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Article

Tourism Support System to Utilize Virtual Reality Space Reflecting Dynamic Information in Real Time

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Abstract: It is important that both static and dynamic information is efficiently used to create a suitable tourism plan. However, collecting, accumulating and managing dynamic information can cost tourists time, money and energy. The present study developed an original tourism support system was designed and developed with the purpose of reducing the burden of tourists who are unfamiliar with the tourist destinations in particular. An original tourism planning support system and web-geographic information systems (Web-GIS) were integrated into a single system, and two original functions were implemented. The system was operated targeting Osaka City, Japan for a period of one month. The information concerning 529 sightseeing spots was collected from tourism-related web media and then saved to the database of the system beforehand. During the operation period, a cumulative total of 160 users accessed the system. Based on the questionnaire survey results, most of the main functions were highly rated regardless of users' travel experiences to the operation target area. Additionally, based on the access log analysis results, it was clear that the use of the system was in line with the purpose of the present study, as the number of visits to the page for the main functions were high.

Keywords: Tourism Planning, Support System; Web-Geographic Information Systems (Web-GIS), Virtual Reality（VR）Space; Dynamic Information; Social Media

1. Introduction

In the advanced information and communications network society of recent years, there is an abundance of a wide variety of information on the internet, and anyone can easily obtain the information they need [1, 2]. With the rise of various social media platforms, as anyone can become both a sender and a recipient, the information inundation on the internet has accelerated [3-7]. This also applies to sightseeing information, as there has been an increase in the use of the internet as a method to easily and effectively obtain various information [8]. Additionally, online reviews on tourism-related web media are seen as an important source of sightseeing information. However, tourists must appropriately sift through the information to find what they need. Tourists who are not familiar with the tourist destinations may find it hard to obtain necessary information and use this to create a satisfactory sightseeing plan that tours various sightseeing spots [9, 10].

Regarding tourism, it is important that both static information such as the preferences of tourists and opening hours of sightseeing spots as well as dynamic information such as the congestion of tourist destinations and temporary events are efficiently used to create a suitable tourism plan. However, collecting, accumulating and managing dynamic information can cost tourists time, money and energy. Based on the above, a system that can provide support for the collection and systemization of various information and activity simulation before travelling as well as the efficient collection of necessary information while traveling is essential. Additionally, according to the survey on travel intentions after COVID-19 pandemic conducted by the Japan Travel Bureau Foundation (2022), there were many comments saying they wish to travel more frequently after COVID-19 pandemic, and that it is important to avoid congestion while traveling [11]. Therefore, a system that

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visualizes and provides the information concerning the situations of sightseeing spots in real time is also necessary.

The present study aims to take the above academic and social background into consideration in order to integrate an original tourism planning support system with the web-geographic information systems (Web-GIS) to develop a system that provide tourism supports specifically for tourists who are not familiar with the tourist destinations. Moreover, two original functions are implemented in this system. One is the function to efficiently collect and update both static and dynamic information in real time from tourism-related web media as well as social media. The other is the function to visualize and display such information in a virtual reality (VR) space which was developed using the three dimension (3D) city model of the tourist destinations.

The area of Osaka City in Japan was selected as the operation target for the system. The first reason why Osaka City was selected is that it is an urban tourist destination with a concentration of many famous sightseeing spots, and many sightseeing plans can be created according to the purpose of travel. The second reason is that many attractive sightseeing spots are concentrated in several specific districts within Osaka City, and it is difficult for tourists to comprehensively grasp the information they require. Additionally, the third reason is that there are many submissions concerning sightseeing spots in Osaka City on social media.

2. Related Work

As mentioned in section 1, the present study develops a unique system by integrating multiple systems such as a tourism planning support system and Web-GIS. Therefore, considering the system characteristics, the present study is related to four study fields, including (1) studies related to tourism planning support systems using Web-GIS, (2) studies related to tourism support systems using VR technology, (3) studies related to information sharing systems, and (4) studies related to systems utilizing social media.

Regarding (1) studies related to tourism planning support systems using Web-GIS, Kurata (2012), Kurata et al. (2015), Zhuang et al. (2015), García-Palomares et al. (2015), Sugimoto (2018), Kaufmann et al. (2018) and Hirota et al. (2019) created tourism potential maps that displayed areas with high tourism potential on the digital maps of Web-GIS, quantifying tourist destination highlights by using data extracted from photo-sharing sites and social media [12-18]. Fajuyigbe et al. (2007), Chang et al. (2011), Singh et al. (2011), Masron et al. (2015, 2016), Bali et al. (2016), Itou et al. (2018) Ikizawa-Naitou et al. (2020) and Koga et al. (2021) developed tourism support systems that displayed various information concerning tourist attractions and routes on the digital maps of Web-GIS [19-26, 9]. In this academic field, it was revealed the necessity of having administrators update the information concerning the operation target area, as users could not plan to visit sightseeing spots that had not been saved to the databases of the systems.

Regarding (2) studies related to tourism support systems using VR technology, Guttentag (2010), Tan et al. (2012), Noguera et al. (2012), Chiao et al. (2018), Beck et a. (2019), Poux et al. (2020), Hou et al. (2021), and Putra et al. (2021) developed tourism simulation systems based on VR technology that met the needs of visit to various sightseeing spots in tourist destinations in the VR spaces [27-34]. Aziz et al. (2014), Bruno et al. (2016), Gretzel et al. (2016), Nayyar et al. (2018), Makino et al. (2019) and Bec et al. (2021) integrated VR, Augmented Reality (AR) and mixed reality (MR) to develop original systems that visualized spatiotemporal information related to sightseeing spots including world heritage sites and guided users to points of their interests in tourist destinations in the VR spaces [35-40]. In this academic field, as the studies developed original 3D models, the development of the systems took a very high cost. The system of Hou et al. (2021) had a low review for the system trial, as it must be used with the head mounted display (HMD) which caused users to feel dizzy. Additionally, this system could not collect information. The system of Noguera et al. (2012) did not use the 3D digital map and the 3D model, and only displayed satellite images, and land uplifts based on elevation as well as the longitude and latitude.

