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A Support System of Sightseeing Tour Planning Using Public Transportation in Japanese Rural Areas

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Abstract: Though most of tourists tend to visit multiple sightseeing spots during their sightseeing tours, it is difficult for them to efficiently acquire information necessary for their sightseeing tour planning. Additionally, in rural area, many people hope to use public transportation which has not developed as much as in urban areas. The present study aims to design and develop a support system of sightseeing tour planning in Japanese rural areas, adopting the information related to real timetables of public transportation on both the sea and the ground, and genetic algorism (GA). The system was developed integrating moving route recommendation system, web-geographic information systems (Web-GIS), and augmented reality (AR) application. Furthermore, Kagawa Prefecture in the western part was selected as the operation target area. The operation of the system was conducted for two months, targeting those inside and outside the operation target area, and web questionnaire surveys were conducted. From the evaluation results based on the web questionnaire surveys, the usefulness of all the original functions as well as of the entire system was analyzed. Additionally, though some users could not easily use the system, it is expected that they will get used to utilizing it by their continuous use.

Key words: Sightseeing tour planning, Web-GIS, moving route recommendation system, AR, GA, public transportation.

1. Introduction

Most of tourists tend to visit multiple sightseeing spots during their sightseeing tours. However, as the number of sightseeing spots where they wish to visit increases, the number of moving routes explosively increases, and the calculation amount of route search also tremendously increases. Leporte et al. [1] named such a problem the "selection traveling salesman problem" which is one of the combinatorial optimization problems. Therefore, it is difficult for tourists to easily make the best sightseeing tour plans. Furthermore, as it is very hard especially for tourists who do not have a good sense of locality to select the most efficient sightseeing tour plans, it is necessary to reduce the burden of information acquisition on them.

Additionally, in recent Japan, in the case of the travel with friends, approximately 40% tourists use public transportation including trains and buses as well as ships as the main moving means to their destinations [2]. However, since the public transportation in the rural areas has not been developed unlike in urban areas, it is essential for tourists to make appropriate sightseeing tour plans in consideration of their departure and arrival times including waiting time, when using public transportation. In the case that sightseeing spots are dotted in islands in addition to lands, it is indispensable to take complicated conditions of the public transportation on both the sea and the ground into consideration. Furthermore, according to the public opinion survey on public transportation conducted by the Cabinet Office [3], the information related to timetables of public transportation is essential for tourists while traveling.

On the other hand, in recent Japan, due to the spread of mobile information terminals such as smartphones and tablet PCs in the advanced communication network society, anyone can easily access the internet,

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and transmit and acquire information. However, as various information is available on the internet, anyone can efficiently search the necessary information. Additionally, as a wide variety and large amount of information is available, it may take a lot of time to search and acquire the necessary information. The above can also be applied to sightseeing. According to the survey on the extension of new technologies and services, lifestyle and travel conducted by the JTB Tourism Research & Consulting Co. [4], the rate of respondents who tended to search local information mainly using mobile information terminals while traveling was 41% in 2018. Therefore, it is effective to support tourists for local information gathering in addition to advanced planning before their sightseeing.

Furthermore, augmented reality (AR) is a technology that visualizes information by displaying digital contents such as images and videos in the actual world by means of wearable terminals including mobile information terminals and smart glasses [5]. There are various types of AR such as the location-based AR, which uses location information acquired using global positioning system (GPS), the image-recognition AR which recognizes images and markers, in addition to the markerless AR which recognizes flat surfaces and spaces. The usefulness of providing sightseeing information using AR is evident from the results of the preceding studies [6-9] which developed the navigation system in normal conditions and in the event of disasters as well as the system to provide sightseeing spot information.

Based on the circumstances mentioned above, in order to support to make sightseeing tour plans in advance and gather local information on the assumption to use public transportation, the present study aims to develop a support system of sightseeing tour planning in Japanese rural areas. Additionally, the system adopts the location-based AR which is the most effective means for providing sightseeing information among various kinds of AR technologies especially while traveling.

2. Related Work

The present study is related to 2 study fields including (1) studies related to sightseeing planning support systems, (2) studies related to sightseeing support system using AR. In (1) studies related sightseeing planning support systems, Maruyama [10] developed a system equipped with sightseeing schedule creation function and navigation function (P-tour), Kurata et al. [11, 12] developed an interactive system (CT-planner) to recommend sightseeing spots and their routes according to user's preference, and Nakagawa et al. [13] proposed a method to recommend a sightseeing route based on the information transmitted by social media. Anacleto et al. [14, 15] respectively proposed recommendation and planning applications designed to support a tourist during his or her vacations, integrating web-geographic information systems (Web-GIS) and recommendation system. Souffriau et al. [16] presented an on-line cycle route planning application which offers personalized cycle routes based on user preferences, and provides cyclists in the field with information on demand using short message services (SMS). Yang et al. [17] developed a travel recommender system (iTravel) for makings attraction recommendation, employing mobile peer-to-peer communications for exchanging ratings via tourists' mobile devices.

Gavalas et al. [18] introduced a context-aware web/mobile application (eCOMPASS) which derives personalized multimodal tours via selected urban attractions. Gavalas et al. [19] also introduced a context-aware mobile city guide (Scenic Athens) which provides tourists with personalized tour planning services. Cenamor et al. [20] presented a system that creates personalized tourist plans using the human-generated information gathered from the minube traveling social network (Plan Tour). Smirnov et al. [21] presented an infomobility system (Tourist Assistant—TAIS) to support tourists for cultural heritage recommendation. Zhou et al. [22] proposed a travel-planning tool to provide tourists with customized information, using geospatial data mining approaches to extract tourism attractions information from Flickr. Shilov et al. [23] proposed an application of the concept of cyber-physical systems to support customized on-demand tours based on the "Connected car" technology. Ravi et al. [24] presented a new hybrid location-based travel recommender system (HLTRS) for mobility and travel planning through exploiting ensemble based co-training method with swarm intelligence algorithms to enhance the personalized travel recommendations.

