Social Geoscape: Visualizing an Image of the City for Mobile UI Using User Generated Geo-Tagged Objects

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Abstract. In this paper, we propose a people-powered location recognition application, Social Geoscape (SGS) that provides highly descriptive geographical information to mobile users. GPS provides the user with latitude and longitude values; however, these values are cumbersome for determining a precise location. A traditional reverse-geocoding database system (i.e., one that converts latitude and longitude values into street addresses) provides locative information based on administrative labeling, but people often do not recognize locations or their surrounding environs from street addresses alone. To address this problem with location recognition, we have created Social Geoscape, a reverse geocoding system that enhances locative data with user-generated information and provides assistance through a mobile interface.

Keywords: Social tagging, Visualization, Design, Urban sensing, Mobile interaction, Reverse geocoding, AR, Social Geoscape.

1 Introduction

In today's world, people often use GIS (geographic information systems) or GPS (global positioning systems) on mobile devices in their everyday lives. People have used these technologies based on latitude and longitude values for navigation and to record people's activities. The values of latitude and longitude are not easily understood by typical users, so several GIS technologies provide the corresponding street addresses using a reverse geocoding database (i.e., a database that converts latitude and longitude values into street addresses); however, users cannot always identify the spatial correlation between the street address and the user's location. Generally speaking, users define their spatial understanding from their memories and personal experiences [1]. Thus, their definition of a space is not the same as a street address defined by an administrative district. According to 'The Image of the City' written by Kevin Lynch [1], people define places by not only street addresses but also using other factors, including landmarks, nodes (e.g. waiting points, stations, intersections), rivers, nicknames of the places, and famous events that occur at a well-known locale. Lynch also pointed out that people build a "public image", which is the overlap of many individual definitions for the living environment. For example, people who live in Tokyo identify places as being "around Tokyo tower"

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(a landmark), “near Sumidagawa” (a river), or “at the front of Shibuya station” (a node), and these places are not defined by street addresses. In this study, we focused on user tags from geotagged photos on the Flickr (www.flickr.com) website. Users tag these photos with descriptions alluding to environments, situations, and interests that were relevant when the user took the photo. Many web services (including Flickr) can provide information that is easily understood by using the user tags as collective intelligence [2]. At present, there are already over one hundred million geotagged photos on Flickr, which include social tagging by their users. In this study, we utilize the user tags as collective intelligence to capture the public image from living environments. The aim of this study is to propose “Social Geoscape” that allows mobile users to provide their image of an environment. This is meant to encourage the retrieval of users’ memories and stimulate discovery in their daily lives through use of geotagged objects such as photos and user tags on the Internet.

2 Visualizing “The Image of the City”

As mentioned above, people often do not recognize places or situations from the street address alone. Figure 1 is a plot of geotagged photos from Flickr that users tagged as ‘Shibuya’ (included in Japanese characters) in Shibuya-ward. In order to plot these images onto the maps we use statistical algorithms with R (a tool for statistical computing and graphics (www.r-project.org)).

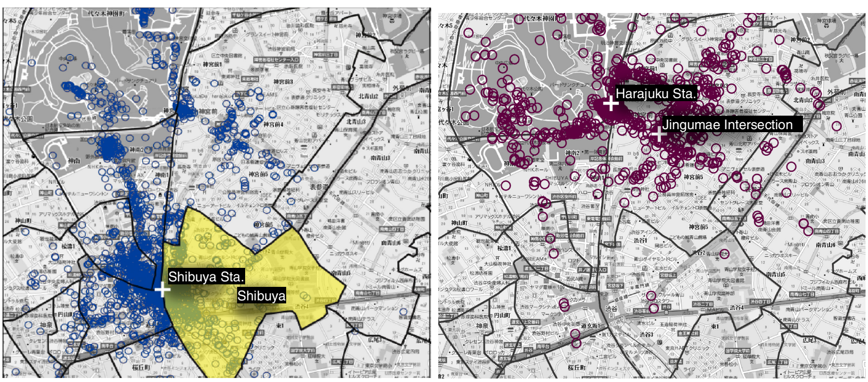

Fig. 1. The plot of photos tagged as ‘Shibuya’ (Blue circles) and Shibuya district defined by street address (yellow area) [Left]. The Plot of photos tagged, as’Harajuku’[Right].