Regarding (3) studies related to information sharing systems, Go et al. (2005), Kanekiyo et al. (2008), Horikawa et al. (2012), Yanagisawa et al. (2012), Nakahara et al. (2013) and Kojima et al. (2014)

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developed information sharing GIS that integrated Web-GIS, Wiki and social network services (SNS) to accumulate local knowledge of the local communities [41-46]. Okazaki et al. (2013), Okuma et al. (2013), Murakoshi et al. (2014), Yamamoto et al. (2015) and Shibata et al. (2018) developed disaster information sharing systems that could be used during normal times as well as when a disaster occurs [47-51]. Ueda et al. (2015), Ohoka et al. (2015) and Kunieda et al. (2019) produced post-sightseeing information from the activities of tourists when sightseeing, and developed systems that could share such information with other users as pre-sightseeing information [52-54]. In this academic field, the systems enabled users to share limited information. Specifically, while the system of Ueda et al. (2015) allowed users to register and share sightseeing spots, travel routes to that destination and the related images, it did not have the SNS function to leave reviews and any functions that supported the online preview of tourist destinations.

Regarding (4) studies related to systems utilizing social media, Yamada et al. (2013), Ishino (2014), Yang et al. (2015) Yamamoto et al. (2017), Yoon et al. (2018), Yamamoto et al. (2021) and Yamada et al. (2022) developed automatic web-based real time service systems that extracted necessary information from submissions on social media and transmited it to users. [55-61]. Kusmawan et al. (2014), Sato et a. (2015), Kwak et al. (2016), Kawai et al. (2018), Tran et al. (2022), Fujihara (2020) utilized location-based SNS to develop original systems that predicted and visualized the congestion for any location and area specified by users [62-67]. In this academic field, though the systems collected information concerning tourist destinations from social media, these did not support tourism planning. Additionally, in most of the system, the number of submissions was low.

In addition to overcoming the issues of the previous studies as introduced above, the present study demonstrates the originality in developing a unique system that makes the following three elements possible. The first element of the originality is that the system can provide the continuous and flexible tourism supports by extracting social media information, having users update the database to produce dynamic information, and using the information as a reference. The second element of originality is that the system can be developed and operated at low cost by effectively using the static and dynamic data and information collected from open data in addition to tourism-related web media and social media. The third originality is that the system enables users to have unique experiences of walking through a tourist destination in the VR space by adopting VR technology.

3. System Design

3.1. System Characteristics

As shown in Figure 1, the system in the present study is made up of an original tourism planning support system and Web-GIS. Additionally, by efficiently collecting information from tourism-related web media and social media, the system can continuously provide information and estimate popular sightseeing spots. The collected information is saved to the database and can be viewed by users.

Furthermore, according to the survey result of Sakiyama et al. (2022), a unique sense of scale, tours through the city in the VR space, efficient previews of tourist destinations, and recollections of travel experiences were a few possibilities for the VR travel content [68]. Additionally, dizziness caused by VR as well as the insufficient replication of the real cityscape were raised as issues. As a solution to these issues, the present study will develop an online VR space without using HMD, and prepare an interface that can switch between the 2D and 3D digital maps. By doing so, users can have a pleasant experience when using the system. Additionally, the dynamic sightseeing information can be collected and saved to the database, and this information can be superimposed and displayed on the 2D and 3D digital maps.

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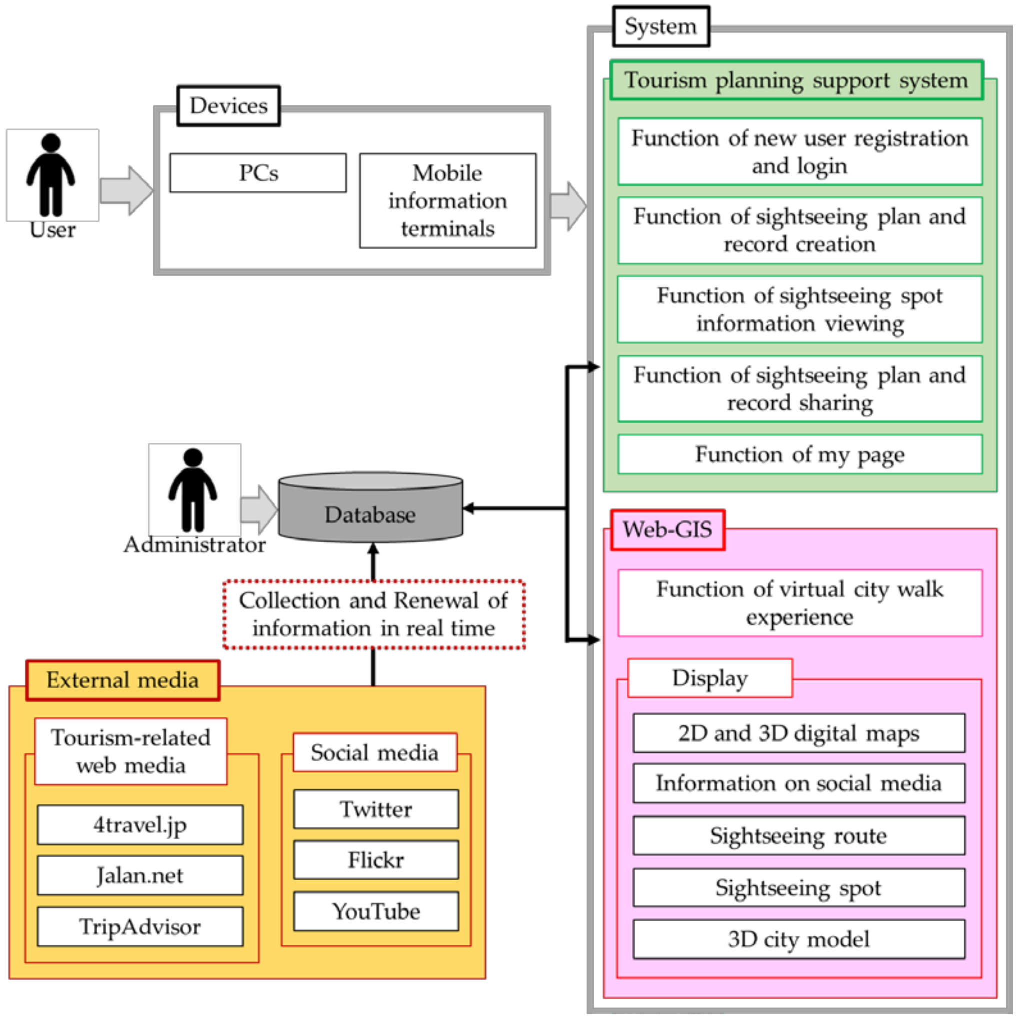

Figure 1. System design.

