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A Study on the Location Search by Landmarks in Consideration of the Spatial Image

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Abstract: In this study, we propose the new location search method in consideration of spatial image. Especially, we focus on the landmark. The landmark is the most important element of the city spatial image. Conventional location search methods which are way of using search keywords or handwritten map require high level Map-Reading skill. On the other hand, our proposal method can search location map by an intuitive and simple operation. In this study, we propose two ways of the location search methods that are easy to use for users by an intuitive operation based on the knowledge of spatial cognition. One proposal method is the location search by the use of relative position of landmarks from user's spatial image. The other way of the location search is by the use of attentional landmarks in actual scenery with visual elements such as building shape and color. From the results of the experiments, we have confirmed that our proposal method is effective for a location search.

Keywords: Spatial Image, Map Reading, Web-GIS, Landmark, Location Search

1. INTRODUCTION

Nowadays, Web-GIS (GIS: Geographic Information Systems) [1], for example Google maps and Yahoo maps, are frequently used in various scenes and many devices such as PC, mobile phone, tablet, and smart phone. GIS is a computer system using digital map and has characteristics of free and smooth map operation differently from paper map. Moreover, GIS can easily switch display and non-display against specific layers. The layer indicates a kind of map elements, for example road layer, building layer, river layer, and so on. GIS is used in many businesses such as facility management, city planning, and marketing analysis. GIS can display a variety of information such as disaster, city planning, on a map, and can share the information through the Internet. GIS that has these characteristics is also available for area marketing, disaster prevention [2], facility management in various fields.

When a user wants to search a location map by the use of Web-GIS, the user usually inputs keywords set relevant to the location. The keywords, for example address and a facility name, are associated with images of the location. However, we sometimes cannot find appropriate keywords because of vague memory relevant to the place. For example, "about 10 years ago, there used to be a high school the name of which I cannot recall. But I can recall the visual scene and some landmarks in the place, such as a beautiful river and an old station".

In this study, we propose two ways of the location search methods that are easy to use for users by an intuitive operation based on the knowledge of spatial cognition. Spatial cognition is the knowledge about spatial environments to determine where they are, how to obtain resources, and how to find their way home [3]. One proposal method is the location search by the use of relative position of landmarks from user's spatial cognition. The other way of the location search method is by the use of attentional landmarks in actual scenery with the relative landmarks position and visual elements such as building shape and color.

The purpose of this paper is to present a new concept to search a location and to discuss the usability of our proposal methods.

2. SPATIAL COGNITION

2.1 Map Reading

Opportunities using Web-GIS are increased, however there are users who are not available map well. The reason is related with ability for reading and understanding of the map. The ability is called Map-Reading. Map-Reading skill needs to match actual scene to two-dimentional map. To put it differently, Map-Reading skill is an ability which correspond route-type map to survey-type map. The route-type map is ground-level perspective, and the survey-type map is aerial perspective [4]. Many Web-GIS is adopted survey-type map and requires Map-Reading skill. Therefore a user who has no sense of direction is difficult to effectively use Web-GIS.

Table 1 The Elements of City Spatial Image

Elements	Type	Definition	Example
Nodes	Point	focal point	intersection, junction
Landmarks	Point	readily identifiable objects	monument, building, station
Paths	Line	routes along which people move throughout the city	street, river, rail track
Edges	Line	boundaries and breaks in continuity	administrative area, coastline
Districts	Face	areas characterized by common characteristics	desert, large park

2.2 Spatial Image

Cognitive maps are mental representations of physical locations and are introduced by E. C. Tolman [5]. In relation to this, five structural features of the city spatial image were defined by Kevin Lynch [6], which is shown Table1. Kevin simplified the structure of a city by paying its attention to the physical side of the city. In the five elements, we focus on the landmark. The landmark is the most important element for identifying the present position in a map. In addition to that, the landmark is the element which is important as a clue when we memorize a movement course in a city. The landmark stated in this study means not only some landmarks shown to Table1, but also many point features such as school, shop, park, police station, and so on. That is to say, any point feature in our spatial image defines as a landmark.

