Assessing Spatiotemporal Context of User's Daily Behavior to Facilitate Subtle Deviation

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Abstract

This paper proposes a guideline for selecting information that is suitable as a trigger to facilitate subtle deviation. In general, individuals tend to recognize and remember a place by noticing unique and subtle elements in it. To enhance place-element recognition, it is preferable to notice unknown objects and/or observe remarkable scenery by walking around the place and visiting various sites within it. This activity, however, is often difficult because a subject's behavior in most places is routine and resistant to the unordinary (i.e., a person may follow the same route every day when attending school or visiting a shop). To encourage subtle deviation to find new elements, the proposed system employs a method wherein information is selected and provided to a user based on the spatiotemporal context of the user's daily behavior. This objective is achieved by analyzing the path that the subject repeatedly follows.

Keywords: spaciotemporal context, mobile application, Shikakeology, context awareness, behavior change

1 Introduction

The purpose of this study is to design a trigger that enhances a subject's recognition of a place with which the subject is already familiar. Places that are visited daily by the subject hold a unique fascination to him/her. For example, the physical symbols of a place, such as the Statue of the Liberty, or an abstract one, such as a deserted road, can evoke a powerful interest in some individuals. We determine that individuals have an affinity toward a certain place by invoking specific fascinating aspects of the place to promote its value.

There are many approaches to engendering a fascination with a place, such as by participating in a walking event or rally, or through hands-on learning. The shared aspect of these practices is to recognize objects and/or phenomena that shape the place in the subject's mind by walking around the target area, such as the scene, building, etc.

On the other hand, in general, an individual's daily movement tends to be routine. An individual usually has a reason for her/his daily paths and directly proceeds to the goal location (e.g., school, store, etc.). Thus, the routine tends to be fixed to specific roads and particular venues. Therefore, it is difficult for a subject to independently obtain new fascinations related to a place.

To address the above issue, Matsumura advocates the concept of "Shikakeology," which is an approach to changing a subject's behavior by using a tiny object with which the subject has become familiar [3]. This approach is employed to engage the subject's unconscious attraction to a place. Based on the above concepts, we implemented a smartphone application that guides the user to tourist attractions (see Figure 1) [8]. This application is intended to help users independently recognize fascinating aspects of a place. This application provides the user with information that can be employed as clues, not direct information, about the destination. This approach encourages movements that lead to "spontaneous notification," which is subtle deviation, such as gazing around, wondering about the destination, and wandering along the way.

However, according to results of user observations when employing this application, the user is frustrated with it because it continuously shows the site with which the user is not familiar. The system randomly shows the site and does not consider the user's experience and knowledge. Thus, the application experience does not address the relationship between the user's real experience and information that is shown by the application. This condition promotes in the user a feeling of being lost and randomly walking around the location.

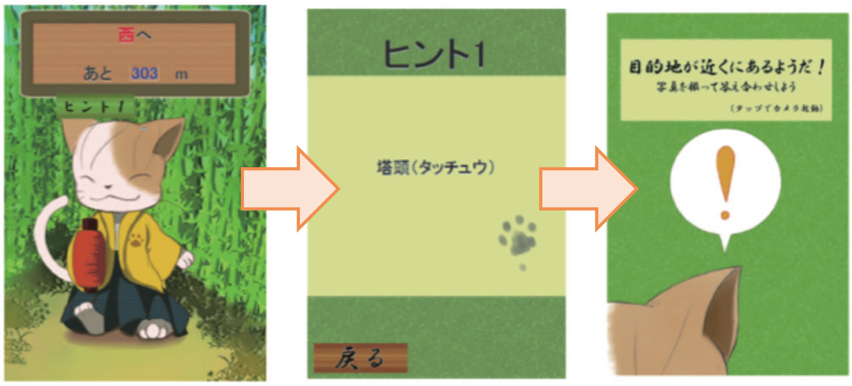

Figure 1. Phased information presentation of implemented application in preceding study [8].

Based on the above issues, in this study, we apprehend the user's activity and experience from the perspective of the spatiotemporal context. We provide information of the area based on this context and consider an approach to encouraging subtle deviation that is suitable for the user.

The contributions of this paper are the following three points: (1) defining the *context* by taking geospatial and temporal aspects of a user's repeated activities into account, (2) providing the definition of *subtle deviation* based on the geospatial and temporal context, and (3) executing a simulation to determine destinations where the user is led as the result of the subtle deviation.

2 User's Context

We explain an approach to address the problem of the user experience with the application described above. In this study, we strive to solve the problem by providing valuable information to the user on the basis of logs collected on the user's actions in the target area.

