Business hours adjustment based on pedestrian count data toward dynamic business hour setting:

Demonstration at a restaurant in Takayama

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Abstract

Tourism is an important industry for Japan. Struggling with labor shortages due to the declining birthrate and aging population, efficient data-based management of tourist destinations is aimed at. However, the utilization of data has not progressed well in stores in tourist areas. In this study, pedestrian count data collected in a town was shared, analyzed, and utilized by a restaurant to reconsider its business hours toward dynamic business hour setting. This study determined the time of a day when the restaurant could expect more customers and extended the last-orders time based on pedestrian count data collected by an AI camera and aggregated for every hour. The result was evaluated by the sales data of the cash register of the restaurant. The strategy was well received by the collaborating restaurant and other local tourism-related businesses in the area, indicating that the business hours can be adjusted by pedestrian count data. On the other hand, it remained an issue that there were days when sales did not increase despite the extension, the shortening of business hours, and commutation of changed business hours to tourists.

Keywords

tourism digital transformation, AI camera, pedestrian count data, data utilization, business hours

1. Introduction

Tourism is an important industry in Japan, regarded as the trump card for regional development. Tourist destinations are struggling with issues such as the aging of tourism-related businesses and labor shortages. Digital Transformation (DX) for tourism is being promoted to solve these problems with the power of Information and Communication Technology (ICT). Tourism DX aims to reconsider business strategies by analyzing and utilizing data.

In this study, pedestrian count data collected in a town was analyzed and utilized at a restaurant in the vicinity of a collection point to adjust business hours based on the data, toward "dynamic business hour setting" to achieve both sustainable sightseeing spot management and tourist satisfaction. This study also organizes issues necessary for dynamic business hour setting.

2. Current state of tourism industry

2.1 Tourism and tourism DX

Tourism is one of the most important industries in Japan. Although the number of domestic tourists has been around 600 million [Japan Tourism Agency, 2023], since the declaration of Japan as a tourism-oriented country in 2003, the number of foreign visitors has been increasing from 5.2 million in 2003 to 31.8 million people in 2019. Especially, the number has rapidly risen since 2014 [Japan National Tourism Organization, n.d.]. Japan is trying to receive more attention from overseas [Cabinet

Decision, 2023].

It is also regarded as important for regional revitalization and it is an industry that involves a wide range of people, with an estimated 4.59 million people indirectly involved in tourism [Japan Travel Industry Association, 2019]. In addition, it has extremely high economic effects, such as contributing to the economic growth of the country through the improvement of the international balance of payments by earning foreign currency through attracting foreign tourists [Arai, 2021]. Tourism also states that it has a security function of contributing to the achievement of world peace. The United Nations has designated tourism as a "passport to peace" [UN Tourism, n.d.].

However, many tourist destinations in Japan are struggling with labor shortages. In addition to the decline in Japan's overall labor force because of the low birthrate and aging population, the labor productivity of the tourism industry is not high compared to other industries, and the working environment and wages are not favorable [Fujiyama, 2023; Kyoto City Tourism Association, 2023]. In recent years, the number of inbound tourists has been increasing rapidly. However, there are hotels that cannot accept guests although they have vacant rooms [Yomiuri Shimbun, 2023], and restaurants that have no choice but to close their doors at night, resulting in a loss of opportunity for both tourist destinations and tourists. In a survey conducted by the Kyoto Tourism Association among tourism-related businesses in Kyoto City, "long working hours, working on holidays, night shifts, etc." was the most common reason for job turnover at 30.7 % [Kyoto City Tourism Association, 2023]. Demographic trends will not change significantly in the future, so management based on the assumption of a small workforce is required. On the other hand, there is concern that focusing

on this way of working will result in a decline in the quality of tourism and a decrease in tourist satisfaction.

In order to solve these problems with the power of ICT, tourism DX is attracting attention [Japan Tourism Agency, n.d.]. Tourism DX is also one of the key policies in the Digital Rural City Nation Concept announced by the Cabinet Secretariat in 2021, which aims to solve local issues through the power of ICT. Tourism DX aims to reconsider business strategies and create new business models by analyzing and utilizing data. Efficient organizational management based on data is expected to ensure sales at stores in tourist areas and improve working styles, and maintain and improve tourist satisfaction.

