Analysis of Scenic Perception and Its Spatial Tendency: Using Digital Cameras, GPS loggers, and GIS

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Abstract

Visitor-employed photography has been used to analyze scenic perceptions with visitors’ on-site experiences. This study conducted an experiment at Hibiya Park in Tokyo, Japan using the visitor-employed photography (VEP) method and applied a spatial analysis approach. A digital camera and GPS logger were used to extract the photographs of preferred scenery and the locations photographed by participants. Kernel density estimation was applied to estimate the density of photo-taking locations. Moreover, we classified the photographs into nine categories, and the distribution of each was visualized. As a result, the spatial potential of the places that interest many participants was quantifiably measured.

Keywords: Scenic perception; visitor-employed photography; spatial analysis; kernel density estimation; urban park; digital camera; GPS; GIS;

1. Introduction

The type of space and scenery that people evaluate highly in leisure space is an important topic for the design and management of tourist destinations. Tourist experiences are generated via a process of perceiving and recognizing a variety of sensory information obtained within a landscape [1]. Visual experiences particularly impress on people the characteristics of the environment. Therefore, knowing which sceneries people evaluate as positive is useful to understand their experiences. This type of study, as human-environment perception research, has developed in various fields such as geography, tourism and recreation, environment psychology, and landscape studies [2]. In relation to it, some researchers point out the importance of study based on on-site experiments [3,1].

A concrete photographic technique called “visitor-employed photography (VEP)” has been used to analyze scenery/landscape perception with on-site experience. This is a method based on participants’ own photography. VEP is a powerful tool that provides visual and evidentiary information to support reactions to, opinions about, and assessment of a visitor’s experiences in specific places or destinations.
Moreover, we can record the memory of visitor’s indistinct experience, which is difficult to capture through the use of a questionnaire [5]. Cherem and Driver [6] used VEP to measure common visitors’ perceptions of natural environments. Following their research, VEP has been used for various types of studies. Taylor, Czarnowski, Sexton, and Flick [7] used VEP as a technique to quantitatively and objectively evaluate the importance of water resources in the Rockies. Oku and Fukamachi [8] collected pictures from visitors of a forest recreation trail and analyzed the kinds of spectacle objects that visitors photographed in relation to the visitors’ activities and attributes. Haywood [4] mentioned the possibility of VEP to assess an urban visit. MacKay and Coul dwell [9] used VEP to extract a tourist image at a tourist destination. Garrod [10] and Yamashita [11] applied it to residents.

In the previous research, what kinds of scenery and experiences people evaluate highly has been intensively studied. However, the spatial distribution of photo-taking locations has not yet been sufficiently analyzed. In detail, if such an analysis is possible, the spatial evaluation structure of the tourist areas can be clarified from the perspectives of visitors, and it will be useful for management. Many researchers have used disposable cameras for VEP, but digital cameras have become popular nowadays. An image taken by a digital camera contains Exif format data, which can record various types of information such as the photo-taking time and name of the camera’s manufacturer and model. Moreover, geographic coordinates can be recorded if GPS data can be combined. If photo-taking locations are managed as point data on a geographical information system (GIS), they can have various usages. On the Internet, photo-based community sites such as Flickr have been created. Many people enjoy such sites by sharing their photos taken on WebGIS [12]. It is also possible to extract point data on desktop-based GIS such as ArcGIS. This software is a strong tool for spatial analysis and visualization of geographical and spatial events. Therefore, this study focuses on a spatial analysis and visualization of photo-taking locations using digital cameras, GPS loggers, and GIS, and clarifies the relation between visitor’s scenic perception and its spatial tendency.

As a case study, we conducted an experiment in Hibiya Park, an urban park in Tokyo, Japan. An urban park is a functional place for residents to escape from stress and for tourists to go sightseeing. While VEP has been applied at national parks, rural areas, and suburban forest trails in previous studies, academic studies at leisure/recreation spaces like urban parks do not seem to have been conducted yet. It is necessary to examine VEP at such urban leisure spaces. In addition, Hibiya Park is suitable for examining this new approach because the park expands over a comparatively small area. This study examines the effectiveness of VEP with the spatial analysis approach in the case of an urban park.

2. Method

2.1. Study area

Hibiya Park is a modern park that opened in 1903. It is adjacent to streets lined with office buildings in the central area of Tokyo, such as Kasumigaseki and Marunouchi. This park has various facilities such as Hibiya Public Hall, Music Bowl, Tokyo Hibiya Public Library, Tennis courts, and Matsumotorou restaurant. In addition, there are natural resources such as pine trees, plum trees, azalea gardens, flowerbeds, and ponds, and cultural resources such as sculptures, monuments, and bronze statues are located all over the park.

