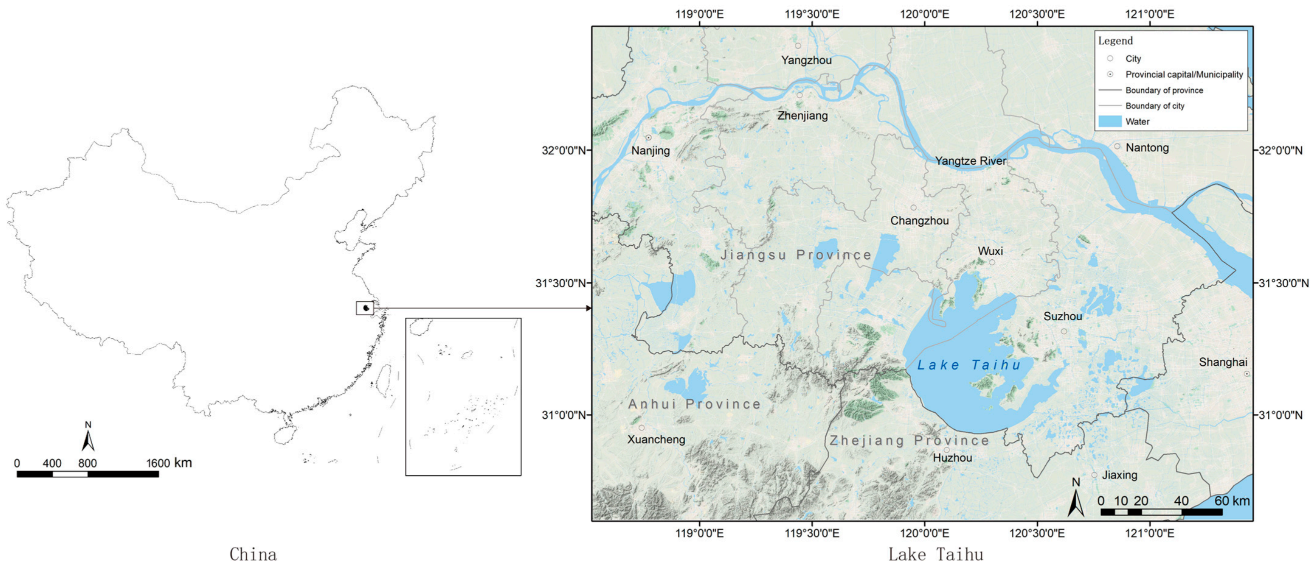

Figure 3. The case study area.

2.2. Experimental Data Investigated

The LTG connects the cities of Changzhou, Wuxi, Suzhou, and Huzhou in the Jiangsu and Zhejiang Provinces. For the purposes of this study, we installed two-step outdoor assistant software on our mobile phones to record the location of the greenway under study and the 118.52 km of greenway suitable for use in fractal theory research. Informed by previous research utilizing fractal theory to study the British shoreline [29] we assessed the section of LTG with the greatest variation in lake adjacency and ecological richness. We began our data collection work from the city of Wuxi, closest to the shoreline of the lake, and set this point as A. We then travelled north along the greenway immediately adjacent to the lake. We collected data in points with open landscape spaces, heavy visitor use, large public buildings, scenic spots, wetlands, and urban parks. Each test point was labelled A–O in the order the data were collected (Figure 4). These locations were selected as test points because they are close to the lake and can effectively support the study of color brightness attraction elements [30]. Greenways sections that are further away from the lake, or even through the city, were not included in this study. In addition, these 15 test sites were selected because they all have the characteristics of open space and contain rich visual attraction elements of the landscape, which can effectively support the study of contour attraction elements [31]. According to the division of China's urban administrative regions, the A–E section of our study is located within Changzhou City, Jiangsu Province, and the F–O sections are in Changzhou City (Figure 5).

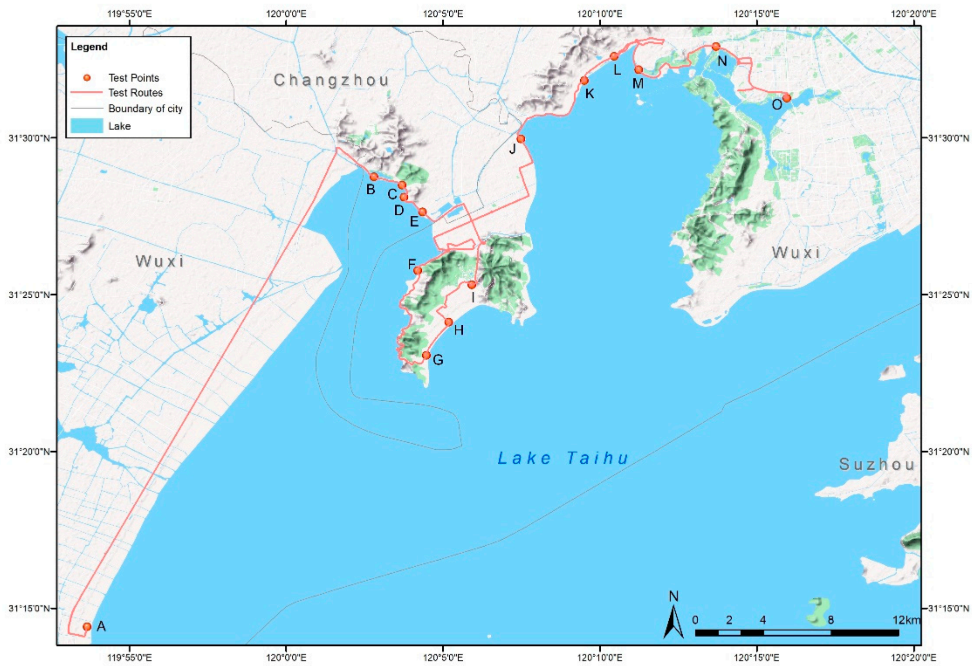

Figure 4. The A–O test points.

Figure 5. The sample (**A**–**O**) of optimal threshold range.

Data collection took place in the morning (8:00 a.m.–12:00 a.m.) and afternoon (1:00 p.m.–7:00 p.m.) of 11–13 November 2020, when the weather in the LTG area was sunny and of a suitable temperature. The autumn vegetation was rich in color [32] and is a peak time for people to be outdoors [33]. Ten experts and professors in the fields of urban and rural green infrastructure planning, environmental psychology, visual perception, and other related research were invited to evaluate and select the photographs obtained on site. The final 124 photographs were then discussed by the panel and selected for testing. Both the expert panel and the research group's criteria for the test photographs included good photographic quality and significant differences between each test section. The team took a total of 2078 photos, 9 photos each of the 15 test sites in the A–O test section, near the lake and away from the lake, for a total of 135 photos of the greenway. Nine photographs were excluded from the test, and 124 photographs were selected for testing.

2.3. Methods

2.3.1. The Theory of Fractional Dimensionality and Its Methods

Fractal dimension (FD) analysis is a commonly used indexing method for visually assessing feature design, fractal art, fractal information, and shape classification in many research fields from mathematics to the design disciplines. The concept of fractal dimensions has been explored in mathematics since the 1600s but it was not until the latter half of the 20th century when mathematician Benoit Mandelbrot first coined the term when he discovered a high correlation of self-similarity between geographical curve length and its detail across spatial scales [29]. The self-similar structure of FDs is suitable for analyzing the irregular patterns in nature [34] that are distinct from Euclidean geometry [21]. The typical irregularity of landscape patterns can be analyzed by FD theory and described by law of proportion to assess visual attraction [35].

Several distinct methods can be used to assess the FD; however, the most common are box-counting, the variance approach, and spectral assessment [36,37]. For visual assessment, box-counting is the simplest method to apply through which visual data are analyzed for self-similarity across spatial scales from a large area into component parts of greater and greater detail [38]. This method has been tested by researchers across a range of disciplines to analyze, for example, city skylines [39], coastlines [40], and visual arts [41], yet the quantitative analysis of visual attraction for landscape elements has yet to be considered. For this research, we use the box-counting method to determine the objectivity and regularity implied in the foundations of visual attraction related to contour and color brightness (Figure 6).