The tourism industry is one of the least advanced areas of data utilization [Fujio et al., 2018]. In order to establish an infrastructural system that can be widely used in the tourism field and support the local community, academic research on data analysis and utilization in tourism is necessary.

2.2 Related studies and cases, and positioning of this study

As related studies, a wide-area analysis has been conducted for a regional tourism DX using the number of passers-by estimated from a Global Positioning System and cellular phone company base station data [Kawakami et al., 2020]. Geographic Information Systems (GIS) data has been also utilized for tourism development [Ridwana et al., 2020]. For example, analyzing GIS, night-light, and Tweet data can help find a tourism area of interests. Such analysis is useful for entities that manage the entire region, such as local governments and regional organizations that promote tourism. However, for tourism DX, it is necessary to reconsider business strategies by analyzing and utilizing data at each store in tourist areas. It is necessary for stores to grasp information on passers-by, such as when people are and are not in the vicinity of the store.

Pedestrian forecasting was also conducted [Joshi at al., 2021]. They discussed a possible solution of building a machine learning model that forecasts the number of pedestrians. Such technological research is important for tourism DX. However, development of usage of such technologies for stores which are not familiar with technologies is also important.

As related cases, a restaurant named Ebiya in Mie Prefecture measures the number of pedestrians in front of the restaurant and visualizes their characteristics to understand the situation [EBILAB, n.d.]. However, only stores with AI cameras installed in their store-fronts can analyze and utilize pedestrian count data through this system. The introduction of AI cameras and measurement of pedestrian data by individual stores is not feasible for small and medium-sized companies in tourist areas because of the costs involved in introducing and running AI cameras and in preserving the landscape of tourist areas. In Japan, there are many sightseeing spots which have established landscape regulations such as the Kyoto Prefectural Landscape Regulation. There are also expressions such as "signboard pollution" [Kerr and Seno, 2019].

If AI cameras are installed in the city center, mainly by the local government, and the collected pedestrian count data is shared and utilized, more stores can utilize the pedestrian count data with a smaller burden. Some areas, including shopping streets, have installed AI cameras to measure the number of pedestrians, but they have only analyzed the measurement results and have yet to reconsider their business strategies by making use of the analysis [City Bureau, Ministry of Land, Infrastructure, Transport, 2023].

In this study, pedestrian count data collected in a region was analyzed and utilized at a store in the vicinity of a collection point to adjust business hours based on the data for dynamic business hour setting to ensure both sales and ease of working, and tourist satisfaction.

By grasping the situation of pedestrians in the area around the store, and realizing flexible "dynamic setting" according to the situation, such as increasing the number of staff during the hours when there are many pedestrians, and taking breaks and reducing staff during the hours when there are few pedestrians, this study aims to coexist the sales of tourist attractions, the work comfort of people who manage tourist attractions, and the satisfaction of tourists. A similar example is "dynamic pricing," in which, for example, hotel room prices and airline ticket prices are adjusted according to demand. In current sales, business strategies are of course adjusted, but this is based on intuition and experience. By basing the adjustments on data, it is possible to make objective and more detailed adjustments.

3. Tourism DX in Takayama City, Gifu Prefecture

Takayama City, in northern Gifu Prefecture Japan, is a tourist destination struggling with a labor shortage. It is famous for its old townscape, also known as "little Kyoto" (Figure 1).

Figure 1: Old streets in main area of Takayama

It receives 4.7 million tourists annually, 52 % of whom are day-trippers and 48 % of whom stay overnight. Of the overnight visitors, 25 %, or about 500,000 are foreign tourists [Takayama City, 2023]. In Takayama City, the working population is also decreasing, and the lack of labor for tourism-related businesses is an issue (Figure 2).

