2.2 Selection and comparison of transport big data

As shown in Table 1, a series of transport big data as described in the subsection were summarized according to criteria such as successive trips, traffic modes, data acquisition, and data volume. As a result, in order to analyze trip behaviors within a walking distance, Wi-Fi data have been selected as they can easily collect the sequential data of person trips. Also, mobile phone location data have been selected as they cover the largest population distribution in the study area.

Table 1. Transport big data for estimating people's movements

Type	Data obtained	Attrib -ute	Purpose of behavior	Location	Suc-cessive trips	Time	Traffic mode			Feeling	Surround -ing condition	Data acqui -sition	Data volume
							Public transport	Vehicle	Pedes -trian				
Public transport IC card	History of getting on and off trains and buses of users	○	×	○	○	○	○	×	×	×	×	B	b
Wi-Fi	Number of devices within the network	×	×	○	○	○	○	○	○	×	×	A	b
Smartphone GPS data	Location information of users	×	×	○	○	○	○	○	○	×	×	A	c
SNS (Twitter)	Opinions and feelings	×	△	△	×	○	△	△	△	△	×	A	a
Mobile phone location data	Communication records of mobile phone	○	×	○	×	○	○	○	○	×	×	A	a

Legend ○: available △: partially available ×: not available A: easy B: difficult a: large b: medium c: small

3. METHOD FOR ESTIMATING SHORT DISTANCE TRIPS

In this paper, the authors developed a method for estimating trip volume within a walking distance using the big data selected in the previous chapter. The data sets used for estimating the trip volume are both Wi-Fi data collected from Wi-Fi packet sensors and the statistics of population distribution obtained through the processing of mobile phone location data. This method is distinctive in that short distance trip behaviors that cannot be found by traditional travel surveys can be estimated by simple surveying and easy data processing.

Trip volume is the number of people who move between 2 different points every hour. As indicated in Figure 2, the analytical procedure is divided into (a) calculation of the trip coefficient, (b) calculation of the outgoing, incoming, and floating populations for every point, and (c) calculation of the hourly trip volume between 2 points. First, using the OD (origin-destination) volume calculated based on collected Wi-Fi data, the distribution ratio of each trip volume (hereinafter referred to as the "trip coefficient"), from a particular starting point (hereinafter referred to as the "origin") to the next point (hereinafter referred to as the "destination") can be calculated. Second, the incoming ratio, outgoing ratio, and floating ratio per hour for each point can be calculated from the OD volume between the points. The outgoing population for each point is calculated by multiplying the outgoing ratio by the number of visitors at the origin. In cases where the number of visitors cannot be counted, the number of people for each point can be calculated using statistics of the population distribution. Finally, sets of trip volumes between 2 points can be calculated by multiplying the outgoing population by the trip coefficient. Details of the calculation for each step will be described in the following subsections.

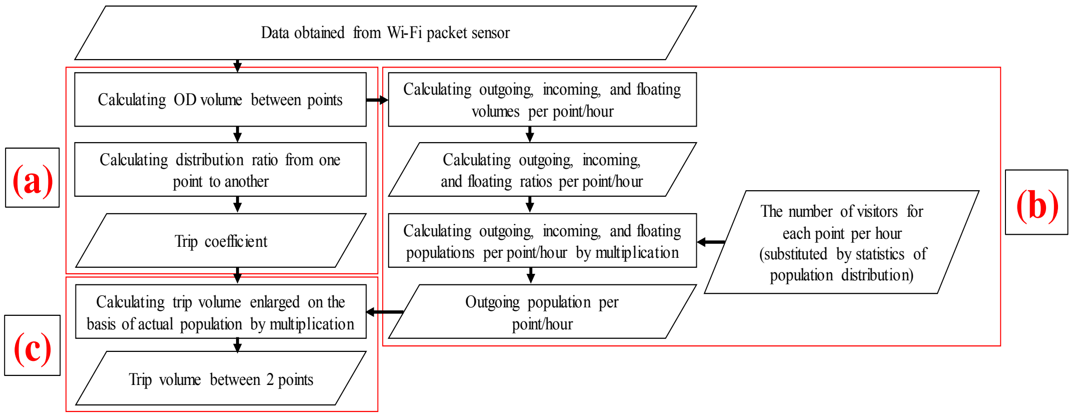

Figure 2. Analytical procedure to estimate trip volume

(a) Calculation of trip coefficient

Figure 3 shows an illustration for how to calculate the trip coefficient, which indicates the distribution rate of smartphone devices moving from a particular point to the next points. First, the number of devices moving between 2 points is calculated by aggregating the Wi-Fi data linked with user IDs. Second, the trip coefficient is hourly calculated by dividing the calculated number of OD trips by the total number of trips generated at the origin.