3.2. Target Devices

Though it is assumed that this system will be mostly used on PCs or mobile information terminals, there is no difference between devices used, and both types of devices can use the same functions. PC users are assumed to be mainly indoors, and will use the system to collect sightseeing information to supplement their travel activities, and evaluate sightseeing spots that have already been registered in the system. On the other hand, mobile information terminal users are assumed to be both indoors and outdoors, and will use the system to collect sightseeing information to supplement their travel activities, submit new sightseeing spot information, and evaluate sightseeing spots that have already been registered in the system.

3.3. System Operating Environment

This system operates using a Web server, database server, and GIS server. Figure 2 shows the system operating environment. Heroku, which was adopted for both the Web server and database server, is a PaaS provided by the Salesforce, Inc. ArcGIS Online provided by the Environmental Systems Research Institute, Inc. (ESRI) was adopted for the GIS server. Web applications developed in the system has PHP, JavaScript, and HTML as the main language, and Laravel of the PHP framework was adopted for the implementation.

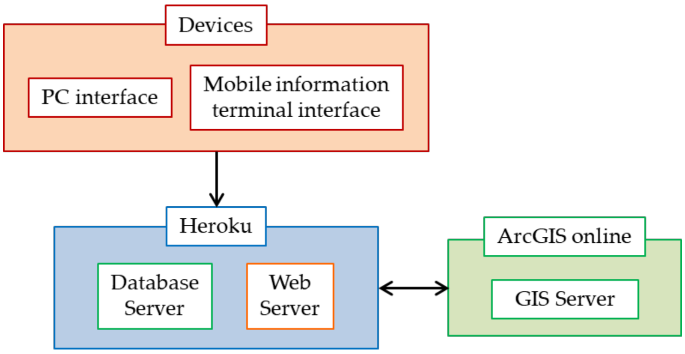

Figure 2. System operating environment.

3.4. Design of Each System

3.4.1 Tourism Planning Support System

An original tourism planning support system is integrated into the system of the present study in order to lessen the burden of users when collecting sightseeing information. This system is implemented with the functions of new user registration and login, sightseeing plan and record creation, sightseeing spot information viewing, sightseeing plan and record sharing, and my page.

3.4.2 Web-GIS

The system of the present study adopts the ArcGIS API for JavaScript of Web-GIS provided by the ESRI. This does not require users to install any special software and allows them to use the system on a web browser as well as visualizes route searches and information on the 2D and 3D digital maps. Regarding the digital map adopted with Web-GIS, the 2D digital map provided by the Geospatial Information Authority of Japan is adopted. Additionally, this is overlaid with the 3D city model provided by the project PLATEAU of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) to develop and adopt a 3D digital map. The above 2D digital map and 3D city model are open data. The Web-GIS is implemented with the function of virtual city walk experience.

3.4.3 Social Media

In order to support the production of high-quality sightseeing plans, the system collects dynamic tourism-related information from social media. The social media platforms used as information sources are Twitter, Flickr as well as YouTube. Additionally, real time information is collected using each API, and is superimposed and displayed on the 2D and 3D digital maps. Regarding Twitter, the names of the sightseeing spots are searched using the Twitter Search API provided by the X Corp., and the information excluding sensitive submissions and retweets are saved to the database. For Flickr, Flickr API provided by the SmugMug, Inc. is used, and submissions related to sightseeing spots are obtained and saved to the database. Regarding YouTube, YouTube Data API provided by the Google LLC is used, and the top 10 most played videos related to sightseeing spots are obtained and saved to the database. As the system automatically conducts the data search and save process daily, users can obtain sightseeing spot information on social media in real time.

4. System Development

4.1 System Frontend

The present study will implement original functions of this system designed for users as described in detail below.

(1) Function of new user registration and login

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When users use the system for the first time, they will register their email addresses and passwords on the page for the function of new user registration. After the second time, users can enter their email addresses and passwords on the page for the function of login.

(2) Function of sightseeing plan and record creation

Figure 3 shows the page for the function of sightseeing plan and record creation. As shown in Figure 3, several sightseeing spots on the digital map of Web-GIS are selected, and sightseeing plan and record are created. By means of this function, a list of sightseeing spots that were previously registered to the database of the system is displayed, users can register new sightseeing spots as well as save the information to the database. Pop-ups of sightseeing spot information can be displayed by clicking or tapping on the icon located on the digital map. By registering new sightseeing spot information (name, notes, travel time, images and social media information) to the pop-ups, users can create sightseeing plans.

No.	Description
1	Navigation bar (A: Questionnaire survey, B: Function of virtual city walk experience, C: Function of creation of sightseeing plan and record, D: Function of viewing sightseeing spot information, E: Function of sharing sightseeing plan and record, F: User
2	Page for the function of creation of sightseeing plan and record
3	2D digital map of Web-GIS
4	Registration of new sightseeing spot information (name, notes, travel time, images and social media information)
5	Selection of the location of a new sightseeing spot on the 2D digital map
6	Timeline of sightseeing plan
7	List of nearby sightseeing spots

Figure 3. Page for the function of sightseeing plan and record creation.

Figure 4 shows the process of sightseeing plan and record creation. After adding sightseeing spots and clicking or tapping on the "save" button, users will be redirected to a page where they can enter the date, title and description of their sightseeing plans and records. The sightseeing plan is completed when users click or tap on the "register" button on this page.