A restaurant owner wants to make it easier for his employees to work by shortening their working hours as much as possible. The owner of a stationery store is considering unmanned op-
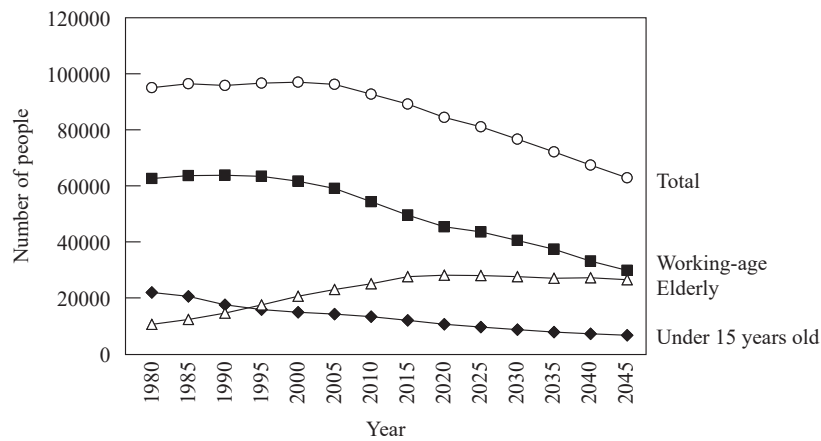
Figure 2: Population trends in Takayama City

eration because he has a limited number of workers, but he also wants to provide courteous service to satisfy the tourists. Efficient store management is required, and the local government of Takayama City also hopes to "share various information through ICT with the entire community, including stores and hotels, to promote 'effective' information dissemination and vibrant community development" [NEC Solution Innovator, n.d.]. In the Takayama City DX Promotion Plan announced in 2022, the city "promotes the creation of a town where data is used to solve local issues," and "promoting the use of big data in the region" is a priority initiative of the promotion plan [Takayama City, 2022].

In 2020, Takayama City, NEC Solution Innovator, Ltd. and Nagoya University signed an "Agreement on Community Development Using ICT" and installed 13 AI cameras in tourist areas of Takayama City (Figure 3) [Hori et al., 2023]. These AI cameras measure the number of pedestrians person by person. 4 AI cameras (light-colored in Figure 3) in front of the station, the old streets, the Gyojin Bridge and the Enako River also estimate the age and sex of pedestrians (Figure 4). In addition to pedestrians, the other 9 AI cameras (dark-colored in Figure
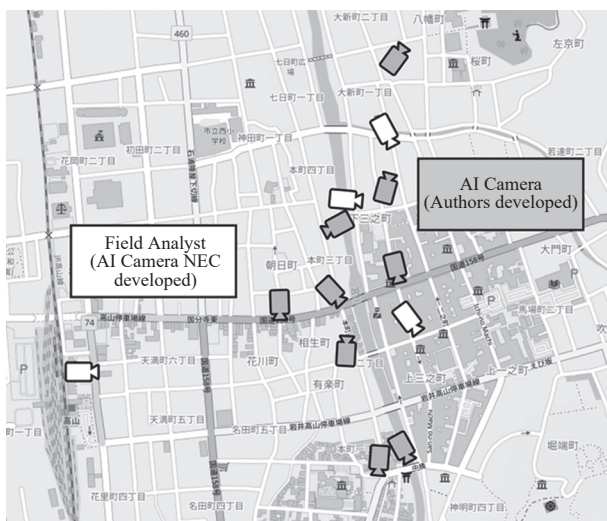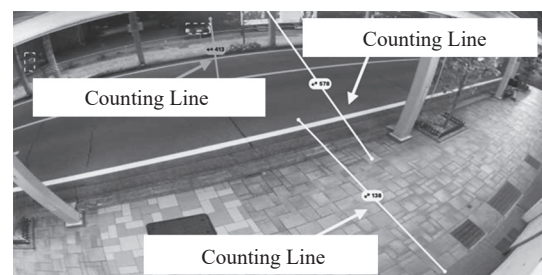

Figure 4: AI cameras counting pedestrians

3) also measure the number of vehicles such as cars, buses, trucks, motorcycles, and bicycles.