2.3 Conventional Location Search Method and Issues

The most common method is a way to search a location map using the keywords such as an address and a facility name. If a search keyword is clear, this method is so effective. However, we may not find an appropriate keyword to search a location map. For example, if memory of the location is ambiguous, we cannot recall the keywords about the spatial image.

Other method is a way to use a handwritten map. "Spatial Query by Sketch [7]" is the representative method. This method uses a handwritten map for querying location search request to a spatial database. This method compares the topology of handwritten map and real map data to search the location map. Moreover this method has to compare each shape of the handwritten map and the real map by geometry judgment (intersect, contain, cross, overlap, and so on). In this way this method needs cartological map drawn by handwritten. High Map-Reading skill is necessary to draw a map exactly. It is necessary for the handwritten map to draw the reality world on the two-dimensional plane based on projection or geodesy, and it is difficult correctly to draw map elements. Table2 shows the comparison between cognitive map and cartological map.

Table 2 Comparison with Cognitive map and Cartological map

Cognitive map	Cartological map
Subjective	Objective
Non - Euclidean space (Distance sense differs by personal.)	Euclidean space （Space is based on mathematical distance）
Uneven scale and azimuth	Accurate scale and azimuth
Personal Image	Measurement
Perceived world	Real world

Nowadays, we can search a present location by using smart phone with GPS (Global Positioning System). However, the way of location search with GPS may be unavailable underground or in a building structure or a bad condition area. In these cases, when we explain someone where the present location using a telephone, we tell landmarks which are a characteristic building or attached sign etc. However, we may not explain the present location to the waiting partner well.

As we have seen above, these conventional methods have some issues to be solved such as the need for Map-Reading skill.

3. LOCATION SEARCH BY THE USE OF RELATIVE POSITION OF LANDMARKS

3.1 Purpose

We propose a simple location search method not to need high Map-Reading skill. The proposal method uses relative position of landmarks based on user's spatial image and can search a location by the simple operation that only plots the landmarks. The proposal method offers us high usability and performance by a user interface that is simple and easy to use. In this paper, the proposal method is called ILS (Incremental Location Search). Compared with existing methods, ILS allowed location search without clear spatial image. Table3

Table 3 Comparison with Related Researches

Location search method	Proposal method（ILS）	Spatial Query by Sketch	Text search
Input data	Landmarks(Point) that are plotted at relative position	Handwritten map	Keyword set relevant real world
Concept	ILS searches a plurality of candidate location by the use of relative landmark positions.	Spatial Query by Sketch searches a location by the use of feature's topologies.	This method searches a location corresponding to a keyword using a search engine.

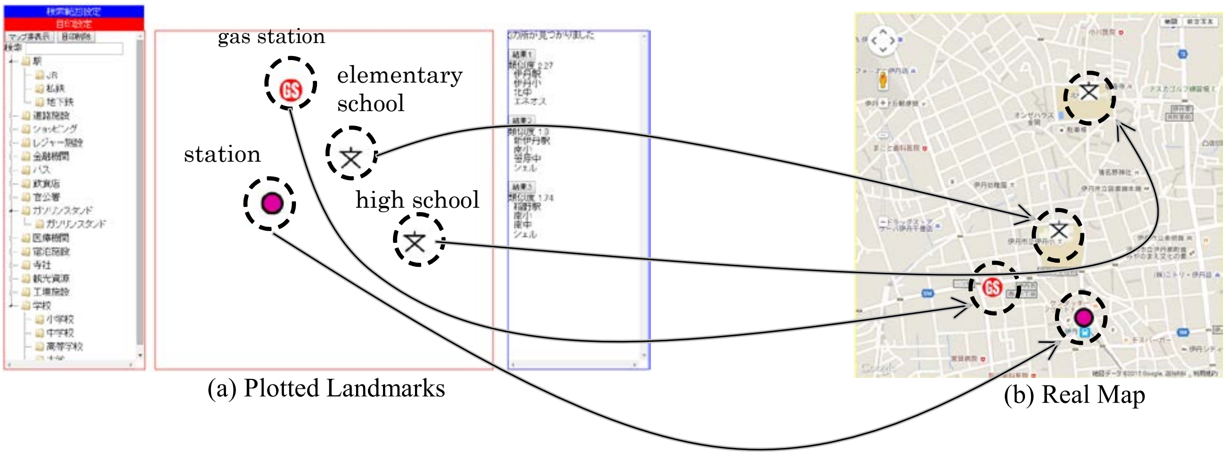

Fig.1 Landmarks Layout and Result

shows a comparison of our proposal method and the conventional map search methods.