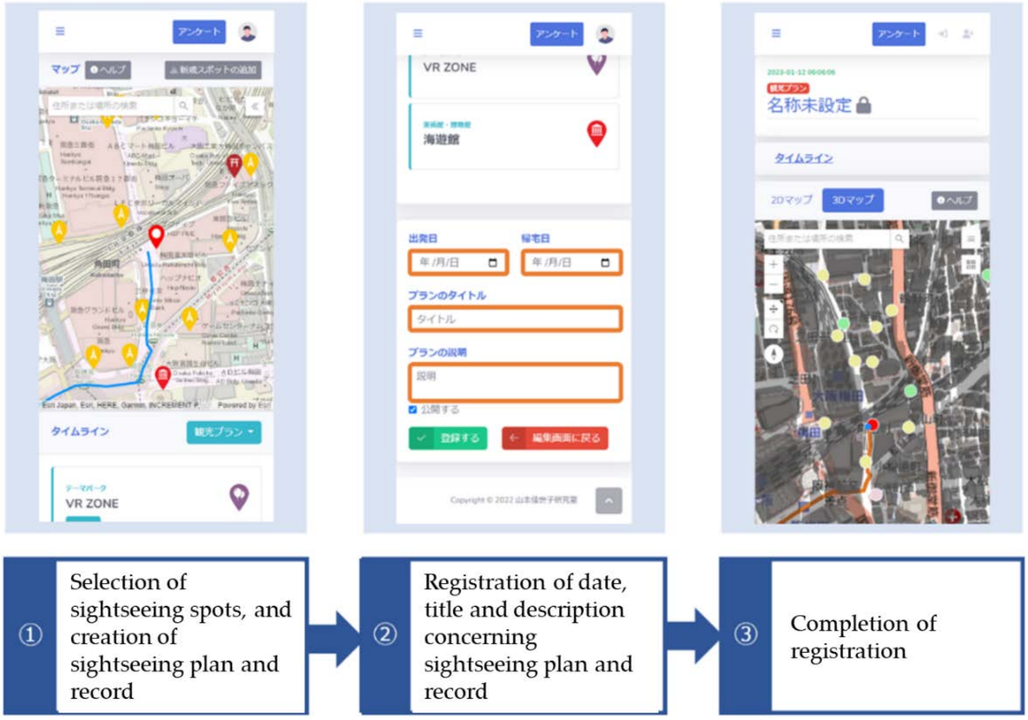

Figure 4. Process of sightseeing plan and record creation.

Figure 5 shows the page for the registration of new sightseeing spots. In order to register new sightseeing spots and save the information to the database, users have to click or tap on the "add a new spot" button on the top of the digital map which will take them to the page for the registration of new sightseeing spots (Figure 5). On this page, users will enter the "sightseeing spot name" and select a "category" in addition to the address and website. Categories include "notable and historical site", "park and botanical garden", "public facilities", "drinking and eating establishment", "temple and shrine", "art museum and museum", "hot springs", "cherry-blossom viewing", "festival and event", "theme park", and "other".

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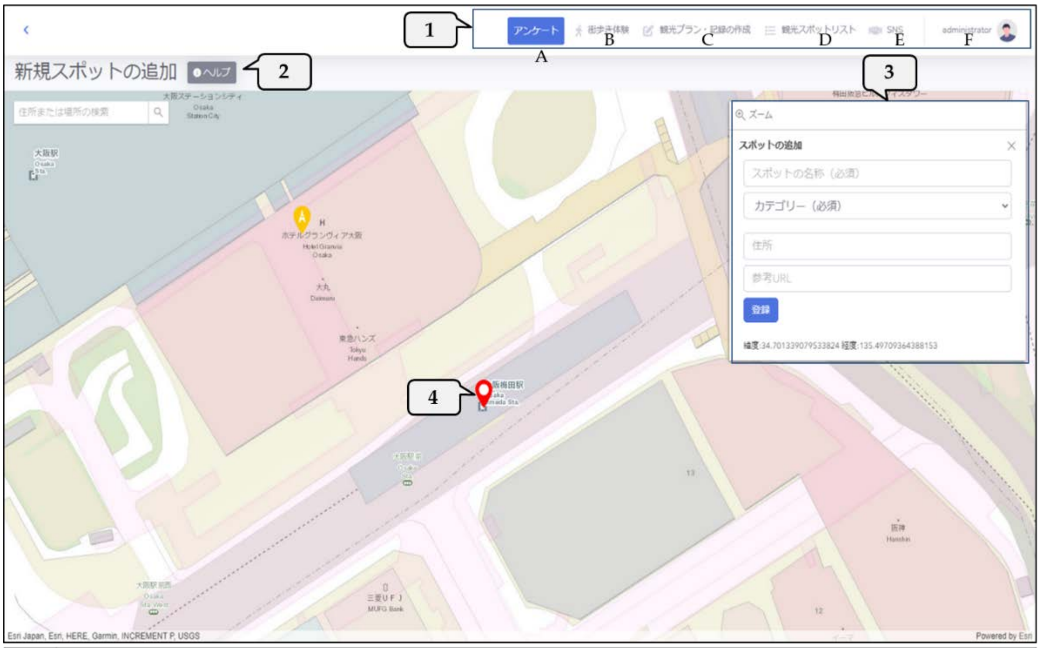
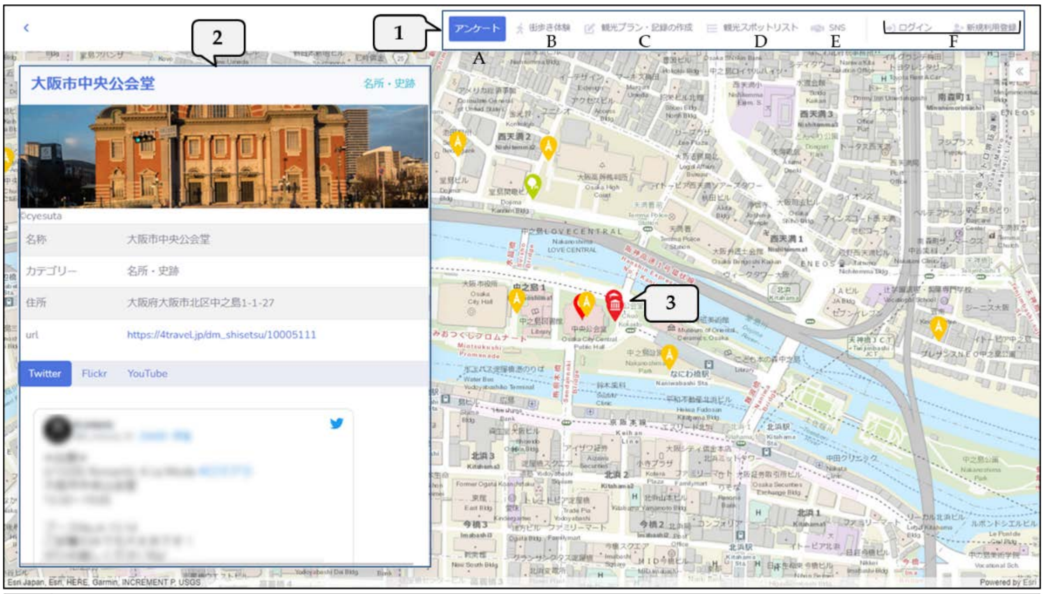


No.	Description
1	Navigation bar (A: Questionnaire survey, B: Function of virtual city walk experience, C: Function of creation of sightseeing plan and record, D: Function of viewing sightseeing spot information, E: Function of sharing sightseeing plan and record, F: User
2	Page for the registration of a new sightseeing spot
3	Registration of new sightseeing spot information by entering the "sightseeing spot name" and selecting a "category" in addition to the address and website
4	Selection of the location of a new sightseeing spot on the 2D digital map

Figure 5. Page for the registration of new sightseeing spots.

