Exploring Spatial Pattern of Tourist Behavior Using Geographic Information Techniques

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Abstract: - With rapid advances in science and technology, the global positioning system (GPS) tracking techniques have improved and become more convenient for exploring spatial patterns of tourist behavior. In this study, we collected the movement data of touristsusing GPS trackers and anAndriod application (APP) executed on smartphone platform to explore the spatial behaviors and characteristics of tourist. The availabletourist tracksare 206.Weused the method of grid and buffer analysis to analyse the followings: (1) the degree of tourist aggregation, (2) stay time and (3) average movement speed of tourist.The results show that the spatial patterns of popular paths and points of interest.

Key-Words: -Spatial Analysis, Spatial Behavior, Tourist, GPS tracking, Spatial Pattern

1 Introduction

Assessments of tourist flows in recreational areas can improvespatial allocations of public facilities in parks and scenic points[1]. Managers and administrators can also use spatial information of tourists to increase management efficiency to meet conservation and recreational requirements.Spatial knowledge of travel behavior is very important for several tourism business management operations[2]. For example, spatial knowledge of travel behavior is useful to solve the following questions: (1) What are the main visited places in the park? (2) What are the visitor flows from the entrances to the main places? and (3) What are the visitor flows between the main places?[3]The researchersexecuted a geo-temporal data analysis and proposed developmentsuggestions for recreational facilities (roads, viewing platform, buildings, etc.) based on the understanding for the relationship of tourists flows and levels of crowding in the recreational area at the Twelve Apostles National Park, Victoria(Australia)[4].Thus, spatial information of tourist, such as movement path acquired from global positioning system (GPS) tracking or other tracking techniques, is useful for us to know the travel path, stopover locations and stopover duration[2].

In the past researches, tourists' movement patterncan be divided into six categories: (1) Single point, (2) Base site, (3) Stopover, (4) Chaining loop, (5) Destination region loop, (6) Complex neighborhood[5]. Some factors affecting tourists' movement pattern include: (1) Human factors, (2) Physical factors, (3) Trip factors, (4) Time factor[5]. The tourists' movement patterns are affected by personal characteristics, environmental conditions and destination attractions etc.

With rapid advances in science and technology, the spatial tracking techniquesfor tourists have mature and useful to collect and utilize spatial information. For example, 107 tourist routes collected to derive spatial information, such as locations and travel sequences in a specific geographic region [6].Further, the spatial information could be shared to other users using the internet.

The social platform has become popular for people to freely share their personal daily information, such as photos, videos or notes. Facebook is the most popular social platform globally. Most social networking users choose Facebook to share their location using mobile device to check in. They also share other personal information, such as evaluation for restaurant or attraction, to their friends. Thus, the users become a participant for the volunteered geographic information when they share personal experiences in their life to the social platform on the web.

Khetarpaul et al. (2011) collected 165 user trajectoriesfrom Microsoft Research Asia and randomly selected 62 trajectories from the dataset[7].

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They got a list of location-of-interest and the rank of attraction using spatial analysis for user trajectory.Furthermore, people could also share photos with time and geographic coordinate to Flickr [8]. The photos on Flickr are helpful for analyzing travel pattern of tourist at local scale.

2 Materials and Methods

2.1 Study Area

The location of YehliuGeopark is on the north coast of Taiwan in the town of Wanlibetween Taipei and Keelung. The total distance measured from the entrance of the YehliuGeopark to the end of the cape is about 1.7 km(Fig.1).

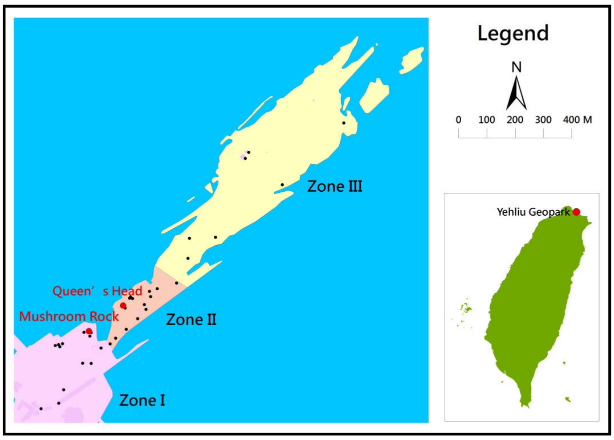

Fig.1 The location of YehliuGeopark

The YehliuGeopark is famous with rock landscape which is shaped by natural driving forces (wave, rock weathering, salt erosion etc.). Rocks are mainly composed of sand stones. The study area is divided into three areas: (1) Zone I contains the Mushroom rocks and the Ginger rocks, (2) The Zone II is similar to the Zone I. The main attraction of YehliuGeopark, Queen's Head, is located in this area, (3) The Zone III is the wave-cut platform located in the cape of the YehliuGeopark. The most famous attraction is thesand stone shaped like a Queen's Head. Other sand stones shaped likeFairy's Shoe, Tofu, and elephantare also attractive to tourists.