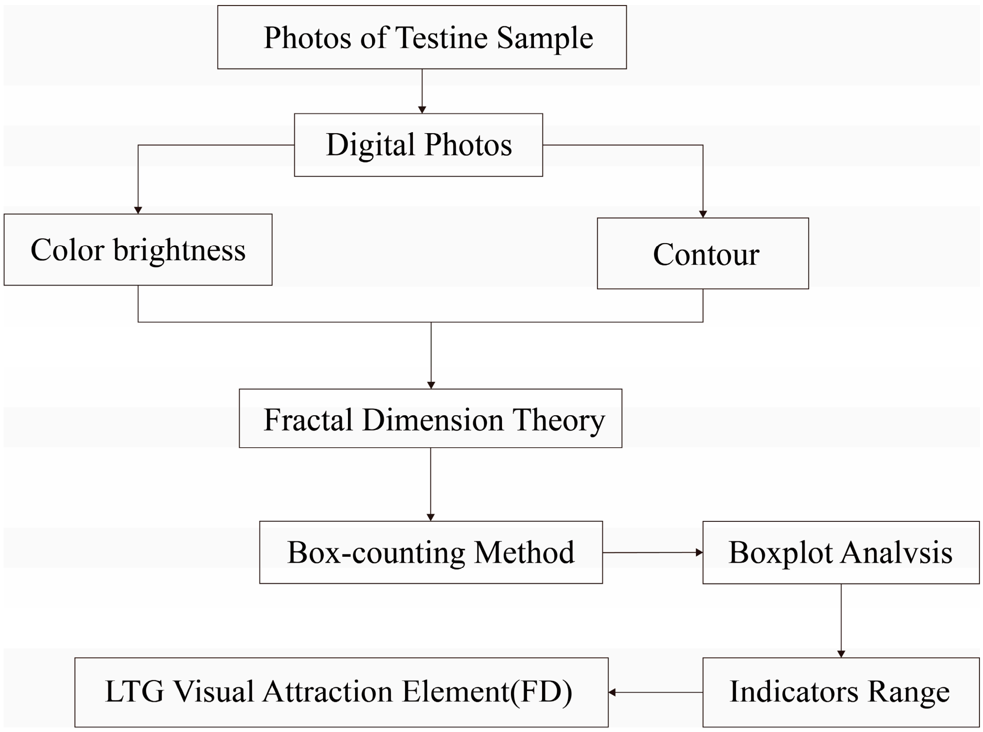

Figure 6. Study method flowchart.

Fractal Dimension

Fractal is a new geometric language that may be used to describe objective objects in nature and human culture [42]. It is a new field of modern mathematics that compensates for the limitation of classic Euclidean geometry to quantitatively describe complex, relational forms. As a result, fractal theory was developed to express the irregular, yet self-similar geometric structures. Some patterns in nature follow defined geometric laws, while others do not. Many reveal patterns of self-similarity in the relationships between a part and the whole in terms of shape, structure, information, function, time, and energy.

For Euclidean fractals (D), the diminishing linear size in each spatial orientation to 1/r results in N = rD times of original size in its measurement (length, area, or volume). The equation can be advanced by adding the logarithm of both sides of the equation as log(N) = Dlog(r), from which a result of Fractal D can be identified. Thus, Equation (1) is derived:

$$D = \log(N)/\log(r) \tag{1}$$

When applied to the objective world, D can be a fraction, and does not have to be an integer. The value range of D is from 1 to 2.

Box-Counting Fractal Dimension

The Boxing-counting method involves covering the fractal object under investigation with a two-dimensional grid of diminishing size. A box-counting dimension formula is used to calculate the fractal dimension of the research item by computing the number of two-dimensional grids filled by the fractal object. The box-counting dimension is used by most researchers in the study of landscape visual complexity to compute the fractal dimension, and the numerical precision of the computation is governed by the image size [43].

Box-counting for FD is also termed as box fractal dimension or Minkowski fractal [44]. It is a quantitative method for measuring distance (X, d), particularly in Hausdorff space, as the fractal dimension of ε in Euclidean space. The method for calculating fractal dimensions is to overlay the fractal on an equally spaced grid, and to count the number of grids covered by a given fractal. With gradual refinement of the grids, the variability in the number of grids covered by a given fractal is recorded to calculate box-counting fractal dimension.

$$D_{box} = \lim_{\varepsilon \to 0} \frac{\log N(\varepsilon)}{\log(1/\varepsilon)} \tag{2}$$

In Equation (2) [45], D_{box} refers to box-counting fractal dimension; $N(\varepsilon)$ is the number of small graph; $1/\varepsilon$ is the length of segments of each small graph.

Boxplot Analysis

To assure the correctness of the test values, we used the box plot's intuitive expression approach to minimize outliers examined by the box-counting dimension while retaining the legitimate value range. A box plot is a statistical graph that displays information about the collection of data's dispersion. It is created using regularly used statistics and can give important information about the data's location and dispersion; named from its box-like shape. It is mostly used to represent the features of the original data distribution, but it may also be used to compare the distribution characteristics of several data sets. It can show the highest, lowest, median, and upper and lower quartiles of a collection of data. The Boxplot was a popular univariate data display originated by John W. Tukey [46] who described it as a "schematic plot", and the box-and-whiskers plot [47,48]. The rectangle box has two lines which are extending from opposite edges of the box. The ends of the lines represent the upper limit edge and lower limit edge. The third quartile and first quartile are distributed on both sides of the median which is a line parallel to the two limit edges. The boxplot displays two quartiles, with potential outliers and the median [49] (Figure 7).

2.3.2. Analysis

Fractal theory was selected to analyze the visual attraction elements of the landscape color brightness and contours of the Taihu Greenway, due to the characteristics of the fractal theory described above. The A-1 image from the test map was first chosen as an example (Figure 8). In the binary diagram generated by a Fraclab 2.2 operation, trees, shrubs, and footpaths can be quantified by a grid of different cell side length scales r, each with a number of small squares N. Equating each square side length r to form a new square side length scale is called one iteration. When the side lengths of the square grid keep on iterating r = 1, r = 1/2, r = 1/4, r = 1/8, ..., the number of squares N increases and extends in an endless iteration, and the more accurately the side lengths of the irregular contours can be calculated. The graph after each iteration reveals a high degree of self-similarity to the shape of the graph before the iteration. The properties of the box-counting dimensionality method of fractal theory are therefore well-suited to the analysis of irregular contour elements in the landscape.

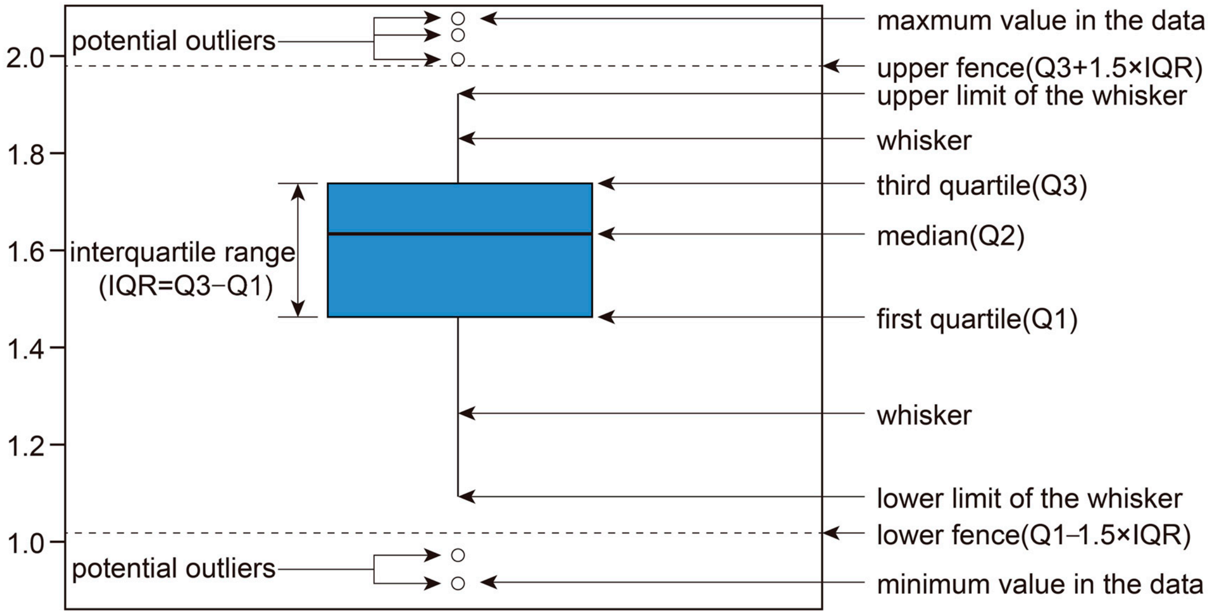

Figure 7. Main components of a boxplot.