(3) Function of sightseeing spot information viewing

The sightseeing spot information saved to the database of the system can be viewed. Figure 6 shows the page for the details of sightseeing spot. The page with the list of sightseeing spots displays the name, the images, the category, the number of Twitter submissions as well as the number of Flickr submissions for each sightseeing spot. The images of the sightseeing spots are either taken from Flickr or the database of the system. Additionally, by clicking or tapping on the name of each sightseeing spot, users will be moved to the page for the details of sightseeing spot (Figure 6). On this page, basic information concerning sightseeing spots, information taken from social media and the location on the 2D digital map will be displayed. Pop-up contains the name, note, travel time, image, address, website and social media information of the selected sightseeing spot.



No.	Description
1	Navigation bar (A: Questionnaire survey, B: Function of virtual city walk experience, C: Function of creation of sightseeing plan and record, D: Function of viewing sightseeing spot information, E: Function of sharing sightseeing plan and record, F: Log in and registration
2	Selected sightseeing spot information (name, notes, travel time, images address, website and social media information)
3	Location of selected sightseeing spot on the 2D digital map

Figure 6. Page for the details of sightseeing spot.

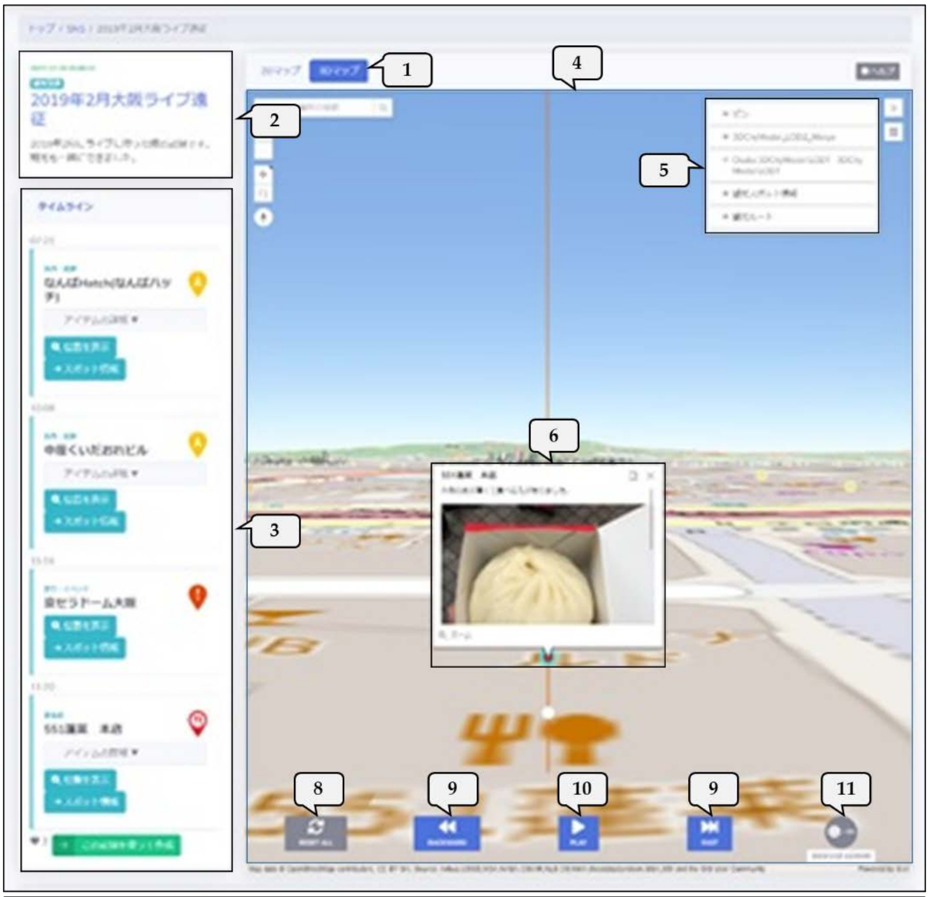
(4) Function of sightseeing plan and record sharing

Figure 7 shows the page for the function of sightseeing plan and record sharing, and Figure 8 shows the page for the details of sightseeing plan and record. Users can submit and share their sightseeing plan and record after adding their reviews and comments on the sightseeing spots they have traveled to with other users. Additionally, users can evaluate travel plans and records created by other users by using the "like" button. Users can click or tap on the "SNS" in the navigation bar on the top of the screen to move to the page for the function of sightseeing plan and record sharing. On this page, information concerning sightseeing plan and record including the "user name", "sightseeing plan and record", "date of registration", "title", "overview of the sightseeing plan and record", "added images", "the "like" button", and the "number of "likes" it has received" are displayed.

By clicking or tapping on the box of each sightseeing plan and record or the "details" button, users will be moved to the page for the details of sightseeing plan and record (Figure 8). On this page, users can view the sightseeing plans on the 2D and 3D digital maps. Additionally, this page also shows the submitted time and title of the sightseeing plan and record, a description, a timeline of the sightseeing spots, the shortest route on the 2D and 3D digital maps as well as a list of nearby sightseeing spots. The function of virtual city walk experience introduced in the next section can be used from this page.

No.	Description
1	Navigation bar (A: Function of virtual city walk experience, B: Function of creation of sightseeing plan and record, C: Function of viewing sightseeing spot information, D: Function of sharing sightseeing plan and record, F: Log in and registration
2	Page for the function of sharing sightseeing plan and record
3	Sightseeing plan and record

Figure 7. Page for the function of sightseeing plan and record sharing.



No.	Description
1	Switch between the 2D and 3D digital maps
2	Selected sightseeing plan
3	Timeline of sightseeing plan
4	Screen of the details of sightseeing plan and record on the 3D digital map
5	Items (Present location, 3D digital map, 3D city model, sightseeing spot information and sightseeing route)
6	Reverse of the direction of the course, and change of the perspective
7	Acceleration of the perspective movement
8	Stop
9	Insolation (Every time the button is clicked or tapped on, the time in the virtual space moves forward which changes the insolation.)