Data obtained

ID	Point	Time	ID	Point	Time
111	C	11:00	111	C	11:34
112	B	11:01	112	B	11:37
112	A	11:05	112	C	11:40
111	A	11:10	112	A	11:43
112	C	11:13	111	B	11:43
111	C	11:21	113	A	11:45
111	B	11:25	112	B	11:50
111	A	11:31	113	C	11:55

Aggregating the number of trips

O \ D	A	B	C
A	-	1	4
B	2	-	1
C	2	3	-

(trip)

Calculating trip coefficient

O \ D	A	B	C
A	-	20	80
B	66	-	33
C	40	60	-

(%)

Figure 3. Illustration for calculating the trip coefficient

(b) Calculation of outgoing, incoming, and floating populations for every point

The outgoing population, incoming population, and floating population are the number of people who start, arrive, and stay at every point, respectively, enlarged on the basis of the actual population in the respective time zones of a day. Figure 4 shows an illustration for how to calculate them. First, trips that moved from one point to another would be extracted by linking them with user IDs. Incoming and outgoing volumes for a particular point are calculated for every hour (from 00 to 59 minutes for each hour). If the same ID is observed in a particular point for two consecutive times before and after the hour (00 minutes), the device is regarded as the floating population. Second, the hourly outgoing, incoming, and floating ratios can be calculated by dividing the outgoing, incoming, and floating volumes by the total population. Finally, the outgoing, incoming, and floating populations for a particular point can be calculated by multiplying the number of visitors (or statistics of the population distribution) by their respective ratios.

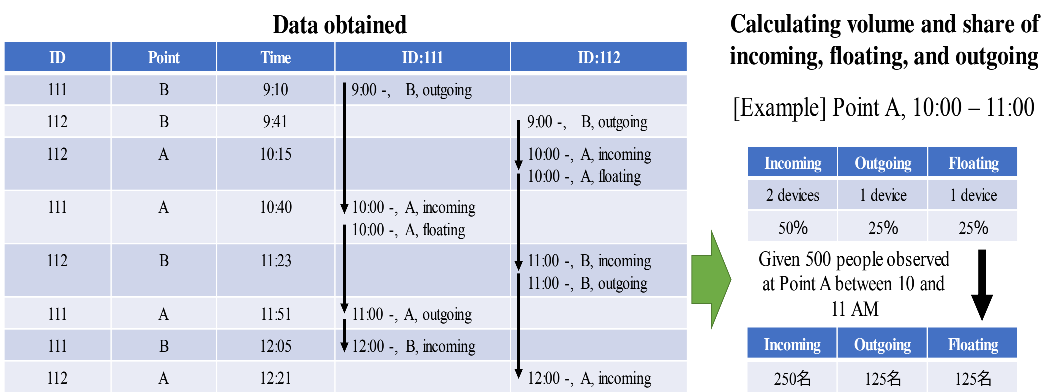

Figure 4. Illustration for calculating the outgoing population

(c) Calculation of trip volumes between two points

The trip volume is the number of people traveling between 2 points, enlarged on the basis of the actual population. The trip volume between the 2 points can be estimated by multiplying the outgoing population calculated by the trip coefficient.

4. CASE STUDY TO VALIDATE THE PROPOSED METHOD

4.1 Overview of the study area

A case study has been carried out in Tachikawa City, located about 40 kilometers west of central Tokyo. The study area is in the area of Tachikawa Station in the center of Tachikawa City, where some urban renewal projects have been ongoing. As the national Showa Memorial Park and the Mitsui Shopping Park are located within 1 kilometer and 2 kilometers of the station, respectively, many visitors come from a relatively long distance. The flat land allows people to travel on foot or by bicycle easily in the central district of Tachikawa City, where the sizes of the zones and blocks are nearly the same as that of other countries (see Figure 5).