In (2) studies related to sightseeing support system using AR, Jang et al. [25] developed a navigation system to display the data related to Point of Interests (POI) on mobile information terminals. Furuta et al. [26] developed a mobile application system for sightseeing guidance which enables users to submit, improve and share sightseeing information using mobile phones. Chung et al. [27] developed an AR application as a part of smart tourism to provide information about destination. Adopting AR smart glasses, Fujita et al. [6] developed a real-time dynamic navigation system, and Zhou et al. [7] developed a system to support tourists' excursion behaviors. These studies developed the system integrating Web-GIS, recommendation system and social media in addition to location-based AR. Sato et al. [28] suggested a new tourist information system by AR, using the information of the beacon which can provide tour information based on POI. Hang et al. [29] investigated tourist requirements for the development of mobile AR tourism applications in the urban heritage tourism context. Sonobe et al. [30] proposed a tourism support system for tourists' migratory behaviors using AR.

Sasaki et al. [8] developed a system to provide guidance and information concerning sightseeing spots by integrating location-based AR and object-recognition AR and using pictograms. Additionally, Makino et al. [9] developed a system that visualizes spatiotemporal information in both real and virtual spaces to support sightseeing, integrating Social Networking Services (SNS), Web-GIS, Mixed Reality (MR) and the gallery system as well as Wikitude, and connecting external social media. Onodera et al. [31] proposed an application system using location-based AR to display historical sites. Rahimi et al. [32] focused on the effectiveness of AR supported applications for both mobile and wearable devices during the visitation of tourist destinations.

(1) Studies related to sightseeing planning support systems just supported sightseeing planning without adopting real timetables of transportation. Though (2) studies related to sightseeing support system using AR utilized AR technologies to support tourists' excursion behaviors, these did not support tourists for sightseeing tour planning. Additionally, the existing systems developed in (1) and (2) studies did not calculate the appropriate moving route among multiple points. In comparison with the above preceding studies, the present study demonstrates the technical originality by integrating moving route recommendation system and Web-GIS as well as location-based AR into a single system. Specifically, in order to support sightseeing in rural areas where public transportation networks have not been completely developed, the system adopts the real timetables of trains and buses as well as ships in the operation target area, and genetic algorism (GA) which reduces the calculation time into the moving route recommendation system. Additionally, adopting location-based AR, the system can support tourists for both making sightseeing tour plans in advance and actual sightseeing tours in rural areas.

3. System Design

3.1 System Characteristics

As shown in Fig. 1, the system in the present study is composed of moving route recommendation system and Web-GIS as well as AR application. Users can use both moving route recommendation system and Web-GIS by inputting their requests on the website. Using moving route recommendation system adopting the real timetables of public transportation in the operation target area and Web-GIS, and targeting Japanese rural areas, the system recommends the most efficient sightseeing tour plans, and displays the shortest routes from each sightseeing spot to the nearest station, bus stop and harbor of public transportation on their information terminal screens. Furthermore, the system displays the images of sightseeing spots using location-based AR, while traveling in the operation target area.

Assuming all of the functions on the website are used from PCs or mobile information terminals, there is no difference in functions on different information terminals, and the same functions can be used from any information terminal. On the other hand, an original AR application developed for the system in the present study can be installed into mobile information terminals.

3.2 Usefulness of the System

The following 3 points explain the usefulness of the system.

3.2.1 Reduce the Burden of Information Acquisition

It takes a lot of time to gather necessary information such as the timetables of public transportation to search moving routes. Furthermore, as there are multiple patterns of moving routes, it is heavy burden on tourists to select the best sightseeing tour plan, when gathering the above information provided in various forms by themselves. However, the system can recommend efficient moving routes to users; it is possible for them to shorten the retrieval processing time.

3.2.2 Efficient Support for Tourists Who Do Not Have a Good Sense of Locality

Most of tourists are often unfamiliar with the rural areas where they hope to visit, and have seldom local knowledge. Though maps in both paper and digital formats are essential to them, some people are not skilled at reading maps and they cannot grasp the accurate direction to their destinations. However, as the system displays the images indicating the direction of sightseeing spots on users' mobile information terminals using the original AR application; they can intuitively recognize the positions.

3.2.3 Reduction of Temporal and Spatial Constraints

During sightseeing, as users sometimes change their schedules in rural areas, it is necessary to revise their sightseeing tour plans on the spot. The system is on the assumption to be used with both PCs and

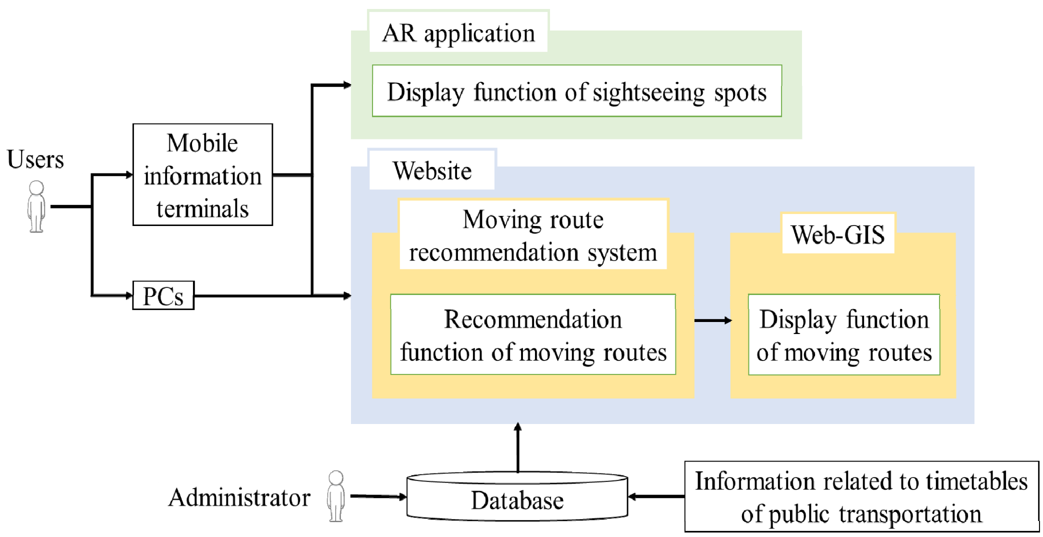


Fig. 1 System design.

mobile information terminals, if they access the internet, they can remake their sightseeing tour plans soon.

3.3 Target Information Terminals and Operating Environment for AR Application

The AR application is meant to be used mainly on mobile information terminals both indoors and outdoors. As the mobile application used on mobile information terminals is set to be an Android application, the operating system (OS) is also required to be Android (5.0 or higher). Due to the system requirement of Wikitude SDK used in application development, mobile information terminals must have a compass, network positioning, an accelerometer, high resolution, high-performance CPU and OpenGL (2.0 or higher), in addition to a camera and function.

