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Analysis of Tourist Behavior and Interest Based on Country of Residence Using Photos and Metadata: With a Focus on Kyoto City Area

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ABSTRACT

Overcrowding at popular sightseeing spots was a persistent issue prior to the onset of the COVID-19 pandemic. Understanding the behavior of tourists is crucial for mitigating this problem. In the digital age, tourists frequently share their travel experiences by posting photos online. These images and metadata offer insights into the “where” and “what” aspects of tourist interests. This study aims to illuminate the patterns of tourist interests and behavior based on their country of residence by using the photos they share on social media with metadata from various locations around Kyoto City. We conducted correspondence analyses focusing on three factors: the tourists’ country of residence, photo location, and depicted subjects. Our findings revealed significant differences between residents and tourists in terms of their interests. Moreover, by identifying the relations between the preference for sightseeing spots and subjects, we demonstrate tourists by their country of residence that indicated the same trends as those of all tourists and those that did not.

Keywords: Geographic Information Systems, Flickr, EXIF, Correspondence Analysis, Cluster Analysis

1. INTRODUCTION

1.1 Background and Objectives

Prior to the outbreak of infectious diseases, an increase in the number of foreign tourists visiting Japan caused serious congestion problems at popular sightseeing spots. Now that foreign tourists are gradually returning to Japan, it is necessary to understand the actual situation of congestion at popular sightseeing spots and exercise efforts toward alleviating it to prevent infectious diseases and ensure that sightseeing spots do not lose their appeal.

To alleviate congestion at sightseeing spots, it is necessary to understand the behavior of tourists and the characteristics of the sightseeing spots. In this study, we used photos posted on Flickr (https://www.flickr.com/), a photo-sharing service and social media platform, as data for this understanding. It can be assumed that the subjects in photos captured at sightseeing spots and shared on social media are objects or events that are attractive and therefore, tourists want to share them with other tourists. In addition, these photos contain information such as location, shooting date and time, camera type, and settings extracted from metadata known as the exchangeable image file format (EXIF). Using the EXIF and subject information associated with a photo, it should be possible to directly link tourist interests, which are revealed by the entire photo, with tourists' actions.

Kyoto is one of the most popular tourist destinations in Japan and is visited by many foreign and Japanese tourists. According to the Japan tourism statistics data of the Japan National Tourism Organization (JNTO), 32.8% of foreigners visiting Japan for tourism purposes in 2019 visited Kyoto, the third-highest percentage after Osaka and Tokyo (JNTO, n.d.). Regarding the sightseeing behavior of foreign tourists in Kyoto, we should analyze trends by country of residence, focusing not on whether they visited Kyoto, but on whether they took photos there. This will lead to a detailed understanding of the actual crowding at sightseeing spots that foreigners find attractive.

This study aimed to elucidate the relationship between tourist behavior and interest in terms of their place of residence using photos uploaded on social media and metadata from Kyoto City. We utilized both correspondence analysis and cluster analysis. Initially, we conducted three correspondence analyses, focusing on the total number of photos captured and the number of tourists who took those photos: (1) estimated country of residence and sightseeing spots, (2) estimated country of residence and subjects, and (3) sightseeing spots and subjects. (1) and (2) describe tourist behavior and interests by country of residence, and (3) indicates the overall trend of the subject for each sightseeing spot. Subsequently, cluster analysis was performed to identify countries of residence that exhibit similar behavior and

interests. Finally, a correspondence analysis of each cluster was conducted to analyze their characteristics.

1.2 Literature Review

Previous studies have analyzed tourism behavior using photos posted on social media, and tourism behavior in Kyoto using other data. In a study using photos posted on social media, Rugna et al. (2012) used location information to obtain travel histories from photos and estimate the country of residence. However, they did not analyze tourist behavior according to country of residence. Sakuragawa et al. (2015) obtained the location, time spent, and frequency of photos taken in a specific area and classified photographers into two groups: tourists and residents. The locations of the photos posted by the estimated photographers were presented to residents and tourists; however, a detailed analysis of the extracted hotspots was not performed. Kitamura et al. (2019) obtained photos posted on Flickr worldwide and analyzed differences in the proportion of visits to prefectures by country of residence, which were estimated using the number of days the photos were taken. They compared photo locations on city and district scales using tags added to photos by photographers. They found that the characteristics of tourist behavior differed, such as the number of prefectures visited by each country of residence and the extent of areas visited, and that the tags attached to photos by Asians, Europeans, and Americans as well as the spatial distribution of photos differed. However, no analysis of the photo subject or foreign tourists by country has been conducted.

A study of tourist behavior in Kyoto is the annual Kyoto Tourism Survey conducted by the Kyoto City Office of Industry and Tourism (2020). This survey aims to understand the number of tourists, tourist satisfaction, and trends of foreign tourists in Kyoto. It reveals tourist statistics and consumption amounts and places visited in the city. However, the relationship between the places visited and tourist behavior as well as tourist interests has not been analyzed. Yamaki et al. (2021) analyzed tourist flows using data from a transit search application for Kyoto City. Although they have clarified the status of visits to sightseeing spots and tourist flows, they have not been able to analyze tourist interests in the places they visit because of the characteristics of the data they use.

The authors have already worked on estimating the country of residence of tourists and distinguishing between Japanese residents and tourists. This was accomplished by analyzing photos taken at various sightseeing spots in each residential country. Notably, the study revealed a disparity in the preferred photo locations between residents and tourists. These results highlight the tendency of tourists and residents to have different preferences regarding photos of tourist destinations (Togiya et al., 2023). Furthermore, the authors focused their

analysis on the sight and subjects from where the photos were taken. The authors classified the subjects into distinct categories by obtaining labels and applying cluster analysis. Afterward, we visualized the locations where the photos were taken and found that the composition of the subjects differed significantly, depending on the location of the photo shoot. This highlights that sightseeing spots have a pronounced impact on the types of subjects selected for photography (Togiya et al., 2022).

Each of these analyses revealed some relationship between shooting locations and subjects, as well as trends in shooting locations based on the country of residence of the photographer. However, differences in subject trends according to country of residence have not been fully elucidated. This study aimed to address this gap by investigating the interests of tourists from each country of residence . By comparing variations in tourist behavior and interest trends across different countries of residence and the subjects photographed at each sightseeing spot, we aimed to identify distinct patterns among countries of residence. To achieve this, we utilized estimates of country of residence and resident to characterize tourists, specified their interests using photographic subjects, and performed correspondence analyses and cluster analyses based on these data. From a methodological standpoint, a unique aspect of this study is its integration of multiple methods for estimating country of residence and interests into an analytical framework for correspondence analysis and cluster analysis.

2. TARGETING AREA AND DATASET

2.1 Photos of the Area

Flickr is an online photo-sharing service that allows users to post, publish photos, and interact with other users. It is possible to retrieve photos and information that match specific conditions using the Application Programming Interface (API) provided by Flickr. Thus, in addition to the URL of the photo, the user's ID, the date and time at which the photo was taken, and the latitude and longitude of the location where the photo was taken can be obtained as metadata.

