

An Optimal Route Calculation and Short Trip Visualization System Based on ‘Kansei’ of Travelers

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Abstract

In order to realize information provision for tourism, we propose an optimal route calculation and short trip visualization system for the tourist spots along railways and around stations by connecting ‘Kansei’ space and physical space of travelers. ‘Kansei’ corresponds with the ability to feel in things such as impression, emotion and sense. In this system, MMM (Mathematical Model of Meaning) [5, 6] is applied and transformed to the impression and spatio-temporal features related to sightseeing with a metric for subspace feature selection. All locations and events for sightseeing are mapped onto the ‘Kansei’ vector space. This system decreases amount of computation for searching by symbolic filtering and semantic ordering to data in advance. Our motivation for introducing impression, time and distance contexts into the proposal system is to make global tourism recommendation. Using this system, travelers can get off a train easier and visit sightseeing spots and events not listed in guidebooks. In order to confirm feasibility and applicability of this system, we examined the tourist spots from Narita international airport to Tokyo station visualized by this system as an example. The results are shown. Additionally, we discuss new railway service deploying this system through the results.

Keywords: Tourism, Short Trip, Train, Kansei, Mathematical Model of Meaning

1. Introduction

With the rapid development of the ICT (Information-Communication Technology) in recent years, it has become possible to easily acquire information that travelers want before and during trips. Railway service provided at stations and trains have also gone through major changes called MaaS (Mobility as a Service) as a new paradigm [1]. The essence of MaaS is to efficiently enhance the connection

merit among people, things and places by ICT. The system is more enriched mobility environment is built by handling human ‘Kansei’. ‘Kansei’ corresponds with the ability to feel in things such as impression, emotion and sense. In Japan, population is decrease due to declining birthrates and the aging of the population. There is a common concern of many train companies are facing on the social issues involving the population declining such as

economic sustainability, diversity, technology rapid progress [2]. In order to challenge the issues, an innovation for the train traffic system is also required with user experiences (UX) having 'Kansei'.

On the other hand, recently the number of foreign visitors to Japan has increased sharply by 3.4 times in the past 5 years from 2012 to 2017. And, it was at 28.69 million people with the travel expenses amounting to 4,416.2 billion yen, which is a 4.1-fold increase. It has been confirmed that tourism is changing to be the main engine of Japanese future economy [3]. According to a survey by Japan Tourism Agency, foreigners who visit Japan for the first time visit popular cities such as Tokyo, Kyoto and Nara. Also, repeaters tend to visit the Chubu, Hokuriku and Tohoku area [4]. Their tastes for sightseeing are diverse. What is required of foreigners in Japanese tourism is a novel experience not provided by existing tours. In other words, it is experiences which the foreigners can touch the deeper Japanese culture. Providing information such as the route, culture, history etc. where travelers do not know well is dynamically, the attractions of each place will be conveyed and the satisfaction of tourism in Japan will be improved as well.

In this research, we propose an optimal route calculation and short trip visualization system. By connecting 'Kansei' space and physical space of travelers, the tourist spots along railways and around stations are measured the semantic distance, and then a new itinerary is shown to the traveler. 'Kansei' has several meanings and corresponds with the ability to feel in things such as impression, emotion and sense.

We adopted to our system a semantic associative search method named the 'Mathematical Model of Meaning (MMM)' which dynamically calculates semantic relevance among data by subspace selection on multi-dimensional space by a given context [5, 6]. This method has realized to semantically search multimedia data such as image and music data based on 'Kansei' of human that is expressed adjective words.

In this time, a prototype system was developed to show the feasibility and effectiveness of this method and the results are shown in the paper. This system recommends to travelers with rich railway services including tourist information, and travelers will be able to experience the rare Japanese culture along the line while traveling. Also, by combining functions with other railway applications and IC transport cards, this system may bring new value creation of MaaS.

2. Related research

Research of information retrieval in the tourism field has been conducted for a long time. Various route search and visualization systems to efficiently visit sightseeing spots where tourists want to see in limited time have been proposed [7, 8]. There are also many researches on information retrieval using tourists' preferences. One of the methods using user's preference is a tourism information searching method that utilizes the result of evaluating people's feelings to the photographs of tourist spots by the SD method (Semantic Differential Method). Recommendation methods for sightseeing spots according to tourist's impression while estimating it have also been

proposed [9].