In order to discuss the direction of tourism DX in Takayama City with local tourism-related businesses, a workshop has been held every December since 2021 at Takayama City Hall inviting staff from the Takayama City shopping District Promotion Association, Hida Takayama Ryokan Hotel Cooperative Association, Takayama City, and Hida Takayama Tourism & Convention Association (Figure 5) [Hori et al., 2023].

The authors of this study started a collaboration with a restaurant named 'Kyoshi,' which participated in the first workshop and is highly interested in ICT utilization, based on a recommendation from the Takayama City Shopping District Promotion Association in 2022. Kyoshi is located in a main

Figure 3: AI camera locations in tourist areas

Figure 5: Scenes from the workshop

Figure 6: Kyoshi restaurant
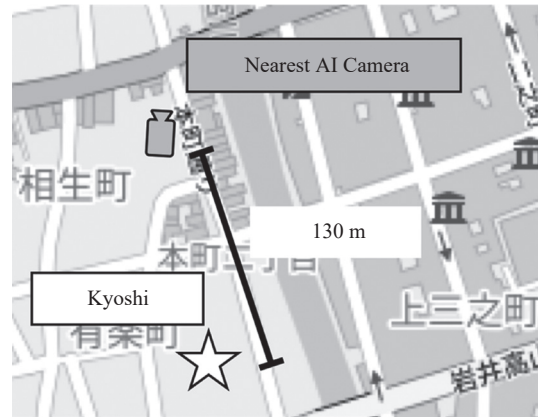

Figure 8: Location of AI camera and Kyoshi restaurant

Figure 7: Discussion with restaurant owner

Figure 9: Actual number of pedestrians on site

tourist area. They serve Hida beef dishes, and seafood dishes brought from Hokuriku (Figure 6). As a commercial enterprise, Kyoshi wants to focus on increasing sales, but at the same time, they also want to solve the labor shortage and the heavy workload of employees, and they also want to satisfy customers. Therefore, this study aimed to adjust business hours based on the analysis of pedestrian traffic data, discussing with the Kyoshi owner and organizing necessary issues toward dynamic business hour setting (Figure 7).

4. Adjustment of business hours based on pedestrian count
4.1 Comparison of pedestrian counts

Before analyzing the data from the AI camera located on the same street as the restaurant, it was confirmed that there was no significant trend discrepancy between the number of measurements from this AI camera and that of pedestrians in front of Kyoshi. This is because Kyoshi is located in Honmachi 2-chome street, but the nearest AI camera is installed in Honmachi 3-chome street, which is 130 meters away with an intersection between the two streets (Figure 8).

On April 10 (Sunday) and 11 (Monday), 2022, measurements were taken by human-hand for every 30 minutes in front of the restaurant from 9:00 to 18:00 (Figure 9). The number of pedestrians measured by the AI camera and that of pedestrians in front of the store were generally the same, although there was an error of 224 % on one occasion (Table 1 and Table 2).

The final aim of this study lies in utilizing pedestrian count data collected not in front of but around stores, so there is probably some difference in counts. Based on this idea, the owner and the authors decided to reconsider the business hours based on the data collected by the AI camera.

4.2 Data analysis and strategy implementation

The pedestrian count data collected using the AI camera from November 23, 2021 to April 3, 2022 was aggregated for every hour. Analysis of pedestrian count data and visualization of the number of pedestrians by time of day for each day of the week, revealed that pedestrians on Saturdays are in town until about one hour later (Figure 10). After discussions with the owner of the restaurant, the last-orders time and closing time on Saturdays were extended because the number of pedestrians on the street in front of the restaurant is roughly proportional to that of customers, and it is higher relative to the number of pedestrians around 18:00, dinner time. Originally, the last-orders time was 18:00 on all days of the week, but on 10 Saturdays from July 23 to September 24, 2022, the last-orders time was set to 19:00. The last-orders time was set at 18:30 on 11 Saturdays from October 1 to December 10 of the same year, in accordance with actual store-front situations. After that the last-orders were changed back to 18:00 because Takayama City is located in the northern part of Gifu Prefecture, where it is cold