The targeting area was defined as Kyoto City and its vicinity (34.876403°N to 35.128871°N, 135.638580°E to 135.831527°E) as presented in Figure 1, and the date of the photo was within the five-year period from April 1, 2015, to March 31, 2020. Photos meeting these criteria were also collected. The area covered above was assumed to include a series of sightseeing activities in and around Kyoto City, including the Kibune Shrine (Sakyo-ku, Kyoto City) in the north, Phoenix Hall of Byodoin Temple (Uji City) in the south, Arashiyama (Nishikyo-ku and Ukyo-ku, Kyoto City) in the west, and Daigo-ji Temple (Fushimi-ku, Kyoto City) in the east.

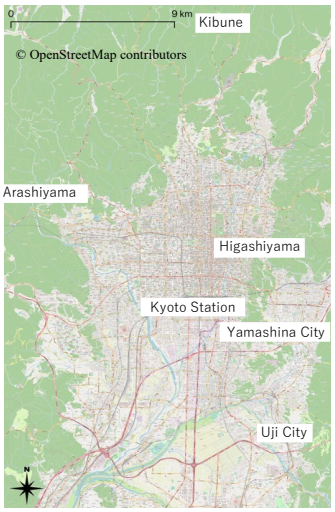


Figure 1: Targeting area.

In total, 173,070 photos were acquired under the aforementioned conditions (date of acquisition: July 5, 2022). We excluded photos taken using action cameras, web cameras, and 360-degree cameras, and used 154,756 photos taken using digital cameras such as digital SLR, mirrorless, compact digital cameras, and smartphones.

2.2 Photos Used to Estimate Country of Residence

To estimate the users' country of residence, all photos uploaded to Flickr were acquired for 3,132 users of the 154,756 photos acquired in Section 2.1 (date of acquisition: October 24, 2022). Of the 20,160,099 photos, 8,022,480 included latitude and longitude location information. Reverse geocoding was performed on the photos. This is the process of obtaining the address of the location where a photo was taken using the latitude and longitude location information contained in the EXIF of the photo. For photos whose location information was on the sea, which were taken on a ship or plane, the photos were considered to have been taken in that country if they were within the exclusive economic zone of the country. Photos taken in other maritime areas were not included in this study.

As presented in Table 1, there were 8,009,513 photos with location information on land for which country names could be obtained and 12,967 photos taken at sea, of which 9,990 were in the exclusive economic zone. Users who took fewer than 30 photos that included location information were excluded from this analysis because they did not use Flickr frequently, and it was difficult to accurately estimate their country of residence. The number of users with 30 or more photos, including location information, was 2,788.

Flickr allows users to register their addresses in their profiles. The number of users who registered their addresses was 1,377 (44% of the total number of users). However, as this information was a free-text entry, it was registered in various languages and formats. Therefore, it was difficult to use this information in the profiles to estimate the country of residence. For those who did not register the name of their country, this was determined from the name of the place and used as correct data to confirm the estimation results.

Table 1: Photos acquired.

Type of photos		Number of photos
Photos acquired		20,160,101
With geotag	On land	8,009,513
	In the EEZ	9,990
	Others	2,977
Without geotag		12,137,621

2.3 Selected Sightseeing Spots in the Area

To select sightseeing spots in the targeting area, we referred to commercial tourism magazines that introduced Kyoto City (JTB publishing, 2023; Lonely Planet, 2021). Figure 2 presents the selected spots. The Higashiyama area (northeast of Kyoto Station) has many sightseeing spots; thus, many photos of the area were captured. The distribution of photos acquired in Section 2.1 was also considered to divide each spot.

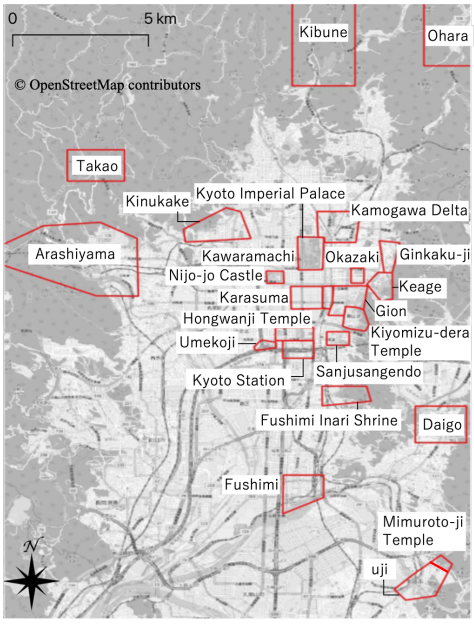


Figure 2: Sightseeing spots.

3. METHODS

3.1 Overview

In this study, we utilized our proposed methods described in our previous study. Figure 3 presents an overall workflow. After estimating the country of residence and residents and classifying subjects of photos, three types of correspondence analysis was conducted using information on sightseeing spots as well as these two.

3.2 Estimation of Country of Residence and Residents

In accordance with our previous study (Togiya et al., 2023), we estimated the country of residence using the following approach (Figure 4):

1. Acquiring all photos uploaded to Flickr by users who have taken photos of the target area.
2. Excluding users with fewer than 30 uploaded photos.
3. Counting the number of photos taken by each user for each country.
4. If the country with the highest photo count constituted more than 40% of the total, it was inferred to be the country of residence.

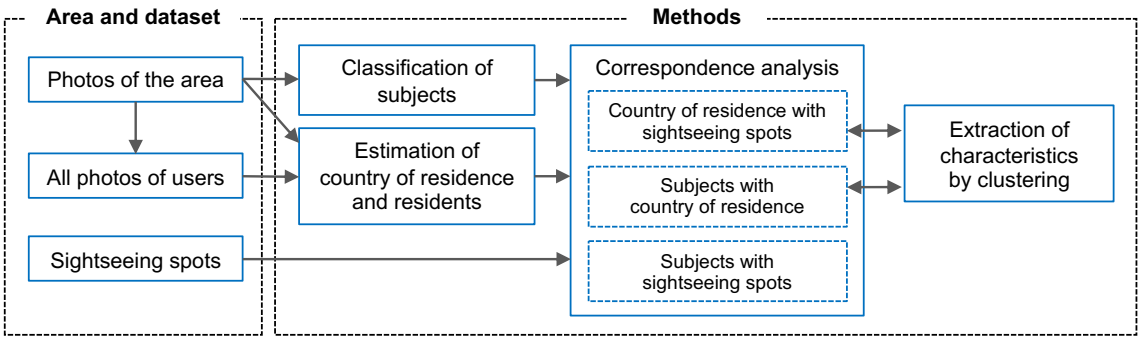


Figure 3: Overall workflow.

