Abstract. We suggest a new method using GPS to investigate human activities in an urban area. The time and space data of tourists’ migration in a specific tourist area from GPS are focused on. The data are visualized on GIS so that ‘Nigiwai’ activity can be analyzed including notion of time. From the analysis, places where pedestrians tend to stay longer or move slower, and those where they don’t, are found. As a case study, we analyze activity in Kamakura City using the suggested method, and examine the possibilities of application for the urban space design.

1. Introduction

The methods of pedestrian flows research used to be classified broadly into 2 categories. One is the so-called “tracking observation”, the other is “fixed-point observation”. Tracking observation, which tracks pedestrians who pass through the given place, enables getting more detailed information of monitor’s migration itinerary. On the other hand, Fixed-point observation enables us to count the traffic of pedestrians passing through a specific place in a given time interval. Tracking observation is effective in obtaining each data of each pedestrian’s migration routes, and Fixed-point observation is effective in obtaining traffic data at each place.

Recently the GPS pedestrian research method has been developed, which has possibility as a new research tool. There are some distinguished advantages: It enables us to get a large number of tourists’ time and space data at a time. If a large number of GPS devices is arranged, many tourists’ itinerary data can easily be acquired.

As a related study, Itahashi and Shinozaki (2003) developed the survey tools such that tourists use GPS cellular phone to retrieve the information of area and the surveyors provide requested information and get the tourists’ properties (including the movement data). Fujita et al. (2003) developed visualization method by polylines which show tourists’ migration tracks. The polyline display can be best suited visualization if pedestrians’ characteristics of walking around qualitatively are researched.

Both time and location data of pedestrians’ migration can be acquired and
directly imported into a PC using GPS. And moving speed can be acquired from the time and space data, too. In this paper, we present a new research method to analyze the tourists’ activity four-dimensionally, including the notion of speed of tourists. We develop a point display visualization method which enables both macroscopic and microscopic analysis for the area and tourist activity.

2. Data Processing

In this section, the method to acquire tourists’ migration’s time and space date is described.

2.1. KAMAKURA CITY

We chose Kamakura City as a subject for the research. In this city, a large amount of income depends on sightseeing. There is beautiful scenery with conservation of old temples and shrines. However, there is a problem, that is regulations for conservation interfere in streets and passes improvements. Old and narrow streets cover the entire city, and tourists move from temples through these web of streets, therefore tracks of tourists in Kamakura are too complicated to evaluate quantitatively using existent methods. We expect to find clarify the characteristics of sight seeing in Kamakura by using the visualization of activities, and figure out activities of tourists.

2.2. DATA ACQUISITION

We use GARMIN Geko201 as GPS portable. This GPS accumulates geodetic latitude and longitude information, geodetic time, and geographic coordinate system each point, and stock 10000 points in this body. 1 second or 1” (North-South axis 3.8m × East-West axis 2.5m) is set up as the minimum geodetic unit. Data precision tolerates 5–15m.

In this survey, we set this GPS portable to stock geodetic information automatically at every 3 seconds interval till it accumulates 10000 points. The total geodetic time comes to 6 hours.

We handed out GPS to tourists at Kamakura and requested them to move around the city. The total number of examinees was 114. Ratio of age and sex were chosen to be almost equal to those of total tourists.

2.3. PROCESSING OF DATA

Procedures of data import and conversion are as follows.

1. Import data of latitude, longitude and time acquired from GPS.
2. Exclude points outside of Kamakura City from GPS as error data.
3. Convert latitude and longitude data into x-y coordinate data.
4. Calculate velocities at each observation point in whole time from changes of one examinee’s points per time on the coordinate.
5. Exclude points as error data that velocities are over 6.2m/s that the ceiling of walking velocity.
6. From the process above, table with data of x-y coordinate, time and velocity on every observation point is made out.
7. Minimum unit (x: 2.5m, y: 3.8m) to measure positions on GPS interrupts to visualize every given point on GIS because several different points measured in the same unit area are indicated on the completely same position. To solve this problem, we gave random numbers to every acquired data in x-y coordinate, which realizes random distribution of points within the unit (x: ±1.25, y: ±1.25).
8. Import the table data into GIS and plot it on the map of GIS.

3. Visualization

First, we show visualization by polylines. Next, we suggest 3 methods for activity visualization: time integration, average travel speed, and distribution of velocity points (density and velocity).