Table 1: Measurement results for Sunday, April 10, 2022

Hour	9:00-	9:30-	10:00-	10:30-	11:00-	11:30-	12:00-	12:30-	13:00-	13:30-
AI Camera	69	112	64	62	92	108	120	120	120	146
Store	72	107	65	72	71	150	107	79	127	146
AI/Store (%)	96	105	98	86	130	72	112	152	94	100

Hour	14:00-	14:30-	15:00-	15:30-	16:00-	16:30-	17:00-	17:30-	Average
AI Camera	130	132	74	91	58	67	49	38	91.8
Store	121	90	62	82	75	70	30	17	85.7
AI/Store (%)	107	147	119	111	77	96	163	224	116

Table 2: Measurement results for Monday, April 11, 2022

Hour	9:00-	9:30-	10:00-	10:30-	11:00-	11:30-	12:00-	12:30-	13:00-	13:30-
AI Camera	45	66	88	79	94	69	93	80	79	72
Store	45	64	85	89	65	59	87	55	–	–
AI/Store (%)	100	103	104	89	145	117	107	145	–	–

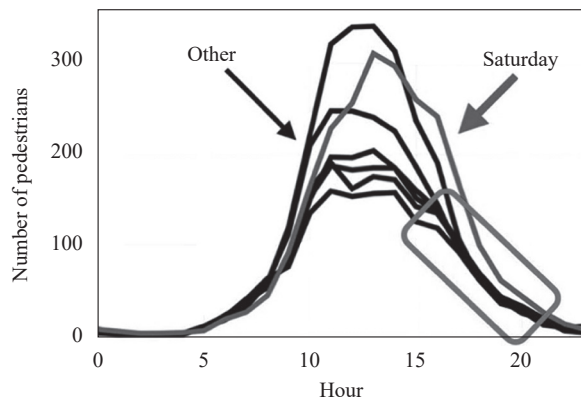| Hour	14:00-	14:30-	15:00-	15:30-	16:00-	16:30-	17:00-	17:30-	Average
AI Camera	67	89	88	98	64	62	48	41	73.4
Store	–	68	60	72	72	70	44	34	64.6
AI/Store (%)	–	131	147	136	89	89	109	121	120

Figure 10: Slow decline in pedestrian traffic on Saturdays

and snowy in winter, and the number of tourists declines during the off-season. There were 21 Saturdays on which the last-orders were extended.

There are some sales strategies that were discussed but not implemented. They include delaying the open time of the store to later than 10:00 every Saturday morning because the morning increase in the number of people is slower than on other days of the week, and setting the last-orders time for other days of the week one hour earlier instead of extending the opening hours on Saturdays.

In response to the owner's concern about whether the business hours were correctly communicated to tourists, the changed business hours were reflected on Google Maps using Google Business Profile, a tool that allows store owners to edit their own store information on Google Maps. On the other hand, the business hours were not changed on the store's web-site because of the cost incurred for each change. In addition, the business hours are listed in various pamphlets but since the change in business hours is only temporary, these also remained unchanged.

4.3 Results of the extension and evaluation of local tourism-related businesses

The sales data is from the cash register of the restaurant. The sales were aggregated for every 30 minutes. Kyoshi serves some takeouts and specially made lunch-boxes, which are excluded from the analysis. The average increase in sales during the extended hours was 7.8 %, minimum 0 %, and maximum 27.9 %, dividing the sales during the extended hours by that from the opening to 18:30 on that day (Table 3 and Table 4). Because the restaurant opened at 10:00, it averages 11.8 % of sales per hour until 18:30. There were 7 Saturdays on which sales per hour were higher than 11.8 %.