3.4 Design of Each System

3.4.1 Moving Route Recommendation System

Users can acquire the information related to moving routes, and departure and arrival times of public transportation, specifying the sightseeing spots and staying time according to their preferences. Adopting the timetables of public transportation in the operation target area, the system can recommend the most efficient sightseeing tour plans to users. Additionally, using GA described in detail in the next section, the system can shorten the retrieval processing time.

3.4.2 Web-GIS

As there are variety types of Web-GIS, it is necessary to select the most suitable type according to the purpose of using the system. In terms of convenience, the system should be used without having to download any special software, which would be inconvenient for users, and it would be desirable if it could be used by accessing the Website on any PC or mobile device connected to the Internet. Therefore, in order to display the information related to sightseeing spots and moving routes to users on the digital maps of the system, the ArcGIS API for JavaScript 4.1.5 by the Environmental Systems Research Institute, Inc. (ESRI) was used. When users select two points, based on the road network database accumulated in the ArcGIS, the shortest route between them is displayed on the digital maps.

3.4.3 AR Application

Using Wikitude SDK, which is the SDK for AR application development and provided by the GrapeCity, Inc., sightseeing spots are displayed by means of location-based AR in the real space. Location-based AR is a method to present arbitrary information to users based on the location information (latitude and longitude) acquired using GPS.

The object of the main sightseeing spots in the operation target area is viewed by location-based AR, which was developed using the Wikitude SDK of the GrapeCity. Location-based AR is a method of presenting arbitrary information to users based on their position information acquired from GPS of their mobile information terminals and latitude and longitude information. Users can view the information through their mobile information terminals such as smartphones or tablet PCs. Using mobile information terminals, users can view arbitrary information.

4. Search Method for Optimal Moving Route and Creation of Database

4.1 Search Method for Optimal Moving Route

4.1.1 Adaptation of GA into Search Method for Optimal Moving Route

GA was proposed by J. H. Holland of the United States (U.S.) in 1975, and it is an algorithm for recursively searching optimal solutions to various problems [33]. In GA, aggregation (population) of local rules is manipulated, and an indicator of superiority or inferiority of units that are candidate solutions is taken as fitness. Additionally, it is determined with the object functions that can be set on case by case basis depending on the problem handled with GA. Main genetic operations in GA are crossover, mutation and selection, and large number of units can be evaluated by repeating these operations until converging into a better solution.

On the other hand, it takes a lot of time to calculate the best solution and search the most efficient moving routes among multiple sightseeing spots. As the number of moving routes explosively increases, the calculation amount of route searches also tremendously increases. Additionally, tourists have to change their schedules in rural areas, if an unanticipated situation occurs while traveling. Therefore, it is necessary to search the approximate solution of an optimal solution within the valid time. Taking these circumstances into consideration, the present study adopts GA into the search method for optimal moving route of the system.

4.1.2 Proposed Method

The application method of GA in the search method for optimal moving route proposed in the present study is shown in the following (1)-(6). Python 3.8.2 was used as the programming language for the algorithm design of the search method for optimal moving route. Additionally, Fig. 2 shows the program configuration of the GA in the proposed method based on the below procedures.

Because users can select up to 10 sightseeing spots and harbors when making their sightseeing tour plans based on the conditions determining the system design as mentioned in the next section, the number of genes is 10. Sensitive analyses were conducted in order to set the group size, the mutation rate, and the number of generation in the GA, focusing on the degree of convergence and the calculation time of evaluation values. Based on the results, the group size is 150, the mutation rate is 0.3, and the number of generations is 50.

(1) Initialization: 150 sightseeing tour plans as prescribed above are generated, randomly sorting multiple sightseeing spots and harbors where a user specified.

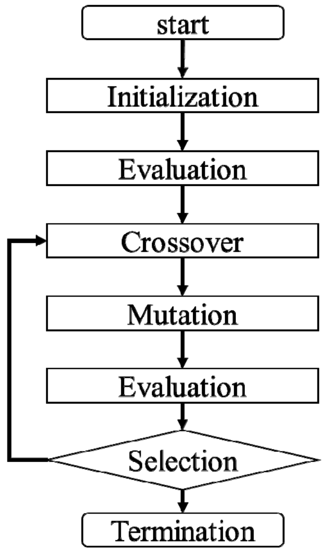


Fig. 2 Program configuration of GA in proposed method.

(2) Evaluation: Evaluation is conducted focusing on the moving times of the generated sightseeing tour plans in (1). The shorter the moving time is, the higher the evaluation value is.

(3) Crossover: Selecting two out of the 150 sightseeing tour plans generated in (1), and breakpoints are randomly determined in the lines of the sightseeing spots and harbors. Considering the breakpoints as boundaries, one parent' genes on the left side and the others on the right side are inherited to children, as shown in Fig. 3.

(4) Mutation: It happens with a certain probability, and the mutation rate is 0.3 as prescribed above. When mutation occurs, randomly selecting two out of the sightseeing spots and harbors in a sightseeing tour plan, and the visiting order of these facilities are reversed, as shown in Fig. 4.

(5) Selection: Randomly selecting three out of the sightseeing tour plans generated until (5), and the one with the highest evaluation value can be remained in the next generation. The same operation is repeated 150 (the number of the group size) times to generate a group in the next generation.

(6) Termination: The above (2) to (5) are repeated for 50 generations as prescribed above, and the sightseeing tour plan with the highest evaluation value

is recommended to the user as the optimal solution.

4.2 Selection of Operation Target Area

Kagawa Prefecture which is located in Shikoku Island in the western part of Japan is selected as the operation target area in the present study. Fig. 5 shows the route map of public transportation and location of major sightseeing spots and harbors in Kagawa Prefecture. In Kagawa Prefecture, as public transportation networks such as trains and buses as well as ships are widely spread as shown in Fig. 5, tourists can visit most of the sightseeing spots using the public transportation. However, the public transportation is not so convenient especially on the sea. Therefore, it is essential for tourists to move around favorite sightseeing spots according to the departure and arrival times of the public transportation.

Additionally, many people visit Kagawa Prefecture from both inside and outside Japan. According to the Japan Travel Bureau Foundation [1], the number of tourists from the outside of Shikoku Island including Kagawa Prefecture accounts for 82% of the total number of domestic tourists to Kagawa Prefecture. Therefore, in Kagawa Prefecture, most of the tourists do not have a good sense of locality, and they need the navigation and the sightseeing tour support.