2.2 The Spatial Analysis ofTourist Behavior

This studycollected spatial records of tourist movementto analyze theirspatial behaviorusing GPS and GIS techniques. The spatial analysis containedgrid and buffer analysis to evaluate the followings: (1) aggregation degree, (2) stay time, and (3) movement speed, and try to find out the most frequently used paths and points of interest. In this study, the grid size is 10m to be a statistical unit for analyzing aggregation degree, stay time and movement speed.Buffer zone analysis is executed to analyzing aggregation degree, trip duration and movement speed for each attractions located in the YehliuGeopark.

2.3 Data Collection

The GPS data in the study was collected using GPS tracker, the former YehliuGeoparkguiding system executed on the Windows Mobile 6 platform (the machine types of the personal digital assistant used in this study are Mio P360 and Getac PS535F) and the new android mGuidingapplication (APP). We used posters to show tourists the data collection purposes of tourist spatial behavior in the front of the entrance of the Geopark. We had to help tourists to download and install the mGuiding APP (Fig.2).

We also collected tourist spatial behavior using GPS tracker (WBT-201 and HOLUX M-241) for tourists who have no smartphones (Table 1). The total interviewed tourists are 2,203. Only 332 tourists provided their trip records to us. The available data is 206.

Table 1 GPS tracker for research

Tracker	WBT-201 GPS	HOLUX M-241
Photo		
Memory	over 130,000 points	over 130,000 points
Format	Google Maps / Virtual Earth	Google Maps / Virtual Earth
Port	miniUSB	miniUSB
Power	12 Hours	12 Hours
Size	60 × 38 × 16mm	32.1 × 30 × 74.5mm

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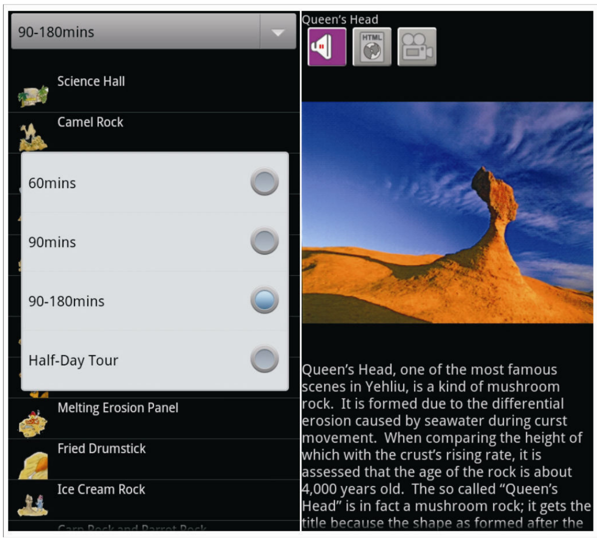

Fig.2 YehliuGeopark android guiding system APP

2.4 Accuracy of GPS Equipment

We useda Trimble R6 GPS receiver to record attractionlocation for 9 minutes and computed accuracy for GPS equipment used in this study. The results of GPS equipment accuracy are as followings: (1) the averagedistance are ±6.78m and ±6.89m that adopting WM6 guiding system by Mio P360 and Getac PS535F, (2) the distance is ±3.27m that adopting Android 2.3 APP guiding system by Motorola XT910, (3) the GPS tracker's distance is ±12.46m by WBT-201 GPS, and the distance is ±8.66m by HOLUX M-241(Table 2).

Table 2 the positioning accuracy of equipment

Version/Model	Equipment	Mean Distance
WM6	Mio P360	±6.89m
	Getac PS535F	±6.78m
Android 2.3	MotorolaXT910	±3.27m
WBT-201 GPS	GPS Tracker	±12.46m
HOLUX M-241	GPS Tracker	±8.66m

3 Results and Discussions

3.1 Spatial Analysis of Aggregation

The spatial analysis of aggregation show the grid intensity of tourist usage. As shown in Fig.3, the main aggregation areas distributed over the main paths from the visitor center to the Statue of Mr. T.J. Lin. Popular scenic spots (Ginger Rock, Mushroom Rock, Queen's Head, Fairy's shoe or Earth Rock etc.) were also observed lots of aggregations. Therefore, the spatial analysis of aggregation could be adopted as an index to assess popular scenic spots in a tourist destination.