Figure 5. Observation points by Wi-Fi packet sensors

The data obtained from Wi-Fi packet sensors on September 1, 2018, and statistics of the population distribution (i.e., mobile phone location data) have been used to validate the proposed method. Population distribution statistics can be used to understand the floating population by the time period, age group, and sex in 500m × 500m square zones in the study area. "Mobile spatial statistics" provided by NTT DOCOMO were employed as population distribution statistics data. Data was collected using Wi-Fi packet sensors installed around Tachikawa Station, as shown in Figure 5, from 10:00 to 18:00 on September 1 (Saturday).

4.2 Estimation of trip volume

Table 2 shows part of the hourly number of trips calculated using the data obtained from Wi-Fi packet sensors (between 10:00 and 11:00). Although many trips were confirmed between the two sites closely located (Tachikawa-Kita Station (B) - Sansan Road (I), and IKEA Tachikawa (D) - Midoricho Park (J)), there is a possibility that travelers could be detected by both sensors while they were staying in the area between the two sites; excessive trips may have been estimated. With regard to the observation points, a great number of trips were found at traffic nodes such as Tachikawa Station (A) and Tachikawa-Kita Station (B). On the other hand, sufficient numbers of trips were not seen at some points such as Showa Kinen Park Nishi-Tachikawa Gate (H). An application using a GPS function called "Profile Passport" was used to check the accuracy of the data, and it was confirmed that the collected data is correct.

Table 2. Number of trips between two points (between 10:00 and 11:00)

Start \ Arrival	(A) Tachikawa Station	(B) Tachikawa -Kita Station	(C) Takamatsu Station	(D) IKEA Tachikawa	(E) LaLaport Tachikawa Tachihi(1F)	(F) LaLaport Tachikawa Tachihi(2F)	(G) Showa Kinen Park Tachikawa Gate	(H) Showa Kinen Park Nishi-Tachikawa Gate	(I) Sansan Road	(J) Midoricho Park	(K) Intersection at 2-chome, Akebonocho	Total
(A) Tachikawa Station		166	19	73	64	51	31	5	124	13	85	631
(B) Tachikawa-Kita Station	97		54	28	22	42	27	1	340	9	13	633
(C) Takamatsu Station	24	65		44	38	34	3	1	46	39	14	308
(D) IKEA Tachikawa	38	18	30		46	34	39	6	45	183	11	450
(E) LaLaport Tachikawa Tachihi(1F)	31	14	13	26		127	9	0	25	5	7	257
(F) LaLaport Tachikawa Tachihi(2F)	15	9	13	23	153		2	2	7	2	8	234
(G) Showa Kinen Park Tachikawa Gate	30	18	14	50	15	9		11	49	8	6	210
(H) Showa Kinen Park Nishi-Tachikawa Gate	3	2	0	2	2	2	3		2	0	0	16
(I) Sansan Road	87	131	26	40	12	26	21	0		34	34	411
(J) Midoricho Park	4	8	27	652	7	3	3	0	20		6	730
(K) Intersection at 2-chome, Akebonocho	66	8	2	17	6	9	7	1	24	15		155

(trip)