As shown in Fig. 5, the target sightseeing spots are the top 9 sightseeing spots with high visiting rates (Kotohira-Gu Shrine (A), Ritsurin Koen Garden (B), Marugame Castle (C) and Takinomiya Temmangu (D) on the ground, and Megijima Island (E), Ogijima Island (F), Naoshima Island(G), Teshima Island (H) and Shodoshima Island (I) on the sea), according to the Kagawa official tourism website provided by the Kagawa Prefecture tourism association [34]. Takamatsu City, which is the prefectural capital and has Ritsurin Koen Garden (see Fig. 9 in the next section), was selected as the "10 of the Top Trending Destinations for Travelers to Explore in 2020" by the online travel reservation site [35]. Additionally, the Setouchi Triennale is held once in three years within the framework of the "Art Setouchi". Consequently, it is expected that the number of tourists from both inside and outside Japan will increase in Kagawa Prefecture.

4.3 Creation of Database

In (2) of the GA flow in Section 4.1, when web scraping is conducted to gather the information related to real timetables of public transportation on the internet to calculate moving routes and times among multiple sightseeing spots, it is difficult to acquire an optimal solution in a short time. Therefore, in the system, it is necessary to create an original database of departure and arrival times of the public transportation in Kagawa Prefecture. For this, referring the timetables of trains and buses as well as ships in Kagawa Prefecture, the above database is created and accumulated in the system.

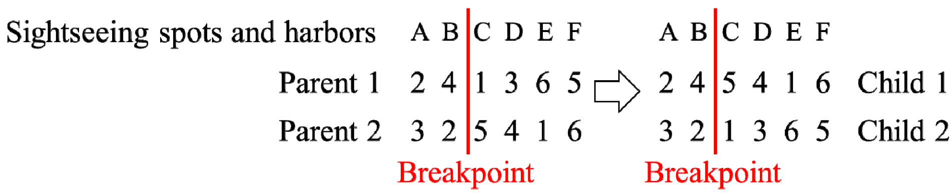


Fig. 3 Conceptual diagram of crossover.

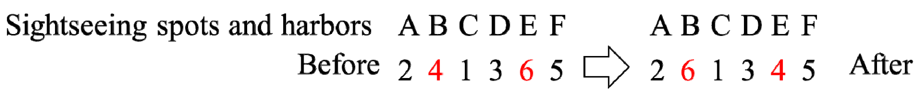


Fig. 4 Conceptual diagram of mutation.

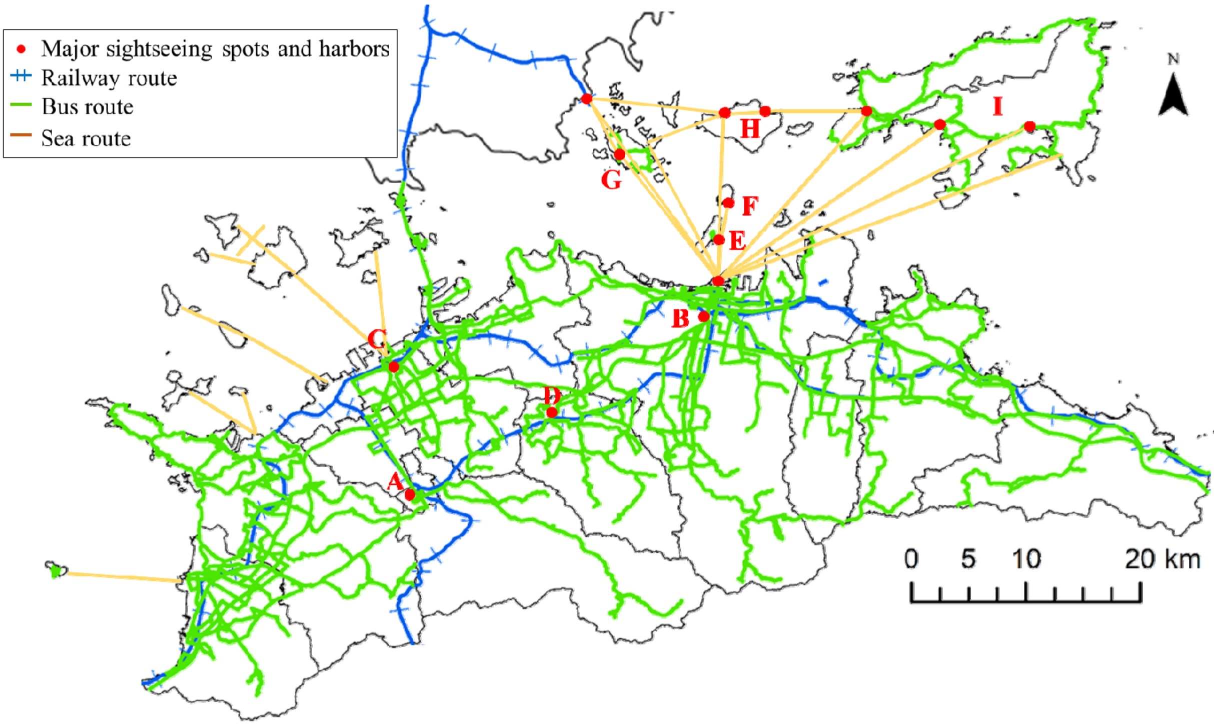


Fig. 5 Route map of public transportation and location of major sightseeing spots and harbors in Kagawa Prefecture.