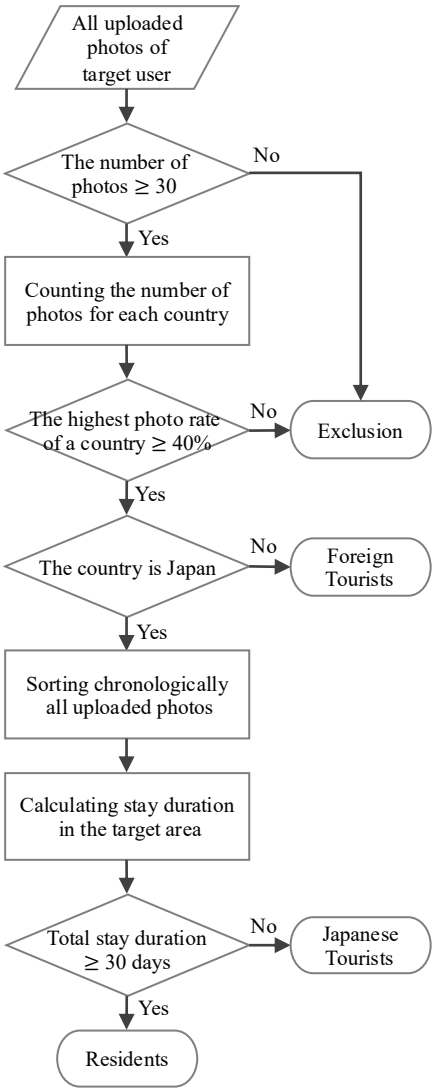


Figure 4: Flowchart for estimating country of residence and residents.

The countries of residence of 2,129 individuals were estimated by applying this method to the data obtained. By comparing each user's estimated country of residence with their actual country of residence registered on their Flickr profiles, we demonstrated that a precision rate of approximately 80% was achieved. To avoid the influence of individual photography behavior, we focused on tourists from 18 countries with 10 or more people.

For tourists whose residence was estimated to be in Japan, an additional estimation was conducted to differentiate between them. This allowed for the categorization of individuals living in Japan into residents and non-residents (tourists). This procedure was devised in our previous study (Togiya et al., 2023) and is outlined as follows (Figure 4).

1. All photos uploaded to Flickr by each user from Japan were sorted chronologically based on capture time.
2. The geographical location of each photo was examined to determine whether the capture point fell within the target area (Figure 1).
3. When consecutive photos were within the target area, the time difference between their capture times was

calculated iteratively, and the sum of these time differences yielded the total stay duration.

4. Tourists with a total stay duration exceeding 30 days are classified as residents.

3.3 Detection and Classification of Subjects

Google Cloud Vision API (https://cloud.google.com/vision), an image recognition tool, was used to identify the subjects in the photos obtained from Flickr. This API is provided by the Google Cloud Platform, and can identify subjects, read text in images, and detect faces. In this study, we used a label detection function to detect the subjects in an image. The text of the label and its confidence level (certainty of the label, a real number ranging from zero to one) were obtained.

The total number of labels obtained was 1,724,312, which comprised 4,100 label types. Among them, 250 labels had more than 1,000 occurrences, and the total number of occurrences for 250 labels was 1,502,094, which corresponds to 87.1% of the total information volume. Some of these labels had similar meanings or tended to be assigned to photos in the same combination. Furthermore, 250 labels are too many to utilize as data for correspondence analysis, making the interpretation of the results difficult. To reduce the information of the 250 labels and facilitate their analysis, a cluster analysis was performed on the 250 labels. Specifically, a data table was created by organizing 250 labels for each photo and assigning a confidence level to those detected and zero to those not detected. Using this table, the labels were classified using hierarchical cluster analysis (Ward's method), with each photo as a variable.

3.4 Correspondence Analysis of Estimated Countries of Residence, Subjects, and Sightseeing Spots

This section focuses on photos for which the tourists' country of residence was estimated and was included in the classification in Section 3.3. Using photos that met these conditions, we analyzed the relationships among the estimated countries of residence, subjects, and sightseeing spots. The number of photos included in the spots in Figure 2 was counted for each estimated country of residence and subject classified. For the estimated country of residence, as photos for which the influence of individuals who took many photos was determined to be significant, we counted not only the number of photos taken but also the number of people who took photos to reduce the influence of such individuals. In addition, an analysis of the estimated countries of residence and sightseeing spots was performed in our previous study (Togiya et al., 2023). However, as a comparison with the results of the subject-based analysis would clarify the relationship between tourist behavior and interest in each estimated country of residence, we excluded photos from the

data that could not be classified properly by subject information and conducted the entire analysis again.

Correspondence analysis was conducted using the data table to quantitatively capture the differences and similarities between the estimated countries of residence, subjects, and spots visited. The overview and concept of correspondence analysis is provided, based largely on Greenacre (2017). In correspondence analysis, each category of the two variables that constitute a cross-tabulation table is utilized as data. Each row or column of the table represents a category of each variable, and the frequency of each row or column divided by its sum is called a profile. Calculating the degree of similarity between these profiles and representing it visually is the essence of correspondence analysis.

The similarity between two profiles is computed using the chi-square distance, a specific instance of the weighted Euclidean distance where the expected values of the profiles serve as weights. The similarity for each pair of profiles is evaluated using the chi-square distance. However, visually representing the relationship between profiles becomes challenging when the number of profiles exceeds four. Therefore, eigenvalue decomposition is performed on the distance matrix to reduce its dimensionality. The eigenvalues indicate the extent to which they explain the variance in the original profiles, and the sum of all eigenvalues equals the chi-square statistic divided by the sum of all frequencies in the original cross-tabulation table (known as inertia).

For the eigenvalues obtained, the coordinates calculated using the eigenvector corresponding to the largest eigenvalue are plotted on the first (horizontal) axis, and the coordinates calculated using the eigenvector corresponding to the second largest eigenvalue are plotted on the second (vertical) axis. This allows each category to be represented on a two-dimensional scatterplot. This plot is called a correspondence analysis map, allowing the correspondence between the categories in each variable to be visually grasped. The closer the categories are to each other, the stronger the correspondence, whereas the farther apart the categories are, the weaker the correspondence (Kawahashi et al., 2018). Also, a point near the origin of a correspondence analysis map represents the average profile. The result may also be plotted on a parabola, that said to be an Arch (“horseshoe”) pattern. In this case, there are two extreme cases, and the area around the vertex can be regarded as an intermediate category (Greenacre, 2017, p. 127).

By combining the results of these three correspondence analyses between the estimated countries of residence, subjects, and spots visited, it is possible to identify “who (what country of residence),”

"where," and "what" is being photographed. Therefore, the estimated country X and subjects Y should be the same direction from the origin in the correspondence analysis map of the estimated country of residence and subjects, and the estimated country X and sightseeing spot Z should also be the same direction from the origin in the map of the estimated country of residence and sightseeing spots. Furthermore, when sights Z and subjects Y are plotted in the same direction from the origin on the map of spots and subjects, we can conclude that the behavior and interests of tourists from the country of residence X are consistent with the overall trend of tourists.