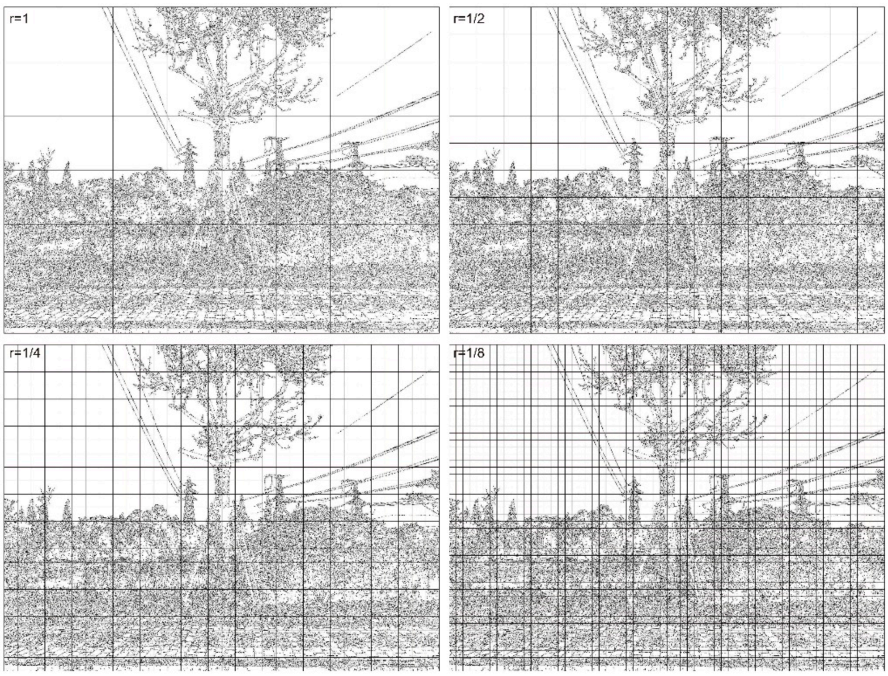

Figure 8. Calculation principle of box counting dimension.

The A-1 diagram output has only two colors, black and white, but to match the visual physiological mechanisms that people use for image recognition. We have switched the two colors of black and white in the diagram, changing the lines that appear black on the diagram to a white presentation, and changing the lines that appear white on the diagram to white. In this way, we believe that we can use the box-counting dimensionality method for the representation of both black and white colors using color lightness intensity. We also chose Boxplot to analyze the values of the two elements because Boxplot can eliminate invalid data that appear in the analyzed data and ensure the concentration and accuracy of the threshold range of the sub-dimensions.

3. Results

3.1. Overview

The 124 test samples were initially imported into MATLAB R2015a software for image processing, and two binary maps of each image were obtained for each sample. Second, the binary maps of these images were imported into Fraclab 2.2 software for calculation to obtain the fractional dimensional values of color brightness and contour elements respectively. Lastly, outliers were removed by plotting box plots to obtain the optimum threshold range between the two elements. This objective reflects the extent to which people's eyes are focused on the strength of the color brightness and contour elements in the Taihu Greenway (Figure 9).

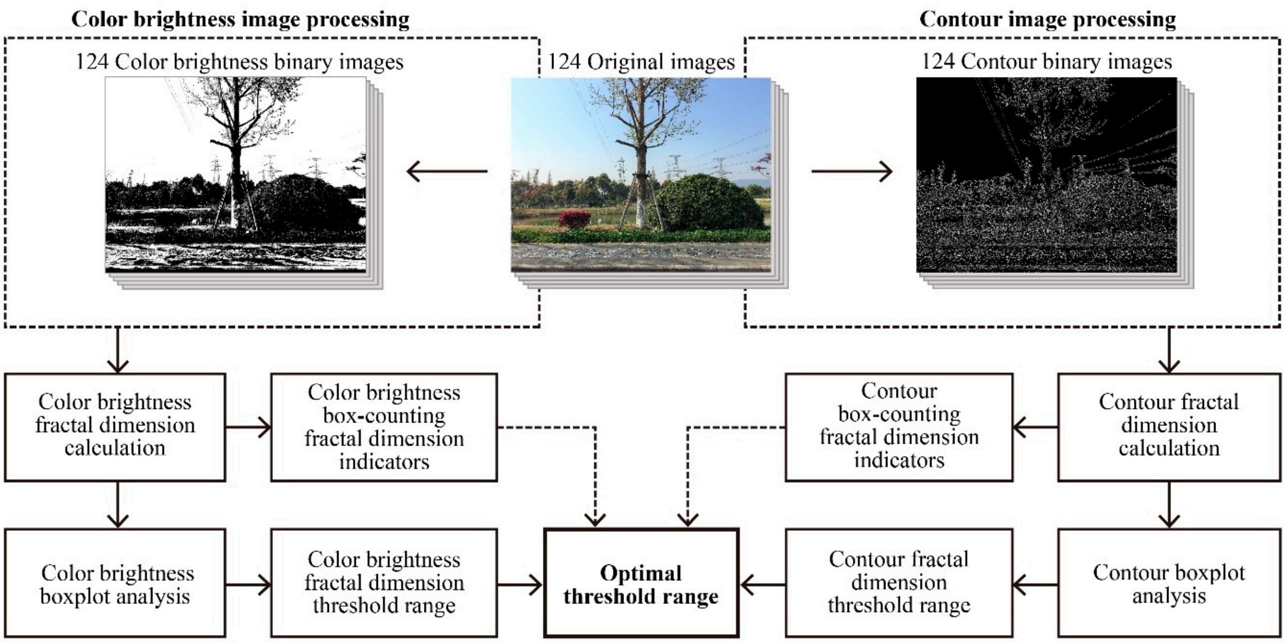

Figure 9. Experimental technical route.

3.2. Image Processing Process and Dimensional Calculation

To quantify the indicators of visual attraction elements of color brightness and contour in LTG, the original image was processed into a visual digital image, and data analysis and numerical calculation were performed. The research team performed data analysis on 124 sample images of 15 test points on a computer with Intel(R) CoreTM i7-8750H and 8.00 GB of RAM and obtained the color brightness and contour binary images and their fractal dimension indicators.

3.2.1. Image Processing Process

A total of 124 image samples were imported into MATLAB R2015a, and the color lightness and contour codes were input for calculation. Each sample image displayed two binary images, which are the color lightness binary image and the contour binary image (Figure 10).

Figure 10. The sample A-1 of binary image. (**a**) A-1 Color brightness binary image. (**b**) A-1 Original image. (**c**) A-1 Contour binary image.

```
Matlab code for color brightness image processing
1. A = imread('A-1.jpg')
2. B = rgb2gray(A)
3. C = im2bw(B,0.5)
4. D = double(C);
5. Figure
Subplot(1,2,1);imshow(A)
Subplot(1,2,2);imshow(D)
6. End
Matlab code for contour image processing
1. A = imread('A-1.jpg')
2. B = rgb2gray(A)
3. C = im2double(B)
4. [K,thresh] = edge(C,'canny')
5. D = double(K)
6. Figure
Subplot(1,2,1);imshow(A)
Subplot(1,2,2);imshow(D)
7. End
```

3.2.2. Box-Counting Fractal Dimension Calculation

Box-counting the fractal dimensions revealed a correlation between the ranges of color brightness and contour across the fractal dimension. The color brightness and contour binary image data were imported into Fraclab 2.2 software. The color fractal dimension indicators range (1.7360–1.9279) (Figure 11) and contour fractal dimension indicators range (1.6461–1.9027) (Figure 12) were obtained by calculation.

From the scatter plot, we can clearly identify the color luminance and contour fractal dimensions of the 15 test points mostly distributed within a specific range, with only a few samples showing a large dispersion from this range. Therefore, we can use the boxplot to exclude outliers and obtain a threshold range of color luminance fractal dimension and contour fractal dimension suitable for the LTG in the experimental area.

We then summarized the color brightness fractal dimension range and contour fractal dimension range of 124 image samples in its test points A–O (Table 2). We found that the number of greenway segments located in Wuxi City was significantly higher than the number of greenway segments in Changzhou City. This is because test points A–B segments and J–O segments are located within the administrative area of Wuxi City and the length of the shoreline along the lake is longer than test points B–I segments, which are located within the administrative area of Changzhou City.

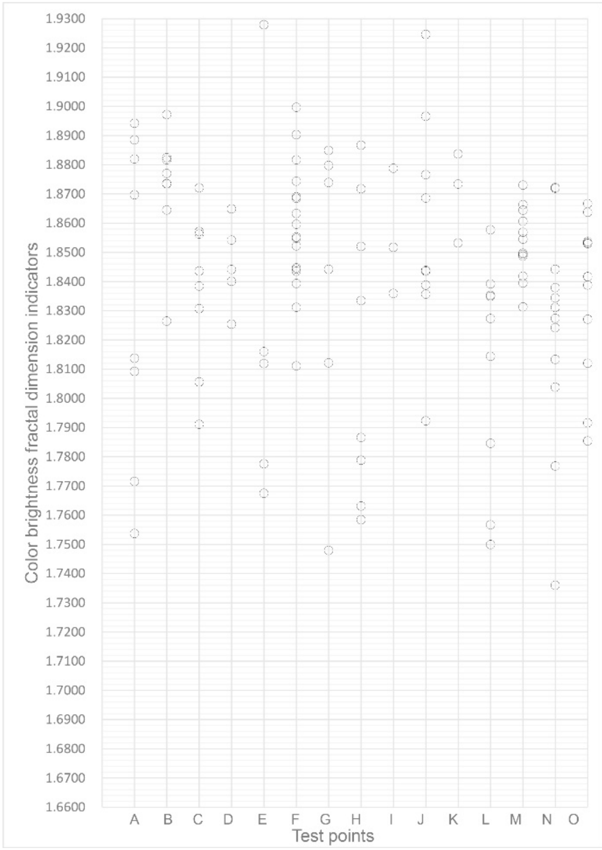

Figure 11. Color brightness fractal dimension indicators.