Some studies have applied MMM to railway space. A ranking method of railway and station utilization service according to the needs of travelers has been proposed [10, 11]. In this study, the context of a traveler is classified as static and dynamic, and further divided into situation and intention. The service of the railway space according to each context is calculated and shown to the traveler.

Furthermore, a method of expressing operation information in the railway space by sign-logo images is also proposed. In this method, the railway operation information and the sign-logo image information are mapped onto the vector space, and the sign-logos semantically closer in distance are retrieved by subspace selection and distance calculation. By arranging the sign-logos based on grammar (5W1H), people including foreigners can visually understand the meaning. Train condition and tourism information are usually measured, and train accident and information for avoiding it are measured under trouble situation [12, 13].

3. An Optimal Route Calculation and Short Trip Visualization Method

3-1. Creation of Railway and 'Kansei' Spaces

In this method, the railway space and the 'Kansei' space of a traveler are connected for the optimum route measurement and the short trip visualization. The railway vector space R is created from 5 dimensions of departure time, arrival time, departure station, arrival station and railway line. Kansei vector space K is created as $p + 5$ dimensions by adjective which expresses sightseeing place name, address, latitude, longitude, recommended staying time

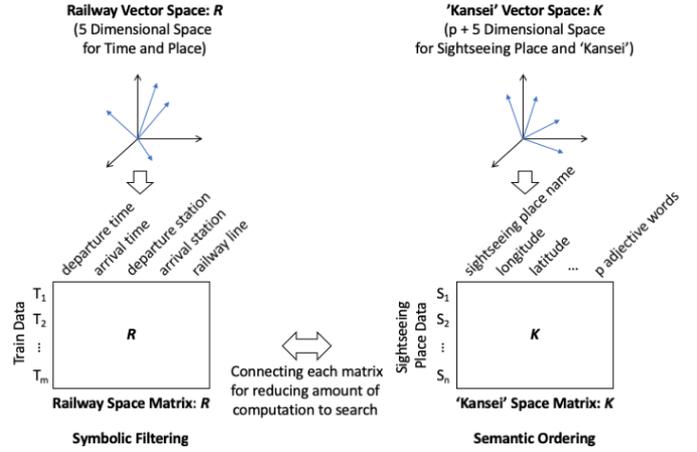


Fig. 1. The created railway vector space and 'Kansei' vector space

of the place, and p adjective words of travels. The created the railway space R and the 'Kansei' space K are shown in Fig. 1. The elements such as Departure time, arrival time, departure station, arrival station and route are arranged as metadata in the row of the train space R . Railway vector data T_i ($i = 1 \dots m$) is registered in the row. This matrix is defined as the railroad vector space R . Adjectives and sightseeing spots are arranged as metadata in columns of the 'Kansei' vector space K . In the row, vector data S_j ($j = 1 \dots n$) composed of tourist spots and their impressions is registered. This matrix is defined as a 'Kansei' vector space K .

There is a train line between Tokyo and Narita Airport, which is frequently used by foreign visitors in Japan. In this time, the train line is adopted to the train vector space R as an example data. This line contains the following major stations. Tokyo International Airport (Narita), Narita, Sakura, Chiba, Tsudanuma, Funabashi, Kinshicho and Tokyo Station. Around these stations, there are many historical buildings and cultural facilities from the Edo period. 18 adjective words for expressing 'Kansei' were selected. These words are often used for

representing impression of sightseeing spots [16]. The 18 adjective words for making metadata are shown in Table 1. We assumed actual walking distance about 2 km (about 30 minutes on foot) from the stations in order to select sightseeing spots around the stations. A total of 95 spots were selected from tourist information sites Trip Advisor [14] and Jalan [15], and 'Kansei' metadata was assigned to each spot manually.

Table 1. The 'Kansei' words used

Fun	Bustling	At ease
Cheerful	Carefree	Relaxed
Healing	Chill	Calm
Feeling good	Interesting	Clamorous
Countryside	Exciting	Beautiful
Delicious	Cultural	Historic

3-2. Context Vector Expressing 'Kansei' of A Traveler and Subspace Selection

The query that the traveler inputs to this system is expressed as a vector data named context vector CX . The vector CX_p representing the physical condition of the traveler and the vector CX_a representing 'Kansei' of a traveler are defined as follows. This time, m and n are given as 5 and 18.