3.5 Extraction of Characteristics by Country of Residence

Correspondence analysis, as implemented in Section 3.4, can visually elucidate differences and similarities within a dataset through the utilization of a correspondence analysis map. While this method facilitates the determination of visual cohesion and groupings, quantitatively comprehending the degree of cohesion poses challenges. Therefore, cluster analysis was conducted on the crosstabulation table used in Section 3.4 to classify the countries of residence based on characteristics for each of the sightseeing spots and the subjects. By employing two distinct techniques to examine the data from differing perspectives, diverse insights can be obtained, and the two approaches can mutually reinforce one another. To integrate these findings, correspondence analysis was additionally conducted based on these clusters.

Furthermore, the data obtained from correspondence analysis is condensed to the extent that it can be represented as a correspondence analysis map. Consequently, for cluster analysis, it is advisable to utilize the original data rather than the dimension scores obtained from correspondence analysis (Arabie et al., 1987).

4. RESULTS

4.1 Estimation of Country of Residence and Residents

We estimated the country of residence of 2,129 users, and the number of residents for those whose country of residence was estimated to be Japan. Table 2 presents the number of people and photos per country of residence for the 18 countries with 10 or more people per country. For those presumed to be in Japan, the results are presented separately for residents and tourists based on the estimation results for residents (Togiya et al., 2023). Table 3 summarizes the number of people per country for those where the number of people per country was less than 10.

4.2 Classification of Subjects

Figure 5 presents the classification results for the 250 targeted labels. The labels were classified into nine clusters: *Music* represents musical instruments and playing scenes; *Water*, *Flower*, and *Tree*

represent nature; *Food* represents food; and *Building* and *Sky* include images in the background of the photo. *Temple* includes the labels "Temple" and "Travel," and thus is considered to represent a typical sightseeing tour of Kyoto, including a visit to a historical building.

Based on these results, we classified the photos into nine subjects by allowing them to be duplicated. Consequently, 9,555 photos were assigned only to the *Other* cluster. These photos were not included in the corresponding analysis, as described in Section 3.4.

Table 2: Estimated Country of Residence.

Country of residence	Number of people	Number of photos	Country of residence	Number of people	Number of photos
Japan	700	34,626	Canada	40	1,444
Japan (Residents)	117	35,567	Germany	27	762
The United States	303	9,534	Thailand	25	575
Taiwan	249	20,108	Singapore	20	604
TheUnited Kingdom	119	4,250	South Korea	18	568
China	94	1,996	New Zealand	17	292
Australia	70	2,899	The Netherlands	15	426
France	60	1,257	Switzerland	12	85
Spain	58	1,312	The Philippines	12	70
Italy	47	537			

Table 3: Estimated Country of Residence (less than 10 people).

Number of people	Estimated country of residence	Number of people	Estimated country of residence
9	Finland	3	Austria, Argentina
8	Vietnam, Malaysia	2	Iceland, Israel, Bulgaria, Costa Rica, Qatar, Turkey, Russia
7	Norway, Denmark, Sweden	1	Hungary, Georgia, Myanmar, Nepal, United Arab Emirates, Czechia, Honduras, Cuba, Isle of Man, Slovakia, Romania, Colombia, Estonia, Tunisia, Laos
6	India		
5	Belgium, Portugal, Mexico		
4	Chile, Ireland, Poland, Indonesia, Brazil		

4.3 Correspondence Analysis

4.3.1 Country of Residence with Sightseeing Spots

For 18 countries of residence whose number of people was 10 or more, as estimated in Section 4.1, the number of photos taken and photographers were counted at the selected sightseeing spots, and a correspondence analysis was conducted. A correspondence analysis examining these two trends has already been conducted (Togiya et al., 2023). However, the data handled were slightly different because the photos included in the *Other* cluster were excluded.

Figure 6 presents the eigenvalues, contribution ratios, and correspondence analysis maps of the number of photographers and photos captured.

Figure 6 (a), the number of photos, displays the number of photos taken at each sightseeing spot, with the Umekoji and Australia prominently plotted in the upper left. This may be owing to the strong influence of Australian tourists, who took many photos at the Kyoto Railway Museum in the Umekoji area. Figure 6 (b) displays the number of people who captured photos. Compared with Figure 6 (a), it is possible to exclude the influence of individuals taking many photos. The cumulative contribution ratio to the second axis is 75.4%. The first axis, which has a contribution of 49.1%, indicates that residents are plotted on the right, and tourists are clustered on the left. Many sightseeing spots plotted around residents are in the suburbs, such as Takao, Fushimi, Daigo, Kurama, and Kibune. On the left side of the tourist plot, we can see famous sightseeing spots in Kyoto, such as Arashiyama, Kiyomizu-dera Temple, and Nijo-jo Castle. Thus, a smaller value on the first axis indicates the degree to which the sightseeing spots are major sightseeing spots.

The above results indicate that tourists from North America, South Korea, and Australia tend to visit famous sightseeing spots, such as the Fushimi Inari Taisha Shrine, Nijo-jo Castle, and Kiyomizu-dera Temple, to take photos. Furthermore, a comparison of the behaviors of foreign tourists and residents reveals that suburban sightseeing spots are plotted together in the vicinity of residents, indicating that residents' photographic behavior is distinctive. As these results do not differ significantly from previous results, it can be concluded that the exclusion of some photos based on the classification of the subjects did not have a significant effect on the results (Togiya et al., 2023).