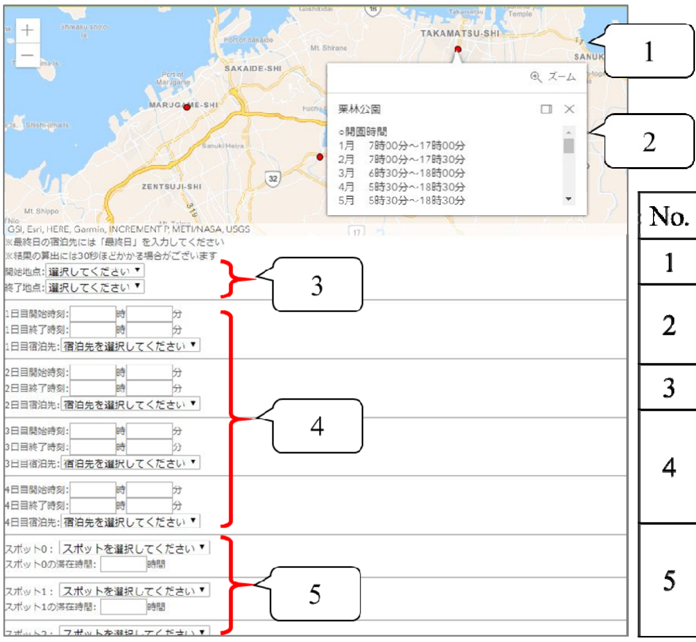
5. System Development

5.1 The Front End of the System

The system will implement three unique functions for users, which will be mentioned below, in response to the aim of the present study, as mentioned in Section 1. To implement the unique functions below, the system is composed of moving route recommendation system and Web-GIS as well as AR application, and the latter is uniquely developed by location-based AR. The recommendation function of moving routes and the display function of moving routes can be used on the website, the display function of sightseeing spots can be used by means of the original AR application of the system and users' mobile information terminals.

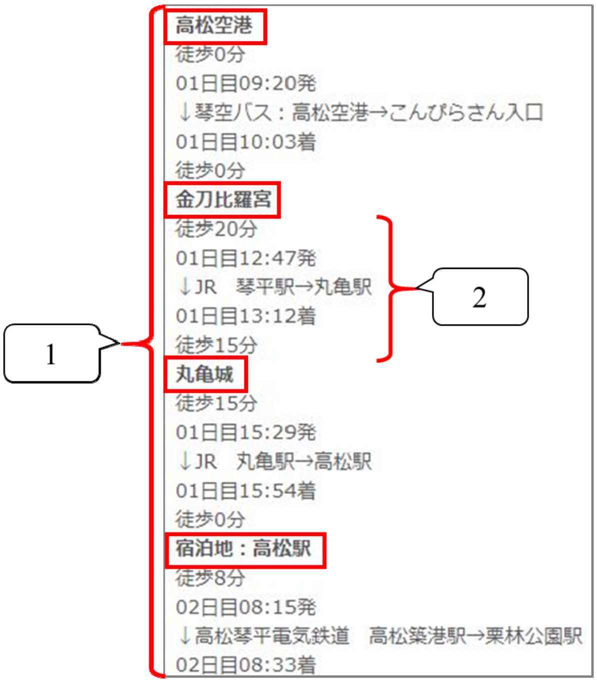
5.1.1 Route Recommendation Function of Moving Routes

Using the recommendation function of moving routes, the system recommends users the most efficient moving routes among multiple sightseeing spots using public transportation. Figs. 6 and 7 show the input and output screens of the function. As shown in Figs. 6 and 7, when users input the start and ending points of sightseeing, the period of stay (up to 10 days) , the places where they hope to stay, and the start and ending times of sightseeing, and the sightseeing spots and harbors where users hope to visit (up to 10 facilities), and the staying time as their requests, the system displays the visiting order of sightseeing spots and harbors, and the detailed information concerning moving routes using public transportation on their information terminal screens. In this way, users can select sightseeing spots in land, and harbors in islands. Because the islands are sightseeing spots in themselves, two out of them have more than two harbors. However, when users input unrealizable requests, the system can encourage them to input other ones. Additionally, on the upper part of the input screen of the function, clicking the markers of the sightseeing spots and harbors on the digital map of Web-GIS, users can identify the detailed information concerning these facilities. Accordingly, due to the function, users can easily search moving routes, visit more sightseeing spots, and satisfy with their sightseeing tours using public transportation.



No.	Description
1	Digital map of Kagawa Prefecture
2	Detailed information concerning sightseeing spots and harbors
3	Start and ending points of sightseeing
4	Period of stay (up to 10 days) , places where users hope to stay, and start and ending times of sightseeing
5	Sightseeing spots and harbors where users hopc to visit (up to 10 facilitics), and staying time

Fig. 6 Input screen of recommendation function of moving routes.

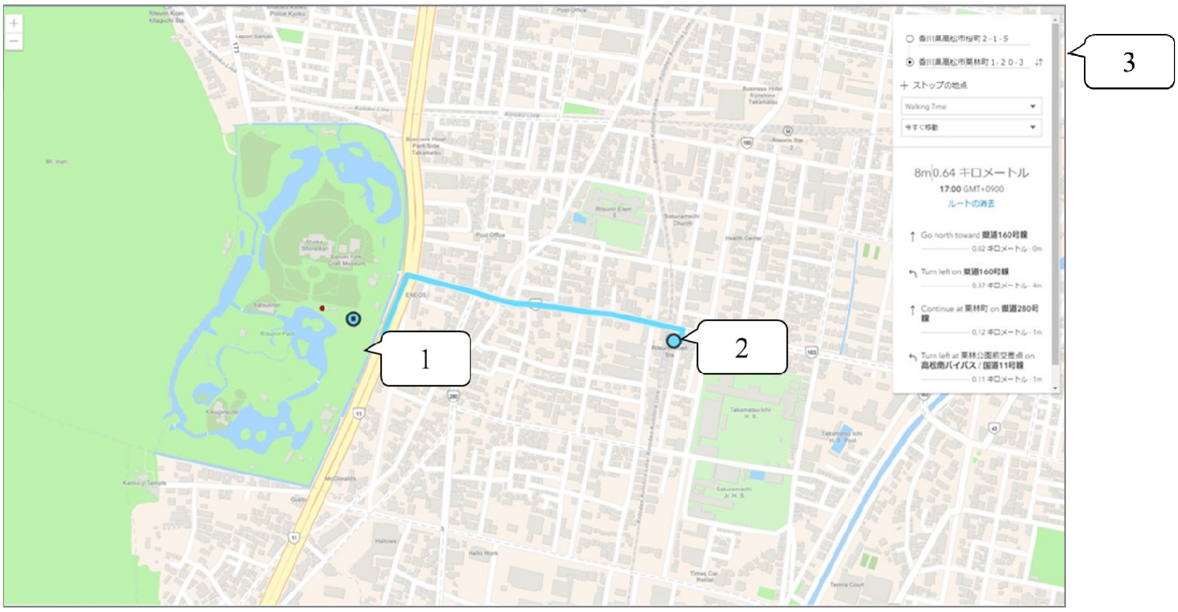


No.	Description
1	Visiting order of sightseeing spots and harbors
2	Detailed information concerning moving routes using public transportation

Fig. 7 Output screen of recommendation function of moving routes.