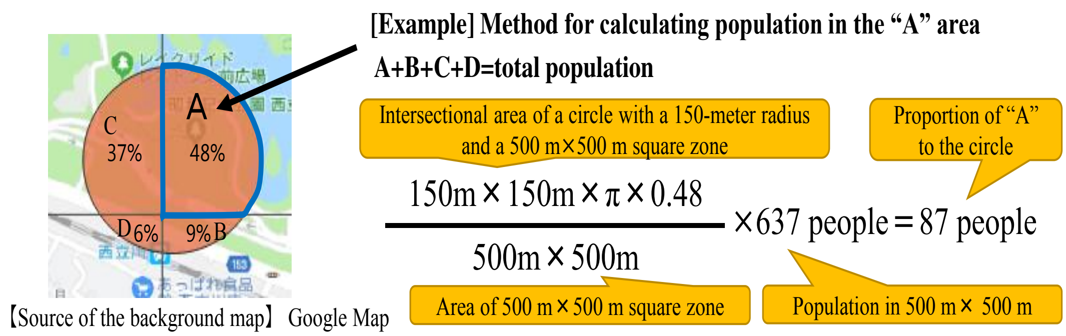

Figure 6. Illustration for calculating the total population

In this case study, the hourly number of visitors was calculated using statistics of the population distribution at every site. As shown in Figure 6, population in 500m×500m square zone in Figure 6 is an estimated population through data processing according to the market penetration of NTT DOCOMO in Japan. In consideration of the detecting range of the sensor from the point where the Wi-Fi packet sensor was installed, a circle of 150 meters radius is made for each point (Ichii et al. 2018). The circle is divided into 4 portions according to the intersection of 500m × 500m square zones and the circle. The total population (outgoing population + incoming population + floating population) can be calculated according to each of the intersectional areas of the circle (Terada et al. 2012). As discussed in the analytical procedure shown in Figure 2, the outgoing population, incoming population, and floating population for each point can be calculated by multiplying the total population for each point by the outgoing ratio, incoming ratio, and floating ratio for every hour, respectively.

Table 3 shows part of the trip volume (between 10:00 and 11:00) calculated by multiplying the hourly outgoing population by the trip coefficient between points. Table 4 shows the calculated results of the number of people incoming for each point. The accuracy of the estimated trip volume can be confirmed by comparing it with the hourly number of visitors to the sites. Based on interviews with the managers of the shopping sites observed by the Wi-Fi packet sensors, it was confirmed that the estimated trips were nearly the same as the actual situations.

Table 3. Hourly trip volume between two points (between 10:00 and 11:00)

Start \ Arrival		(A) Tachikawa Station	(B) Tachikawa -Kita Station	(C) Takamatsu Station	(D) IKEA Tachikawa	(E) LaLaport Tachikawa Tachihi(1F)	(F) LaLaport Tachikawa Tachihi(2F)	(G) Showa Kinen Park Tachikawa Gate	(H) Showa Kinen Park Nishi-Tachikawa Gate	(I) Sansan Road	(J) Midoricho Park	(K) Intersection at 2-chome, Akebonocho	Total
(A)	Tachikawa Station		427	49	188	165	131	80	13	319	33	219	1,624
(B)	Tachikawa-Kita Station	186		104	54	42	81	52	2	652	17	25	1,214
(C)	Takamatsu Station	15	40		27	23	21	2	1	28	24	9	189
(D)	IKEA Tachikawa	23	11	18		28	21	24	4	28	112	7	276
(E)	LaLaport Tachikawa Tachihi(1F)	26	12	11	22		107	8	0	21	4	6	216
(F)	LaLaport Tachikawa Tachihi(2F)	13	8	12	20	136		2	2	6	2	7	208
(G)	Showa Kinen Park Tachikawa Gate	32	19	15	53	16	10		12	52	8	6	223
(H)	Showa Kinen Park Nishi-Tachikawa Gate	25	17	0	17	17	17	25		17	0	0	136
(I)	Sansan Road	182	274	54	84	25	54	44	0		71	71	860
(J)	Midoricho Park	2	5	16	396	4	2	2	0	12		4	443
(K)	Intersection at 2-chome, Akebonocho	493	60	15	127	45	67	52	7	179	112		1,159
Total		999	873	294	987	502	510	290	40	1,315	384	353	6,547