In this paper, we refer to the user's previous, logged activities as the "context." Many definitions of that term exist in this field. For example, Sumi *et al.* defined context as the "user's own condition and interests" [5]. We herein define context as the "stream of spatiotemporal information," such as the time in which the user is in a location, or the activity in which the user participates at the location.

With context information, we can guide the user to navigate a location based on the user's previous experience. We describe the sights as a series of information flows. By applying this information, we intend to expand the notifications that the user receives. Furthermore, we strive to increase the allure of the information provided by the application. Accordingly, we determine whether a location is sufficiently familiar to the user. That location then serves as a milestone of information provisioning to the user.

However, it is not appropriate to regard the location as familiar to the user only because the user visited it several times. It is not often that a user will travel along all routes toward the destination; the user often repeats the route to and from the same place. This gives the impression that the area is changing depending on the user's experience, even if the user becomes familiar with the location. We thus call the flow of information that the user gains in a geospatial situation the "geospatial context."

Furthermore, even in a well-known place, this information is variable depending on the time zone. For example, individuals who visit a transportation station only for commuting have the impression that the location is always crowded; other individuals who visit the station during off-peak times have the impression that the same location is relatively quiet. Moreover, some places differ according to the season, such as being white in snow or imbued with autumnal tints. We call these flows of information that change depending on time zone or season the "temporal context." In the next section, we discuss a method based on each described context.

3 Information Presentation Based on the Geospatial Context

We implemented a method for obtaining locations of paths on which a user travels and sorted the information based on the logs to solve the above-described problem.

Figure 2 shows the relationships between the paths that a user frequently pursues and the sites in the surrounding area. Most sites along the path of the user are estimated as sites that are well-known to the user. Even if we provide the information about the sites (e.g., facility summaries), it is difficult to discover the fascinating aspects of the site. However, providing information about extremely distant spots from the user cannot be expected. This is because the information is less related to the user's knowledge. Therefore, the user cannot connect with her/his own geospatial context, which makes it difficult to implement the approach of notifications on the user's fascinations with certain sites.

Considering these points, it is desirable to identify a given place—specifically a site near the path that the user frequently follows—and estimate whether the user is familiar with it. In Figure 2, the site, P, seems unknown to the user; however, it is more proximate to the user compared with other sites. Therefore, guiding the user toward P is expected to enable the user to "try subtle deviation."

Finally, we strive to lead the user to a site unknown to the user, which can thereby evoke a new fascination. The system causes the user's behavior to change to encourage user notifications by considering the paths followed by the user in the past. The system then sorts and applies that information.

4 Information Presentation Based on Temporal Context

We focus on temporal divisions to utilize the temporal context to solve the stated problem. Temporal division refers to the identifying of discrete times, such as specific times of the day, or specific seasons of the year. Our approach serves to identify the temporal division in which the user participates and to provide other temporal information.

Figure 3 shows an example of the number of times the user passes site Q, which the user passes on a daily basis. In this figure, it is evident that user frequently passes site Q in a temporal division of t_1 and t_3. This result suggests that site Q is a well-known site to the user based on the temporal context of temporal division t_1 and t_3.

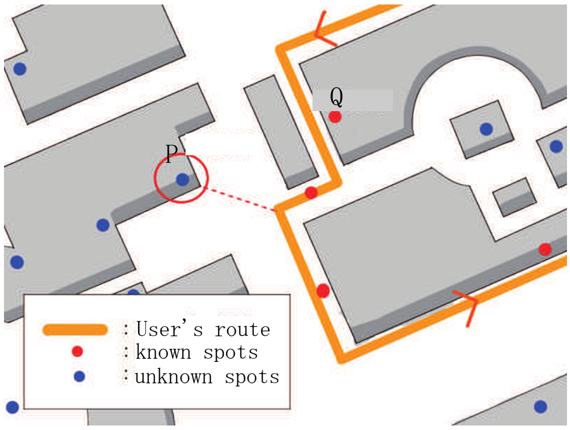

Figure 2. Examples of geospatial context

However, site Q in temporal division t_2 can be regarded as an unknown area. This is because the user almost never visits site Q in the temporal division. Therefore, we provide more observed information on the temporal division t_2 as a priority, and less observed information on temporal division t_1 and t_3. This approach is expected to enable the information to "trigger" the user into finding the new site fascinations.

In this study, we intend to establish several information-transmitting terminals (hereafter, we refer to the equipment as a beacon).