Figure 8. Page for the details of sightseeing plan and record (3D digital map).

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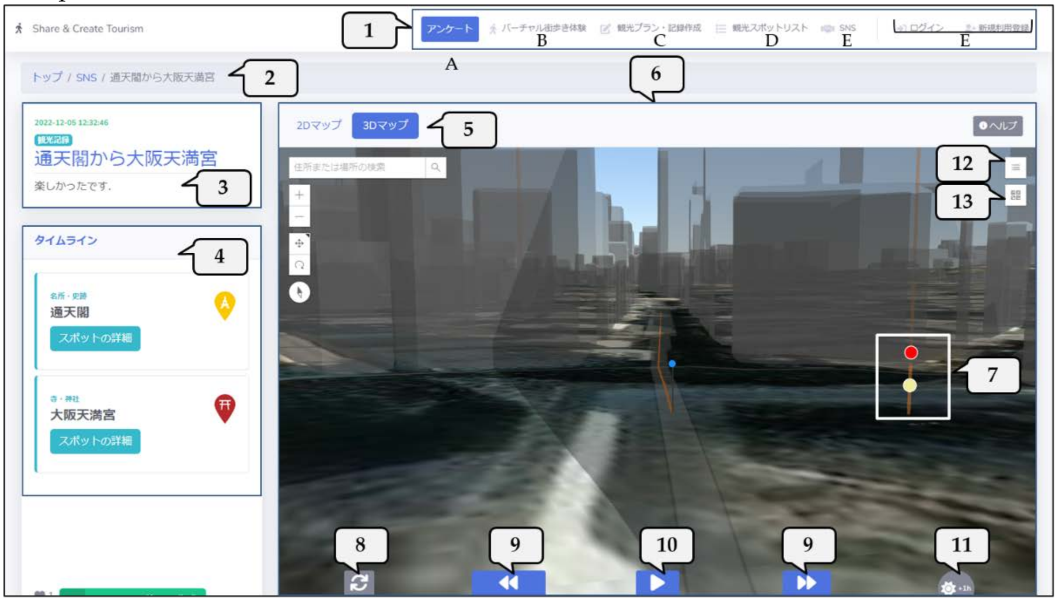
(5) Function of virtual city walk experience

Figure 9 shows the page for the function of virtual city walk experience. By selecting the “3D map” tab on each sightseeing plan and record on this page, users can use this function. Additionally, they can shift the perspective or change the lighting by clicking or tapping on the button on the 3D digital map.



No.	Description
1	Navigation bar (A: Questionnaire survey, B: Function of virtual city walk experience, C: Function of creation of sightseeing plan and record, D: Function of viewing sightseeing spot information, E: Function of sharing sightseeing plan and record, F: Log in and registration
2	Page for the function of sharing sightseeing plan and record
3	Selected sightseeing plan
4	Timeline of sightseeing plan
5	Switch between the 2D and 3D digital maps
6	Screen of virtual city walk experience
7	Reset of the perspective on the 3D map
8	Reverse of the direction of the course, and change of the perspective
9	Acceleration of the perspective movement
10	Stop
11	Insolation (Every time the button is clicked or tapped on, the time in the virtual space moves forward which changes the insolation.)
12	Change layer
13	Change of base maps (3D digital map and 3D city model)

Figure 9. Page for the function of virtual city walk experience (3D city model).

(6) Function of my page

Users can be moved to the page for the function of my page by clicking or tapping on the user name at the top of the screen and selecting “Mypage”. On this page, users can view the sightseeing plans and records that they have made as well as a list of sightseeing plan and record they have “liked”.

4.2 System Backend

The following processes are handled by the system backend.

(1) The processing for the function of new user registration and login

New user information is saved to the Heroku database. Passwords are hashed using the function of PHP Hash and saved in the database. When logging in, the password hashing is conducted and the login is processed, if the ID and password within the database are matched. If there is no match, an error message will be displayed and the login information must be reentered.

(2) The processing for the function of sightseeing plan and record creation

The process of saving the information submitted using the function of sightseeing plan and record creation to the database is conducted. In the database, there will be two tables for the information concerning sightseeing plan and record as well as the sightseeing spots are created and save.

(3) The processing for the function of sightseeing plan and record sharing

The processing includes displaying the sightseeing plan and record saved in the database in chronological order on the screen, and evaluating by means of the "like" button.

(4) The processing for the function of virtual city walk experience

In order to implement each button for the function of virtual city walk experience, the user perspective is updated using the functions of ArcGIS for JavaScript.

(5) The processing for the display of social media information

The location information from the submissions on each social media platform in addition to information related to sightseeing spots in texts are extracted and saved to the database. Additionally, information is integrated into each sightseeing spot within the database and is displayed on the 2D map of Web-GIS.

(6) Derivation of the shortest routes between sightseeing spots

Using the road database provided by the Network Analysis Service of ArcGIS, the shortest route between sightseeing spots are derived.

4.3 System Interface

There are two types of interfaces in this system. One is the screen for PC and mobile information terminals of users, and the other is the screen for PC of administrators. In this way, a responsive screen is adopted into the system, and two types of interfaces are used according to the screen size of the devices used. With the page for administrators, users, registered sightseeing spot information as well as submitted information can be managed. By adopting graphical user interface (GUI), users with malicious intent and inappropriate sightseeing spot information can be deleted without the influence of the information technology (IT) literacy of the administrators.

5. System Operation

5.1 Sightseeing Spot Ddata

In order to make the functions of the system available for use immediately after the start of the operation, sightseeing spot information must be collected and registered to the database beforehand. Information concerning a total of 529 sightseeing spots in the operation target area (Osaka City) was collected from tourism-related web media such as 4travel.jp, Jalen.net and TripAdvisor. These sightseeing spots were divided into the 10 categories introduced in the section 4.1.

5.2 Operation Result

The operation of this system was conducted on people both within and outside the operation target area over a one-month period from December 21st, 2022 to January 24th, 2023. The system use was advertised on the website, and Twitter and Facebook accounts of the authors' lab. The total number of users was 56, which included 36 men, 18 women and 2 others. 48% of users were in their 20s which was the highest percentage. 13% were in their 30s, 11% were under 20, 11% were in their 40s as well as over 60, and 7% were in their 50s respectively. Though the majority of users are a younger generation, it is used by a wide range of age groups. Additionally, during the operation period of the system, users registered 10 sightseeing plans and one travel record, and submitted seven sightseeing spot information. However, if the system were operated for a longer period of time, there would be a high potential for more multifaceted use.