5.1.2 Display Function of Moving Routes

Using the display function of moving routes, users can view the shortest routes between the nearest stations, bus stops and harbors of public transportation, and their destinations (selected sightseeing spots) on the digital maps of Web-GIS. Fig. 8 shows the screen of this function. Additionally, on the right side of the screen, the system displays the detailed information concerning moving routes. Therefore, the system can efficiently support tourists' sightseeing tours, even if they do not have a good sense of locality in the operation target area.



No.	Description
1	Users' destinations (Selected sightseeing spots, Ritsurin Koen Garden in this case)
2	Nearest stations, bus stops and harbors of public transportation (Nearest station in this case)
3	Detailed information concerning moving routes

Fig. 8 Screen of display function of moving routes.

Fig. 9 Screen of AR application.

5.1.3 Display Function of Sightseeing Spots

Regarding the display function of sightseeing spots, the system can display the objects in the direction of the major 9 sightseeing spots as mentioned in Section 4.2. Fig. 9 shows the screen of AR application on mobile information terminals. The AR application can be downloaded from the homepage of the system. When users tap the objects on the screen, the image of each sightseeing spot is displayed on the mobile information terminal screen. Using the function, it is possible for users to identify the landscape in specific seasons, and enjoy sightseeing more. Additionally, since the above objects are displayed in the direction of sightseeing spots, the function can also play the role of the navigation for tourists.

5.2 The Back End of the System

5.2.1 Calculation Process of Moving Route Recommendation

Referring users' requests mentioned in Section 5.1.1 as the conditions in the front end, and using the GA introduced in Section 4.1, the system can calculate the most efficient moving routes among multiple sightseeing spots using public transportation. Based on the calculation results, the system can recommend the moving routes with high evaluation values which meet users' requests in the shortest time.

5.2.2 Calculation Process of Moving Route

The system calculates the shortest routes from the nearest stations, bus stops and harbors of public transportation to the sightseeing spots where users hope to visit, using the ArcGIS API for JavaScript provided by the ESRI. The shortest routes are calculated using the road network database accumulated in the ArcGIS. Users can check the positional relationship between the above facilities, referring the moving routes recommended by the system.

5.2.3 Display Process of Images on AR

As the administrator input the information related to sightseeing spots including images in advance, the system can access it at the same time of the activation. Additionally, based on the current location of users acquired from GPS, the image of each sightseeing spot is displayed on the screens of their mobile information terminals.

5.3 System Interface

The interfaces are optimized according to the input and output screens of the recommendation function of moving routes (Figs. 6 and 7), the screen of the display function of moving routes (Fig. 8), and the screen of AR application (Fig. 9). When users register their requests as the conditions and press the button of "send" in Fig. 6, the results are displayed as illustrated in Fig. 7. Furthermore, when users press the button of "check the route from the nearest station" on the output screen (Fig. 7), the shortest moving routes from the nearest stations, bus stops and harbors of public transportation, and their destinations (selected sightseeing spots) are displayed on the digital maps of Web-GIS (Fig. 8).

6. Operation

6.1 Operation Overview

The system was operated for 2 months (November 21, 2019-January 22, 2020) with participants both inside and outside the operation target area. Whether inside or outside the operation target area, the operation of the system was advertised using the website of the authors' lab, as well as Twitter and Facebook. Additionally, the tourism division of the Kagawa prefectural government supported the present study by distributing pamphlets and user's manuals. After accessing the homepage of the system, users can use the functions and download the original AR application. Just after the operations, all users were required to answer the web questionnaire survey.

6.2 Operation Results

Table 1 indicates an overview of the system users. Firstly, the result of the operation directly via the web

Table 1 Overviews of system users.

Age groups of users	10-19	20-29	30-39	40-49	50-59	60+	Total
Number of users (operation directly via the web using PCs and mobile information terminals)	28	39	10	12	17	9	115
Number of users (operation via the AR application)	7	7	2	5	9	10	40

using PCs and mobile information terminals was introduced. There were a total of 115 users, with 77 male users and 38 female users. Regarding the age groups, there were many users in their 10s and 20s for both males and females, making up 24% and 34% of the total. 15% were in their 50s, 10% were in their 40s, and 9% were in their 30s. These statistics show that the system was not only used by younger generations but also by various age groups. Furthermore, regarding the frequency of visits to Kagawa Prefecture, 43% answered "never", 10% respectively answered "once" and "a few times", and 34% answered "I am a resident". Therefore, approximately half of the users had not visited Kagawa Prefecture, and it is evident that they are not familiar with this area.

Additionally, the access log analysis of users during the operation period of the system was conducted. The study incorporated an API of Google Analytics into the developed program, and then the access analysis will be conducted. The total number of sessions was 270, and regarding the information terminals used as the method for accessing to the system, PCs were 32%, smartphones were 65% and tablet PCs were 3%. The total number of accesses to the system was 185. From the result, it can be said that mobile information terminals were used rather than PCs as access methods to the system.

Secondly, the results of the operation via the AR application were introduced. There were a total 40 users, with 18 male users and 22 female users. Though the AR application was used by a wide range of age groups, 90% of the users live in Kagawa Prefecture.

7. Evaluation

After the end of the operation, a web questionnaire survey was conducted to evaluate the system developed in the present study.

7.1 Evaluation Based on the Questionnaire Survey Results Concerning the Operation Directly via the Web Using PCs and Mobile Information Terminals

7.1.1 Overview of the Web Questionnaire Survey

Along with the aim of the present study, a web questionnaire survey was implemented to conduct an (1) evaluation concerning the usage of the system, and an (2) evaluation concerning the functions of the system.

7.1.2 Evaluation Concerning the Usage of the System

Regarding the main moving means in the sightseeing areas, though 51% answered "public transportation", 33% answered "private cars and motorbikes", and 7% answered "rental cars". From this, it is evident that more than half of the users tend to use public transportation while traveling. Additionally, as mentioned in Section 4.2, it can be expected that the number of tourists will increase in Kagawa Prefecture. Since such tourists do not have a good sense of locality, they have the possibility to use public transportation. Therefore, it is effective to design and develop a support system of sightseeing tour planning in rural areas adopting the information related to real timetables of public transportation.