By receiving these transmissions via the user's mobile device, we provide information that encourages changes in the user's site-visiting behavior. Following is an example of utilizing beacons to change user behavior. Wakao *et al.* proposed a game-formed application intended to be used in a large business space [7]. The user installs an application on a mobile device for visiting some checkpoints located in the business space. The user can play many types of games in the checkpoint and receive rewards depending on the score. Using these mechanisms, this approach helps guide the user toward various sites.

In the next section, we examine a method of selecting the information that should be provided in our application depending on the estimated contexts.

Table 1. Examples of Information Category

experience	senses	genres	geospatial property		temporal property		condition
			divisions	details	divisions	details	
see the twilight at a terraced paddy field	see hear	climate and nature	districts	Hara district	periodic(day)	sunup	sunny day
see a swarms of firefly	see	climate and nature	paths	Akutagawa river	periodic(day)	night	dunny day
see a autumunal tints	see hear	climate and nature	districts	Settsukyou Sakura Park	periodic(season)	autumn	sunny day
find a satelite	see	sudden events	districts	Kansai Univ.(Takatsuki)	periodic(day)	night	sunny day
hiking	see hear smell	equipment	paths	Mt.Ponpon	everytime	none	sunny day
see a elaborate matrix	see	equipment	landmarks	Takatuki City Hall	everytime	none	workday
join a beer factory festival	see taste	History and culture	nodes	Settsutonda Countryside	periodic(year)	2nd Sat. on Sep.	none
join a jazzstreet festival	see hear taste	History and culture	paths	Takatsuki Mizuki Street	periodic(year)	1st week on May	none
find a special patterns of splicing chamber	see	History and culture	districts	Takatuki City area	everytime	none	none

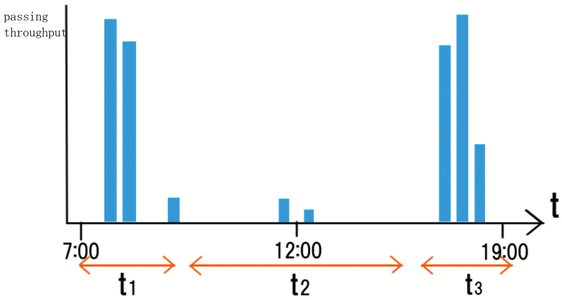

Figure 3. Examples of temporal context

5 Categorizing Information

As mentioned in the proposed framework, we strive to gently prompt the user to focus of a given site. First, we classify information on the fascination in Takatsuki prefecture, Osaka, as shown in Table 1.

In the table, we classify the senses used to experience an event under five topics: "see," "hear," "taste," "touch," and "smell." The topic "sees" is an event that mainly provides visual information. The topic "hears" is an event that mainly provides sound information. The topic "tastes" is an event pertaining to an action of eating. The topic "touches" is an event that provides an experience of touching something with a part of the body. The topic "smells" is an event that provides a unique scent.

The class is a category of an event that has occurred or may possibly occur. We classify it under four topics: "climate and nature," "equipment," "history and culture," and "sudden events." "Climate and natural events" means the characteristics of a target area depending on the environment and season. "Equipment" refers to official facilities or equipment that is provided as a public service. We regard "hiking" in table 1 as an event using a public hiking course established by the government. Therefore, we classify the topic in this group. "History and culture" refers to some events or equipment that concern the history or culture of the area. "Find special patterns of the splicing chamber" in Table 1 is classified because it reflects cultural characteristics with patterns. "Events" means those that take place on a previously determined date. Most events are provide as an "Experience" and do not have physical substance. "Find a satellite" in Table 1 is classified in this group because this event places is considerably based on observation.

We classified these groups under four topics: "Paths," "Districts," "Nodes," and "Landmarks." This classification is based on the image of the city and its elements[1], as proposed by Lynch [2].

In the section of "Detail," we describe the site that will be physically shown for Takatsuki city, Osaka. Paths are the channels along which the observer customarily, occasionally, or potentially moves. For example, "Hiking," or the course of a street, occur in "Jazz street Takatsuki" in Table 1.

Districts are medium-to-large sections of the city and are conceived of as having two-dimensionality, in which the observer mentally enters and which are recognizable as having some common identifying character.

Nodes are points or strategic locations in a city into which an observer can enter. These are the intensive foci to and from which the user travels. We classify the site that has a "point" location and correlate it with "see" in the item of "modality of experiences."

Landmarks are another type of reference point; however, in this case, the observer does not enter within them. Instead, they are external. We classify the site as having a "point" property and correlate it with "see" in the item of "modality of experiences."