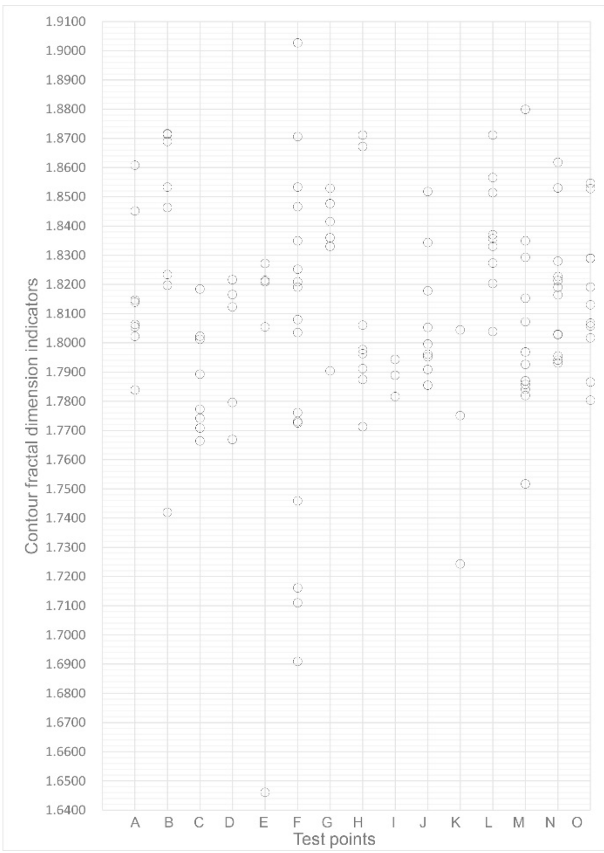

Figure 12. Contour fractal dimension indicators.

Table 2. The fractal dimension interval testing results of 124 samples.

Test Points	Latitude and Longitude Coordinates	City	Sample Size	Color Brightness Fractal Dimension Interval	Contour Fractal Dimension Interval
A	(31°14′24″ N, 119°53′38″ E)	Wuxi	8	(1.7537, 1.8942)	(1.7839, 1.8608)
B	(31°28′45″ N, 120°02′47″ E)	Changzhou	8	(1.8264, 1.8972)	(1.7420, 1.8716)
C	(31°28′29″ N, 120°03′41″ E)	Changzhou	8	(1.7911, 1.8721)	(1.7664, 1.8184)
D	(31°28′06″ N, 120°03′45″ E)	Changzhou	5	(1.8254, 1.8649)	(1.7669, 1.8216)
E	(31°27′37″ N, 120°04′20″ E)	Changzhou	5	(1.7675, 1.9279)	(1.6461, 1.8272)
F	(31°25′45″ N, 120°04′11″ E)	Wuxi	17	(1.8111, 1.8997)	(1.6909, 1.9027)
G	(31°23′03″ N, 120°04′27″ E)	Wuxi	6	(1.7479, 1.8849)	(1.7904, 1.8529)
H	(31°24′07″ N, 120°05′10″ E)	Wuxi	8	(1.7584, 1.8867)	(1.7713, 1.8712)
I	(31°25′18″ N, 120°05′54″ E)	Wuxi	3	(1.8359, 1.8788)	(1.7816, 1.7943)
J	(31°29′57″ N, 120°07′28″ E)	Wuxi	9	(1.7923, 1.9246)	(1.7855, 1.8518)
K	(31°31′49″N, 120°09′30″ E)	Wuxi	3	(1.8532, 1.8837)	(1.7243, 1.8044)
L	(31°32′35″N, 120°10′27″ E)	Wuxi	9	(1.7499, 1.8577)	(1.8039, 1.8712)
M	(31°32′09″N, 120°11′13″ E)	Wuxi	12	(1.8313, 1.8730)	(1.7517, 1.8799)
N	(31°32′54″N, 120°13′41″ E)	Wuxi	12	(1.7360, 1.8722)	(1.7931, 1.8618)
O	(31°31′15″N, 120°15′57″ E)	Wuxi	11	(1.7854, 1.8667)	(1.7804, 1.8546)

3.3. Boxplot Analysis Threshold

Using the boxplot analysis method to eliminate outliers helped to determine the optimal threshold range. We identified six color luminance indicators (Figure 12) and five contour indicators (Figure 13) as outliers. Because the six color brightness indicators (1.7360 (N-3), 1.7479 (G-5), 1.7499 (L-9), 1.7537 (A-4), 1.7567 (L-4), 1.7584 (H-5)) were distributed outside the thresholds (Lower Quartile: Q1 − 1.5 × IQR, Upper Quartile), it can be concluded that the optimal threshold range for visual attraction of color brightness is (1.7608, 1.9337). The five contour indicators (1.6461 (E-1), 1.6909 (F-6), 1.7110 (F-7), 1.7161 (F-9), 1.9027 (F-13)) are distributed outside the threshold values (Lower Quartile: Q1 − 1.5 × IQR, Upper Quartile: Q3 + 1.5 × IQR). Therefore, these five values are also outliers. The contour visual attraction adheres to the optimal threshold range of (1.7230, 1.9006). The results show that the six outliers color brightness elements test images are evenly distributed across the different test passages. In contrast, four of the five outliers contour element test images were in paragraph F and the other outlier was located in paragraph E. This is in line with the fact that the color brightness boxplot Q1–Q3 range (Figure 13) is wider than the contour element boxplot Q1–Q3 range (Figure 14). The wider the boxplot Q1–Q3 blue range, the more dispersed the values in this range. the narrower the boxplot Q1–Q3 blue range, the more concentrated the values in this range (Table 3).

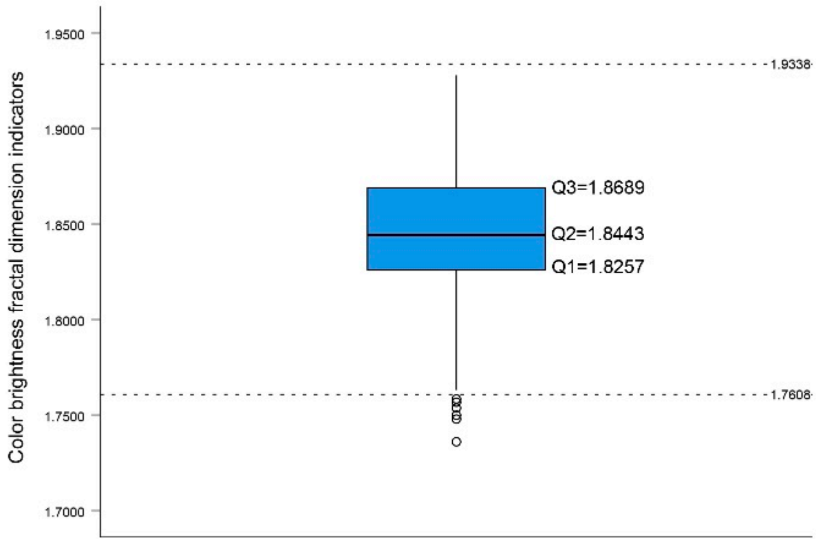

Figure 13. Boxplot of color brightness fractal dimension.

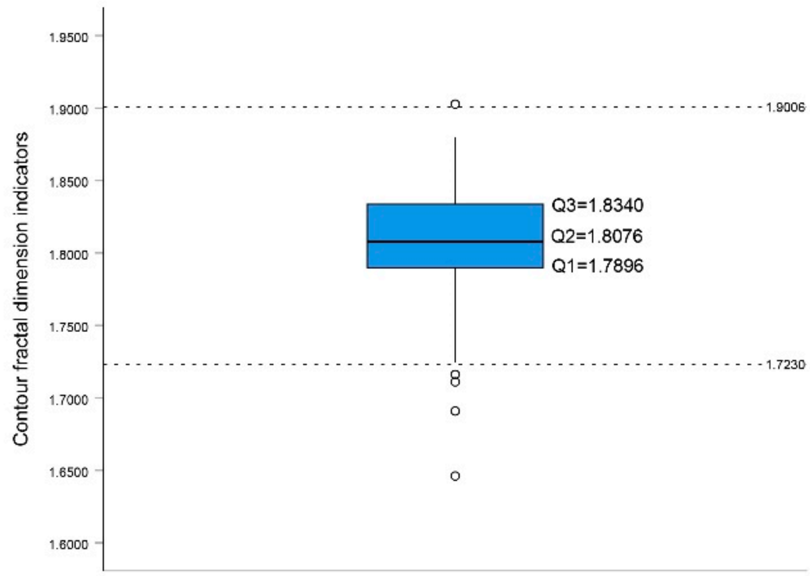

Figure 14. Boxplot of contour fractal dimension.