3.2 System Image

ILS presents to users a plurality of candidate locations as search results by comparing landmarks that are plotted at relative position and real map.

Fig.1 shows the relations with the placement of the landmarks that a user plots by ILS (a) and the search results on the real map (b). A user plots landmarks in consideration of distance and direction of the landmarks based on user's spatial image. ILS executes a location search by comparing relative distance and direction of plotted landmarks with real map.

It is thought that it is rare that a user misunderstands the classification of the landmark. In addition, about the distance, it is considered that the relative distance between plural landmarks does not greatly differ. It is not important for ILS to set the correct direction and distance among landmarks. However a user needs to set the relative position relations of the landmarks. In other words, ILS is allowed the distortion as the spatial image. ILS does not have to draw map elements reality shape and position like a cartological map exactly. In addition, anyone can perform a location search easily because ILS does not need high Map-Reading skill.

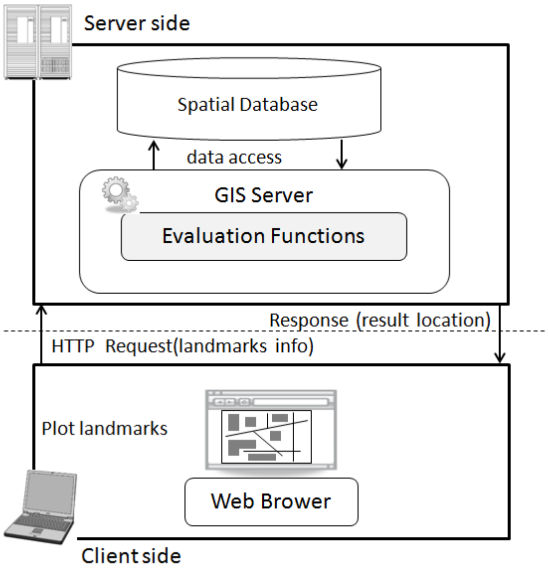

Fig.2 ILS System Architecture

3.3 System Architecture

A schematic drawing of ILS system architecture is shown in Fig.2. ILS is Web-GIS application, which uses Ajax (Asynchronous JavaScript and XML) technology. The Ajax offers merits that are fast-loading and asynchronous updates only necessary html parts. At the client side, a user plots a landmark by drag and drop operation, then the client transfers the information about the position and its layer as HTTP Request to the GIS Server. On the other hand, the server side is composed of the GIS server and the spatial database. The spatial database is a suitable database to manage map data, and is implemented spatial index in order to fast access to map data. The GIS server has an evaluation function. The evaluation function is the logic to search a location map based on a search request from the client side. In this study, ILS is implemented the logic which evaluates the similarity of the shape from the relative position relations of plotted landmarks and real map data. In order to evaluate the relative position relations of them, we use evaluation criteria called "Coefficient of spatial association" [8]. It is evaluated the similarity by comparing difference of two point distributions.

3.4 Location Search Method

A display design of ILS application is shown in Fig.3. The left side of the display is the layer tree which is classified according to the type of landmarks. An icon to make it easy to understand a kind of layer intuitively is assigned to each landmark. The center of the display is the canvas area, and a user can plot a selected landmark of the layer tree onto the canvas. The right side of the display is the search results display area. Search results are updated as soon as a user plots a landmark. In the user interface, a user can easily plot landmarks from the layer tree to the canvas by drag and drop operation.