In short, this group concerns temporal elements in which target events occur. In our study,

[1] In this paper, we do not classify "Edge," as Lynch proposed, because no related site is applicable in the target area.

we focused on the periodicity of the event and classified it under two topics, periodic or not. In the "Details" section, we describe its concrete date or the period (e.g., day, month, or season). This group thus concerns non-spatiotemporal conditions, such as weather, and non-naturally occurring conditions.

6 Simulation for Estimating the User's Spatiotemporal Context Using a Beacon

The proposed method aims to estimate the user's spatiotemporal context in the target area to detect beacons in the environment by the user's smartphone. Each beacon is an anchor of information for the target environment. A decision of whether to equip a site with a beacon, b_1, depends on if the site is well known or how long the user was there.

The degree of familiarity X_i about the position of beacon b_i during observation period T is denoted as:

$$X_i \stackrel{\text{def}}{=} \sum_{t \in T} \text{detect}(||\vec{p}(t) - \vec{b}_i|| < r) \qquad (1)$$

where $\vec{p}(t)$ denotes the position of user p at time t, which thus represents each beacon's detection radius (it is constant). Function detect() returns 1 if the condition is satisfied and 0 if the condition is not satisfied.

Beacons installed in the target environment are related to each other. If a user exists within the detectable range of a Beacon b_i, the detected beacon, b_i, propagates that fact to the relevant beacon b_j. By this propagation, each Beacon will be stored as information that the user is in "proximity." Based on this concept, Neighborhood activity N_j With the Beacon b_j is denoted as:

$$N_j = \sum_{i \neq j} \omega_{ij} X_i - X_j \qquad (2)$$

where ω_{ij} is a coefficient that represents the degree of association between beacon i and beacon j. This coefficient considers various design methods. For example, we denote the site priority belonging to the same genre as another site in the design that emphasizes the neighborhood.

On the contrary, if we aim to connect with different categories, we can detect for the user the target spot that belongs to a different genre from the site in which the user currently exists. Now, we set the coefficient to be gradually reduced in accordance with the distance, as shown in the following equation.

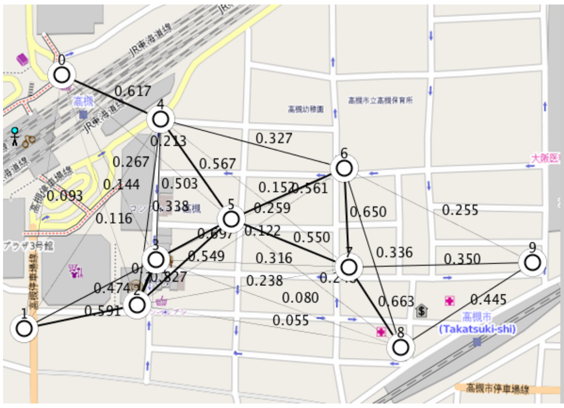

Figure 4. Degree of associations between each beacons

This equation can define a variety of neighborhoods by adjusting ω_{ij}.

$$\omega_{ij} = \frac{\alpha}{||\vec{b}_i - \vec{b}_j||} \qquad (3)$$

This α is a parameter for adjusting the value based on the distribution density of the beacon.

Figure 4 shows the degree of associations between each beacon.

Based on the above equations, we conducted a simulation based on ten days of a user's logged data. Figure 5 shows the result of the simulation that calculates the familiarity degree and the neighborhood activity degree. In Figure 5, a map showing the geospatial context is on the right; a graph showing the temporal context of each beacon is on the left.

Some points on the map on the left of Figure 5 show that the beacon is situated on these sites. These points are denoted in red in accordance with the known degree. The outer portion in green shows the proximity degree of activity of each beacon. The result of this simulation shows that beacons equipped in streets on which the user frequently travels are deep red. We hence determine the information for the user based on the known degree and proximity degree.

For example, in one site with a high familiarity degree, we refer to the temporal context and provide information that shifts earlier or later based on the temporal property. Additionally, in one