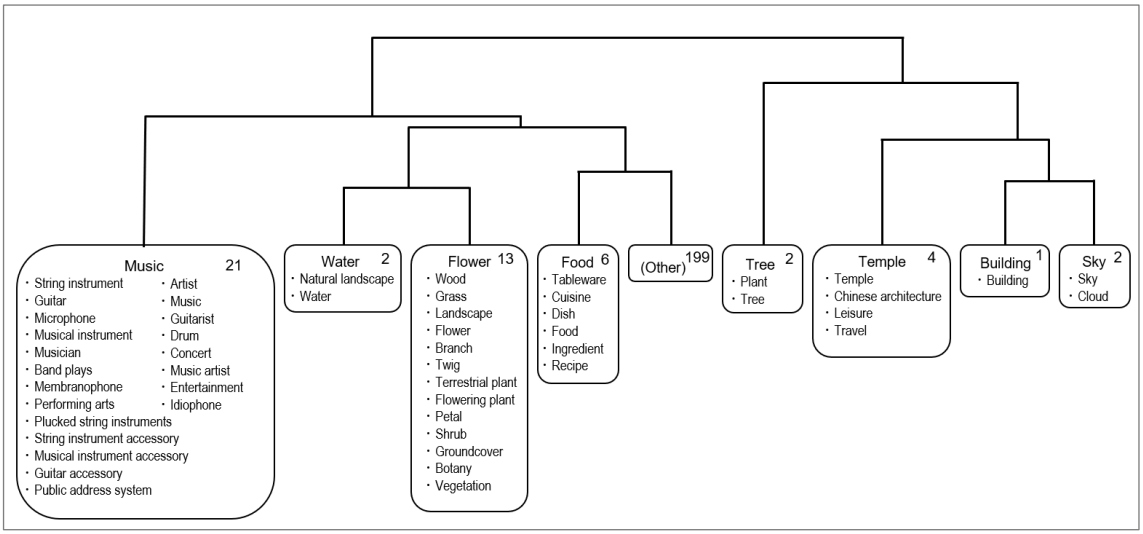
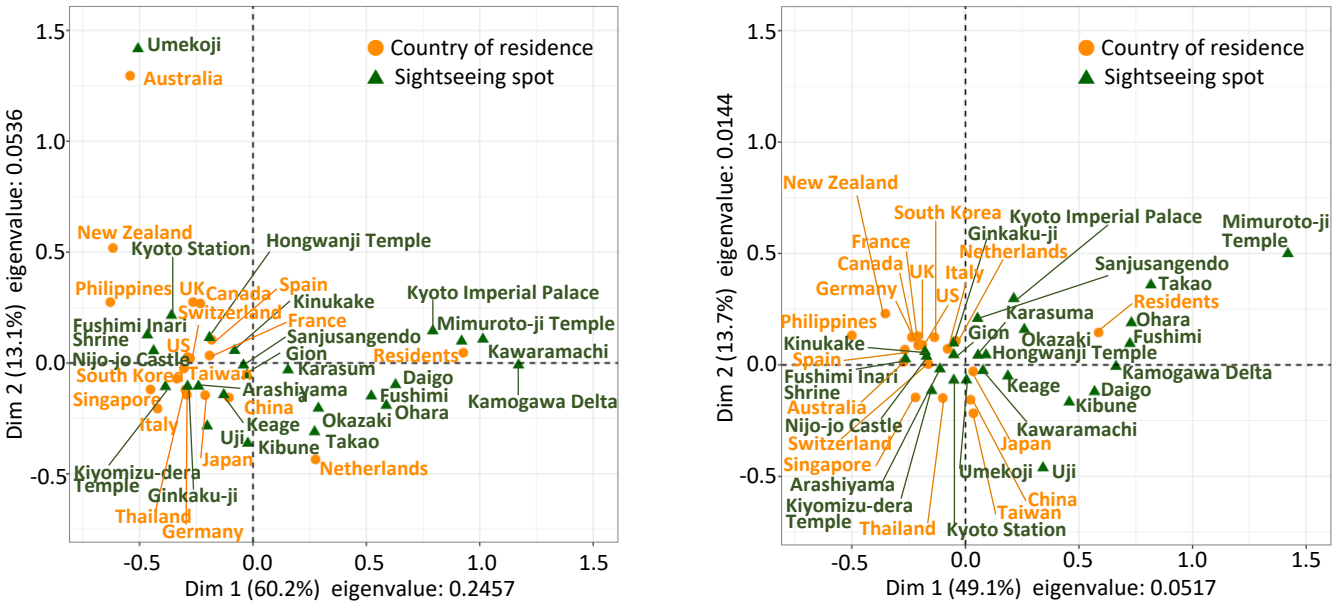


Figure 5: The result of cluster analysis for the labels. The name and number in each cluster present its subject and the number of labels classified in the cluster, respectively.



(a) Number of photos (b) Number of people

Figure 6: Correspondence analysis map of the country of residence and sightseeing spots.

4.3.2 Subjects with Country of Residence and Sightseeing Spots

A correspondence analysis was conducted for the classified subjects, counting the number of photos taken at each of the selected sightseeing spots and the tourists' country of residence. The eigenvalues, contribution ratios, and corresponding analysis maps of the results for each explanatory axis are presented in Figures 7 and 8. Figure 7 demonstrates the trends in photos taken by tourists for each country of residence, with *Music* on the right, followed by the residents. This may be because certain residents captured many photos of the music. Figure 8 demonstrates the trend of photos taken by tourists at each sightseeing spot, with *Music* and Kawaramachi plotted on the right and away from the origin. These results indicate that *Music* is plotted away from the origin in both the analysis of sightseeing spots and the country of residence and is distinctive compared with the other subjects. As it would be difficult to read the characteristics of interests and sightseeing spots for each country of residence from these graphs, we conducted another correspondence analysis using the dataset excluding *Music*.

The eigenvalues, contribution ratios, and corresponding analysis maps for each axis are presented in Figures 9 and 10. The contribution rate of the first axis is as high as 80.5% in Figure 9. The plots for each country of residence display residents on the left and tourists on the right. The Philippines plotted slightly farther away, possibly because of the fewer number of people and photos estimated (Table 2). The left side, where residents are plotted, displays subjects such as *Flower*, *Water*,

and *Tree*. On the right, where tourists are plotted, subjects such as *Sky*, *Building*, and *Temple* can be found. As mentioned in Section 4.2, the subjects for *Building* and *Sky* are considered to include those that are reflected in the background of the photo. The first axis represents the size of the subject being photographed. Tourists visit temples and shrines and take many photos that capture the entire scenery, while residents take photos of food, flowers, water, and other elements that they want to photograph clearly. The second axis demonstrates that European countries have smaller values, whereas Asian countries and *Food* products have larger values. This indicates that Asian tourists are more likely to take photos of food than European tourists.

According to Figure 10, the contributions of the first and second axes are 63.2% and 24.5%, respectively. The subjects along the first axis are plotted as *Water*, *Tree*, *Flower*, *Sky*, *Building*, and *Food*, beginning from the left side. The smaller the value, the more natural the landscape and its inclusions are plotted, whereas the larger the value, the more manmade subjects are plotted. Furthermore, the graph can be viewed as a parabolic plot. The upper-right corner is labeled *Food* and includes Karasuma, Kyoto Station, Kawaramachi, and other downtown areas where tourists can enjoy eating and walking. The top of the parabola is plotted with subjects such as *Temple* and sightseeing spots with a history typical of Kyoto, such as Fushimi Inari Shrine, Kiyomizu-dera Temple, and Hongwanji Temple. These results suggest that taking photos of temples, other sightseeing spots with rich natural settings, and downtown areas where people can enjoy eating and walking are three characteristic examples of photographic behavior in Kyoto.