Table 3. The boxplot results of fractal dimension indicators.

The Boxplot Calculation		**The Boxplot Results**		
		Threshold Range	**Outliers**	**Sample Number of Outliers**
Color brightness boxplot				
Q1	1.8257	(1.7608, 1.9337)	1.7360	N-3
Q2	1.8443		1.7479	G-5
Q3	1.8689		1.7499	L-9
IQR	0.0432		1.7537	A-4
			1.7567	L-4
			1.7584	H-5
Contour boxplot				
Q1	1.7896	(1.7230, 1.9006)	1.6461	E-1
Q2	1.8076		1.6909	F-6
Q3	1.8340		1.7110	F-7
			1.7161	F-9
IQR	0.0444		1.9027	F-13

4. Discussion

4.1. Visual Attraction Elements of Color Brightness and Contour

Color brightness and contour are two important visual attraction variables in the LTG. Previous research reveals forest landscape space resolution, spectrum resolution, scale effect of landscape pattern, complex geomorphological information capacity, and the prediction of habitat patchiness with gently curved perimeter can all be analyzed by fractal theory [50]. From the test results, it can be seen that the color brightness and contour visual attraction elements in the Taihu Greenway can be analyzed using the fractal theory of fractal number method, and the boxplot analysis method in this theory can effectively eliminate invalid values.

Elements with higher color brightness are affected by the light intensity in landscape space. Even on sunny days, shaded areas, backlit surfaces, and landscape elements with varying degrees of surface texture can have a significant impact on color brightness. The greenway along the lake, which is paved with wooden planks, is also characterized by a high degree of color brightness due to the combination of reflection from the lake and direct sunlight (Figure 15).

Figure 15. Binary image analysis of color brightness elements.

The contour-rich landscape elements generally consist of vegetation and solid landscape features, and the fluidity of the vegetation contours adds a sense of movement to the greenway landscape space. It is easy to see from the black and white binary diagram that the trees not only have the outer contours of the entire tree form, but also the unusually rich inner contours of the branches and leaves; while the contours of the landscape walls, landscape pavilions, and road grooves are relatively more complete and concise. The abundance of contour lines is a contouring feature of the richness of each landscape element in the landscape space, highlighting the richness and fluidity of the contoured visual attraction elements [51] (Figure 16).

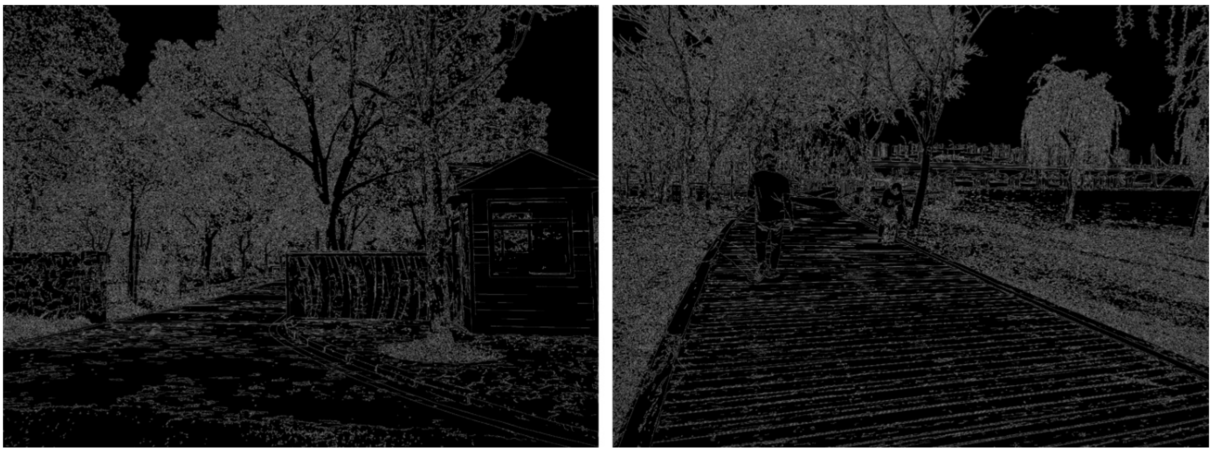

Figure 16. Binary image analysis of contour elements.

The minimum and maximum fractal dimension values of color brightness and contour elements in visual attraction express the intensity of attraction to human eyes by various visual elements in landscape space. The comparison between three black-white binary images selected from testing samples with maximum fractal dimension values and three images with minimum values more easily reveals the difference among fractal dimension values in visual attraction.

We selected three test images with the smallest and three with the largest fractional dimensional values for comparison. It was found that the minimum fractional dimensional number image consisted mainly of plants and pavilions with rich contours, and the minimum fractional dimensional value image consisted mainly of the lake, the sky, and the area in direct sunlight. This suggests that the smaller the value, the more significant the contour-attracting elements contained in the landscape, within a range of thresholds that create a strong attraction for people (Figure 17). The larger the value, the more significant the element of color brightness contained in the landscape (Figure 18).

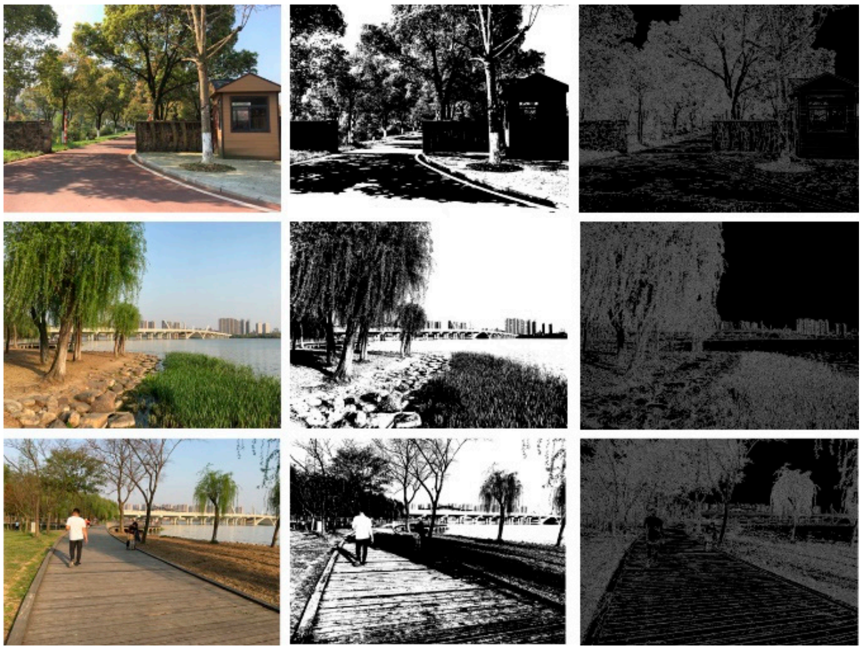

Figure 17. Minimum absolute value of differences analysis.

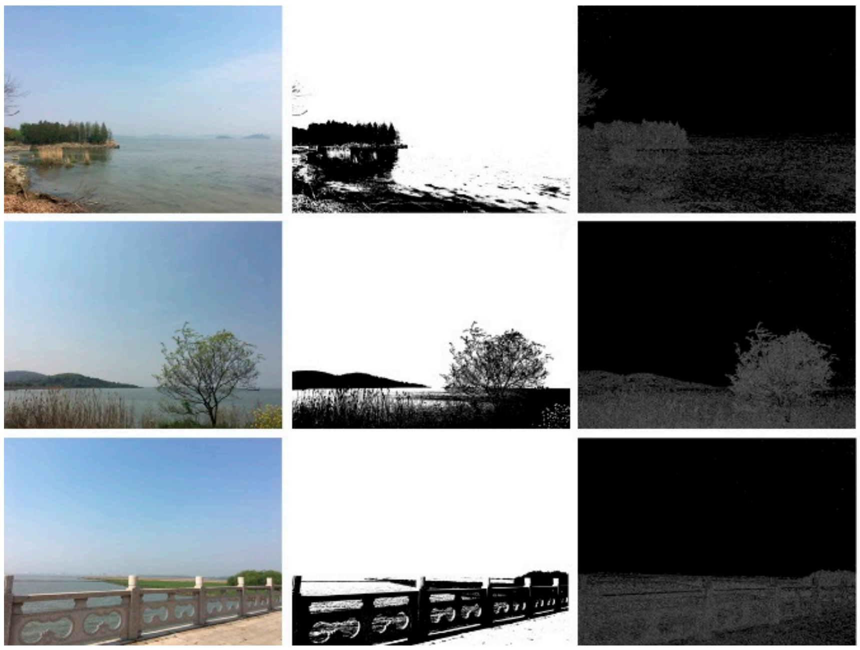

Figure 18. Maximum absolute value of differences analysis.