A user can find the location map of spatial image from some search results. Search results are listed in order of a similarity

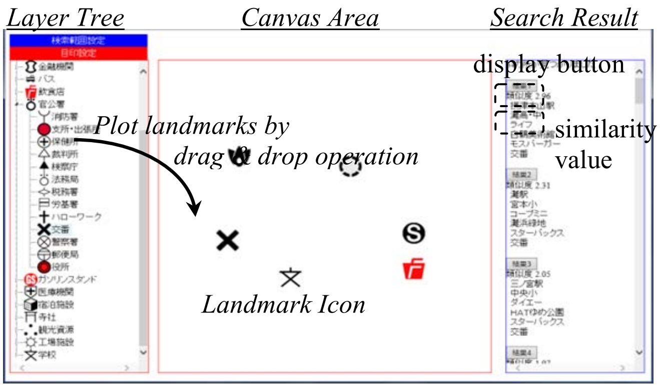

Fig.3 ILS Application Screen

value "Coefficient of spatial association (Cs) ". Cs compares the distribution shape between plotted landmark distribution and real map data. Cs measures the distance of closest approach from a landmark constituting distribution to other landmarks. Cs value is an index to evaluate the similar degree. Cs is found from a following formula. The closest distance from the i-th point in the distribution A and B to the other each point defines dAi, dBi. The closest distance from the i-th point in the distribution A to the point of the distribution B is defined as dABi. The same applies to dBAi too. The "n" is the total number of points of the distribution A, The "m" is the total number of points of the distribution B.

$$C_S = \frac{\{(\sum_{i=1}^{n} dA_i + \sum_{i=1}^{m} dB_i) - (\sum_{i=1}^{n} dAB_i + \sum_{i=1}^{m} dBA_i)\}}{\{(\sum_{i=1}^{n} dA_i + \sum_{i=1}^{m} dB_i) + (\sum_{i=1}^{n} dAB_i + \sum_{i=1}^{m} dBA_i)\}}$$

The search result area is consisted of three parts which are map display button, similarity value, and landmark name. When a user presses a map display button, ILS displays the real map which is overlapped plotted landmarks at the actual location. As a result, the user can confirm the location by comparing the real map and spatial image.

3.5 Experimental and Discussion

We conducted an experiment to confirm whether we can search the location based on a spatial image. This experiment used commercially map data, which has 43 kinds of landmarks. Eighteen selected researcher participated as examinees in the experiment. The examinees imaged the place that they wanted to search and then plotted the landmarks of the place using ILS. If there is the place that examinees imaged within the high rank third of search results, we consider the experiment to have been able to search the place.

As a result, our proposal method was able to search an expected location by plotting an average of 5.4 landmarks. In addition, proposal location search method is found to discover an unexpected landmark such as" I don' t know there is a junior high school here". When a user wants to recall an ambiguous sightseeing spot which has gone in old days, this method may be available.

Another point to consider is the subsidiary effect of ILS about a landmark of retrieval result. In an evaluation experiment, an examinee plotted a landmark that imagined on ILS, but the landmark of retrieval result was different from the landmark the examinee expected. For example, an examinee plotted a landmark in the image of a convenience store A, but a convenience B has been shown by the search results. However, the examinee said that this was new discovery "there was a different convenience store in such a place".

On the other hand, a different examinee said that if ILS can use data not to be included in general marketing map data, such as "busy street" and "forest where fireflies inhabit" and "gradual slope" and so on, it will become more convenient.

From the view point of a user interface, there is an opinion from some examinee that it is necessary to add user interface, which is scale bar to understand a feeling of distance between landmarks. The grid map that is easy to understand a feeling distance is shown as an example in Fig.6. Moreover we consider adding a user interface to set a moving time by foot or car in order to more easily understand a feeling of distance between landmarks. It is thought that the usability of ILS improves more by adding such improvements to the user interface.

4. LOCATION SEARCH BY ACTUAL SCENERY

ILS can easily search the location by plotting landmarks onto the canvas with simple operation. However there still remains the issue that we have to use survey map in order to search locations. This chapter explains how to search locations by visible things in the view that is actually seen without the use of survey map. The proposal method with an intuitive operation in a form close to the feeling of a human is called LSAS (Location Search by Actual Scenery).

4.1 Attentional Landmarks in Actual Scenery

For example, how do we explain the current place when we meet our friends in the city? Many people may tell a friend some characteristic place such as a department store and a big intersection, etc. as the landmarks. As mentioned above, a landmark is a most important element of a city spatial image. Landmarks stand out in scenery if they have certain visual characteristics such as a sharp contrast with their surroundings or backgrounds [9]. Moreover Raubal[10] defines three types of landmark attractions, which are the (1)visual, (2)semantic, and (3)structural attraction of features in human spatial reasoning and communication.