7.1.3 Evaluation Concerning the Functions of the System

(1) Evaluation Concerning the Usefulness of the Original Functions

Fig. 10 shows the evaluation results concerning the usefulness of the original functions such as the recommendation function of moving routes and the display function of moving routes. As described below, most of the users were satisfied with the above original functions, even though approximately half of the users are not familiar with Kagawa Prefecture as noted in Section 6.2.

Firstly, the recommendation function of moving routes is evaluated. Regarding the shortening of the time for sightseeing tour planning and the improvement of users' satisfaction for sightseeing tours, 89% answered "useful" or "somewhat useful", and 11% answered "not so useful" or "not useful". Accordingly, it can be said that the parameters adopted in the GA of the system mentioned in Section 4.1 were appropriate. Regarding the recommendation results for sightseeing tour planning, 84% answered "useful" or "somewhat useful", and 16% answered "not so useful" or "not useful". Therefore, it is evident that the system could recommend the users the appropriate moving routes, based on the information related to the timetables of public transportation.

Secondly, the display function of moving routes is evaluated. Regarding the information provision of moving routes, 84% answered "useful" or "somewhat useful", and 16% answered "not so useful" or "not useful". Since the system displays the shortest moving routes on the digital maps of Web-GIS, and the detailed information, most of the users can clearly understand the navigation provided by the system. Regarding the support for users' sightseeing tours, 89% answered "useful" or "somewhat useful", and 11% answered "not so useful" or "not useful". Consequently, it is expected that the system can efficiently support the users' sightseeing tours using the function.

(2) Evaluation Concerning the Usefulness of the Entire System

Fig. 11 shows the evaluation results concerning the entire system. Regarding the ease of use of the system, 74% answered "I think so" or "I somewhat think so", indicating that the system developed in the present study was easy to use. However, 26% answered "I do not think so" or "I do not think so at all". If the users continuously use the system, it will not be difficult for them to use it.

Additionally, the effect of sightseeing support provided by the system was highly rated, as 45% answered "I think so" and 48% answered "I somewhat think so". Therefore, the present study could develop a system that effectively supports sightseeing tour planning. Regarding the wish to continue using the system in the future, 35% answered "I think so" and 46% "I somewhat think so", indicating that the system can be used in the long term. However, 19% answered "I do not think so" or "I do not think so at all", because approximately half of the users did not have opportunities to visit Kagawa Prefecture, as mentioned in Section 6.2.

7.2 Evaluation Based on the Questionnaire Survey Results of the Operation via the AR Application

7.2.1 Overview of the Web Questionnaire Survey

Along with the aim of the present study, a web questionnaire survey was also implemented to conduct an (1) evaluation concerning the usage of the AR application, and an (2) evaluation concerning the entire AR application.

7.2.2 Evaluation Concerning the Usage of the AR Application

Regarding the use of applications with AR, 27% regularly used it, while 73% did not. However, regarding the ease of the usage of the system, 80% answered "I think so" or "I somewhat think so", and 20% answered "I do not think so" or "I do not think so at all". Therefore, though most of the users were not familiar with the applications with AR, many of them could easily use it. If the users continuously use the AR application, it will not be difficult for them to use it.

7.2.3 Evaluation Concerning the AR Application

Fig. 12 shows the evaluation results concerning the entire AR application from the viewpoints of the navigation and the sightseeing tour support for tourists. As described below, it is expected that the AR application of the system can effectively navigate the users to their destinations and support their

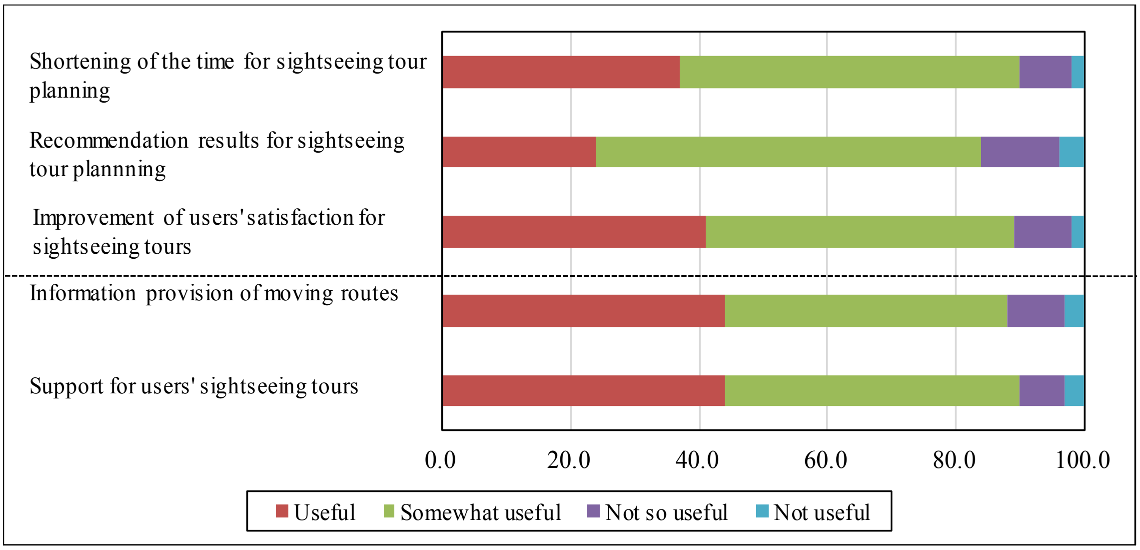


Fig. 10 Evaluation results concerning the usefulness of the original functions.

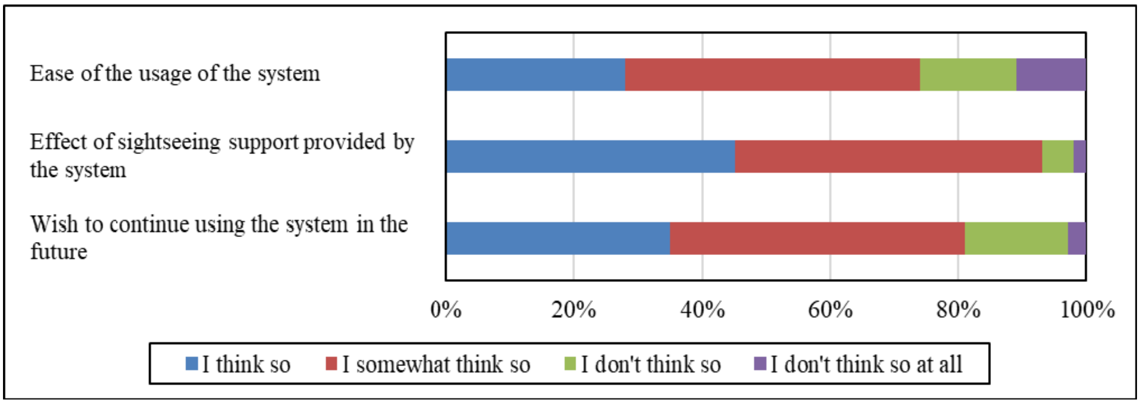


Fig. 11 Evaluation results concerning the entire systems.