A comparison of these two thresholds of visual attractiveness found that there was an overlap. Combined with the test images, we determined that the Taihu Greenway has both the strongest color brightness and contour richness within the (1.7608–1.9006) element threshold range. The visual appeal to people reaches the maximum interval range (Figure 19).

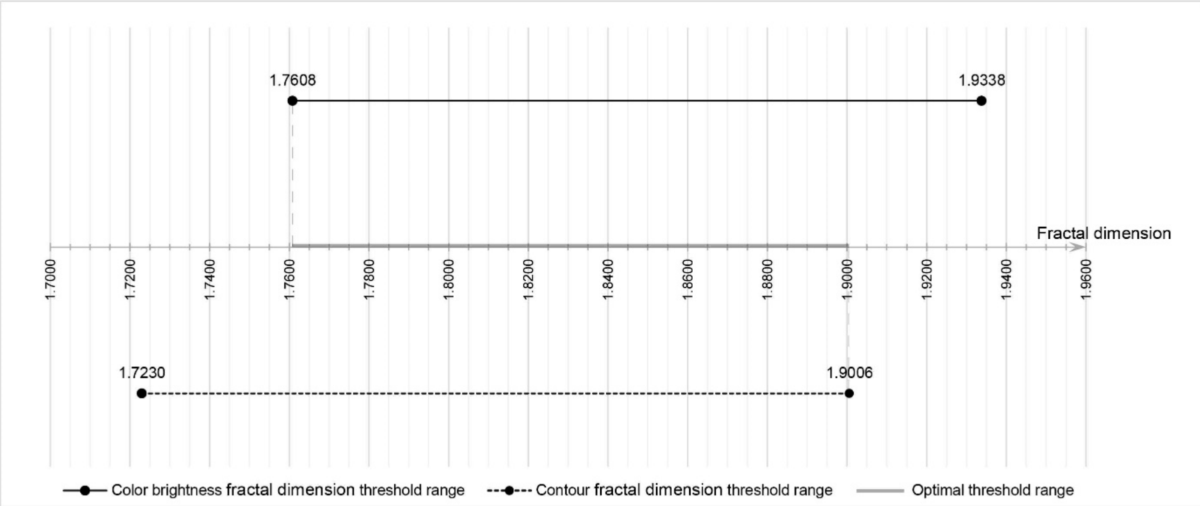

Figure 19. Optimal threshold range.

4.2. Interpreting Observed Elements of Visual Attraction in Relation to the Distribution of Greenways and Water Bodies

After the understanding of the common visual attraction capability by color brightness and contour elements of visual attraction, landscape visual feature variance is identified between samples with large absolute values of fractal dimensions and the value differences of two elements and samples with small absolute value (for better expression and understanding, the difference value is uniformly set as absolute value) (Figure 20). Three samples (A-2, O-8, O-4) with minimum absolute difference were selected for further investigation. We observed that samples with minimum absolute difference were generally located in areas with greatest distance between the green way and the lake surface or contained small portion of lake body and sky in the visual threshold (Figure 16). The reason for this observation is that, in the greenway area a significant distance from the lake, the contour forms of other landscape elements such as verdant vegetation, architectures, buildings, and miscellaneous solid scenic features, are abundant, so the associated fractal dimension value is higher. Moreover, the color brightness fractal dimension value of landscape space with direct sunlight is also high. Hence, the minimum absolute difference of fractal dimension of two elements suggests that the higher the color brightness element of visual attraction, and the more abundant the contour element of visual attraction, the more visually attractive the Lake Taihu landscape space to human eyes.

The comparison is also conducted among three samples (K-1, F-10, B-8) with maximum absolute difference (Table 4). It explains that the sample with maximum absolute difference is either a closer distance from greenway to lake surface or it contains a large portion of lake and sky in the visual threshold. The reason of this observation is that, in landscape space of Lake Taihu, the lake is the principal and dominant landscape element, and, especially when the color of the lake water' blends with the color of the sky. The reflection of lake surface enhances color brightness, making it most potent visual attraction as well as the highest value of fractal dimension of color brightness (Figure 17). Since the greenway is adjacent to the broad and reflective surface of Lake Taihu, the visual connection to the sky contributes to high color brightness, resulting in a high fractal dimension value (Figure 16). Because the farther part of lake surface blends with the sky along the horizon, the crossing contour of sky and lake surface is simple, and hence the fractal dimension value is low. Thus, the reason why absolute difference of color brightness and contour elements of visual attraction is large is the relatively large proportion of sky and water body in human vision and the relatively smaller proportion of other scenic features. This research also confirms that water adjacent greenways have a higher degree of aesthetic appeal and more favorable psychological signals than non-water adjacent greenway spaces.

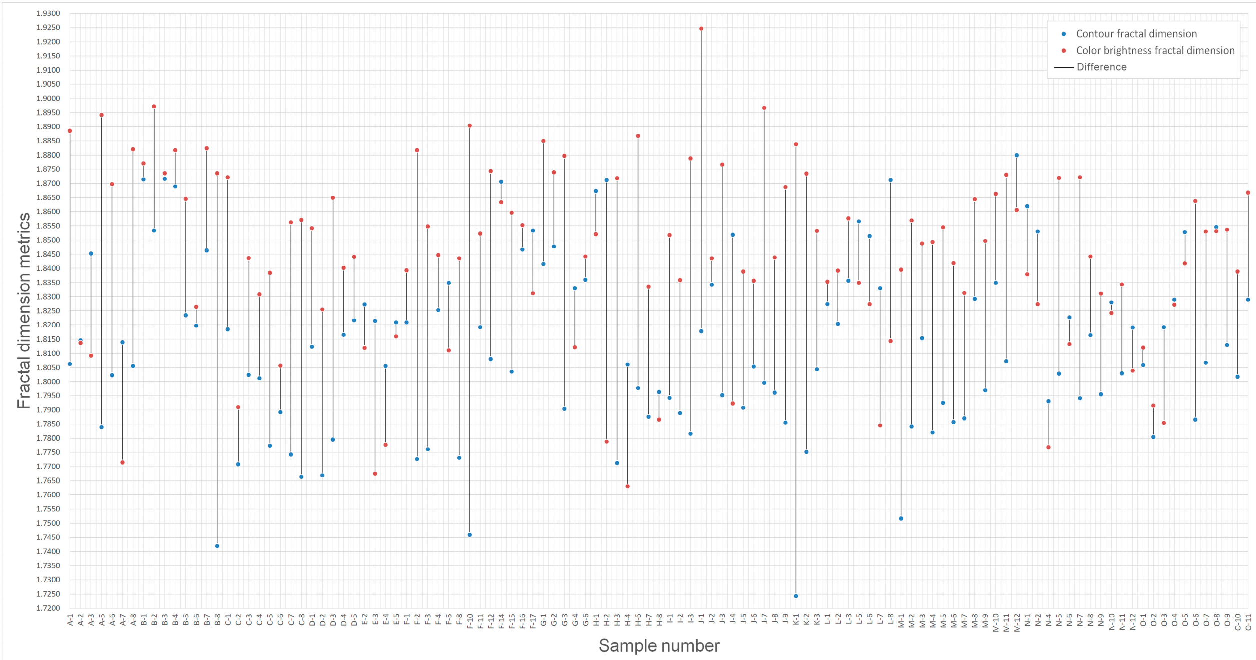

Figure 20. Comparison chart of effective fractal dimension difference.

Table 4. The difference between fractal dimension metrics.

Sample Number	Fractal Dimension Metrics		
	Color Brightness Fractal Dimension	**Contour Fractal Dimension**	**Absolute Value of Difference**
	Three samples with the smallest difference		
A-2	1.8137	1.8146	0.0009
O-8	1.8531	1.8546	0.0015
O-4	1.8271	1.8289	0.0018
	Three samples with the largest difference		
K-1	1.8837	1.7243	0.1594
F-10	1.8903	1.7459	0.1444
B-8	1.8735	1.7420	0.1315

To these ends, along the LTG, the segments furthest from the latke contain abundant scenic features, and these features possess highlighted color brightness and easily identified contour lines in clear days, so better visual attraction can be perceived by users. In planning and design, the scenic features with abundant contours and miscellaneous combinations can create lakeside greenway landscape space model with sparseness and dense, concentration and dispersion, openness, and hiddenness.