The left of Fig 1 shows the plot of photos tagged as “Shibuya” and Shibuya district defined by street address. (Shibuya-ward area is one of busy downtown area in Tokyo. Also this area has a lot of geotagged photos on Flickr.) As can be seen in this figure, we compared the area tagged ‘Shibuya’ in the geotagged photos with ‘Shibuya’ defined by the street address (yellow area located on the east side of Shibuya station). Outside the western boundaries of the Shibuya area, as defined by street addresses, many users tagged more of the area as “Shibuya” (blue circles in Figure 1). We can assume that many users recognize both the eastern and western areas of Shibuya station as Shibuya. The right of Fig 1 shows the points tagged as ‘Harajuku.’ Harajuku is not currently a street address, although ‘Harajuku’ was a street address located in the northeastern parts of the Jingumae intersection 50 years ago., close to where the points extend around Harajuku station. We can observe that the users recognize the place "Harajuku" by the station name and not by a street address. We can observe the difference between users' definition of the space and definitions of the street addresses.

2.1 Visualizing Spatial Definition Using Kernel Density Estimation

The public image often defines a space as an overlap, so it is difficult to describe a tree structure as merely street addresses. According to 'A City Is Not a Tree' by C. Alexander [3], a city is composed of many factors overlapping one another. Thus, the structure of the city is a semi-lattice form, not a tree. Alternately, a tree structure defines the structure of street addresses. Table 1 samples geotagged photos from Flickr that have the tag "Omotesando" in the map in Table 1. We can find other place names such as Tokyo, Harajuku, and Meiji-jingu (a Shinto shrine) in the photos (indicated red in a font). The users who took these photos tagged them with place names according to their recognition of the place. Social tagging allows users to collectively classify and find information from spatial, temporal, and social contextual metadata [4]. Using this metadata, we apply social tagging to the real space to visualize an image of the city that is easier for users to understand.

Table 1. The sample of photos tagged as "Omotesando"

Tags
,aoyama,...,omotesando,geo:lat=35.664...
Tokyo...omotesando,...,aoyama ...
Tokyo,omotesando,...,aoyama... tower,geotagged,earth@
..,tokyo,...,omotesando,harajuku,...,表参道,原宿,神宮前,jingumae,
Tokyo,jingumae,night,light,omotesando ...hills,geotagged,geo:...

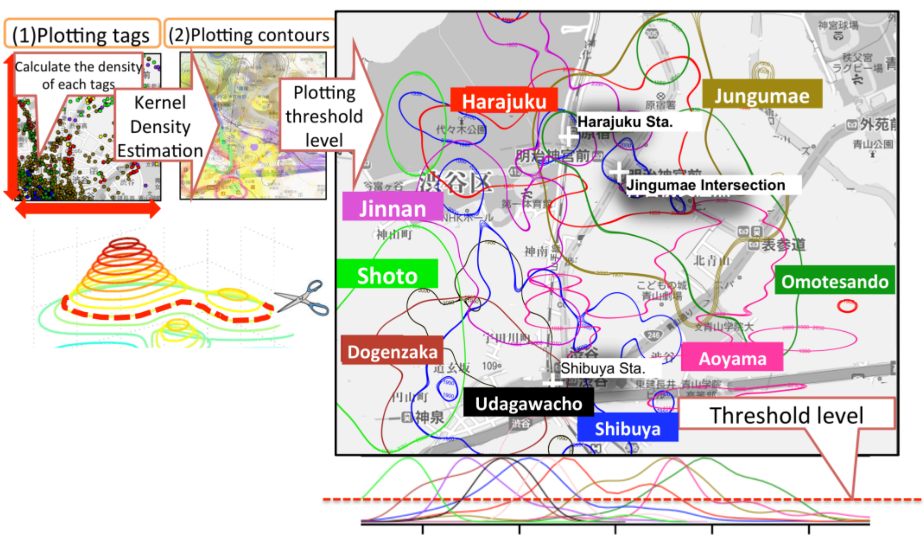

Fig. 2. Overlapping areas

Figure 2 shows the people-defined Shibuya map using kernel density estimation, plotted by using functions of the statistical programming language R. Kernel density estimation is an algorithm that makes it possible to extrapolate the data to the entire population. In this case, we use a library of R that is named “kde2d.”[5] We extracted 7918 photos with tagged place names (street addresses, station, street name) from Flickr, and plotted contour lines of the place names. In this case, we calculated the density of these tags (Table 2) to indicate the areas of the geotagged objects, which we plotted with the following procedures:

