Technical Report

Promotion of big data utilization for tourism-based community development:
Analysis of traffic routes at intersections

Ryo Hori (Graduate School of Informatics, Nagoya University, hori.ryo.w9@s.mail.nagoya-u.ac.jp, Japan)
Tomoki Uga (School of Informatics, Nagoya University, uga.tomoki.k9@s.mail.nagoya-u.ac.jp, Japan)
Mayu Urata (Graduate School of Informatics, Nagoya University, mayu@i.nagoya-u.ac.jp, Japan)
Mamoru Endo (Graduate School of Informatics, Nagoya University, endo@i.nagoya-u.ac.jp, Japan)
Takami Yasuda (Graduate School of Informatics, Nagoya University, yasuda@i.nagoya-u.ac.jp, Japan)
Masahiko Yamada (General Affairs Department, Takayama City, m.yamada@city.takayama.lg.jp, Japan)

Abstract
Tourism, which is ranked as an important policy pillar in Japan, is changing. For instance, attention is paid to "not famous" sightseeing spots, or demand for work vacation is expanding. It is essential to accurately grasp and respond to these changes. Information and communication technology (ICT) utilization, especially big data utilization, is an important area of focus. However, tourism is a field where ICT or big data utilization has not been fully employed. According to a survey, the reasons for this are: personnel do not have concrete content, and lack of human resource and technical expertise. Therefore, in this study, we analyze the traffic tracking data collected and propose ways to utilize it to show what kind of data can be used, its effects and merits, and create concrete examples of big data utilization. The analysis ensured prevailing situations are understood to be utilized for evaluating the effects of measures in the future and for countermeasures against traffic congestion. We also showed a merit of big data utilization by discovering present situations which were different from the perceptions of the locals.

Keywords
evidence based policy making, smart city, digital transformation, artificial intelligence, object tracking

1. Introduction

Tourism has been ranked as an important policy pillar in Japan, and "tourism-based community development," which promotes tourism and improves the lives of the community-dwellers, has been emphasized. The nature of tourism is changing daily: attention is being paid to regional tourism at "not famous" sightseeing spots, and the demand for work vacations is expanding due to COVID-19. It is essential to accurately grasp and respond to these changes.

Big data utilization is attracting attention to respond effectively to such changes, but in the tourism field, there is a lot of room for promotion due to issues such as "can't imagine concrete content," or "lack of human resources and know-how."

We have been conducting research on an ICT-based tourism city development in Takayama City, Gifu Prefecture, and installed 12 AI cameras to collect big data on traffic of pedestrians and vehicles (Figure 1) [Hori et al., 2022].

This study aims to promote the utilization of big data in tourism by showing what kind of data can be used, its effects and merits, and creating concrete examples of big data utilization. In this study, we will analyze the traffic tracking data collected at intersections and propose ways to utilize it.

2. Big data utilization

It will be necessary to maintain and improve various industries or regions efficiently. The use of ICT is attracting attention for replacement and effective use of labor. In particular, big data utilization is considered important, and it is expected that its absence will make it difficult to manage stores and organizations in the future.

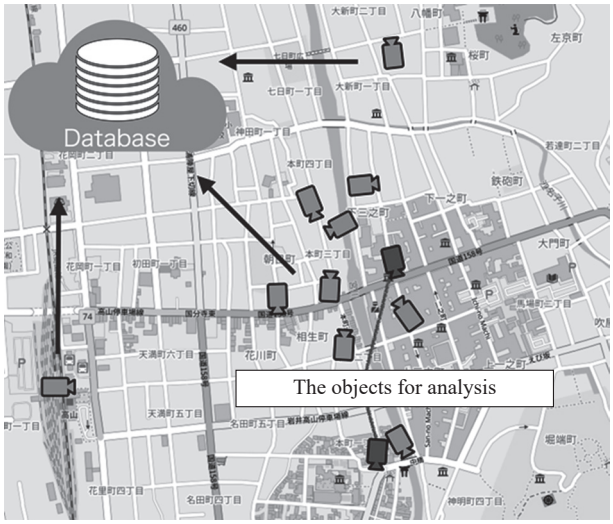

Figure 1: AI cameras installed in Takayama City

However, in the tourism sector, big data utilization has not taken root yet compared to others, and it relies on the experience and intuition of local people [Fuji and Fujiu, 2019]. For instance, according to a survey on inbound tourism, less than 40 % of municipalities are promoting the use of ICT, which is indispensable for the utilization of big data. In addition, less than 10 % of the municipalities have started or are planning to start analyzing various logs such as access logs and GPS logs.