At regional scale, the aggregation degree of Zone II is higher than Zone I and Zone III. Even Zone I is closer to the entrance than Zone II. The most popular scenic spot, Queen's Head, is located at Zone II. The result shows that most popular scenic spot in a tourist destination has a comprehensive attraction for tourists. The lowest area of tourist aggregation is the Zone III with an approximate trip duration of 3 to 4 hours.

3.2Spatial Analysis of Stay Time

The spatial analysis of stay time shows the spatial distribution of popular scenic spots in the Geopark (Fig. 4). Further, the intersections and main paths also show high stay time in the map.

The popular scenic spots, such as Queen's Head, Mushroom Rock, Statue of T.J. Lin and Speed Test Stand, have high stay time. The spatial analysis of stay time could also be adopted as an index to assess popular scenic spots in a tourist destination.

3.3Average Movement speed

The calculation of average movement speed is divided into two steps:(1) firstly, we calculated the tourist movement speed (TMS) as follows:

$$TMS = \frac{\Sigma(\text{the frequency of aggregation} \times \text{tourist'speed})}{\Sigma\,(\text{the frequency of aggregation})}$$

(2) using the TMS to be divided by the total grid number in the specific area (the study area, Zone I, ZoneII and Zone III).

The average movement speed of tourist in the Geopark is 3.326 km/hr. In the comparison of Zone I, II and III, the average movement speed of tourist are 3.632 km/hr, 2.797 km/hr and 3.251 km/hr.Zone II has the slowest average movement speed of tourist compared to Zone I and III.