(1)The visual attraction consists of four elements which are façade area, shape, color, and visibility. The façade area is an important property by contrast with surrounding objects. The

Table 4 Visual Elements

Elements	Meanings
Type	Building, Road facility, Natural object, etc
Use	House, Commerce, Office, Parking, etc
Shape	Size (Height, Width)
Color	Typical color (white, red , blue, black, etc)
Text	Letters on the signboard
Condition	Old or New
Others	Style(Western, Japanese), Texture, etc

shape represents the proportion of height and width. The color is also an important element to distinguish among surrounding objects. The visibility is the prominence of spatial.

(2) The semantic attraction focuses on the meanings of a landmark such as cultural and historical importance or explicit marks. The two are elements to determine whether a landmark is outstanding by the comparison with the surroundings and the background.

(3)The structural attraction means nodes and boundaries. Nodes are key traffics such as intersection and station. Boundaries represent the separator such as the administrative district and similar perceivable boundary like an office district.

Based on the above, in this study, we focus particularly on the visual elements of the exterior of landmarks in order to search the location by the search key in the actual scenery. Table 4 shows the visual elements.

4.2 Location Search Interface

In this study, we focus on attentional landmarks in actual scenery and set as search condition the relative landmarks position and visual elements.

Relative landmarks position has two conditions that are perceptional position (front-back, left-right, and far) and feeling distance (far, medium, and close). We propose two kinds of location search in LSAS. One is the way of using icon, and the other is the way of using voice input.

First we describe the location search by using icon. The icon represents the landmark. Fig.4 shows the example of input display. A user selects an attentional landmark from the index

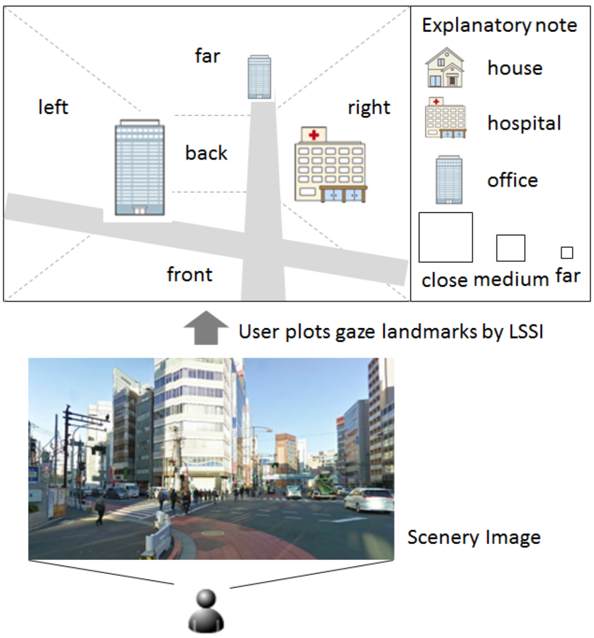

Fig.4 Icon Input Display

and then plots it to the perceptional position. LSAS uses the auxiliary line divided by the perceptional position in order to easily recognize attentional landmark position. About the feeling distance, we express it icon size. If the icon size is large, it means that the distance between the user and the landmark is close. To the contrary, if the icon size is small, it means that the distance between the user and the landmark is far. For example, the icon size is set in three stages, we express the feeling distance from user's viewpoint using icon size, such as a large size means within 100 meters, a medium size from 100 to 150 meters, small-sized 150-200 meters. About the visual elements, a user can add the information about the landmark concerned by choosing the icon which user selected. Because the landmarks plotted by the above-mentioned method are viewed from the human eyes, it is necessary to convert the two-dimensional plane in order to location search by using LSAS. In this way, LSAS searches the candidate of the places in accord with search condition using information converted into a two-dimensional map. The search logic of relative position of landmarks is the same as ILS. In addition, LSAS uses visual element to search the location map.