Table 2. Frequency of place names occurring in tags

Name of place	Qty
shibuya (or “渋谷”)	4250
harajuku (or “原宿”)	2043
omotesando (or “表参道”)	727
aoyama (or “青山”)	301
dogenzaka (or “道玄坂”)	150
jinnan (or “神南”)	141
jingumae (or “神宮前”)	140
udagawacho (or “宇田川町”)	96
shoto (or “松濤”)	14

1. Dividing each latitude and longitude axis of the area (Fig. 1) into 1000 parts, and plotting the geotagged photos in these areas, which are named according to the place names (Table 2: total of 7918 photos).
2. Estimating the density of the cluster of tags by the function “kde2d” (Fig. 2 (1))
3. Plotting the contour lines of these clusters of tags (Fig. 2(2)).
4. Extracting the contour line, thresholded 2% of the height of these clustered tags, and plotting it onto the map (Fig. 2).

2.1.1 Findings

As can be seen in this figure, the areas overlap each other, which is similar to what is shown in Figure 1. For example, three areas at Jingumae intersection surrounding the location. (“Omotesando” (green), “Harajuku” (red), and “Jingumae”(golden)). The result indicates that SGS users can utilize this map as a public image to aid cognition. In this case, defining the threshold level is used to optimize the density of each clustered tags; however, we found a case that did not produce a relevant definition of the area from the clustered tags, due to quite low density in the area. In the case of the tag cluster “shoto (or 松濤)”, the defined area is divided into 2 areas (circled areas as light green in Figure 2). The photo in the north side is a shot of a post office, and was incorrectly geotagged photo (i.e, it did not exist in the area). Basically, social tagging provides information that is easily understood by using the user tags even if it contains outlier tags or values. The erroneous result indicates that we should find a minimum amount of tags that enable relevant definition of an area. In addition, this finding also indicates a need for requiring outlier detection by statistical procedures.

2.2 Visualizing Boundary of Districts Using SVM

People recognize the boundaries of districts that adjoin each other in their public images. Usually, we recognize a district by its geographical features or scenery (e.g., a government office quarter, a shopping zone, a park)[1]. Therefore, we recognize a boundary when the features of the scenery change. Some geotagged photos contain a tag that describes the geographical names using the users’ spatial definition. The characteristics of the place also affect the tag. Thus, we classify geotagged photos to visualize the boundaries of districts using SVM (support-vector machines, which are methods used for classification and regression). SVM is a set of related supervised learning methods used for classification with an algorithm that is similar to a spam-filtering algorithm. In this study, we also borrowed the algorithm from functions "ksvm" of statistical programming language R [6].