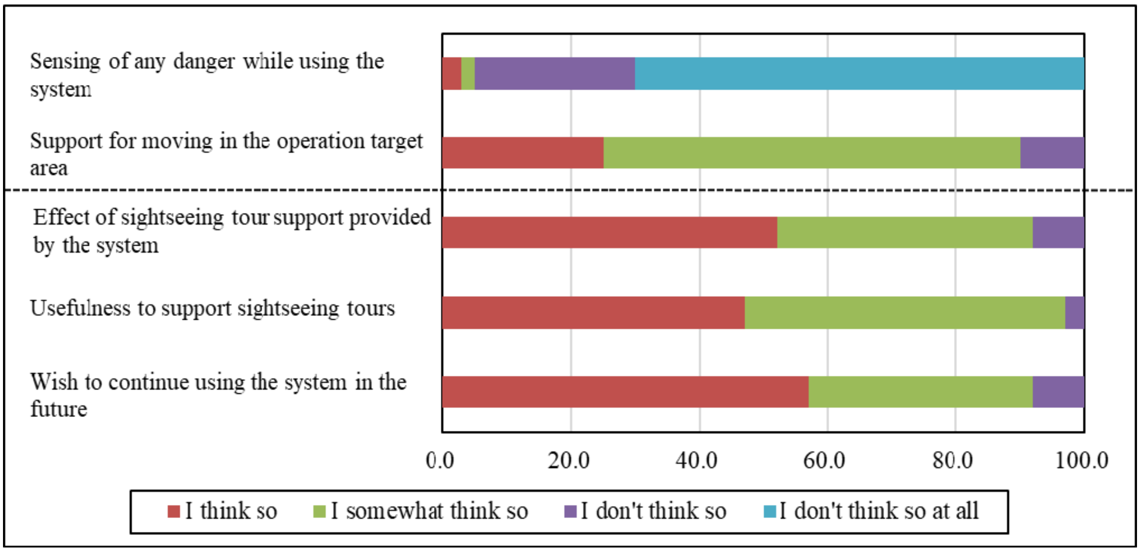


Fig. 12 Evaluation results concerning the entire AR application.

sightseeing tours. Additionally, by continuously using the system, the users will get used to utilizing it.

Firstly, from the viewpoint of the navigation for tourists, regarding the sensing of any danger while using the system, 5% answered "I think so" or "I somewhat think so", which indicates that almost all the users felt barely any type of danger while using the system. Regarding the support for moving in the operation target area, 90% answered "I think so" or "I somewhat think so". Therefore, the AR application of the system was useful as the tools of the navigation for tourists.

Secondly, from the viewpoint of the sightseeing tour support for tourists, regarding the effect of sightseeing tour support provided by the system and the wish to continue using the system in the future, 92% answered "I think so" or "I somewhat think so". Additionally, regarding the usefulness to support sightseeing tours, 98% answered "I think so" or "I somewhat think so". From these, it is evident that the original AR application of the system was highly evaluated from the viewpoint of the sightseeing tour support for tourists.

7.3 Extraction of Improvement Measures

The issues concerning the system were extracted based on the results of the web questionnaire survey, as well as the access analysis of users' log data, and are summarized below.

7.3.1 Recommendation Function of Moving Routes

The recommendation function of moving routes is designed to recommend the most efficient moving routes according to users' requests. However, as mentioned in Section 5.1, when users input unrealizable requests, the system can encourage them to input other ones. In this case, in order to raise the usability of the function, considering users' requests as close as possible, it is necessary to search and recommend the second best moving routes.

7.3.2 AR Application

Using the AR application of the system, the images of 9 popular sightseeing spots can be displayed on the mobile information terminals. Therefore, in order to raise users' satisfaction, it is necessary to input the images concerning other sightseeing spots into the AR application. Additionally, it is desirable that users can submit the images of other sightseeing spots into the system.

8. Conclusion

The present study designed and developed a system as well as a search method for optimal moving route, and created an original database (Sections 3-5), conducted a test of the system operation (Section 6), and evaluated and extracted improvement measures (Section 7). The present study can be summarized into the following 3 points:

(1) In order to support to make sightseeing tour plans in advance and gather local information on the assumption to use public transportation, the present study designed and developed a support system of sightseeing tour planning in Japanese rural areas. Additionally, the system adopted the information related to real timetables of public transportation on both the sea and the ground and GA. The system enabled users to reduce the burden of information acquisition, receive the efficient support, and reduce the temporal and spatial constraints. Kagawa Prefecture was selected as the operation target area for the system, and the operation and evaluation of the system were conducted.

(2) The operation directly via the web using PCs and mobile information terminals was conducted over a period of two months, targeting those inside and outside the operation target area, and a web questionnaire survey was conducted with a total number of 115 users. Based on the results of the web questionnaire survey, the usefulness of the original functions as well as of the entire system, were highly evaluated, indicating that efficient sightseeing support for users can be expected. From the results of the access analysis of users' log data, mobile information

terminals were used rather than PCs as access methods to the system.

(3) The operation directly via the AR application was conducted over the same period as the web using PCs and mobile information terminals, and concerning the 40 users who participated, many were from different age groups. Though most of the users were not familiar with the application that used AR, they highly evaluated the application using location-based AR. Additionally, it is expected that the AR application of the system can effectively navigate the users to their destinations and support their sightseeing tours, and they will get used to utilizing it by their continuous use.

As future study projects, the improvement of the system based on the results in Section 7.3, as well as the enhancement of the significance of using the system by gaining more data from other rural areas inside and outside Japan, can be raised.

Acknowledgement

In the operation of the support system of sightseeing tour planning using public transportation and the web questionnaire surveys of the present study, enormous cooperation was received from participants in various parts of Japan and the tourism division of the Kagawa prefectural government. We would like to take this opportunity to gratefully acknowledge them.

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