Contrastingly, tourism ranks first as a field that should utilize big data, and about 80 % of the municipalities are interested in utilizing it. In addition, the number of municipalities that are concerned about the organizational structure and security for the utilization decreased from 2014 to 2016, thus, notably, understanding of big data utilization has been increasing.

Regarding challenges in utilization, more than 60 % of the municipalities answered that "the specific situation of utilization is not clear" and 50 % answered that "the effects and benefits are not clear." In addition, more than 40 % of them answered "we lack finances and human resources" [InfoCom Research, 2017].

Therefore, it is important to create examples of big data utilization, and to show not only the analysis but also the effects and benefits. In addition, as more data is utilized, the utilization and its methods will become more common, the necessary costs will decrease, and the problems of financial and human resource shortages will be solved.

3. Position of this study

Our laboratory has been collecting data on traffic volume and object tracking data, (x, y) coordinates in screen, in Takayama City (Figure 2). In this study, we use two intersections of the acquired data to (1) analyze the current situation of traffic routes to take measures and evaluate the effects, and (2) propose specific examples of its utilization.

Such analysis can clarify the flow and number of pedestrians from a relatively detailed viewpoint. This is expected to be useful for guiding the flow in a city or preventing traffic congestion, leading to the creation of a tourist city that combines convenience for tourists and livability for residents.

A related example is the statistical data of location information [NTT Docomo, n.a.; KDDI, n.a.; Navitime Japan, n.a.]. This includes spatial data over a wide area based on GPS from smartphones and route analysis based on GPS from car navigation systems. Moreover a related study analyzes migratory behavior by renting bicycles and a GPS-equipped device to subjects to track their routes [Kuboyama et al., 2019].

These methods have the advantage of measuring and tracking devices without exception. However, some pedestrians do not possess GPS-equipped devices, and each service must estimate traffic information from its limited amount of GPS data. Takayama City has had a trial of using similar GPS-based data, but it was not sufficiently accurate. In addition, most of them capture movements over a wide area such as 250 m^2, making detailed analysis of places such as intersections difficult.

Contrastingly, cameras can survey the entire population. At the present stage, they are inferior to GPS in that they may not recognize a person overlapped, but it can be estimated that the camera's recognition level will become more sophisticated with the development of technology. In addition, while they cannot capture a wide range of movement, they can analyze a specific area in detail.

Also, a traffic volume measurement is performed by human resources. In Takayama City, the traffic volume is measured manually every spring and autumn at several locations on weekdays and holidays, with the cooperation of retired senior citizens. However, because much labor and time are required, the number of days for measurement is limited to a few days per year, hence data accumulation is not sufficient. In the tourism industry, more continuous measurement is necessary because there are changes caused by various factors through a year, such as local events, domestic and international holidays, and seasons.

Figure 2: Tracked pedestrians and cars with tracking lines

4. Analysis of traffic routes

4.1 Measurement places

In this study, we analyze the path of the traffic data collected with cameras at two intersections in front of Takayama Jinnya-mae and the Takayama branch of Juroku bank.

Takayama Jinnya-mae intersection is located between two famous places: Takayama Jinnya and Naka-bashi Bridge. Across the bridge is Shinmei parking lot, making it an intersection that is easily accessible by tourist cars and buses.

The area in front of the Takayama branch of Juroku bank is located on Yasukawa Street. In Takayama City, tourists are currently concentrated to the south of the street, and the city is aiming to shift the flow of visitors northwards. We analyze the route at this point to measure the transition in the future.

4.2 Acquired data

The data is acquired using OpenDataCam [move lab, n.a.], open-source software for object tracking. After recognizing the objects, the system can track them from frame to frame, so that the movement of data can be obtained as a point (x, y) on the screen (Figure 2).

The acquisition period of the data used in this pathway analysis is from October 1, 2021 to October 31, 2021.

We put up a notice near cameras that informed the pedestrians of the purpose of cameras and that the video data acquired, for privacy purposes, are discarded immediately after obtaining the object types and their position (Figure 3).