6. System Evaluation

After the operation, an online questionnaire survey towards users as well as an access log analysis were conducted to evaluate the system. All users responded to the questionnaire survey.

6.1 Evaluations Based on the Questionnaire Survey

6.1.1 Overview of an Online Questionnaire Survey

In line with the purpose of the present study, an online questionnaire survey towards users was conducted to evaluate (1) the main functions and (2) the system as a whole. The questionnaire survey was conducted one week after the start of the operation. Regarding the number of visits to the operation target area, 27% responded "never", "once", or "2~5 times" respectively, 7% responded "6~9 times", 10% responded "10 times or more", and 1% responded "I am living here" and "I used to live there" respectively. Therefore, it was revealed that the system was mainly used by people living outside Osaka City. With the focus on the number of visits to Osaka City, users who answered "0~1 time" are considered to have little travel experience, and users who answered "2 or more times" are considered to have travel experience.

6.1.2 Evaluation of the Main Functions

In this section, the main functions of the system are evaluated. Tables 1-8 show the cross-tabulation tables of each evaluation item for the main functions and users' travel experiences to the operation target area. Whether or not the travel experience to the operation target area causes bias in evaluations is confirmed by conducting the Pearson's chi-square test for these tables.

(1) Function of sightseeing plan and record creation

Regarding the usefulness of the function of sightseeing plan and record creation, 93% of users very highly rated this function as they responded with "strongly agree" and "agree". As a result of the chi-square test for Table 1, there was no bias in the evaluations caused by the different travel experiences to the operation target area ($\chi^2(1) = 2.099,\ p > .05$). Therefore, regardless of users' travel experiences to the operation target area, the function was designed to be easy to use.

Table 1. Cross-tabulation table of the evaluation for the usefulness of the function of sightseeing plan and record creation.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	**Had travel experience**	24 (24.6)	2 (1.4)	26
	Had little travel experience	29 (28.4)	1 (1.6)	30
Total		53	3	56

The value in ( ) is the expected frequency.

Regarding the appropriateness of the function of sightseeing plan and record creation, 88% highly rated this function as they responded with "strongly agree" or "agree". However, as a result of the chi-square test for Table 2, it showed that there were negative evaluations from users who had travel experiences to the operation target area ($\chi^2(1) = 0.344,\ p < .05$). Regarding the reasons for this, as some users wrote "the system was slow" and "it took time for the pages to be displayed" in the comments section. Therefore, it was revealed that some users who had travel experiences to the target area felt that the function was hard to use, as it was slow when using it on their smartphones.

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Table 2. Cross-tabulation table of the evaluation for the appropriateness of the function of sightseeing plan and record creation.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	**Had travel experience**	21 (23.2)	5 (2.8)	26
	Had little travel experience	29 (26.8)	1 (3.2)	30
Total		50	6	56

The value in ( ) is the expected frequency.

(2) Function of sightseeing spot information viewing

Regarding the usefulness of the function of sightseeing spot information viewing, 95% very highly rated this function as they responded with “strongly agree” or “agree”. As a result of the chi-square test for Table 3, there was no bias in the evaluations caused by the different travel experiences to the operation target area ($\chi^2(1) = 0.423,\ p > .05$). Therefore, this shows that the function greatly contributed to the collecting of new sightseeing information, as it produced and provided dynamic information in real time.

Table 3. Cross-tabulation table of the evaluation for the usefulness of the function of sightseeing spot information viewing.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	24 (24.6)	1 (0.4)	25
	Had little travel experience	31 (30.4)	0 (0.6)	31
Total		55	1	56

The value in ( ) is the expected frequency.

(3) Function of sightseeing plan and record sharing

Regarding the usefulness of the function of sightseeing plan and record sharing, 95% very highly rated this function as they responded with “strongly agree” or “agree”. As a result of the chi-square test for Table 4, there was no bias in the evaluations caused by the different travel experiences to the operation target area($\chi^2(1) = 3.214,\ p > .05$). Therefore, the function which allowed users to share sightseeing information with other users and accumulate such information was effective in collecting information before traveling.

Table 4. Cross-tabulation table of the evaluation for the usefulness of the SNS function.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	24 (24.6)	1 (0.4)	25
	Had little travel experience	31 (30.4)	0 (0.6)	31
Total		55	1	56

The value in ( ) is the expected frequency.

(4) Function of virtual city walk experience

Regarding the usefulness of the function of virtual city walk experience, 88% highly rated this function as they responded with “strongly agree” or “agree”. As a result of the chi-square test for Table 5, there was no bias in the evaluations caused by the different travel experiences to the

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operation target area ($\chi^2(1) = 2.605,\ p > .05$). Therefore, regardless of users' travel experiences to the operation target area, the function was useful in reducing the burden of previewing tourist destinations.

Table 5. Cross-tabulation table of the evaluation for the usefulness of the function of virtual city walk experience function.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	22 (22.8)	4 (3.3)	26
	Had little travel experience	27 (26.3)	3 (3.8)	30
Total		49	7	56

The value in ( ) is the expected frequency.

Regarding the appropriateness of the function of virtual city walk experience, 68% responded with "strongly agree" or "agree" while 32% responded with "disagree" or "strongly disagree". Therefore, users can generally have a detailed image of the operation target area by using this function. On the other hand, the function had many negative evaluations in comparison with the other functions, and the expressiveness of the 3D city model itself mentioned in the comment section was raised as the reason. As the data of the 3D city model is continuously being updated, it can be expected that users' evaluations will also improve. However, as a result of the chi-square test for Table 6, there was no bias in the evaluations caused by the different travel experiences to the operation target area $\chi^2(1) = 3.767,\ p > .05$). Accordingly, regardless of users' travel experiences to the operation target area, they can grasp the general image by using the function.

Table 6. Cross-tabulation table of the evaluation for the appropriateness of the function of virtual city walk experience.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	17 (17.6)	9 (8.4)	26
	Had little travel experience	21 (20.4)	9 (9.6)	30
Total		38	18	56

The value in ( ) is the expected frequency.