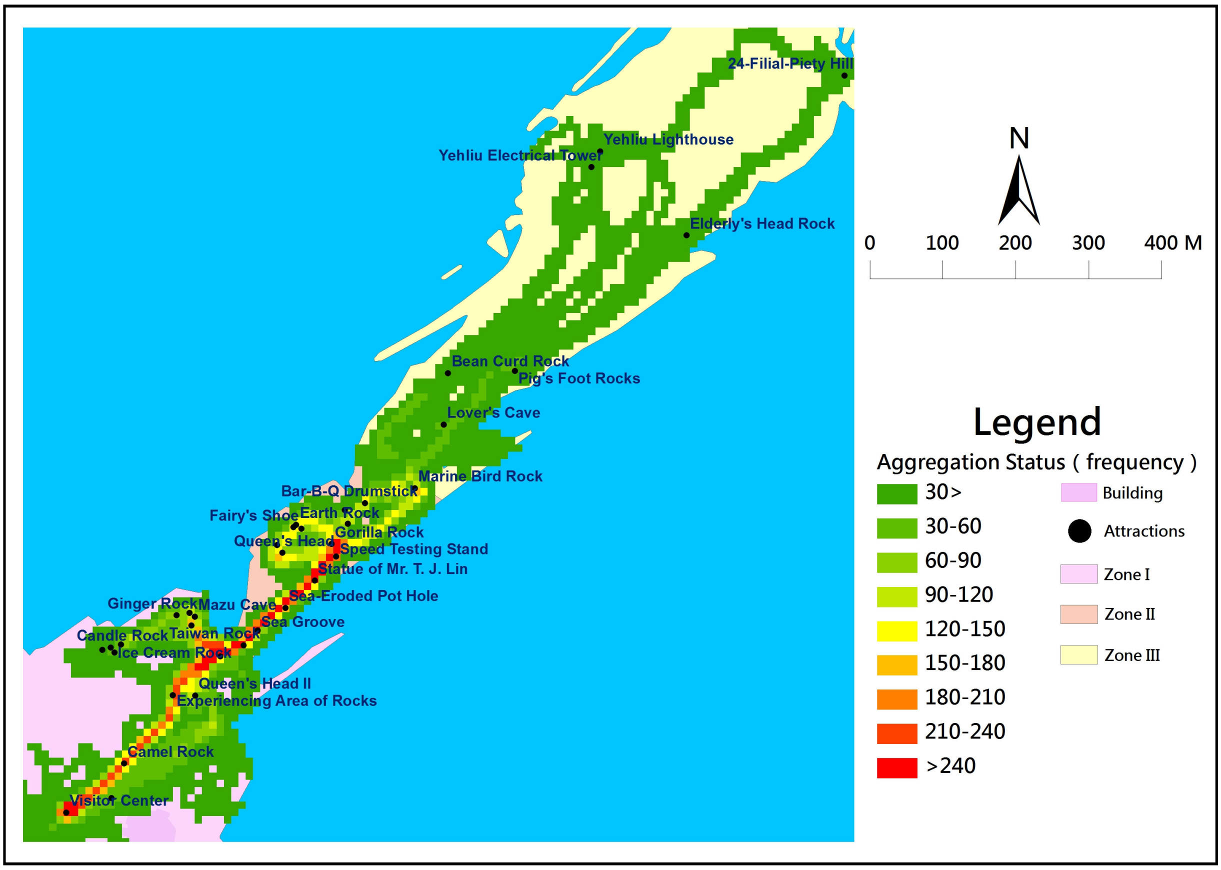

Fig.3 The degree of aggregation of tourist in the study area

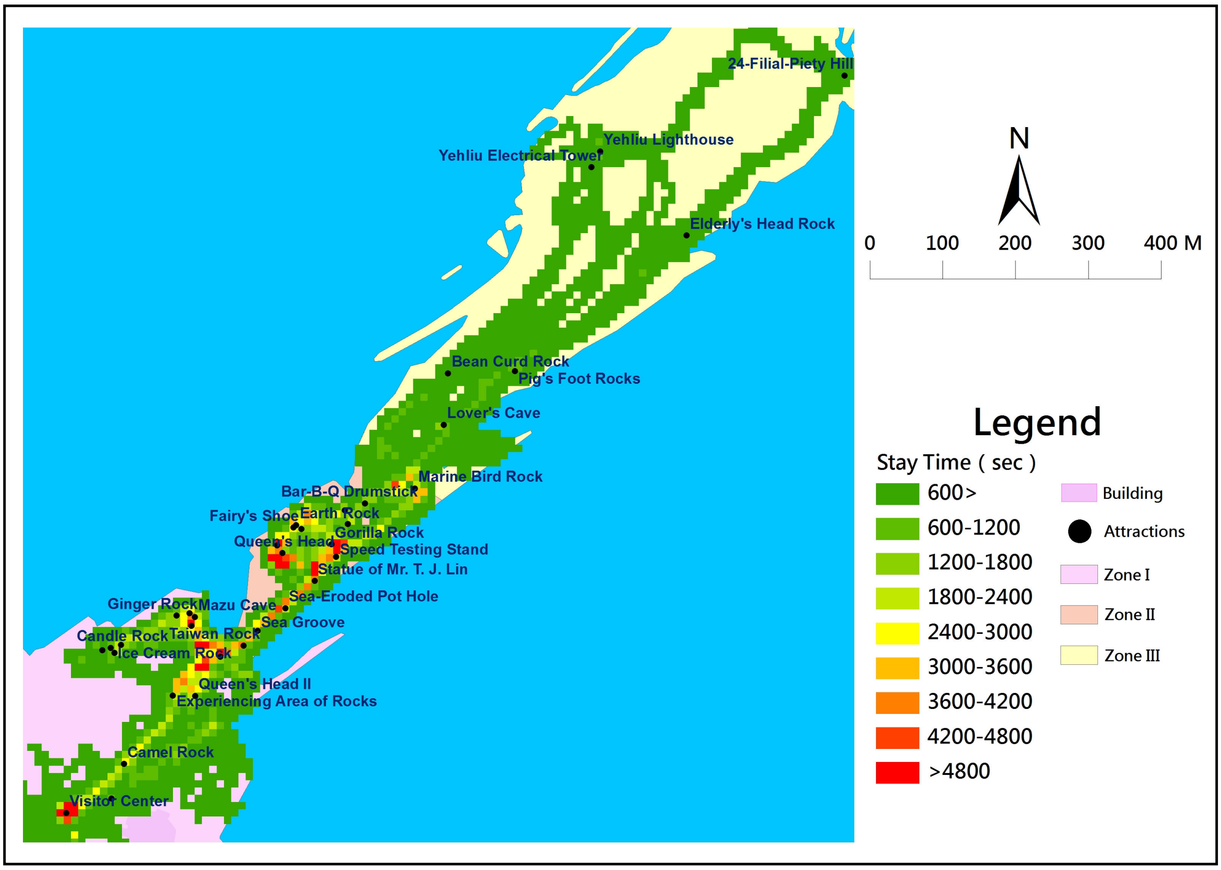

Fig.4 The spatial distribution of stay timefor each grid in the YehliuGeopark.