4.3 Method

For analysis, we use the point where the object was first re-

Figure 3: A notice and a camera

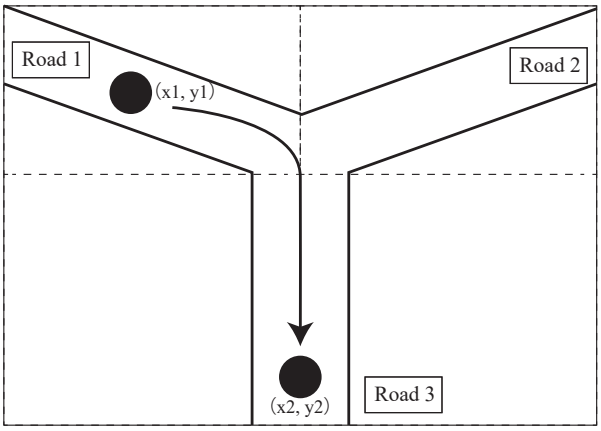

Figure 4: Method of assuming the path

corded (x1,y1) and the point where it was last recorded (x2,y2). We divided intersections into several regions on the screen and assumed that an object moved from the region where (x1, y1) belongs to the region where (x2, y2) belongs (Figure 4). One region corresponds to one road, and we compared the amount of traffic moving from each road to other at each period.

5. Results and discussion

5.1 Jinya-mae intersection

We divided the area as shown in Figure 5 and took vehicles: cars, trucks, and buses as the objects for analysis. We analyzed 24 combinations of weekdays, weekends and routes. The following are their characteristic results (Figure 6).