Next, we explain the location search by using voice input. As a result of advances in communication technology, we can use a speech recognizing devices that are installed in smart-phone or smart watch in order to search information such as "Tokyo famous restaurant". When we use voice input as a search condition, it is difficult to accurately extract search keywords from the speech contents. Therefore, it is necessary to make an input method a speech rule. In this study, we set a search condition by speaking the combination of the search key and the value. Table 5 shows the speech rule. User needs to speak "equal" to distinguish a key and a value. In this way, LSAS can distinguish the combination of the key and its value. In addition, when there are some combinations of plural keys and values, user needs to speak "next" and shift to the next combination. Furthermore, when user inputs the next landmark information, user needs to speak "break". When input is completed, user speaks "finish". For example, in such case "there is the house in the left close distance and there is the brown hospital to the right medium distance", user needs to speak as follow.

Table 5 Speech Rule

Key	Value
Position	Left, Right, Front, Back, Far
Distance	Close, Medium, Far
Type	House, hospital, office, etc.
Use	Residence, work, business, etc.
Shape	Large(5F～), Medium(2F～4F), Small(1F)
Color	White, brown, blue, black, etc.
Text	“ABC building”
Condition	New, Old

[SPEECH SAMPLE]

Position *equal* Left *next*
Distance *equal* Close *next*
Type *equal* House
break
Position *equal* Right *next*
Distance *equal* Medium *next*
Type *equal* Hospital *next*
Color *equal* Brown
Finish

By the above-mentioned the speech rule, LSAS becomes able to set the search condition as well as using the icon. Speech contents are converted into character strings. Then the strings are interpreted to relative landmarks position and visual elements, and the information is used as search condition.

4.3 System Architecture

In this section, we explain the LSAS system architecture in Fig.6. LSAS is Web-GIS application as well as ILS. There is the main difference with ILS whether visual elements are included LSAS in search condition. The location search logic of LSAS uses ILS logic that evaluates the similarity of the shape from the relative position relations of plotted landmarks and real map data. Thus, the server side of LSAS can build the evaluation function by expanding the search function using visual elements. The spatial database in the server side is created for commercial map data. However visual elements such as color and size are not included in a general map data. Therefore we create the map data which is added these visual elements by Google street view and field work. On the other hand, client side is implemented by smart phone or smart watch. In case of icon, user plots attentional landmarks in actual scenery using the input display (Fig.4) and adds some visual elements such as type and color, etc. And then, the client transfers the landmark information about the position and its visual elements as HTTP Request to the GIS Server. LSAS presents a plurality of candidate locations as some search result by comparing landmarks with map data that are plotted at relative position and real map as well as ILS. In the case of a location search by the voice input, the user sets search condition using the terminal device equipped with voice input system such as smart phone and smart watch. The user confirms the search results with the display devices such as smartphones and looks for the location from the plural candidates.

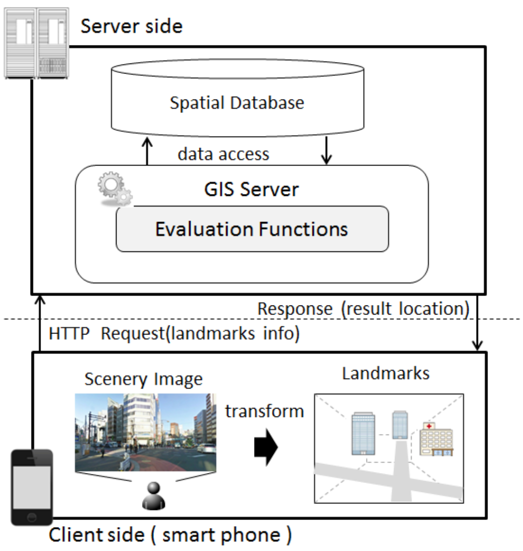

Fig.6 LSAS System Architecture

5. CONCLUSION AND SUMMARY

In this study, we proposed the new location search methods in consideration of the spatial image. Especially, we focused on the landmarks and proposed two location search methods. ILS is one of the location search method by the use of relative position of landmarks from user's spatial image. From the results of the experiments, we confirmed that ILS has been able to search the locations where a user imaged by plotting average 5.4 landmarks. LSAS is another method by the use of attentional landmarks in the actual scenery with the relative landmarks position and visual elements. About LSAS, we plan to carry out an experiment to evaluate the effectiveness in the future.

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