3.4 Tourist Behavior in Points of Interest

The results of tourist behavior analysis in points of interestare shown in Table 4.We selected top 10 scenic spots for aggregation degree, stay time and movement speed.

The results of aggregation in points of interest show that over 80% of tourists has visited the Mushroom Rock, Queen's Head, Mazu Cave, Fairy's Shoe, Earth Rock and Pineapple Bun. The above scenic spots have wide-ranging attractions for visitors in the YehliuGeopark. The results of aggregation in points of interest also fit the spatial analysis of aggregation shown in Fig. 3. In the top 10 scenic spots of aggregation, there is no one from Zone III and six scenic spots are from Zone II.

The results of stay time in points of interest show that the rank is similar to the results of aggregation. The average stay time for each tourist is about 25 second to 1.35 minute (stay time of attraction/the total tourists). The stay time of scenic spots in the YehliuGeopark is too short. Adding stay time of points of interest is important for the administration in the YehliuGeopark.

The results of average movement speed in points of interest show that the Queen's Head and Yehliu Lighthouse have lowest average movement speed of tourist. It means the Yehliu Lighthouse located in the Zone III has potential to become another famous scenic spot in the YehliuGeopark. In the same viewpoint, the Ice Cream Rock also has potential to be an attractive scenic spot. There are six scenic spots located in the Zone I to list in the top 10 scenic spots of slowest average movement speed.

The above information helps the administration of the YehliuGeopark to disperse crowded visitors in the Zone II. Some scenic spots have potential to be attractive scenic spots or landmarks in the YehliuGeopark. The administration could choose some potential scenic spots based on the spatial analysis of tourist behavior executed in this study to be the highlights of tourism marketing.

Table 4 Points of Interest in YehliuGeopark

Rank	Aggregation degree			Stay time			Average movement speed		
	Attraction	Frequency	Zone	Attraction	Min	Zone	Attraction	Km/hr	Zone
1	Mushroom Rock	198	I	Queen's Head	280.49	II	Queen's Head	0.576	II
2	Queen's Head	181	II	Mushroom Rock	256.57	I	Yehliu Lighthouse	0.576	III
3	Mazu Cave	180	I	Mazu Cave	202.31	I	Ice Cream Rock	0.684	I
4	Fairy's Shoe	180	II	Elephant Rock	175.77	II	Mushroom Rock	0.864	I
5	Earth Rock	172	II	Playful Princess	163.92	I	Mazu Cave	0.900	I
6	Pineapple Bun	172	II	Earth Rock	142.88	II	Melting Erosion Panel	0.936	I
7	Elephant Rock	156	II	Fairy's Shoe	127.42	II	Playful Princess	0.937	I
8	Playful Princess	155	I	Queen's Head II	104.78	I	Elephant Rock	0.938	II
9	Queen's Head II	136	I	Ice Cream Rock	91.15	I	Dragon's Head Rock	0.972	II
10	Bar-B-Q Drumstick	129	II	Pineapple Bun	85.91	II	Ginger Rock	1.044	I

4 Conclusions

This studyattempted to develop spatial analysis methods for analysing tourist spatial behaviour. We collected tourist movement paths using PDA, smartphone and GPS tracker. The grid and buffer analysis were computed to obtain spatial information of tourist behavior. The popular paths and scenic spots are acquired spatially.

The main areas of high tourist aggregation are Zone I and II. Popular paths primarily distributed from the visitor center to the Queen' Head and the intersection of scenic spots in Zone I. Zone III has the lowest aggregation of tourist usage. Thus, the area could be planed as a protected area for natural landscape.

The results of tourist behavior in points of interest provide the administration spatial information to improve the spatial pattern of public facilities. The administration could also use the spatial information of tourist behavior to promote potential scenic spots in tourism marketing. The Yehliu lighthouse and the scenic spots located in the Zone I have potential to become attractive landmarks in the YehliuGeopark. We found that popular points of interest have clustering phenomenon in the study area.

The spatial analysis of tourist behavior is important for planner, manager and administrator to support their decision-making processes spatially. This study has improved our knowledge in spatial information of tourist movement in a tourist destination.

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