Table 4. Hourly incoming volume for each point

	Name of location	10:00 -	11:00 -	12:00 -	13:00 -	14:00 -	15:00 -	16:00 -	17:00 -
(A)	Tachikawa Station	999	1,341	1,357	1,388	1,516	1,705	1,802	1,970
(B)	Tachikawa-Kita Station	873	1,211	1,435	1,510	1,656	1,742	1,695	1,651
(C)	Takamatsu Station	294	389	519	579	480	575	666	596
(D)	IKEA Tachikawa	987	1,050	1,335	1,303	1,272	1,161	1,271	1,221
(E)	LaLaport Tachikawa Tachihi(1F)	502	611	656	773	843	781	790	617
(F)	LaLaport Tachikawa Tachihi(2F)	510	716	690	796	754	677	614	325
(G)	Showa Kinen Park Tachikawa Gate	290	138	73	72	52	24	12	7
(H)	Showa Kinen Park Nishi-Tachikawa Gate	40	52	77	82	73	36	43	53
(I)	Sansan Road	1,315	1,323	1,445	1,436	1,636	1,552	1,071	1,128
(J)	Midoricho Park	384	489	735	733	799	823	495	742
(K)	Intersection at 2-chome, Akebonocho	353	467	435	531	506	534	743	655

(Number of people)

5. CONCLUSIONS

This paper developed a method for acquiring trip volume, which indicates the hourly number of people who traveled between 2 different points within a walking distance. First, the authors reviewed the characteristics of 6 kinds of transport big data, which can be considered useful in measuring actual urban conditions such as trips within a walking distance and changes in the dynamics of a population over several years. As a result, two types of data were selected: Wi-Fi data for acquiring successive pedestrian trips and mobile phone location data for surveying the population mobility precisely with a small zone size. The proposed method was applied to the case study in Tachikawa City, Tokyo. MAC address data for smartphones measured by Wi-Fi packet sensors and statistics of the population distribution data processed by mobile phone location data have been employed to validate the accuracy of the estimated results of the proposed method. The case study produced findings, including: (1) it was confirmed by interviews with the managers of the shopping sites that the estimated trip volume was almost the same as the trip volume actually observed each day; (2) the proposed method is useful to evaluate urban planning as well as urban management because it is capable of monitoring short distance trips not found by traditional statistical surveys. For future work, an advanced method to estimate more detailed trip behaviors, such as trip purpose and means of transportation, needs to be proposed, in addition to further field testing in other cities besides Japanese cities to improve the usability.

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Layout Planning Methods of Tourism Road Considering Tourism Value and Traffic Demand

Zhen-Guo Liu[1] and Tian-Tian Zhang[2]

[1]China Academy of Transportation Science, Beijing, China. Email: liuzg211@qq.com
[2]China Academy of Transportation Science, Beijing, China. Email: 937313561@qq.com

ABSTRACT

Tourism road is the transport facilities with the dual function of transportation and tourism. In recent years, the construction of tourist highway in the country has formed a new wave, and many places have carried out the planning and construction of tourist routes. Especially in Hainan Province, the Government proposed to build the first complete provincial tourism road system. Based on the analysis of the characteristics and function of tourism road, a set of planning method for tourism road are proposed. The method is based on the traditional road network planning and layout methods and combine the tourism resources evaluation and landscape value evaluation methods. Firstly, the trend and demand forecast of tourist traffic and tourist highway are analyzed, and the accessibility demand of tourist attractions is investigated. Then the tourism road network can be built based on the traffic demand. Secondly, by constructing the tourism value evaluation system and evaluating the tourism value of the road network, the tourism road planning scheme based on the landscape value is gained. Finally, by integrating the results of the previous two stages, the comprehensive planning and layout scheme can meet the travel demand and provide good travel value experience. Through the eco-environment evaluation of the comprehensive layout planning scheme, the final layout plan of tourist highway is obtained. The method has been applied in the planning of tourism road in Hainan Province, and has achieved good effects.

Keywords: Tourism road; Tourism value; Layout planning method.

1. INTRODUCTION

Tourism traffic is one of the indispensable elements of tourist activity, a premise condition, as well as a lifeblood of production and development of the tourism industry. With the economic development and social advancement, the tourism traffic volume is increasing sharply. The major traffic demand is commuting and official business traffic demand in current, and will gradually transform into the combination of commuting, official business and leisure tourism traffic demand in the future, which mean these traffic demand will play an equally important role (Guan et al.,2001; Fan, 2012). The tourism traffic conditions have been improved continuously in recent years and a great deal of traffic infrastructure represented by tourism roads has been planned and constructed, however the imbalance between supply and demand of tourism traffic is still prominent and many problems such as the traffic congestion, outdated structure and imperfect spatial network are still impeding the development of the tourism industry (Wu, 2001).