2.2. Survey schema

Participants were recruited as part of the preparation for the experiment. They consisted of 13 individuals who were students and faculty members of our department and members of society, of whom 10 were males and three were females. Most of the participants, nine people, were in their 20s, and the others were aged from 30 to 60. We asked the participants to bring their own digital cameras.
For the experiment, Black Gold 1300, a GPS logger made by Q-STARZ, was used. This logger is able to record 200 thousand track points and to continue working for approximately 12 hours. We set the logger’s frequency of data collection to one second.

The experiment was conducted on Sunday, October 10, 2010. The appointed place was Kamome Hiroba, the place at the southwest end of the park. After experiencing some cloudy weather, the weather on that day turned out to be fine. A special event, the Railroad Festival, was taking place in the park. Many types of companies and associations had set up booths near Large Fountain, the Second Flower Garden, and Nirenoki Hiroba. Moreover, the participants were unable to enter the Large Music Bowl because a famous Japanese musician was holding a concert there. We handed GPS loggers and maps of the park to each participant. They then walked around the park, taking pictures freely. When they returned, we collected all the equipment and distributed a questionnaire, called a sign map, to each participant.

After the experiment, the point data of photo-taking locations was extracted. First, the log data of GPS loggers was extracted in Q-Travel and converted to GPX format using the logger’s software. Next, GPX was synchronized to the temporal data of the digital photographs using Kashmir3D [13]. We also added geotags to digital photographs because the log data had been registered at one-second intervals. It is possible to add geotags in Q-Travel, but the operation in Kashmir3D is much quicker. Following this operation, we captured the Exif data of digital photographs in ArcPhoto, a part of the functions of ArcGIS, and extracted the point data of the photo-taking locations. Moreover, only the point data confirmed the large gap from an original position because of the error margin of GPS that was corrected to the proper position by corresponding to the photographic imagery.

Pictures taken by participants often include multiple elements. For example, if a picture includes multiple elements such as water, greenery, and animals, it is difficult, if not impossible, to know which was the most impressive object for the person who took the picture. Yet, it is important to understand which element is the main object of the photograph in order to evaluate the visitors’ experiences. Therefore, each of the participants was asked to specify the main element of each photograph. At this time, if there were multiple photographs that targeted the same object, we removed the photos taken later from the analysis, and included only the one that had been taken first. Moreover, we removed the photos that had a negative object or were the result of mistakes in the operation of the digital camera.

2.3. Data analysis

This study mainly focuses on analyzing the distribution of photo-taking locations. Kernel density estimation (KDE) was applied to all the photo-taking locations to visualize their density. KDE tools are already made available in the Spatial Analyst Extension of ArcGIS. Next, we categorized the pictures into types and visualized their locations on the digital maps. Then, these maps were compared with the density maps produced by KDE. Finally, we analyzed the relation between the density distributions of photo-taking locations and the participants’ overall evaluations as given in their responses to the questionnaire. The questionnaire showed a map of the park and asked participants to circle the locations where they had received positive impressions and to describe what they found to be was impressive.

3. Results

3.1. Number of photographs

In total, the participants took 538 photographs. Each participant took 41 photos on average (18 to 85 photos per person), with a standard deviation of approximately 22.

The photographs were categorized into nine types on the basis of their elements. Various methods of categorization were used in previous studies. In most studies, the author classified the photographs, but this study asked the participants about their intentions for each picture. It is important to understand what
elements the participants were impressed with in each of their photos because the photographs sometimes have multiple elements. We classified the photos by their subjects (“people,” “animal,” “vegetation,” “management feature,” and “structure”) as well as their spatial extension (“street (vista),” “water,” and “open space”). The remaining photos were labeled “other.” Table 1 shows the nine categories, their components, and the number of photographs in each category. The results revealed that “people” were seen in 77 photos, “animal” in 55, “vegetation” in 78, “management feature” in 74, “structure” in 121, “street (vista)” in 44, “water” in 38, “open space” in 40, and “other” in 11. We found that it was easier to recognize objects of interest if they belonged to “structure,” “vegetation,” or “people,” while recognition of objects with a spatial extension, such as “street (vista),” “water,” and “open space,” were difficult to recognize. This indicates the reaction of visitors against the complicated spatial characterization composed by various elements in Hibiya Park.