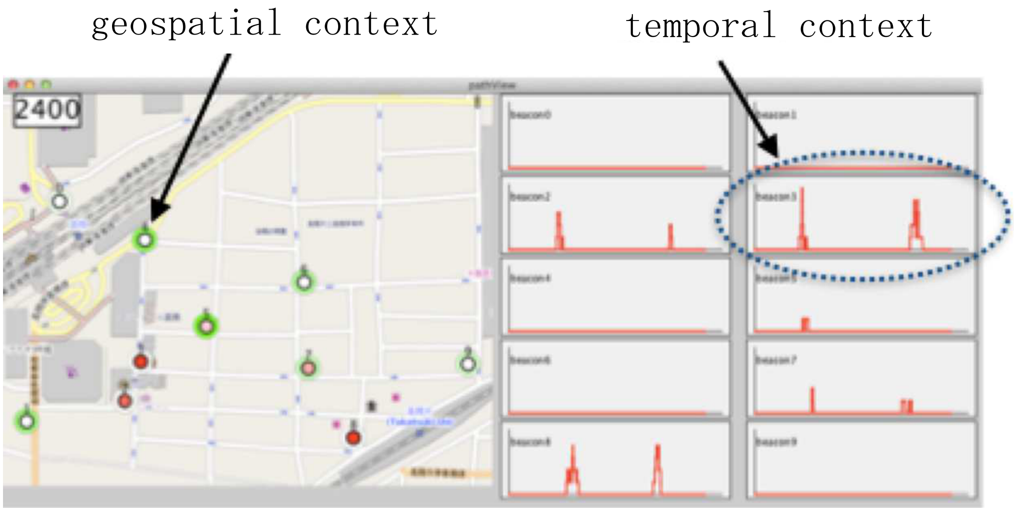

Figure 5. Simulation result: a spatiotemporal context that beacons observed

site of the high neighborhood activity degree, we provide universal information that is free of the temporal context (for example, “Equipment” in Table 1). This practice can provide information in which the user may be interested. We will consider operating a concrete information presentation strategy in future.

7 Related Work

Many navigation methods based on location information have been proposed. These methods aim to support walking. Aslan *et al.* considered obtaining geospatial knowledge by utilizing mobile navigation. In this practice, Aslan indicates that a mobile device is useful for obtaining definite geospatial knowledge in a separate area; however, it is not sufficient for obtaining meta-viewpoint knowledge of a whole area.

In addition, Vermeulen *et al.* [6] proposed “Stroly,” an application that indicates a user’s location on different generation maps, such as “picture scroll of the Edo period” or “national map of the 18th century.” The workshop that took place in Ina city, Nagano prefecture, is a case study of Stroly.

In this study, the topic of a picture scroll was suggested by participants, some of whom commented that they felt that past landscapes are like time slipping by. We surmise that this result was due to the display of location information on the top of the picture scroll on which the Takato district was drawn. Its “point” was indicated, thereby showing the current location to which to navigate in real time.

Furthermore, Yonekura *et al.* proposed a navigation system that avoids traffic accidents using a street map [9]. This system employs landmarks that are viewable and memorable, such as a “post office” or “convenience store.” It shows the positional relationship between the user and surrounding buildings or roads. This system aims to avoid danger caused by overgazing at street maps when one is strolling in an unknown town. The study suggests changing the user’s viewpoint to convert the map into a different modality.

Some methods cause the “foreignization” of a place with which the user is familiar by providing different viewpoints. This study aims to encourage the realization of the value of a place.

Kobayashi *et al.* conducts a “Data HANDAI” workshop, which changes the viewpoint of the university to the participants [1]. This workshop aims to change the relationship between participants and university campus. Participants collect information about the university through fieldwork, literature search, or conversations. After the research, participants make postcard format worksheets and compare collected information with external data.

Through these studies, participants gain knowledge and experience about the campus. They eventually notice a landscape that they had previously overlooked, or they found new meaning in the landscape.

Additionally, Shirozu conducts the “Paradise Scope,” which takes place in a university-student group format [4]. This workshop offers a perspective that differs from daily life by comparing the frequently visited campus with other things. The mentor thereby compiles a guidebook of the campus. The study aims to enable each participant to develop an attachment to the campus through the subject. For example, participants visit some previously unknown sites on their campus, or they notice through fieldwork the landscape that they previously overlooked.

As a result of the workshop, the behaviors of participants changed, such as by now "taking pictures of the campus" or viewing the "school as being improved."

8 Conclusions

In this study, we implemented a walking application for mobile devices to encourage user movements that lead to spontaneous notifications about locations. The results of our experiment show that the degree of the user's familiarity with the target area, such as through knowledge or experiences, must be considered.

We prioritized the gathered information utilizing temporal and geospatial contexts. In addition, we considered the method of providing information for each user; that is, roughly estimating their degree of familiarity in the field. In future research, the results of this study can be applied to collecting fascinating aspects of an area and classifying it in terms of temporal and geospatial perspectives.

In this paper, we furthermore re-examined our previous method of providing information, rebuilt the system to test our hypotheses, and evaluated the results.

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