3.1. VISUALIZATION OF PEDESTRIANS’ ITINERARY BY POLYLINES

In Figure 1, all pedestrians’ itineraries are visualized by polylines. The visualization is too complicated to analyze the activity in the area.

![Polyline display.](image)

3.2. VISUALIZATION OF TIME-INTEGRATION OF PEDESTRIANS

Divide the city area into 10m square meshes, count number of acquired points
within each mesh, and visualize them by colours. Counted number means time integration of pedestrians’ data on the mesh. High valued mesh means that pedestrian stays there longer or many pedestrians pass through there. Figure 2 shows distribution of time integral, where deep coloured means high time integral.

3.3. VISUALIZATION OF THE AVERAGE TRAVEL SPEED AT ALL MEASURING POINTS WITHIN MESHED MAP

Calculate the average travel speed in each mesh. Figure 3 shows average travel speed. Travel speed is slow at red coloured and it means tourists tend to stop at these areas.

Figure 2. Distribution of time integration.

Figure 3. Distribution of the average travel speed at all measuring points within meshed map.

3.4. VISUALIZATION OF SPEED POINTS OF PEDESTRIANS

Figure 4 is visualization of speed points’ distribution. All pedestrians’ all acquired points at the interval of 3 seconds are plotted on a map. Points are coloured by pedestrian’s moving speed. Blue coloured point indicates pedestrian walked
fast when pedestrian passed there. Red coloured point indicates pedestrian walked slowly.

Figure 4. Distribution of velocity points (whole Kamakura city).

4. Activity Analysis

We analyze firstly wide area activities, secondly narrow area in detail at the centre of the city, and finally NIGIWAI activities of the whole city.

4.1. WIDE AREA

From the aforementioned visualized maps Figure 2 and Figure 4, levels of tourists’ concentration at each spots can be clearly compared. The activity around Kamakura terminal station of JR-line, Eno-den, and buses, and shopping arcade is extremely high. They walk slower and stay longer there. On the approaches to shrines and temples and the route to the sightseeing place, the activities are relatively high. But on the route which connects sightseeing spots, especially on slopes, they walk faster and don’t spend much time. The following are the points that we qualitatively analyzed on sightseeing at Kamakura.

In Kamakura, shrines and temples are located like satellites, and narrow streets have been developed to connect them. Many tourists pass through those narrow streets. From our research it is clear that velocities of tourists tend to be rapid at...
streets between each sight, and become slower near the goal, crossings, or deadends.

Especially, visualization of speed points makes it easier to know where they are gathering, walking slowly, walking fast, stopping, or not going. Then we can find out places whose commercial potential is high or how much it is crowded at the famous sights.

4.2. NARROW AREA

Figure 5 is a close-up view of Figure 4 at central area. By closing up, details of activities around the station come out.

From Figure 5 and 4, firstly we recognize low velocities at the square in front of the station, at crossings, T intersection, dead ends. Analyzing in detail, velocities are low and time integral is high at traffic signals, along narrow streets and shopping arcades. And, contrary to our expectations, velocities are very high on slopes.

![Figure 5. Distribution of velocity point (centre of Kamakura city).](image)

4.3. NIGIWAI IN KAMAKURA CITY

By visualization of Figures 4 and 5, the speed of movement and the number of pedestrians can be analyzed simultaneously. In Japanese, there is a word ‘Nigiwai’ which explains the atmosphere of urban space such as condition of bustling, busy and flourishing. It seems that Figures 4 and 5 explain Nigiwai condition, because they show characteristics about both speed and density. Density and velocity in the urban area have a negative factor and a positive factor. For example, crowded situation for waiting at stoplights is negative and shopping mall abounding with pedestrians is positive. Each level is divided into high/low/nothing. Then, using the concept of Nigiwai the pedestrians’ activities can be classified and organized as shown in Figure 6.
5. Conclusion

By the research method using GPS, we investigated the characteristics of activity in Kamakura city. One is the characteristic from time-integral and the other is from tourists’ speed. These two characteristics are visualized by two methods. Then by the visualization of velocity points, we succeeded in showing the places where tourists tend to stay, or pass and analyze the relation between urban space and pedestrians’ activities. Finally, by the concept of ‘Nigiwai’ we classified and structured the pedestrians’ activities.

As we moved forward, there were problems caused by low accuracy of GPS, like correction of error data and study of its method. Moreover, comparison with other cities is necessary.

Figure 6. Structure of NIGIWAI.
References