### Table 1. Categorization of photographs taken by participants, together with the number and rating of the pictures in each category (Nos. 1–5 are based on their subjects, Nos. 6–8 are based on spatial extension, and No. 9 is remaining)

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Numbers</th>
<th>Rating</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>People</td>
<td>77</td>
<td>14.3</td>
<td>Walking, resting, chatting, taking a picture, festival</td>
</tr>
<tr>
<td>2</td>
<td>Animal</td>
<td>55</td>
<td>10.2</td>
<td>Bird, fish, cat, dog, turtle</td>
</tr>
<tr>
<td>3</td>
<td>Vegetation</td>
<td>78</td>
<td>14.5</td>
<td>Tree, flower</td>
</tr>
<tr>
<td>4</td>
<td>Management Feature</td>
<td>74</td>
<td>13.8</td>
<td>Monument, bench, sign, bronze statue</td>
</tr>
<tr>
<td>5</td>
<td>Structure</td>
<td>121</td>
<td>22.5</td>
<td>Architecture, building, bridge, stone wall, fountain</td>
</tr>
<tr>
<td>6</td>
<td>Street (vista)</td>
<td>44</td>
<td>8.2</td>
<td>Scenery centered on a street</td>
</tr>
<tr>
<td>7</td>
<td>Water</td>
<td>38</td>
<td>7.1</td>
<td>Scenery centered on a water element</td>
</tr>
<tr>
<td>8</td>
<td>Open Space</td>
<td>40</td>
<td>7.4</td>
<td>Scenery centered on an open space</td>
</tr>
<tr>
<td>9</td>
<td>Other</td>
<td>11</td>
<td>2.0</td>
<td>Non-categorized to Nos. 1–8</td>
</tr>
</tbody>
</table>

**Total** 538 100

3.2. Density estimation of photo-taking locations

Spatial analysis of point events, known as point pattern analysis (PPA), has been widely examined by spatial scientists, and KDE is one of the most commonly used methods for analyzing the first-order properties of a point event distribution [14,15,16]. The purpose of KDE is to produce a smooth density surface of point events over space by computing event intensity as density estimation [16]. It is effective for finding “hot spots,” locations where a peculiar value is seen. Moreover, the various accumulation patterns can be found by changing a parameter of the search bandwidth. If the bandwidth is small, density shows a local accumulation pattern of point events. On the contrary, if the bandwidth is large, density shows a spatial tendency on a more global scale. In this study, we apply KDE tools to specify the spaces where many participants took photographs, in other words, the spaces that impressed participants. In addition, it is possible to clarify the difference between each characteristic of a space that interested many participants and each characteristic that did not interest many participants. We set two types of bandwidths: A 20-meter bandwidth which was used as a small scale and a 70-meter bandwidth which was used as a medium scale. Figs. 1-(c) and 1-(d) show the maps of density distribution on each scale.

In the case of the small-scale bandwidth, it is found that the density is high around the attractions and on the park trails. For example, the density is high at the park trails near Shinji Pond, Park Museum, and the First Flower Garden, and also surrounding the Kumogata Pond, Matsumotorou restaurant, and Large Fountain. For the medium-scale bandwidth, we found that the density is especially high in the spaces at
the Shinji Pond and the First Flower Garden, which are located in the northeast area of Hibiya Park. We also found a high accumulation of photo-taking locations at the Kumogata Pond, Matsumotorou restaurant, and the Second Flower Garden. When density distribution on the small scale is calculated and visualized, it is not clear whether the photo-taking locations are distributed in the surrounding of these attractions. The density was lower at the Kusachi Hiroba, the west side of the tennis court and the surrounding of the Hibiya Library and Hibiya Hall. The reason for this is that most participants did not visit that place; this became clear by checking their GPS logs.
3.3. Distribution of the categorized photo-taking locations

We examined the distribution of the photo-taking locations in the nine categories. First, a 50 m mesh was made within the range of Hibiya Park. Then, the number of the photo-taking locations included in each mesh was calculated for each category, and the result was visualized in the form of a chart (Fig. 2). The kind of places and number of photographs that were taken can visually be understood from this figure. The distinctive trend is as follows.

First, many photos of “water” and “animal” were taken of the area surrounding the Shinji Pond. Also, many photos were taken at the north end of the pond at the Hibiya Mitsuke mark, the historical stonewall. It is understandable that many “water” photos were taken near Shinji Pond, but just as many “animal” photos were taken, for example, of wild cats and birds. It is natural that the participants took waterside photos because of the spatial characterization of waterside, but it is interesting that they also took “animal” photos. Wong and Domroes [17] pointed out that the settings that include water, greenery, and animals were evaluated the most highly among the various settings in photography taken by residents and tourists who visited an urban park. In this study, we found a similar tendency. The surroundings of Kumogata Pond contain many “management feature” photos. Crane’s statue is at the center of the pond; therefore, the participants were more highly impressed by Crane’s statue than by the waterside elements. It is likely that water scenery comparatively could not impress the participants as much as a “main” resource did in Hibiya Park.

