An Intelligent City Guide with a "Metal Detector" Interface

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ABSTRACT
In this paper, we propose an intelligent location-aware city guide system which uses a "metal detector" interface for navigating users. Our system allows users to detect shops that match their preferences, in the same way an actual metal detector would be used to find metal objects. The procedure for finding shops that match users' preferences includes a novel algorithm for learning frequented shops. Evaluation test results validate our overall approach.

ACM Classification H5.m [Information interfaces and presentation]: Miscellaneous.

General Terms Design, Algorithms

Keywords: location-aware, recommendation

Introduction
Location-aware systems, which provide tailored services according to the user's current location, have long been a popular research topic. The most common type of location-aware systems is city guides[1], and with the growing popularity of handheld GPS receivers and GPS-embedded mobile phones, they are finally beginning to see widespread use. However, services offered by conventional location-aware city guides have mostly been limited to listing shops and restaurants in the user's nearby area, and the only way they could account for each user's individual preferences was through manual parameter adjustments.

In this paper, we propose an intelligent city guide system for GPS-equipped mobile devices, which finds and recommends shops that match each user's preferences, and navigates users through those shops with a "metal detector" interface. The basic idea is to apply the sophisticated recommendation algorithms, found in online shopping sites such as Amazon.com, to real-world shop recommendation. The procedure for finding shops that match each user's preferences includes a novel place learning algorithm, which can effectively detect each user's frequented shops by their proper names (e.g. "Ueno Royal Museum", etc.). Also, our "metal detector" interface allows users to use our system without having to pay consistent attention to the device. Evaluation results validate our overall approach.

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Finding Matching Shops
Finding shops that match each user's preferences is done by first detecting users' frequented shops by analyzing their GPS location history, and then using the shops as input to the item-based collaborative filtering algorithm.

Detecting users' frequented shops could not be done in a straightforward way, due to errors induced by GPS. This is where our new place learning algorithm comes into use. Our algorithm is able to find users' frequented shops by their proper names, while conventional algorithms[2][3] output latitude and longitude values.

The actual procedure is as follows. First, each user's GPS location history is converted into a record of *visits*, by defining visits as occasions where GPS signals had been continuously lost for a period of time longer than a threshold. Then, for each shop in the database (the system requires a database containing the names and locations of the shops in the area) the system searches for past visits within a predefined distance from the location of the shop. We call these *sample visits*. And by applying a two-tailed *t*-test to the sample visits, the system tries to judge if the mean location of the sample visits can be regarded as *statistically identical* to the actual shop location. If the two locations could be regarded as statistically identical, the system judges that the shop was frequented by the user. Figure 1 illustrates this procedure.

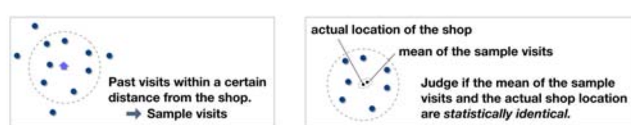

Figure 1: Our place learning algorithm

Shops that have been judged as frequented are included in the user's list of frequented shops, with rating values calculated from the number of sample visits around the shop, and the average duration of those visits. This list is used as input to the item-based collaborative filtering algorithm[4], of which the general idea can be described as "if a large portion of people who like shop A also likes shop B, then a person who likes shop A should have a high chance of also liking shop B”. This way, shops which can be assumed to match a user’s preferences can be picked out, by using all users’ lists of frequented shops.

The "Metal Detector" Interface

Shops picked out through the previous step are shown using icons on the screen (Figure 2). While this alone fully serves the objective of recommending shops to users, since we are developing not a recommendation system for online shopping but a city guide for use in the real world, we cannot expect users to be always looking closely at a small screen. Therefore, it would help if we adopt an interface that enables users to use our system without requiring as much attention.

Figure 2: System screenshot

To this end, we incorporate a “metal detector” interface. While an actual metal detector detects metal objects, our system detects shops that match each user’s preferences. Repetitive beeping sounds are emitted when the user is within a certain distance from a recommended shop, and the intervals between the beeps become shorter as the user moves closer (Figure 3, left). Since beeping sounds do not require the user to be looking at the screen to be noticed, the user can freely enjoy themselves in the city, only becoming notified when there is a shop nearby which may match his/her preferences.

Also, we provide a “pointing” mode in which users can “point” their mobile devices to find out the directions in which many recommended shops are located (Figure 3, right). This function is realized by using an electronic compass, which is often embedded in recent GPS receivers. Note that direction information acquired from an electronic compass is different from that acquired from normal (i.e. without electronic compasses) GPS receivers. The latter is the direction of user movement calculated from changes in user locations, and therefore is not necessarily the same as the direction in which the user is pointing the device. Since our interface needs to know which direction the device is pointing to, and not the direction of user movement, an electronic compass-embedded receiver is required.

Evaluation

We first conducted an evaluation of our place learning algorithm at Daikanyama, Tokyo. The test was carried out by asking ten users to freely enjoy shopping inside the area, while carrying a PDA (Toshiba Genio 550G) running our system, equipped with a GPS receiver (IO-DATA CFGPS2). The length of time used for the test was one or two days, depending on the user. We compared the shops actually frequented by users with those detected by our system, and calculated the precision and recall of the algorithm. As a result, we acquired a precision of 53% and a recall of 31%. The low recall may be due to the the fact that we conducted our test

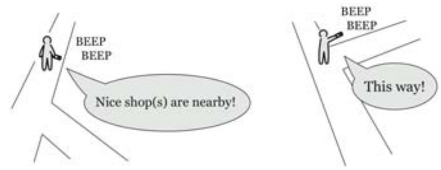

Figure 3: The "metal detector" interface

in a building-crowded shopping district inside Tokyo, which has low GPS coverage. The precision is mediocre, but as a later test with one user using two weeks of test time yielded a precision of 73%, we believe that the precision increases with the length of time used for learning.

We also evaluated the subjective satisfaction of our shop recommendation results compared with conventional location-aware city guides using two users, but we have not been able to acquire statistically significant results.

A wizard-of-oz study of the “metal detector” interface was conducted at the city of Kashiwa. We implemented the system on a Sony Vaio VGN-U71P, with a Garmin Geko 301 GPS receiver. Recommended locations were arbitrarily chosen. We had two users use both our “metal detector” interface and GUI-only navigation, and observed how the different interfaces affected their behaviors, and administered questionnaires afterwards. As a result, we found that when using the “metal detector” interface, users visited recommended locations more often in the same time span (16 visits, compared to 12 for GUI only), and scrolled the map to search for recommended locations less often (less GUI manipulation). Questionnaires revealed that users felt that they had to pay less attention to the device when using our “metal detector” interface, although they also said that the beeping sounds were somewhat irritating at times. We are investigating the use of vibration as a substitute for beeping sounds.

Conclusion and Future Work

In this paper, we have proposed an intelligent city guide system, which enables users to find shops that match their preferences using a “metal detector” interface. Evaluation results have validated our overall approach. We plan to conduct a more thorough evaluation in the future.

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