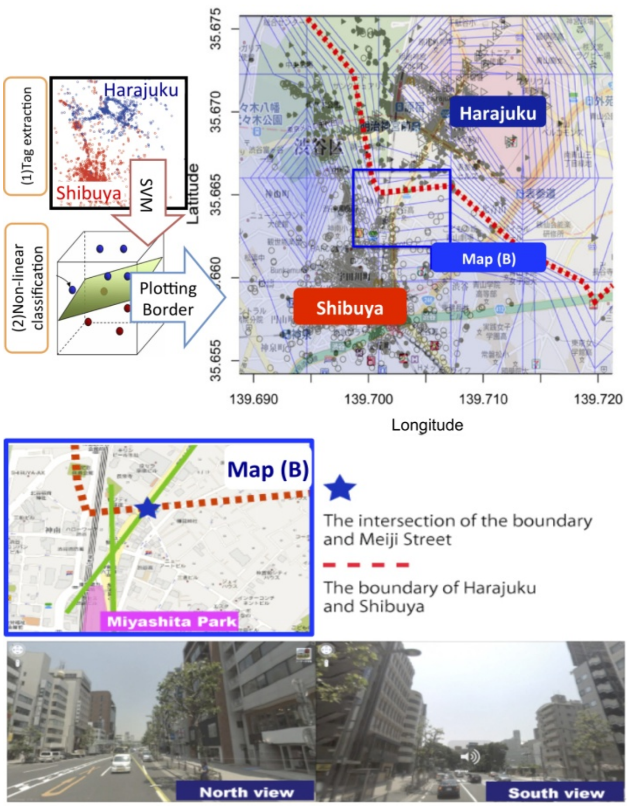

Fig. 3. Plot of the boundary (Shibuya and Harajuku) by SVM using tags in geotagged photos from flickr (4250(Shibuya) and 2043(Harajuku) of 53522 photos in this area.)) In map (B), the boundary is plotted by SVM (the red line in the top figure). Around the intersection of the boundary and the street (blue star), the scenery changes from buildings lining the street to the park opened to the sky (the north and south views in the lower right photos), and the street is curved.

2.2.1 Findings

In Fig. 3, we classify the photos, which include a tag for "Shibuya" or "Harajuku," into two areas using SVM. The zoomed map in Fig.3 shows the point crossing the boundary line (red line) and Meiji-dori Street (the street lined by green lines). In the area around this point, the scenery changes from buildings lining the street to an area that is more open to the sky than the surroundings (Miyashita Park). In addition, Meiji-dori Street is curved. (The lower two photos in Fig.3 are from the Google street view.) According to 'The Image of the City', these visual features can be viewed as the boundaries of the district for residents. The north/south view of the crossing point indicates the suggested method can be used to find a boundary of districts.

3 Preliminary Evaluations

3.1 Social Geoscape vs. Traditional Reverse Geocoding

We conducted an evaluation to compare normal reverse geocoding with Social Geoscape. In the experiment, the subject walked around with a GPS logger, but was not notified the aim of experiment. The GPS used in this experiment was a Holux M-241. After that we asked the subject to describe his path using place names he knows. We logged 3.2Km of his path in central Tokyo for about 5.5 hours. A week after the experiment, we interviewed the participant, to exclude affects of short-term memory. Fig.4 shows the results of the experiment. As can be seen in the table, the subject described his paths as places where he had walked. The subject did not describe "Sotokanda" (a street address near the Akihabara station. Akihabara is a largest electrical devices shopping area and a mecca of Japanese pop culture) and "Kanda surugadai" (a street address near "Ochanomizu station"), and did not describe block number (e.g. "1 chome"). The descriptions from the subject were summarized the same as SGS except "Yushima (a district of near the University of Tokyo)."

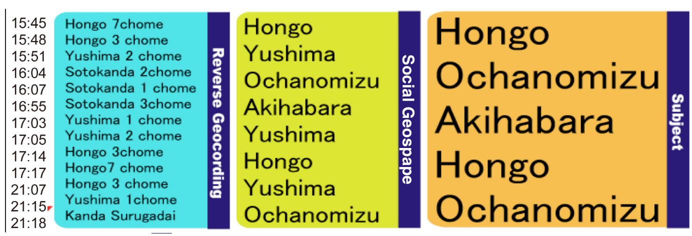

Fig. 4. Comparing with the activity logs by street address provided by traditional reverse geocoding (Left), SGS (Center), and description of the subject (Right)

In Yushima area, there are a lot of photos tagged with the name of a place rather than nearby other areas, because the area has a famous shrine named Yushima Tenjin (湯島天神) and places related to the shrine. According to the interview, the subject recognized the shrine is not close to his path of this experiment, as the subject has used a different path to go to the shrine. Otherwise the result indicated that the subject was able to review or recall their track more easily using Social Geoscape from Flickr's user tags than traditional reverse geocoding.

3.2 SGS vs. "The Image of the City" ~Drawing Cognitive Maps Using Geotagged Objects~

Comparing SGS with the cognition maps made for 'The Image of the City', in Lynch's research, he surveyed Boston, Los Angeles, and Jersey City in the 1960's. He plotted cognitive maps of these cities based on the result of interviewing to the residents and observing residents' behaviors. In this section, we compare Lynch's map with SGS's maps defined by social tagging in Los Angeles. In this case, we observe that both definitions have a connection to each other. In addition, we describe the interesting fact that the SGS map references the historical changes in Los Angeles.