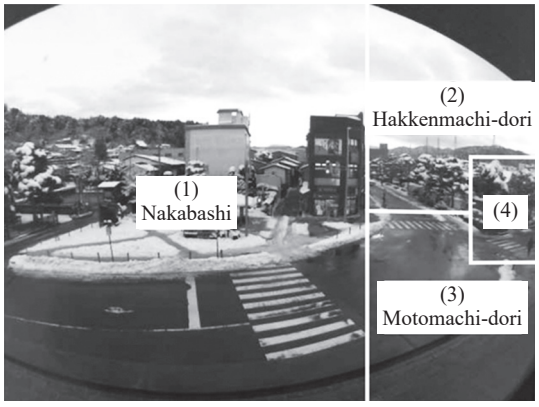

Figure 5: Camera video and divided area of Jinya-mae intersection

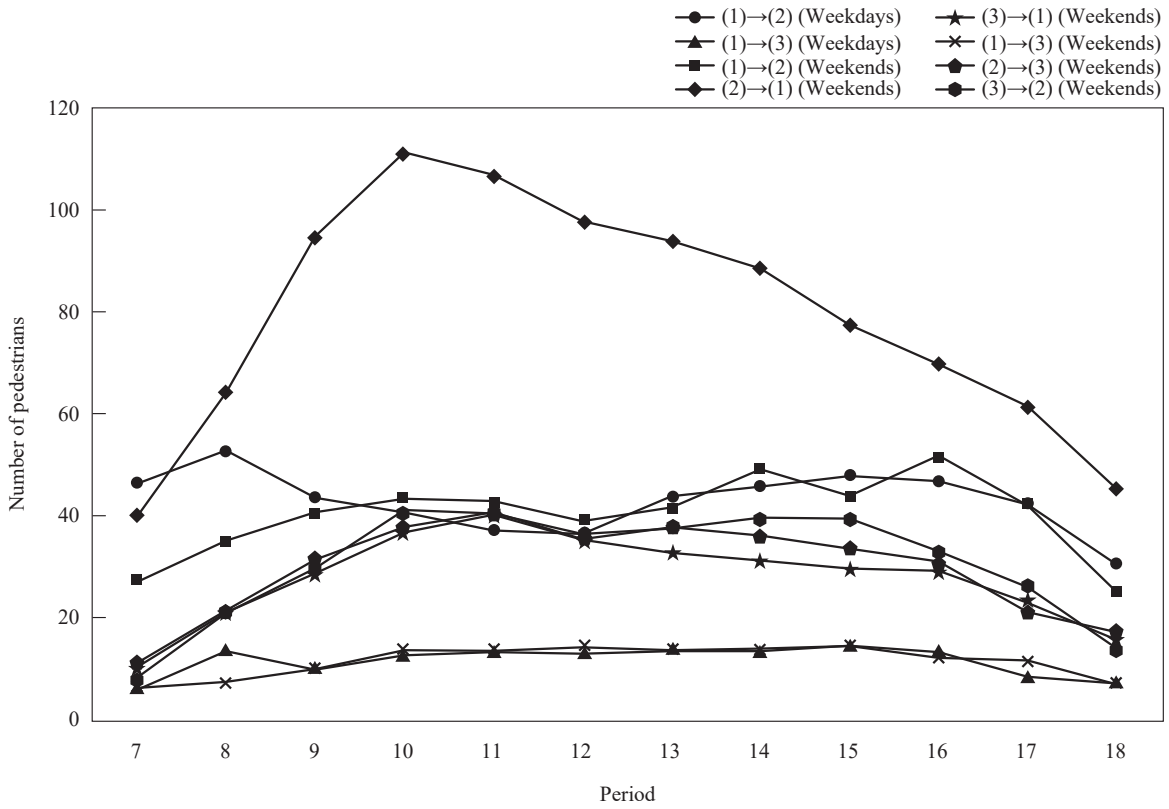

Figure 6: Hourly average of the number of vehicles for each rote on weekends and weekdays

First, in the average value of weekends, the route from (2) Hachikenmachi-dori Street to (1) Nakabashi Bridge (◆) had the largest number of vehicles, approximately 950, and the opposite route from (1) to (2) (■) had the second-largest number, approximately 480. Since there is a parking lot for tourists across (1) Nakabashi Bridge from the intersection, it can be concluded that many cars head there. The traffic volume of the route from (2) to (1) (◆) was high around 10:00 a.m. and that of the opposite route (■) was high from 2:00 p.m. to 5:00 p.m. It is considered that the route (◆) is used by tourists' cars visiting Takayama, while the opposite route (■) is used when they are leaving.

Next, while the traffic volume from (2) Hakkenmachi-dori Street to (3) Motomachi-dori Street (⬟) and that of the opposite direction (⬢) are equal, the traffic volume (2) to (1) (◆), and (3) to (1) (★) are more than double that from (1) in both the routes of (1) to (2) (■), and (1) to (3) (×) respectively. It can be concluded that this is an intersection with many vehicles heading in the direction of (1).

Finally, in the average value of weekdays, the traffic volume on the routes from (1) to (2) (●) and (1) to (3) (▲) temporarily increases around 8:00 a.m., indicating that the routes are used for commuting during this time.

5.2 Intersection in front of Juroku bank

We divided the area as shown in Figure 7 and took pedestrians as the object of analysis. As above, we mention the characteristic results (Figure 8).

First, we revealed that few pedestrians pass from (1) south to (3) north. Takayama city is aiming to increase the volume of traffic from (1), an end of the famous tourism street where a row of historical houses lies, to (3), an area which is not popular now, but we confirmed that the volume of the route is much lower than was expected.

Next, in comparing weekdays and holidays, the number of pedestrians passing from (1) south to (3) north increased slightly from 52.6 on weekdays to 54.6 on holidays. Presumably, most of the pedestrians currently passing from (1) to (3) are residents.

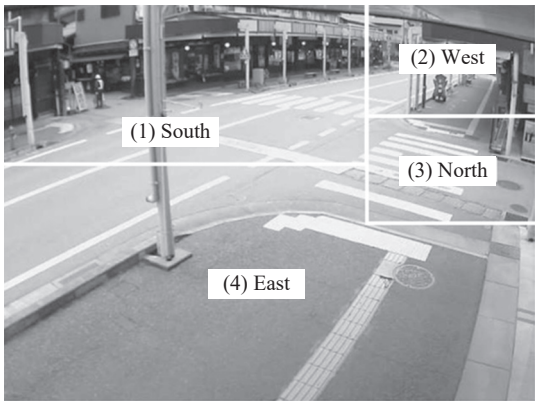

Figure 7: Camera video and divided area in front of Juroku Bank

Finally, 3/4 of the pedestrians who came out of the historical street and crossed the intersection went (2) west. On the west side is Takayama Station, which is currently more crowded than (4), the east side. If we can direct more pedestrians to the (3) north or (4) east, we can increase the time spent by tourists in the city.

5.3 Analysis discussions

We analyzed traffic volume for each route, discovered various characteristics, and confirmed present situations in detail. The analysis results for each route at Jinnya-mae intersection can be used to reconsider traffic regulations. This is effective in realizing smooth traffic with less congestion.

Both analyses can be used to quantify the effects of measures. There are various factors in the real world and it is impossible to conduct strictly controlled experiments. Detailed confirmation of the situation makes it possible to verify the effects more accurately.