$$CX_p = (p_1, p_2, \dots, p_m) \quad (1)$$

$$CX_a = (a_1, a_2, \dots, a_n) \quad (2)$$

The elements of the vector of CX_a are expressed as values from 0 to 1. The elements of these vectors are arranged in the vector CX that is newly defined as follows.

$$CX = (CX_p, CX_a) \\ = (p_1, p_2, \dots, p_m, a_1, a_2, \dots, a_n) \quad (3)$$

Further, the vector CX_b is newly defined as follows. If the value of the element of the vector

CX_a is greater than the threshold th , it is converted to 1, otherwise it is converted to 0. th is externally given as a constant. That is, the elements of the vector CX_b is expressed as a value of 0 or 1.

$$\begin{aligned} &\text{if } CX_a(i) > th: \\ &\quad \text{then } CX_b(i) = 1 \\ &\text{else:} \\ &\quad CX_b(i) = 0 \end{aligned} \quad (4)$$

The vector CX_b and the 'Kansei' matrix K are multiplied according to formula (5), and a subspace S' consisting only of 'Kansei' items emphasized by the traveler is selected.

$$S' = (CX_b) \cdot K \quad (5)$$

3-3. Symbolic Filtering and Semantic Ordering for Suggesting a Short-Trip

This system decreases amount of computation for searching by symbolic filtering and semantic ordering to data in advance.

The suggested time T_p and Location L for itinerary are symbolically calculated on the railway vector space R based on elements of the vector CX_p expressing physical restrictions of a traveler. The suggested time T_p is calculated a following formula. A time when the traveler departs is T_D , and a time when the traveler would arrive at a destination is T_A . T_n is a time for getting to the destination, and T_c is a time for margin during a short-trip. T_p is calculated by the difference between these values.

$$T_p = T_A - T_D - T_n - T_c \quad (6)$$

The recommended spot candidates semantically corresponding to 'Kansei' of a traveler are calculated by the Formula 7. The semantic distance as a metrics is calculated by the inner product between two vectors that are CX_a representing the 'Kansei' of the traveler and

the data in the subspace S' . The ranking of the candidates is obtained by sorting in descending order of vector similarity V_r .

$$V_r = \text{innerproduct}(CX_a, S') = \sum_{i=1}^p (u_i \cdot s'_i) \quad (7)$$

Then, the spot candidates are symbolic classified for each stopover station on the railway route. However, we assume that there are not many numbers to getting off the stations. For this reason, we decided the number of the Stations for breaking journey between the departure station and the arrival station is 1.

After the traveler gets off the station, the following combination is calculated to navigate the route to each spot corresponding to the traveler's time, place and 'Kansei'. This is equivalent to calculate combinations for time to propose a realistic short trip. T_s is the sum of time spent in each spot. T_w is the sum of time spent around each spot from the station and returning to the station. This corresponds to a circular permutation. A combination in which the sum of T_s and T_w is equal to or less than T_p is a recommended short trip. Moreover, the route search and calculation of the required time are delegated to an navigation system.

$$T_s + T_w = \sum_{i=2}^n S(i) + \sum_{i=1}^n t(i \rightarrow i+1) \leq T_p \quad (8)$$

4. Implementation of A Prototype System

A prototype system that is adopted our proposed method has been developed. The overview of this system is shown on Fig. 2. This system is typical web server and client model. The web application is implemented by PHP and JavaScript, and PostgreSQL is introduced as a database system to store various data and engage matrix calculations.

We utilize the Google Maps API for searching optimal route and visualizing. Google Maps API provides various functions. Inputting name or address of a sightseeing spot to the API, geo-code information (latitude and longitude) is respond. Also, inputting the departure place and the destination, a route and a required time to the destination are searched. Giving latitude and longitude information, a map plotting the place is responded.

The procedure of this system is as follows:

1. Preferences and the departure and arrival times are entered from the user interface
2. Calculating the correlation metrics based on the input 'Kansei' information
3. From calculation results the candidate sightseeing spots are further narrowed down by the station name
4. Finding the optimal permutation solution which can be used to travel around the candidate sightseeing spots within the time entered
5. Getting position and navigation information from Google Maps and displaying it on the