When the greenway is close to the lake, the surface of the water and sky become the subjects of visual attraction due to the diminishment of other scenic features, which makes people perceive broad and wide landscape visual space. This suggests that the lake should be the primary focus of planning, and the construction investment of other landscape elements should be reduced. Within reasonable ecological capacity, tourists should be encouraged to take advantage of waterfront space as frequently as possible, and the interface connecting people to the lake should be enlarged as much as possible to enhance water preferable landscape space along lakeside greenway. In this way, the demands of different visitors can be satisfied, the best status of landscape visual perception can be achieved, and the probability of return visits can be increased.

4.3. Theoretical and Practical Implications for Regional Planning and Design

4.3.1. Theoretical Implications for Regional Planning

The selection of color brightness and contour visual are appealing elements to discuss the quality of the Lake Tai greenway resources, and can provide a stronger appeal to visitors. These findings have important theoretical implications for the planning and design of the area. It has been extensively documented that visual design elements help to improve the rationality and science of the greenway distribution [52] during route selection planning and planning and design [53]. The attractiveness of greenways can be improved if the relationship between color brightness and contour visual attraction elements and greenway distribution is focused on in the early stages of greenway construction.

Specifically, the proximity of these two elements of visual attraction to the lake can have an impact on people's vision, particularly in terms of affinity and visual preference for the water body [25]. There is evidence that the closer a greenway is to a body of water, the more it will be favored [54]. In contrast, the contours of the lake are much simpler than those of other landscape elements. Greenways at a distance from the lake are comprised of many other landscape elements and will therefore have a richer contour element. In the absence of a body of water, people will shift their visual attraction to other landscape elements and experience the different shapes of landscape elements as bringing a completely different visual preference to the body of water [55]. The visual attraction thresholds for both elements can further address the direct relationship between people and the greenway around the lake, increasing the time and frequency of people using the greenway, as well as optimizing the visual resource allocation of the greenway landscape.

4.3.2. Practical Significance towards Resource Quality Enhancement

The use of a two-factor optimal threshold index can be used to assess the practical significance of the frequency of the visual resource quality of the landscape of the greenway around the lake in relation to the interests of the users. It can provide planners of the greenway with a design basis. Importantly, this optimal threshold index can be used to determine the design of unbuilt greenway plans. Although there are areas along the greenway where the visual resources of the landscape are good, the greenway also links areas with a high density of users. Therefore, greenway designers should consider enhancing the visual quality of the various landscape resource points along the Taihu Greenway, especially when these two elements are present, and the proximity of the greenway to water bodies needs to be taken into account.

Consistent with the previous research [56], people have a natural affinity for water, especially along shorelines where they can get close enough to interact with the water where large crowds gather. This can be done by increasing the length of the greenway immediately adjacent to the water during planning and design, while increasing the richness of the shoreline variation design. For example, adding design elements such as different vegetation, stones, and interesting safety railings to the design of natural and artificial barge lines. In the greenway away from the lake, the design of visually appealing physical elements of the landscape with different contours is well-established. The complexity and richness of the silhouette attraction elements can be significantly enhanced by the very rich contours of the plant trunks and branches [57]. Therefore, designers need to focus on the design of planting configurations, where high-quality landscape visual resources are available to expand the connectivity of the greenway with the surrounding landscape space and increase the willingness and frequency of users to visit.

4.4. Limitations

Although we measured the fractional dimensional values of the color brightness and contour elements as important indicators of the visual attractiveness of the Taihu Greenway, there are several limitations to our study. First, the fractional dimensional values for these two visual attraction elements were measured along the Lake Taihu shoreline where the curvature is the highest, the shoreline form is the richest and the distance from the lake is the closest. However, there are many other greenways in the Lake Taihu area that are far from the lake, and most of these are straight and linear, with very little curvature. Second, as one of the important indicators for calculating the visual attractiveness of greenways around the lake, this study only analyzes the distribution of greenways by two visual attractiveness factors, namely color brightness and contour, and the lack of human preference for waterfront greenways is ignored in this paper. Third, although we suggest that the two visual attraction factors of color brightness and contour are important indicators of the quality of visual resources in the LTG landscape, potentially pointing out that this has an impact on people's visual attraction, what specific effects and what behaviors are triggered will need to be further considered in the next study.

5. Conclusions

This study is part of a 10-year continuous evaluation of visual attraction for landscapes.

For the purposes of our study, we selected a greenway segment in the rapidly urbanizing region of Lake Taihu as a case study with the intention of assisting designers to better understand the characteristics of color brightness and contour visual attraction elements of the greenway landscape and the impacts this may have on the planning and design of the greenway.

We conclude that: (1) Fractional dimensional number theory can be used as an effective method to analyze the characteristics of color brightness and contour visual attraction elements in the LTG. In particular, the optimal threshold range of visual attraction for the color brightness element is (1.7608, 1.9337) and the optimal threshold range of visual attraction for the contour element is (1.7230, 1.9006). This reveals that the larger the two visual attraction elements are, the more effective, but they need to be within a reasonable range, which corroborates previous research (Yan et al., 2017).

(2) Color brightness and contour visual attraction elements are important indicators of the quality of the LTG landscape resources. Due to the wide lake surface of Lake Taihu, the bright light from direct sunlight on the lake surface and the strong reflections from the lake surface being illuminated by sunlight are superimposed on each other. The color brightness values of the greenway immediately adjacent to the lake are greatly enhanced. The greenway away from the lake is affected by the large amount of vegetation and other landscape structure features, with a significant increase in the value of the contour visual attraction element.

(3) Color brightness and contour visual appeal elements can influence the distribution of greenways in relation to the distance from the lake. Greenway sections with higher color brightness indices are basically located closer to the lake or even close to it. Greenway sections with a higher contour index are distributed further away from the surface of Lake Taihu. People standing in greenways with a high contour index cannot view the lake and are less intimate with the lake.

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References

1. Little, C.E. *Greenways for America*; Johns Hopkins University Press: Baltimore, MD, USA, 1990.
2. Furuseth, O.J.; Altman, R.E. Who's on the greenway: Socioeconomic, demographic, and locational characteristics of greenway users. *Environ. Manag.* **1991**, *15*, 329–336. [CrossRef]
3. Zhang, F.; Wu, F. Performing the ecological fix under state entrepreneurialism: A case study of Taihu New Town, China. *Urban Stud.* **2022**, *59*, 1068–1084. [CrossRef]
4. Sun, S.C.; Mao, R. *An introduction to lake Taihu. Lake Taihu, China: Dynamics and Environmental Change*; Springer: Berlin/Heidelberg, Germany, 2008; pp. 1–67.
5. Wu, Y.Y.; Wang, C.; Zhang, Z.Y.; Ge, Y. Subsistence, Environment, and Society in the Taihu Lake Area during the Neolithic Era from a Dietary Perspective. *Land* **2022**, *11*, 1229. [CrossRef]
6. Li, Y.; Zheng, N. Integral Protection of Cultural Heritage of the Grand Canal of China: A Perspective of Cultural Spaces. *Front. Soc. Sci. Technol.* **2020**, *2*, 60–69.
7. Thomson, S.L.; Ochoa, G.; Verel, S. The fractal geometry of fitness landscapes at the local optima level. *Nat. Comput.* **2022**, *21*, 1–17. [CrossRef]
8. Li, J.; Zhong, Y.Z.; Li, Y.N.; Hu, W.; Deng, J.Y.; Pierskalla, C.; Zhang, F.A. Past Experience, Motivation, Attitude, and Satisfaction: A Comparison between Locals and Tourists for Taihu Lake International Cherry Blossom Festival. *Forests* **2022**, *13*, 1608. [CrossRef]
9. Bai, Y.; Chen, Y.; Alatalo, J.M.; Yang, Z.Q.; Jiang, B. Scale effects on the relationships between land characteristics and ecosystem services- a case study in Taihu Lake Basin. *China Sci. Total Environ.* **2020**, *716*, 137083. [CrossRef]
10. Xu, L.T.; Chen, S.S.; Xu, Y.; Li, G.; Su, W.Z. Impacts of Land-Use Change on Habitat Quality during 1985–2015 in the Taihu Lake Basin. *Sustainability* **2019**, *11*, 3513. [CrossRef]
11. Su, W.Z.; Gu, C.L.; Yang, G.S.; Chen, S.; Zhen, F. Measuring the impact of urban sprawl on natural landscape pattern of the Western Taihu Lake watershed, China. *Landsc. Urban Plan.* **2010**, *95*, 61–67. [CrossRef]
12. Wang, Y.N.; Li, B.; Yang, G.S. Stream water quality optimized prediction based on human activity intensity and landscape metrics with regional heterogeneity in Taihu Basin, China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 4986–5004. [CrossRef]
13. Bell, S. *Elements of Visual Design in the Landscape*, 2nd ed.; Spon Press: New York, NY, USA, 2004.
14. Fan, R. Evaluation of Visual Attraction of Landscape Spaces Using Analytic Hierarchy Process. *J. Chin. Urban For.* **2016**, *14*, 74–77. [CrossRef]
15. Fan, R. *Visual Attraction Mechanism and Assessment of Landscape Space*; Tongji University Press: Shanghai, China, 2016.
16. Fan, R.; Li, W.Z.; Wu, R. Study on Spatial Visual Attraction of Landscape Space Around Lake Taihu Greenway Based on UAV Image Segmentation. *Chin. Landsc. Archit.* **2019**, *35*, 74–79.
17. Skums, P.; Bunimovich, L. Graph fractal dimension and the structure of fractal networks. *J. Complex Netw.* **2020**, *8*, cnaa037. [CrossRef] [PubMed]
18. Ebrahimi, M.; Bohun, S. Single image super-resolution via non-local normalized graph Laplacian regularization: A self-similarity tribute. *Commun. Nonlinear Sci. Numer. Simul.* **2021**, *93*, 105508. [CrossRef]
19. Forsythe, A.; Nadal, M.; Sheehy, N.; Cela-Conde, C.J.; Sawey, M. Predicting beauty: Fractal dimension and visual complexity in art. *Br. J. Psychol.* **2011**, *102*, 49–70. [CrossRef]
20. Chen, H.; Zheng, X. Improved Newton Iterative Algorithm for Fractal Art Graphic Design. *Complexity* **2020**, *2020*, 6623049. [CrossRef]
21. Mandelbrot, B.B. *The Fractal Geometry of Nature*; W.H. Freeman: San Fransisco, CA, USA, 1983.
22. Eke, A.; Herman, P.; Kocsis, L.; Kozak, L.R. Fractal characterization of complexity in temporal physiological signals. *Physiol. Meas.* **2002**, *23*, R1. [CrossRef]
23. Weaver, W. Science and complexity. *Am. Sci.* **1948**, *36*, 536–544.
24. Sun, W.; Kim, S.W. Visual Preference Analysis of Landscape Elements in Urban Scenic Areas of China. *J. Recreat. Landsc.* **2019**, *13*, 31–38.
25. Polat, A.T.; Akay, A. Relationships between the visual preferences of urban recreation area users and various landscape design elements. *Urban For. Urban Green.* **2015**, *14*, 573–582. [CrossRef]
26. Zhang, H.; Lin, S.H. Affective appraisal of residents and visual elements in the neighborhood: A case study in an established suburban community. *Landsc. Urban Plan.* **2011**, *101*, 11–21. [CrossRef]
27. National Development and Reform Commission. The Overall Programme of Comprehensive Management for Water Environment of Taihu Lake Basin. 2013. Available online: https://www.ndrc.gov.cn/xxgk/zcfb/tz/201401/W020190905508283518222.pdf (accessed on 19 February 2023).
28. Xu, X.; Yang, G.; Tan, Y.; Zhuang, Q.; Li, H.; Wan, R.; Su, W.; Zhang, J. Ecological risk assessment of ecosystem services in the Taihu Lake Basin of China from 1985 to 2020. *Sci. Total Environ.* **2016**, *554*, 7–16. [CrossRef] [PubMed]

