A Computational Location Model Based on Relative Information

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Abstract. In this paper, we proposed the concept "relative location" as a complementary presentation to the traditional "absolute location", which were considered the traditional expression of locations and have pervaded the current locations based services (LBS). Two methods were introduced to make relative location computable and more useful. Prototypes with Data visualization interface were designed and evaluated to test usability of the proposed methods. User experiments shown that integrating relative location information into computing system may help to improve usability of location based applications.

1 Concept and Model

Recent researches on spatial applications suggest that today's absolute location based applications should be more human-centered and integrating more context information [1, 2, 3]. We argued that, relative location information, as widely used in human daily life, could meet this requirement by providing better social context. The existing concept of relative location in geography refers to locations in wide relations to other locations; while absolute location, on the other hand, uses coordinates. In contrary to absolute location's popularity, the usage of relative location in computing system is very limited.

Take one familiar daily usage of Google map as an example, the navigation from place A to B, which in its nature, reflects a relation between A and B based on "transportation methods". Furthermore, people also use the nearby function to find close restaurants or hotels around a specific location from time to time. Thus, both "spatial adjacency" and "functionality" are used as the clues to organize the outcome. All of these different kinds of relations mentioned above, belongs to but not cover the full range of "relative location". Still the social aspects of the concept, such as affiliation, community, and all the other relations defined by human activities, remained to be further utilized.

However, it's difficult to define and implement the concept. The challenges mainly lies in two aspects: On one hand, most relative location are described by human concepts, which are uncomputable; On the other hand, given that even the same location, different users may use different relative locations.

C. Stephanidis (Ed.): HCII 2015 Posters, Part II, CCIS 529, pp. 525–530, 2015.
DOI: 10.1007/978-3-319-21383-5_88

In order to introduce relative locations in a computable way, in this paper, we defined relative locations as follows:

- First, relative locations present a location with relations to other locations.
- Second, the relation from location B to A is defined as, how possible the user will use information of location B while he/she is handling spatial task regarding A. This relation could be denoted as RB → A.
- Third, the relations between location B and A are bidirectional, and not necessarily equals to one another, that is: RB → A ≠ RA → B.

To briefly illustrate the definition, if among every 100 times descriptions, there are 65 times that A is described as "A berthed opposite B" and the other 35 times A is described as "A is close to C", then RB → A = 0.65 and RC → A = 0.35.

As shown in the example, RB → A can be derived from either the statistical features of crowd behaviors or a specific user's data. While in the former occasion, the crowd statistics may be weighted and averaged, hence known as the AH(averaged human) model based. Similarly, we call the latter one SH(specific human) model based.

The main purpose of this paper is to study:

- First, whether the usability of current LBS interfaces can be further improved by leveraging complementary relative location information.
- Second, since differences may exist between methods using AH methods and methods using SH model, what are the advantages or disadvantages in various circumstance.

Our idea has been partially proved by the study of cognitive fit theory in the field of spatial cognition [4, 5]. It has been widely supported by facts and experiments that in problem-solving or decision-making process, performance on a task will be enhanced when there is a cognitive fit, or match between task information presentation and user's mental presentation. As the relative location presentation is much more common in our daily life than absolute locations, according to cognitive fit theory and our common sense, it's an intuitive premise that providing complementary relative location information shall increase the usability of current location based services and applications.

2 Design and Experiment

To further evaluate our idea, we have selected three most common spatial tasks among today's LBS to verify the concept usability of relative locations, respectively:

First, locate a certain place. In some occasions, people are pretty sure about their destination, in which situation web map is used as a navigation tool. While in the other, the word "destination" is a rather vague term, because it might refer to a certain type of locations rather than a fixed place. Or people may just simply find themselves lacking of detailed information to find a certain place using map applications. In the Google map, an accurate keyword, such as name or address, is often required to locate a place; while in the Google field trip, a web recommendation app that people use to find some hangouts, allow users to discover interesting places with or without simple place description. In this paper, our first task focused more on the latter aspect, since it was more common in daily life which has not been well supported by current computing system yet. Moreover, the relative location shows more advantages in handling this kind of spatial tasks as for its more human related nature. To further classify, the task specifically refers to:

Suppose you are an international exchange student in keio university hiyoshi campus. After you arrive on campus, you need to locate the most popular lamen restaurant and the biggest pharmacy as soon as possible.

Fig. 1. User interface used in task 1

To support this task, social activity data of keio students are collected, computed into relative location data, and visualized on an interactive map interface, with absolute location data from google map. White dots are used to display absolute location, while heat map with different colors are used to show relative location data indicating various activities across space. For example, blue means having a meal, red means studying, yellow means shopping, purple means transportation, etc. To better simulate the situation, 10 foreign students were selected as participates and divided into two groups. The control group use mere absolute location data (only white dot), and the experimental group use map interface shown in Fig. 1. Participates were allowed to use other websites to obtain more detailed information about certain locations. Time consumption and user satisfaction measured by 7 point likert scale were collected to compare performance between two groups.

Results shown, the experimental group achieved 17 % less time consumption and 0.6 more satisfaction score. In the discussion after experiment, participates' feedback show that the visualization of relative location data could help them to focus on a relative smaller region and jump quickly between different regions, thus make them more comfortable and effective.