In addition, we were able to clarify the present situations, which differ greatly from the perceptions of the locals: they thought more people pass from (1) north to (3) south than real. We have shown a merit of big data utilization in that we can

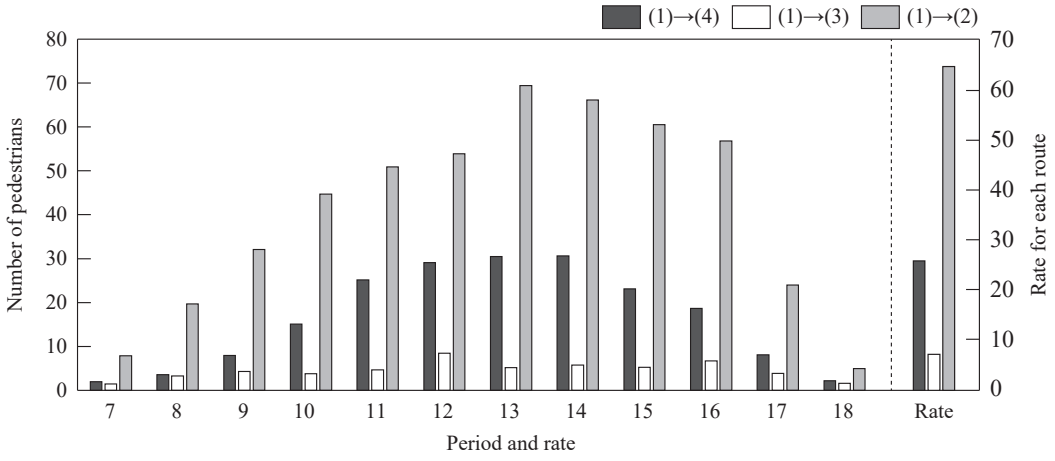

Figure 8: Hourly average of the number of pedestrians for each route

rely on facts rather than senses.

Contrastingly, in this case, we analyzed 24 patterns for one intersection. Although this has the advantage of clarifying the details, it should be noted that as the number of conditions increases so do that of analyses and the amount of effort.

6. Conclusion.

This research aims to promote big data utilization in tourism by creating concrete examples of its utilization in the tourism field, presenting what kind of data can be used, its effects, and its benefits. We (1) analyzed the current situation of traffic routes to take measures and evaluate the effects, and (2) proposed specific examples of its utilization.

We were able to grasp the present situations, including the characteristics for each road separately. We proposed utilizing these analyses for reconsidering traffic regulations, and quantifying the effects of measures in the real world, where complex factors are involved.

In addition, as a merit of big data utilization, the present situations were revealed which is different from the local feeling, and staff of the Tourism Division of Takayama City wanted to know more about it.

We will analyze the traffic congestion situation for each route for countermeasures in the future. We will also implement measures, follow the changes, and examine the effectiveness. Through these efforts, we will create concrete examples of big data utilization.

Acknowledgements

We express our gratitude to the following people for their cooperation: the Tokai Branch Office of NEC Solutions Innovator, Inc., Takayama City Federation of Shopping Center Promotion Associations, Hida-Takayama Tourism & Convention Bureau. This research was supported in part by JSPS KAKENHI Grant Number 20K12545.

References

Fuji, T. and Fujiu, M. (2019). Data utilization in tourism industry.

Hori, R., Yuki, O., Yamada, M., Urata. M., Endo, M., and Takami, Y. (2022). Collecting traffic volume data using edge AI for promoting tourism-based community development. *Proceedings of the 22nd Conference of Society for Tourism Informatics*, 17-20.

InfoCom Research (2017). Survey on the present situations of ICT utilization in regions.

KDDI (n.a.). KDDI location data (Retrieved February 26, 2022 from https://k-locationdata.kddi.com/).

Kuboyama, R., Kanoya, R., Takagi, K., Yamaguchi, K., and Iwasaki, Y. (2019). Analysis of migration behavior of bicycle rental users in tourist attractions: Comparison of Japanese and foreign tourists. *Abstracts of the Conference of the Kansai Branch of The City Planning Institute of Japan*, Vol. 17, 81-84.

move lab. (n.a.). Opendatacam (Retrieved February 26, 2022 from https://opendata.cam/).

Navitime Japan (n.a.). Want to know how the roads are being used (Retrieved February 26, 2022 from https://consulting.navitime.biz/menu/road).

NTT Docomo (n.a.). Mobile special statistics (Retrieved February 26, 2022 from https://mobaku.jp/).

(Received March 22, 2022; accepted April 15, 2022)