6.1.3 Evaluation of the System as a Whole

(1) Usefulness of the system for tourism support

Regarding the usefulness of the system for tourism support, 95% very highly rated this system as they responded with "strongly agree" or "agree". As a result of the Pearson's chi-square test for Table 7, there was no bias in the evaluations caused by the different travel experiences to the operation target area ($\chi^2(1) = 2.210, p > .05$). Therefore, regardless of users' travel experiences to the operation target area, the system can support the travel of users.

Table 7. Cross-tabulation table of the usefulness of the system for tourism support.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	17 (17.6)	9 (8.4)	26
	Had little travel experience	21 (20.4)	9 (9.6)	30
Total		38	18	56

The value in ( ) is the expected frequency.

(2) Expectation to the future use of the system

Regarding the expectation to the future use of the system, 89% responded positively with "strongly agree" or "agree". As a result of the Pearson's chi-square test for Table 8, there was no bias in the evaluations caused by the different travel experiences to the operation target area ($\chi^2(1) = 5.360, p > .05$). Therefore, regardless of users' travel experiences to the operation target, it can be expected that the system will be continuously utilized by users.

Table 8. Cross-tabulation table of the expectation to the future use of the system.

		Evaluation		Total
		Strongly agree/agree	Disagree/strongly disagree	
Travel experience	Had travel experience	23 (23.2)	3 (2.8)	26
	Had little travel experience	27 (26.8)	3 (3.2)	30
Total		50	6	56

The value in ( ) is the expected frequency.

6.2 Evaluation based on access analysis

An access log analysis was conducted using users' log data during the operation of this system. Google Analytics of Google was used in the present study. Specifically, the access log can be obtained by calling the Python Program, which contains the analysis code created with Google Analytics, from the HTML file read on each page within the website subject to the access analysis.

Table 9 shows the analysis result concerning the devices users used to access the system. A cumulative total of 160 users accessed the system during the operation period. In addition, regarding the devices used as a method to access the system, 89 used mobile information terminals while 71 used PCs. Furthermore, there were 155 sessions with engagement, the average ratio of engagement to users was 70%, and the average engagement time was 4 minutes 13 seconds.

Based on these results, it was revealed that while mobile information terminals had a higher access number, the engagement rate was lower than that of PCs. Therefore, this showed that while many users easily used the system on their mobile information terminals, they use PCs to spend a long time to try out the various function. On the other hand, the responsive design that allows the same functions to be used on both mobile information terminals and PCs was effective.

Table 9. Analysis results concerning the devices used by users to access the system.

Accessed device	Number of users	Number of sessions with engagement	Engagement rate (%)	Average engagement time (second)
Mobile information terminal	89	75	63.0	101
PCs	71	80	78.0	436
Total or Average	Total 160	Total 155	Average 70.4	Average 253

Next, Table 10 shows the top 9 pages with the highest number of visits. According to Table 10, the function of virtual city walk experience, the list of sightseeing spots, the function of sightseeing plan and record creation, and the function of sightseeing plan and record sharing have many views. Therefore, there was a high number of visits to the pages of main functions aimed to provide tourism support, which is the purpose of the system. Consequently, it is clear that the use of the system was consistent with the purpose of the present study.

Table 10. Number of visits for each page (top 9).

Ranking	Page name	Number of visits	Rate (%)
1	Top page	321	20.4
2	Function of virtual city walk experience	203	7.3
3	List of sightseeing spots	135	5.8
4	Function of sightseeing plan and record creation	97	5.0
5	Function of sightseeing plan and record sharing	74	4.6
6	Function of login	56	4.3
7	Sightseeing plan "From Tsutenkaku to Osaka Tenmangu"	45	3.0
8	Function of new user registration	42	2.8
9	Details of the sightseeing plan and record	17	2.7

6.3 Extraction of Solutions for the system

The solutions for this system extracted based on the results of the questionnaire survey and the access log analysis can be summarized as shown below.

(1) System operation

By temporarily saving the information in the frontend, the communication between the frontend and backend can be minimized and the page load time can be reduced. Additionally, the effort required of users can be reduced by prioritizing the loading of views instead of fully loading all the data on each page at once, and conducting an asynchronous loading of the internal data afterward. Moving the system even faster and reducing the number of page transitions can reduce the burden of users and improve the utilization value of the system.

(2) Interface

The system was designed with a hierarchical structure that allows users to access each function from the top page as a starting point. However, the website structure will be modified in order for users to be able to select the stage of travel (before, during and after) and search for any information they need at each stage. This change will reduce the number of views and choices of information.

(3) Expansion of the functions used to create sightseeing plans

The amount of information provided for users can be increased by visualizing the view count of sightseeing spots as well as the number of times each spot was included in a sightseeing plan on the digital map. Additionally, by adding videos and audio clips to the sightseeing spot information, it is anticipated that this will help users to have a clearer image of the tourist destination and create satisfying sightseeing plans.

7. Conclusion

In the present study, after designing and developing the system (sections 3 and 4), the operation was conducted (section 5), and the evaluations and solutions were extracted (section 6). Specifically, in the present study, an original tourism support system was designed and developed with the purpose of reducing the burden of tourists who are unfamiliar with the tourist destinations in particular. An original tourism planning support system and Web-GIS were integrated into a single system, and two original functions were implemented. One function enables the system to efficiently collect and update the static and dynamic information in real time from tourism-related web media and social media in real time (the function of sightseeing spot information viewing). The other function visualizes and displays such information in the VR space which was developed adopting a 3D city model of the operation target area (the function of virtual city walk experience).

The area of Osaka City was selected as the operation target area, and the information of a total of 529 sightseeing spots was collected from tourism-related web media, and then saved to the database of the system beforehand. The system was operated for a period of one month during

December 21st, 2022 to January 24th, 2023. During the operation period, a cumulative total of 160 users accessed the system. Additionally, the system had 10 sightseeing plans and one travel record registered as well as seven sightseeing spots submitted by users.

In order to evaluate the system, an online questionnaire survey for 56 users and an access log analysis were conducted. According to the questionnaire survey results, the system was effective for tourism support, and it is anticipated that it will be continuously utilized by users. Furthermore, excluding the function of sightseeing plan and record creation, the main functions were highly rated regardless of users' travel experiences to the operation target area. Additionally, based on the access log analysis results, it was clear that the use of the system was in line with the purpose of the present study, as the number of visits to the page for the main functions were high.

Regarding future study topics, the advancement of the system according to the solutions listed in section 6.3 as well as the improvement of the utilization value by increasing the usage performance through the operation in other urban tourist destinations can be considered.

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