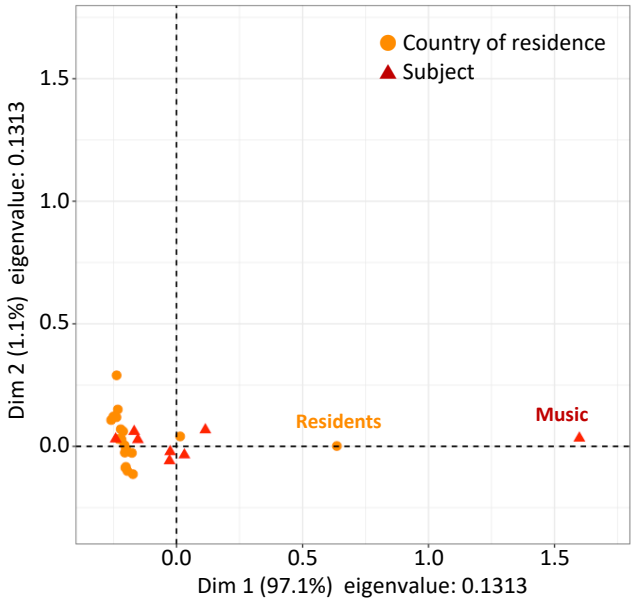


Figure 7: Correspondence analysis map of subjects and country of residence. Some item names are omitted.

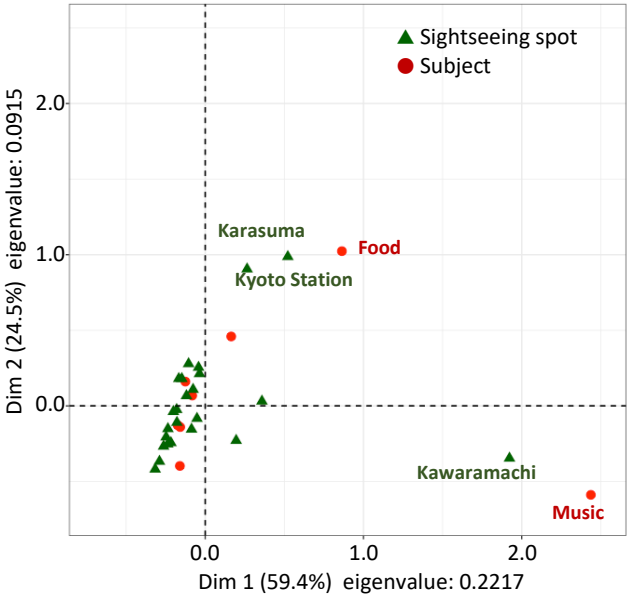


Figure 8: Correspondence analysis map of subjects and sightseeing spots. Some item names are omitted.

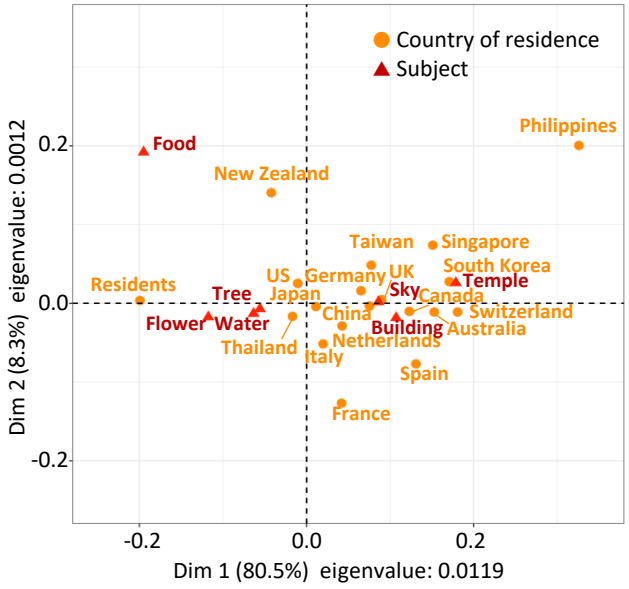


Figure 9: Correspondence analysis map of subjects and country of residence removing *Music* from subjects.

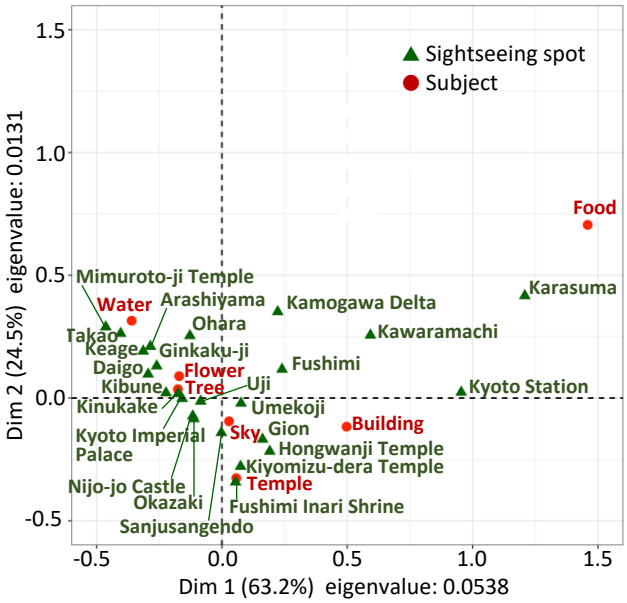


Figure 10: Correspondence analysis map of subjects and sightseeing spots removing *Music* from subjects.

4.4 Characteristics by Country of Residence

4.4.1 Cluster Analysis of Estimated Countries of Residence

For 18 countries of residence whose the number of people was 10 or more, both the number of photos taken and the number of people were counted at the sightseeing spots. We used the number of people for cluster analysis to reduce the influence of individuals who took many photos, rather than the number of photos. To mitigate the impact of numerical disparities, the percentage of each count was utilized as input data for each country of residence.

Table 4 presents the classification results for the 18 countries of residence with a focus on sightseeing spots. The estimated countries of residence were classified into eight clusters: Five countries were assigned to cluster S_1, and eight countries were allocated to cluster S_2. The remaining six clusters consisted of one country each. Residents in cluster S_3 constituted the largest number of people among all countries of residence. Clusters S_4 to S_8 included the Netherlands, New Zealand, Philippines, South Korea, and Thailand, which had few numbers of people compared to other countries (Table 2).

Table 5 presents the classification results for the 18 countries of residence with a focus on the subjects. The estimated countries of residence were also classified into eight clusters: Five countries were assigned to cluster L_1, and four countries were allocated to cluster L_2. Clusters L_3 and L_4 included three countries each. The other four clusters contained one country each. Clusters L_6 to L_8 included the Netherlands, New Zealand, and the Philippines. As described above, these countries have few numbers of people compared to other countries (Table 2).

Based on the results of the two cluster analyses, Table 6 was organized for each estimated country of residence representing similar behaviors and interests. The estimated countries of residence were grouped into 12 categories: Groups A to F comprised more than one country, while groups G to L consisted of one country of residence each. The countries comprising the latter groups were clustered individually in either analysis and exhibited distinct trends in interest or behavior compared to the other countries. Some clusters included countries located closer to each other, while other clusters included countries that were far from each other in the region. Namely, some countries showed similar trends regardless of geography.

Table 4: The result of clustering estimated country of residence focusing on the sightseeing spots.