29. Mandelbrot, B.B. How long is the coast of Britain? Statistical self-similarity and fractional dimension. *Science* **1967**, *156*, 636–638. [CrossRef]
30. Mandelbrot, B.B. *Fractals: Form, Chance and Dimension*; W.H. Freeman: San Francisco, CA, USA, 1977.
31. Huang, A.S.H.; Lin, Y.J. The effect of landscape colour, complexity and preference on viewing behaviour. *Landsc. Res.* **2020**, *45*, 214–227. [CrossRef]
32. Daniel Brandeis, D.; Lehmann, D. Segments of event-related potential map series reveal landscape changes with visual attention and subjective contours. *Electroencephalogr. Clin. Neurophysiol.* **1989**, *73*, 507–519. [CrossRef]
33. Zhang, Z.; Qie, G.; Wang, C.; Jiang, S.; Li, X.; Li, M. Application of eye-tracking assistive technology in forest landscape evaluation. *World For. Res.* **2017**, *30*, 19–23.
34. Wu, X.; Chen, S.; Zhao, R. Analysis of impact factors on forest park passenger flow based on baidu index. *For. Resour. Manag.* **2017**, *1*, 27.
35. Vaughan, J.; Ostwald, M.J. Measuring the geometry of nature and architecture: Comparing the visual properties of frank Lloyd wright's falling water and its natural setting. *Open House Int.* **2022**, *47*, 51–67. [CrossRef]
36. Voss, R.F. Random fractal forgeries. *Fundam. Algorithms Comput. Graph.* **1985**, *17*, 805–835.
37. Voss, R.F. *Random Fractals: Characterization and measurement. Scaling Phenomena in Disordered Systems*; Springer: Boston, MA, USA, 1986; Volume 27–32. [CrossRef]
38. Peitgen, H.O.; Jürgens, H.; Saupe, D. *Chaos and Fractals: New Frontiers of Science*; Springer-Verlag: New York, NY, USA, 1992.
39. Stamps, A.E. Fractals, skylines, nature and beauty. *Landsc. Urban Plan.* **2002**, *60*, 163–184. [CrossRef]
40. Dasgupta, R. Determination of the fractal dimension of a shore platform profile. *J. Geol. Soc. India* **2013**, *81*, 122–128. [CrossRef]
41. D'Alessandro, L.; De Pippo, T.; Donadio, C.; Mazzarella, A.; Miccadei, E. Fractal dimension in Italy: A geomorphological key to interpretation. *Z. Fur Geomorphol.* **2006**, *50*, 479–499. [CrossRef]
42. Sala, N. Fractal geometry in the arts: An overview across the different cultures. *Think. Patterns* **2004**, 177–188.
43. Bourchtein, A.; Bourchtein, L.; Naoumova, N. On the visual complexity of built and natural landscapes. *Fractals-Complex Geom. Patterns Scaling Nat. Soc.* **2014**, *22*, 1450008. [CrossRef]
44. Dubuc, B.; Quiniou, J.F.; Roques-Carmes, C.; Tricot, C.; Zucker, S.W. Evaluating the fractal dimension of profiles. *Phys. Rev. A* **1989**, *39*, 1500. [CrossRef]
45. Schroeder, M. *Fractals, Chaos, Power Laws: Minutes from an Infinite Paradise*; W. H. Freeman: New York, NY, USA, 1991; pp. 41–45.
46. Tukey, J.W. *Exploratory Data Analysis. Reading*; Addison-Wesley Publishing Company: Boston, MA, USA, 1977.
47. Benjamini, Y. Opening the box of a boxplot. *Am. Stat.* **1988**, *42*, 257–262. [CrossRef]
48. Frigge, M.; Hoaglin, D.C.; Iglewicz, B. Some Implementations of the Boxplot. *Am. Stat.* **1989**, *43*, 50–54. [CrossRef]
49. Ferreira, J.E.V.; Miranda, R.M.; Figueiredo, A.F.; Barbosa, J.P.; Brasil, E.M. Box-and-Whisker Plots Applied to Food Chemistry. *J. Chem. Educ.* **2016**, *93*, 2026–2032. [CrossRef]
50. Al-Hamdan, M.; Cruise, J.; Rickman, D.; Quattrochi, D. Effects of Spatial and Spectral Resolutions on Fractal Dimensions in Forested Landscapes. *Remote Sens.* **2010**, *2*, 611–640. [CrossRef]
51. Juliani, A.W.; Bies, A.J.; Boydston, C.R.; Taylor, R.P.; Sereno, M.E. Navigation performance in virtual environments varies with fractal dimension of landscape. *J. Environ. Psychol.* **2016**, *47*, 155–165. [CrossRef]
52. Liu, S. Application of big data technology in urban greenway design. *Secur. Commun. Netw.* **2022**, *2022*, 4826523. [CrossRef]
53. Lu, J.; Wu, X. Research on Urban Greenway Alignment Selection Based on Multisource Data. *Sustainability* **2022**, *14*, 12382. [CrossRef]
54. Gobster, P.H.; Westphal, L.M. The human dimensions of urban greenways: Planning for recreation and related experiences. *Landsc. Urban Plan.* **2004**, *68*, 147–165. [CrossRef]
55. Yang, B.E.; Brown, T.J. A cross-cultural comparison of preferences for landscape styles and landscape elements. *Environ. Behav.* **1992**, *24*, 471–507. [CrossRef]
56. Nordh, H.; Hartig, T.; Hagerhall, C.M.; Fry, G. Components of small urban parks that predict the possibility for restoration. *Urban For. Urban Green.* **2009**, *8*, 225–235. [CrossRef]
57. Ding, M.; Zhang, Q.; Li, G.; Li, W.; Chen, F.; Wang, Y.; Li, Q.; Qu, Z.; Fu, L. Fractal dimension-based analysis of rockery contour morphological characteristics for Chinese classical gardens south of the Yangtze River. *J. Asian Archit. Build. Eng.* **2023**, 1–16. [CrossRef]