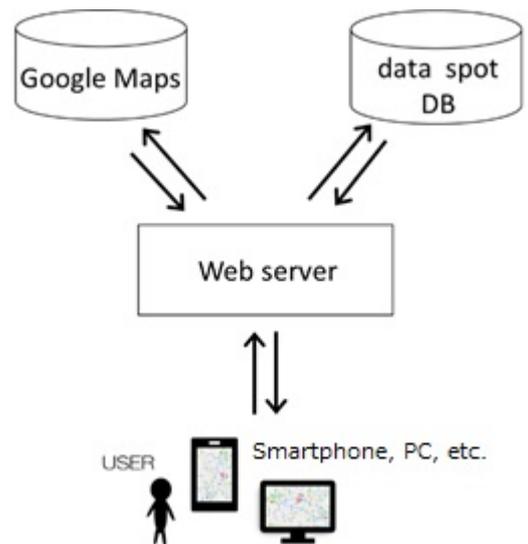


Fig. 2. System overview and operating procedure

user interface on a smartphone, etc.

5. Experiment and Discussion

In order to confirm feasibility and effectivity of our system, an experiment has been conducted. In this experiment, we chose Chiba Station as a station of breaking an itinerary from Tokyo International Airport (Narita) to Tokyo Station. A short trip was supposed to be on foot.

The results of calculating the correlation by 'Kansei' about shopping is shown in Table 2. The ranking went in the order of "Chiba-kun Bussan Museum", "Chiba Shopping Center C One", "Chiba Port Square", etc. "Chiba-kun Bussan Museum" is a famous retail store dealing in local products. The Fig.4. is shown the results. Tour spots and routes which can be walked around within the time were displayed on Google Maps. Tourists can visit spots following the ranking and navigation.

Table 2. Ranking results of sightseeing spots around Chiba Station

ID	Name	Score
9	Chiba-kun Bussan Museum	2
15	Chiba Shopping Center C One	2
20	Chiba Port Square	2
18	Chiba Port Tower	1
16	Chiba City Museum of Science	1
14	Chiba-shi Gokoku Shrine	0
21	Chiba Prefectural Museum of Art	0
17	Chiba City Museum of Art	0
19	Chiba Castle	0
10	Chiba Park	0
12	Towatari Shrine	0
11	Chiba Shrine	0
13	Chiba Municipal Central Park	0

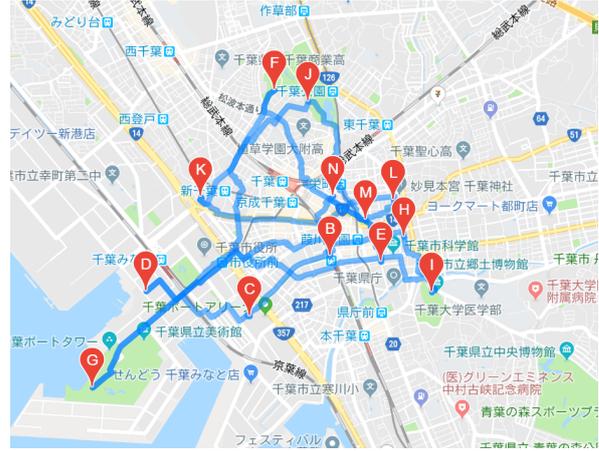


Fig. 4. Tour spots and routes which can be walked around within the time

The experimental results suggest that it is possible to recommend sightseeing spots that can be visited based on the traveler's physical constraints and 'Kansei' information. However, due to reasons such as sightseeing spots being adjacent to each other, there were cases when it was not possible to display accurate positions based on the geographic location information, which is latitude and longitude. There also were cases in which the listed address of a sightseeing spot and the actual spot were far apart. We noticed that it is necessary to adjust position information to provide more precise visualizations.

6. Summary and Future Works

We proposed an optimal route calculation and short trip visualization system for the tourist spots along railways and around stations by connecting 'Kansei' space and physical space of travelers. Through the experiments using the prototype system, we shown the feasibility and the effectivity of our system. This system can recommend short trips considering traveler's time, location and 'Kansei'.

As future works, we have provided various

application systems to the customers as mobile apps. that's why, an integration with legacy systems and our proposed system is required to improve customer experiences (CX). For these reasons, demonstration experiments in actual railway space are needed. The vision of this study is shown in Fig.5.



Fig. 5 The vision of this study

Also, in order to refine this service, it is necessary to combine with the train operation schedule, the trouble supports, multilingualization for foreigners, and visual communication. According to a tourism report [15], the nationalities of the foreigners visiting Japan, about 75% of them are travelers those who do not speak English from the Asian region. While considering the balance between system simplification and functionalization, we need to launch our proposed system.

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