Clusters	Estimated country of residence
S_1	Japan, Taiwan, China, Singapore, Switzerland
S_2	The United States, Germany, Canada, Spain, The United Kingdom, France, Italy, Australia
S_3	Residents
S_4	The Netherlands
S_5	New Zealand
S_6	The Philippines
S_7	South Korea
S_8	Thailand

Table 5: The result of clustering estimated country of residence focusing on the subjects.

Clusters	Estimated country of residence
L_1	Japan, Taiwan, China, The United States, Germany
L_2	Singapore, Switzerland, Australia, South Korea
L_3	Canada, Spain, The United Kingdom,
L_4	France, Italy, Thailand
L_5	Residents
L_6	The Netherlands
L_7	New Zealand
L_8	The Philippines

Table 6: Country of residence exhibiting similar trends.

Clusters			Estimated country of residence
Groups	Sightseeing spot	Subjects	
A	S_1	L_1	Japan, Taiwan, China
B	S_1	L_2	Singapore, Switzerland
C	S_2	L_1	The United States, Germany
D	S_2	L_3	Canada, Spain, The United Kingdom
E	S_2	L_4	France, Italy
F	S_2	L_2	Australia
G	S_3	L_5	Residents
H	S_7	L_2	South Korea
I	S_8	L_4	Thailand
J	S_5	L_7	New Zealand
K	S_6	L_8	The Philippines
L	S_4	L_6	The Netherlands

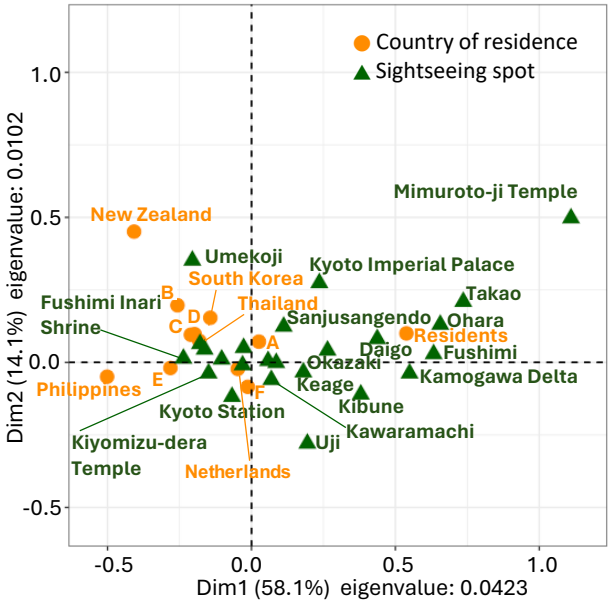


Figure 11: Correspondence analysis map of the country of residence and sightseeing spots with groups A to F.

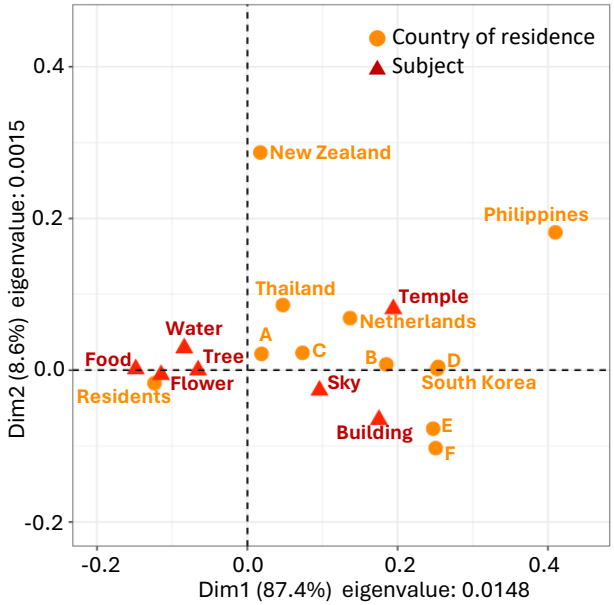


Figure 12: Correspondence analysis map of the country of residence and subjects with groups A to F.

4.4.2 Correspondence Analysis Based on Grouped Estimated Countries of Residence

For the 12 groups presented in Section 4.4.1, a correspondence analysis was conducted. For groups A to F, we calculated the mean number of people for each sightseeing spot and the mean number of photos for each subject. We performed correspondence analyses examining the country of residence with the sightseeing spots and the country of residence with the subjects using the same method as described in Section 4.3. Each group was treated as one country, utilizing these means.

Figure 11 presents the eigenvalues, contribution ratios, and correspondence analysis maps of the number of photos at each sightseeing spot. The contribution rate of the first axis is as high as 58.1%. The plot for each country of residence displays residents on the right and tourists on the left. The graph can be viewed as a parabolic plot. Mimuroto-ji Temple, Takao and Ohara are plotted in the upper-right corner, while the other side is labeled Umekoji, New Zealand and Cluster B.

Figure 12 presents the eigenvalues, contribution ratios, and correspondence analysis maps of the number of photos at each subject. The contribution rate of the first axis is as high as 87.4%. The plot for each country of residence displays residents on the left and tourists on the right.

Table 7 summarizes the result of correspondence analyses in Figures 11 and 12. The table displays the sightseeing spots and subjects that plotted in the same direction as the estimated countries of residence. The farther the point plotted from the origin, the stronger the characteristics are apparent. The

table demonstrates that tourists' interests and behaviors do not necessarily rely on geographical regions. For instance, in cluster B, tourists from Singapore and Switzerland showed similar trends despite their geographical distance. Furthermore, although some countries exhibit similar behavioral trends, their interests vary.

Table 7: The Result of Correspondence Analysis.

Groups	Estimated country of residence	Sightseeing spots (Figure 11)	Subjects (Figure 12)
A	Japan, Taiwan, China	(near the origin)	(near the origin)
B	Singapore, Switzerland	Nijo-jo Castle, Kinukake	Temple, Sky
C	The United States, Germany	Nijo-jo Castle, Kinukake	Temple
D	Canada, Spain, The United Kingdom	Nijo-jo Castle, Kinukake	Temple, Sky
E	France, Italy	Kiyomizu-dera Temple, Gion	Building
F	Australia	Kyoto Station	Building
G	Residents	Ohara, Takao, Daigo	Water, Flower, Tree, Food
H	South Korea	Ginkaku-ji Temple	Temple
I	Thailand	Nijo-jo Castle, Kinukake	Temple
J	New Zealand	Umekoji	Temple
K	The Philippines	Kiyomizu-dera Temple, Gion	Temple
L	The Netherlands	Gion	Temple

5. DISCUSSION

5.1 Subject Classification and Trends

In Figure 5, *Music* appears in the third branch from the top, and labels, including instruments related to live performances and their appearances, are classified. In the correspondence analyses using the classification of subjects, *Music* was related to residents and Kawaramachi, which were plotted at a distance from the origin. To confirm the actual locations and subjects of the photos, many photos were taken by residents at a live music club in Kawaramachi. Although the branching of *Music* was not at the top of the dendrogram, it was plotted farther away from the other subjects in the correspondence analysis maps. Thus, *Music* was revealed to be distinctive.