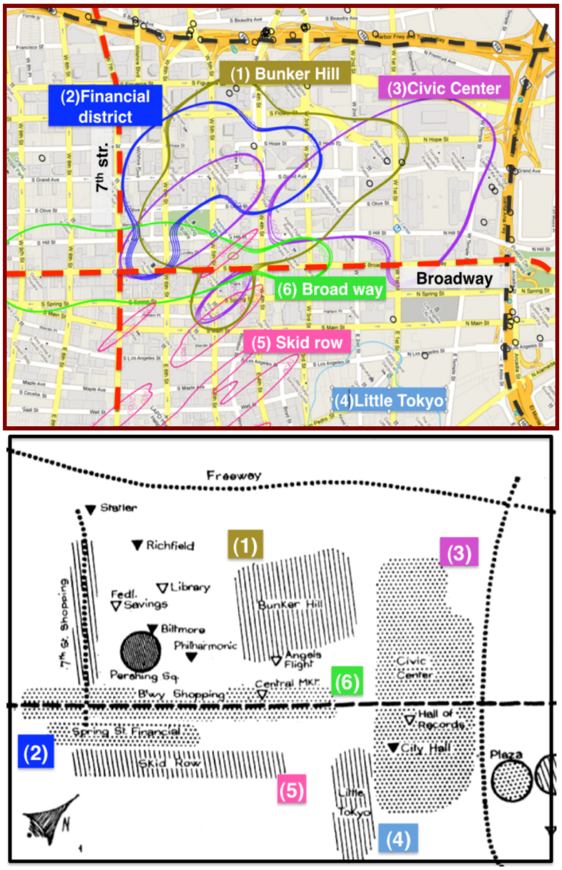

Fig. 5. Comparison of the significant elements of L.A. in the 1960's and the 2000's

3.2.1 Comparison of the Significant Elements of L.A. in the 1960's and the 2000's

These two maps indicate the districts of the central part of Los Angeles (L.A.). The bottom map is from The Image of the City (Fig.5). This map shows the significant elements of L.A. in the 1960's. The top map indicates the same districts as the bottom one but uses SGS. In Table 3, the quoted photos were taken from 2003 to 2010 with "Bunker Hill" in the golden area (1), "Financial district" in the blue area (2), "Civic Center" in the purple area (3), "Little Tokyo" in the sky-blue area (4), "Skid Row" in the pink area (5), and "Broadway" in the green area. (6). As can be seen in the top map, it cannot find "Shopping districts." (There is no photo that was tagged as "shopping" in this map.) Actually, "Shopping district" are defined on the suburban area located outside of the map area. So we can guess the user did not choose to define the shopping district as "shopping area." "Little Tokyo" and "Broadway" are almost the same as the 1960's. These areas have had clear definitions by the people for nearly 50 years.

On the other hand, the definition of "Financial district" has completely changed. By the 1960's, the district was mainly located on Spring Street, however, between the 1970-1980's, the district began to decline and the main parts of the financial district have been moving to the western area of "Spring Street" until now [7]. "Bunker Hill", "Civic Center", and "Skid Row" have changed slightly. In addition, we found some quite

Table 3. The number of tags from Downtown Los Angeles area on Flickr (Jun. 2010)

Place label	Qty
bunker hill	221
civic center	40
financial-district	178
little tokyo	3398
skid row	191
broadway	664
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disney	3476
anime	6930

vivid elements that emerged after the 1960's such as the Walt Disney Concert Hall. There are over 3000 tags related with this hall (tagged "disney", "disney hall", and "disney concert hall") around the location. Using geotagged objects from the Internet, these results indicate not only the plotting of a collective intelligent cognitive map by use but also reflecting on the changing of a city.

4 Applications

As an application of Social Geoscape, we developed 'Kioku Hacker' (kioku means memory in Japanese), a navigation/life-logging Apple iPhone application designed to apply our concept and to obtain user evaluations. The aim of this application is to assist the users in reviewing (or rediscovering) their activities and to grasp the image of their environs using their mobile devices. 'Kioku Hacker' allows the mobile users navigation and life logging functionalities, (1) providing people-defined geographical information (2) providing recommended tags from social tagging by user-generated geotagged objects using Flickr's API.

Fig. 6. This system enables overlaying the local maps and cognitive maps defined by geotagged social tagging. The user of the system is able to use zooming search the place by choosing the words from tags suggested by a use of this system.