Second, plan a route. In logistics, route planning refers to a classic optimization task that: given a certain group of points with more or less constraints, to find the shortest path or least duration to visit every point. However, the route planning in our life does not always stick strictly to this definition. Take travelling as an example, travelers may decide to go to the most attractive places first, and skip other less attractive places in consideration of time and cost. In this situation, computing system is hard to organize an optimistic route since the objective and constraints are both uncertain. Relative location, which derived from historical visiting data of travelers, could play a big role to solve this kind of problem. In this task, we discussed how relative location theory could better meet daily needs on route scheduling under varying uncertain conditions. To further classify, the task specifically refers to: Given 30 most famous attractions in Tokyo, select attractions in list and plan a one day journey.

To support this task, itineraries posted by travelers on a trip advice website were collected, relative location data were computed by travel records between every two location, data visualization were provided on a map interface. Users could click one location to open its information window and show relation data with other locations, or take an overview of all locations by closing the information window. The value of relation data from low to high were mapped into different colors from blue to red.

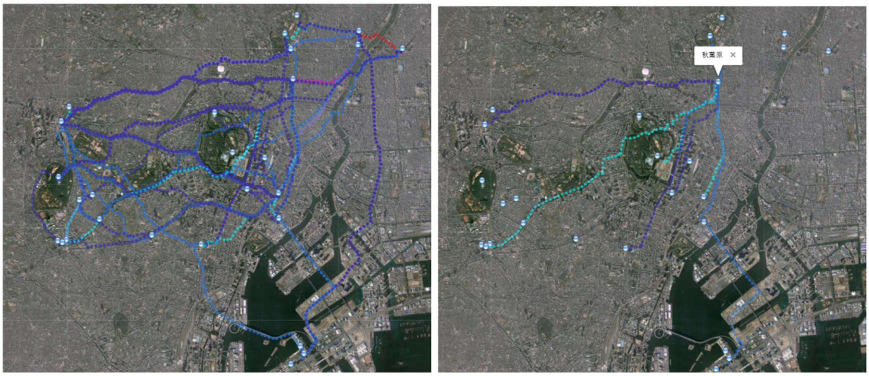

Fig. 2. User interface used in task 2

Participates were divided into 3 groups. Like the previous task, the control group use interface with mere absolute location, and the experimental group use the interface shown in Fig. 2. After the control group and experimental group finished their task, the third group will give each route plan a score. Score and time consumption were recorded to compare performance of two groups. Results shown, the experimental group achieved 62 % less time consumption and 9 % better score. Participates feedback confirmed that: (1) showing location relations derived from other traveler's experiences will help users to simplify their task and reduce cognitive burden; (2) the relative location contains more social information that reflects human activity across space, which could not be provided by absolute location.

Third, manage data in relation to locations. Nowadays, lots of extra information is attached to map interface, including: points of interests, news, photos, even sensors. Researches have shown that organizing data in spatial format is more consistent with human cognition than in tabular format, and thus result in a better performance in spatial tasks [6]. However, most map interfaces used by current apps only nail objects down on the map according to their absolute locations, e.g. coordinates. In this paper, we argued that by leveraging relative locations, the usability of location based applications could be further increased because it gives deeper social context than absolute location. For example, imagine you have taken some photos on the way to a tourist attraction and posted in Instagram. Now Instagram will display exactly where the photos were taken on the photo map, which may be some unknown roads. However, if the relation between these unknown roads with the tourist attraction on your trip is clearly visualized, the photo gallery will better describe your situation. Furthermore, using relative location could also help to group locations in a more meaningful way. To further classify, the task specifically refers to: After browsing 100 photos on the map, given 5 photos in sequence, find the corresponding photos on the map.

Fig. 3. User interface used in task 3

To support this task, two interfaces were provided, as shown in Fig. 3. The left one is similar to Instagram map interface, showing photos according to its absolute location. The right one attaches photos to nearby landmarks. Landmarks and relations between them are extracted and visualized by using the same technique in task 2. However, in this task, two models were used to generate relative location data, include: AH model, which means data are computed from travel routes of a crowd of people; and SH model, which mean data are computed from historical route of the participates themselves. To avoid bias, pictures from virtual reality environment are used instead of real photos.

Participates were divided into 3 groups, the first group is control group which use interface absolute location based interface (left one in Fig. 3), the second group is experimental group which use relative location based interface with AH model, the third group is another experimental group which use relative location based interface with SH model. Time consumptions were recorded to compare performance of three groups. Results shown, the third group achieved the best score, which is 5 % less than the second group and 18 % less than the first group. Screen capture show that participates in the control group have much more clicks and many of them are far away from the desired objects. One reason may be spatial cues that provided by relative location could help to limit down the search scope. Also, the fact that the third group achieved the best performance indicates that the SH model may give the best cognitive fit if users already have some experiences about objective space.

3 Conclusion and Discussion

All three tasks have shown, providing complementary relative location information with well-designed visualization method will give users more spatial cues about relations between locations. These relations are generated by human activities, and may be used to quickly recognize and manage spatial environments and objects, which result in: (1) In most circumstances, providing complementary relative location information helps to enhance user performance; (2) In certain circumstances, user performances under SH model have increased more than under AH model; (3) Information entropy, here referring to how much a user has already known about a task and related locations etc., was a critical factor that affecting users' performance under AH and SH models.

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