Furthermore, *Water* and *Flower*, or *Sky* and *Building* are close to each other because they merge at the bottom of the dendrogram. These subjects are plotted close to each other in Figure 9, and in the same direction as the origin in Figure 10. This may be because they have similarities in that *Sky* and *Building* are easily captured in the background and that *Water* and *Flower* represent the natural scenery itself or things contained in it. *Tree* is included on the same right side as *Sky* and *Building* in the dendrogram, however, they are plotted near *Water* and *Flower* in the correspondence analysis map. They were on the same side in the dendrogram because *Tree* includes the label "Plant," which means flower as well as tree, and they are easily captured as a background. However, from the perspective of the

number of photos per area and the number of photos per country of residence, it appears that the photos were often taken in rivers and natural landscapes and plotted near *Water* and *Flower*.

5.2 Relation among Three Types of Correspondence Analysis

Combining the results of these three correspondence analyses enabled us to uncover the country of residence of tourists, the location of the photo, and trends in the subject matter. For example, when we focus on tourists visiting from the U.K., a sightseeing spot called Kinukake is plotted in Figure 6 (b), and the subjects *Sky* and *Building* are plotted in Figure 9. This indicates that tourists visiting from the U.K. tend to visit Kinukake and take photos that include *Sky* and *Building*. However, Figure 10 demonstrates that Kinukake and *Tree* are plotted close to each other and in the same direction from the origin. Thus, we found that the behavior of tourists visiting from the U.K. was not consistent with the overall trend. Moreover, it is important to note that plotted close to each other simply mean that the relationship between them is relatively strong and that there are other subjects and behaviors as well.

Of the 817 photographers who were estimated to have lived in Japan, 117 were residents. They demonstrated tendencies different from tourists in terms of both spots and subjects in their photos. In Figure 6 (b), the sightseeing spots plotted in the same direction as the residents were Mimuroto-ji Temple, Takao, Ohara, and Daigo. In addition, the correspondence analysis map in Figure 9 demonstrates that *Flower*, *Water*, and *Tree* are plotted in the same direction as the residents, and the map in Figure 10 demonstrates that they are plotted together in the upper left corner of the figure. Thus, it can be said that residents tend to visit places such as Mimuroto-ji Temple, Takao, Ohara, and Daigo and take photos of *Flower*, *Water*, and *Tree*. This trend was consistent with the overall trend.

While residents visited places different from tourists in terms of sightseeing spots, there were no significant differences between the estimated countries of residence for tourists (Figure 6). The subjects are also characterized by residents and sightseeing spots on the first axis. However, when we focus on the second axis, tourists from Asian countries are plotted at the top and those from Europe at the bottom, indicating that tourists from Asian countries tend to take photos with *Food* subjects (Figure 9). Tourists visit and take photos of various places, regardless of their estimated country of residence, however, there are differences in the subjects of the photos they take.

5.3 Tourists' Behavior and Interests Based on the Cluster of Country of Residence

By employing clustering techniques to analyze the countries of residence and understand trends in their behavior and

interests, it was observed that certain countries did not cluster with others (Table 7). Specifically, residents living near Kyoto or tourists from South Korea, Thailand, New Zealand, the Philippines, and the Netherlands were not grouped with other countries. Residents represent the largest number of samples, while the other five countries have fewer samples, potentially impacting the results. Referring to Table 2, it appears that a minimum of twenty individuals from each country is necessary to conduct a thorough analysis of the prevailing situation.

Furthermore, apart from the aforementioned countries, thirteen countries were clustered into 6 groups (Table 7). Countries within the same groups do not necessarily share similar geographic location. This implies that analyzing tourists' behavior solely based on geographic cohesion, such as continent or region, might not be appropriate. Unlike the methodology of Kitamura et al. (2019), this study uniquely analyzes countries individually rather than categorizing them by broader regions like Asia or Europe, with the results supporting the validity of this approach.

Upon examining the relationship between sightseeing spots and subjects in each group, both groups E and K, including tourists from France and Italy, and the Philippines respectively, tend to visit Kiyomizudera-Temple and Gion (Table 9). However, while group E aligns in the same direction from the origin towards *Building* and the Philippines aligns with *Temple* (Figure 12). This indicates that although they frequent similar locales, they photograph different subjects.

Furthermore, focusing on groups B, C, and D in Table 7, their trends appear similar. However, Figures 11 and 12 reveal that the distance from the origin differs even though their direction from the origin is the same. This indicates variations in the degree to which the tendency is observed. The closer a point is plotted to the origin, the more representative it is of the average behavior of the respective country, whereas greater distance suggests stronger characteristic inclinations. Figure 12 illustrates that group D is plotted farthest from the origin, suggesting that the countries within this cluster exhibit pronounced tendencies towards photographing subjects related to *building* or *temple*.

6. CONCLUSION

This study aimed to elucidate the relationship between tourist behavior and interest conducted correspondence analyses using location-based photos obtained from a photo-sharing service in and around Kyoto City, focusing on the country of residence, sightseeing spots, and the subjects of the photos. The primary findings of this study are as follows:

1) Labels representing the subjects of the photos were obtained, and cluster

analysis was conducted using the confidence level and classified into eight clusters with interpretable characteristics. As a result of the correspondence analysis for each country of residence and sightseeing spot using these classification results, the subject *Music* demonstrated the characteristics of residents and Kawaramachi, and photos with the subjects *Sky* and *Building* were taken by many foreign tourists. This is because these subjects were considered the backgrounds of photos with the intention of capturing the entire scenery.

2) The results of the correspondence analysis for country of residence and sightseeing spots and for country of residence and subjects revealed that tourists' behavior and interests were different from each country of residence. Particularly, Japanese tourists hailing from the vicinity of Kyoto (Residents) exhibited distinct trends compared to tourists from other countries. Furthermore, by comparing these results with those of the correspondence analysis for subjects and sightseeing spots, we clarified whether these trends concerning country of residence were consistent with the overall trend.

3) The cluster analysis based on country of residence revealed that countries within the same groups did not necessarily share similar geographic locations. Integration of results from two cluster analyses focusing on sightseeing spots and subjects yielded six groups comprising 13 countries, with six countries remaining unclustered. These groups encompassed countries spanning significant geographic distances, highlighting shared trends irrespective of proximity. This underscores the effectiveness of our methodology, which assesses tourists' interests and behavior by country rather than by region, in contrast to previous studies. Moreover, based on countries not included in any cluster, a sample size exceeding twenty individuals was deemed necessary for conducting a meaningful analysis.

4) In the result of the correspondence analysis incorporating the groups derived from the clustering analysis, we elucidated the prevailing trends exhibited by each cluster. Particularly, by considering the distance from the origin on the correspondence analysis map, we identified the strength of the observed features.

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