The Kyoshi owner looked at these results and said, "I think the numbers are not bad. Sales are coming in on very busy days. On normal Saturdays, there may not be much (sales). (The extension of the last-orders time to) 18:30 may be good. On the other hand, if you look at normal Saturdays, there are days when we had no sales." Based on the overall results, it was decided to extend the last-orders time in the following summer as well. The results were shared with 20 local tourism-related businesses at the second ICT-based workshop held on October 29, 2022, and a questionnaire survey was conducted. Twelve respondents answered that they would like to extend the closing time or last-orders time of their stores if the same analysis results were obtained at a AI camera near their store. In addi-

Table 3: Percentage increase in sales for last-orders at 19:00

Datetime	7/23	7/30	8/6	8/13	8/20	8/27	9/3	9/10	9/17	9/24	Average
%	2.7	3	0	17.7	0	15.3	0	5.6	11.7	10.6	6.7

Table 4: Percentage increase in sales for last-orders at 18:30

Datetime	10/1	10/8	10/15	10/22	10/29	11/5	11/12	11/19	11/26	12/3	12/10	Average
%	0	11.3	27.9	19.4	1.5	9.2	5.2	19.4	2.1	0	0	8.7
% (per an hour)	0	22.6	55.8	38.8	3.0	18.4	10.4	38.8	4.2	0	0	17.5

tion, five respondents responded that they would like to adjust the opening hours of their stores.

5. Discussion

Sales increased during the extended closing hours, and the owner wanted to extend the hours the following year as well. Other tourism-related businesses that learned of the results also expressed an interest in doing the same. This study was able to demonstrate the re-examination of the data-based sales strategy that tourism DX aims for. Pedestrian count data collected in the city was analyzed and utilized. Although it depends on the type of business, it is thought that other stores in the neighborhood can adopt a similar sales strategy.

However, in this demonstration experiment, there were Saturdays when there were no sales. This is because the result of the analysis showing that people stay relatively late on Saturdays is only a past-trend. It is necessary to be able to predict the necessity of future adjustment of business hours day by day.

This study was able to achieve an adjustment to increase business hours, but dynamic business hour setting also requires adjustments to reduce them. In the discussion of business strategies with the restaurant owner, the discussion included delaying the opening time to later than 10:00 every morning, and conversely, moving the last-orders time earlier on the other days of the week when the number of customers is likely to be low. For tourist attractions that are short of staff, it is necessary to have a well-defined business strategy, such as opening during the hours when sales are easy to increase and at the same time taking a break or not opening during the hours when it is difficult to increase sales. First, it should be possible to estimate the dates and times when sales are likely to increase with a higher accuracy, and then to present this fact by data, which will foster confidence of local businesses in the data and make it possible to realize dynamic business hour setting.

In doing so, it is also important to consider how to inform visitors of daily changes in business hours. Even now, some tourists say that they were disappointed to find that the store was closed when they went there after checking the business hours. Visitors can be categorized into the following three types: (1) those who know the store and its hours of operation before their trip, (2) those who check the store and know its hours of operation during their trip, and (3) those who pass by the store during their trip and visit it. If the opening hours are changed too dynamically, visitors who know the opening hours in advance, such as those in (1), may find that the opening hours are different from what they expected on the day of their visit. In order to balance the management of tourist attractions and the satisfaction of tourists, it is necessary to examine how dynamically business hours can be changed in tourism DX and to develop a new style of tourism based on dynamic business hour setting.

6. Conclusion

In this study, for dynamic business hour setting, the analysis of pedestrian count data collected in a city was utilized to determine when a restaurant in a tourist area could expect visitors and extend the last-orders time. The project was well received by the collaborating restaurant and local tourism-related businesses in the area, indicating that the business strategy of opening hours can be reconsidered by utilizing the analysis of pedestrian count data. It was an analysis and utilization of the data collected in the city, which indicated that similar strategies can be applied to other stores as well. On the other hand, the days when sales did not increase, the shortening of business hours, and the way of communicating business hours remain as issues to be solved.

In the future, the authors of this study would like to go beyond the analysis of rough past-trends and use machine learning to predict the future day by day. The authors would like to establish a system to examine whether it is necessary to extend or shorten business hours for each day with emphasis on accuracy, and a system to inform tourists of irregular business hours, and demonstrate dynamic business hour setting at tourist attractions.

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