In the First Flower Garden, many photos were taken of “open space,” “vegetation,” and “animal.” These photos were of the open spaces at the center of the garden, of planted flowers and trees, and cats. A high distribution of “structure” is also found in the north end of this area. This includes photos of Park Museum. For the Second Flower Garden, Large Fountain, and Nirenoki Hiroba, there are numerous photographs of “people.” Most are of the Railway Festival. A remarkable thing is that, in a comparison on the First Flower Garden and the Second Flower Garden, the visitors’ recognition of the places, which have similar spatial characterization, differs by the movement factors at that time. We can say that the influence of movement factors was large for the participants.

Figure 2. Distribution of photo-taking locations according to nine categories
It is understood that photos in the category “structure” are not highly concentrated on a specific location as a distinctive trend; they are distributed widely. It can be said that “structure” was experienced most frequently as a resource by the result of totalling the data. However, even if “structure” is recognized frequently as a result, we cannot say whether these experiences remained as the participants’ impressions. Section 3.4 analyzes what characteristics of the space in Hibiya Park strongly impressed the participants, using data from the questionnaire on the overall evaluation of the participants’ experiences.

3.4. Sign map for overall evaluation

Sign map is one technique of cognitive survey and is similar to Lynch’s [18] sketch map. Sketch map is a technique in which the participants provide a description with an image map on paper. Sign map asks the participants to describe with a spatial range their answer to the question on the map [19, 20]. The participants can easily answer with their thoughts on the area. In this study, a sign map is applied to collect the data about participants’ spatial preferences in Hibiya Park after the experiment was conducted. Fig. 3 shows the circle signs all participants recorded on the map. The results reveal that eight people out of 13 answered that Kumogata Pond and the First Flower Garden were impressive. In addition, six people answered that the most impressive was the Second Flower Garden, and five answered that it was Matsumotorou restaurant and Shinji Pond. In these places, the accumulation of the photo-taking locations was also very high. This indicates that we can extract the spatial potential of the place where participants’ demonstrated interest and concern by analyzing the density distribution of the photo-taking locations.

![Figure 3. Sign map focusing on participants’ positive feelings](image-url)
4. Conclusion and discussion

This study examined VEP in an urban park, adopting a spatial analysis approach using digital tools. We identified favored locations through analyzing the density distribution of photo-taking locations. In other words, it is possible to determine which spaces interest visitors by conducting a spatial analysis on where they choose to take photos. The KDE method is effective to understand the accumulation of point events on a 2-D planar space. However, the standard KDE is not sufficient to visualize the density of point events on a network space. In the experiment, the participants who moved around Hibiya Park mainly walked along on the park trails, and most of their photo-taking locations were on these trails. This indicates that the point events are near the network-based events. Therefore, it is necessary for network KDE [21, 16], another KDE specialized in network analysis, to be applied to this research and to be compared with a case of standard planar KDE.

The scenic type of spaces was quantitatively extracted by classifying photos into nine categories. Moreover, visualization of the spatial distribution of categorized data is effective to understand visitors’ visual experiences of specific spatial characteristics. In the example of two gardens in Hibiya Park, although each space has a similar landscape/design element, visitors received a different impression from each space because of movement factors and the arrangement of different resources. This is important for discussing the destination image formation after visitors’ experiences. Additional and various types of participants should be employed in the experiment because participants in this study were relatively few. If visitors’ preferences for scenery and space in each group can be clarified, this knowledge will be more useful for park management.

Digital cameras are nicely combined with GPS loggers and GIS for research. Development of VEP with the spatial analysis approach will necessitate more detailed analysis techniques such as for photo-taking directions and visual fields. At the same time, “meanings” not visibly expressed in the landscape/scenery will be also important information to consider [2]. Integration of these physical and psychological data sets as well as the examination of other tourist destinations are future challenges.

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References


Appendix A. Places evaluated by many participants

(a) Shinji Pond and Crane’s statue

(b) Kumogata Pond and the stonewall

(c) First Flower Garden

(d) Second Flower Garden and visitors

(e) Matsumotorou restaurant

(f) Large Fountain, event booths, and visitors