4.1 Zoomable Socioscape Navigator

Fig. 6 shows a navigation user interface that enables overlaying the local maps and cognitive maps defined by SGS. The user can understand the scale of spatial keywords by simply tapping the tag (in Fig. 6) suggested through use of SGS. The interface is not always able to fit on the screen by using conventional geographical navigation systems, as can be seen in Fig. 6, the screen shots of this sample application. When the user selects the word "浅草 (asakusa)", the map zooms in (or out) to the area of the place quickly and to specify recommendation range of the tags define by SGS. Now we are developing a navigation tool that provides a better understanding of navigation supported by the folksonomic spatial definition using SGS as daily mobile navigation tool. (The spaces are defined by using kernel density estimation described in the previous section of this paper.) This system allows the user to access the 'navigate' function by jumping to a relevant area and adjusting the relevant scale of each area by selecting the recommended tags indicated on the screen, without using the keyboard on the mobile device.

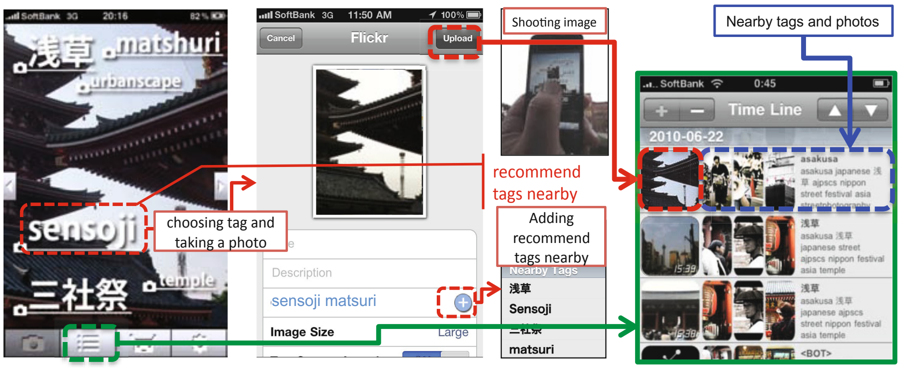

Fig. 7. Easy tagging Cam: Simultaneous photo capture and tagging conducted by tapping the overlaid tag recommendation. The taken photos are listed with nearby tags and photos as timeline style lifelog

4.2 Easy Tagging Cam: Tagging Recommendation System for Sustainable Life-Logging

'Kioku Hacker' is equipped with a digital image recording function equipped with multiple shutter buttons (Fig. 7). Tagging is a powerful method to retrieve (or find) user's records and to develop a re-usable life-log. At the same time, tagging is time consuming. This function lets users capture and tag photographs simultaneously. Hence allowing the user to be set free from tagging tasks. (According to Flickr, iPhone users tag 2% of their geotagged photos. Other non-smart mobile phone (Nokia N73) users tag 0.4% of their photos.) Watanabe et al., also developed 'WillCam', which enables users to capture various information, such as location, temperature, ambient noise, and photographer facial expression, aimed to avoid spending the time and effort to carry out annotation [8]. In our case, we utilized the system to provide recommended tags from social tagging, including geotagged photos on mobile devices. The user is able to develop a reusable life log and contribute to developing social tagging simultanously. This system also utilizes a life-log system, which facilitates the easy retrieval of information. Moreover, our application indicates both nearby photos and nearby tags on a unit of record to assist the user (Fig.7). According to the work of Kalnikaite et al., different types of memory promote the lifelog user's recollections [9]. In this figure is a case of a walk around Asakusa (An old town in Tokyo); nearby photos are laid out in order of the distance from a recorded point and nearby tags are indicated in order of the densities on the unit of the record. The user can view the image from the feature of both the sceneries (architectures) and the related words of its environs (e.g. temple, asakusa, matsuri (festival), sensoji (name of temple)). Through use of the function, the timeline augments the stream of the user's track by using geotagged objects.

5 Related Work

Kennedy et al. proposed a method of classifying photos using Flickr to automatically extract places and events from the assigned tags [10, 11, 12]. Persson et al [13], Masui et al. [14] and Nakanishi et al [15] proposed methods and interfaces to provide a visual/context based geographical information retrieval/sharing procedure. Additionally, we aimed to complement and enhance activity recording and navigation assistance by using geotagged objects for mobile user interfaces. There are interesting studies of spatial/social context-based photo browsing for mobile user interfaces, proposed as Mobiphos [16] and Zurfur [17]. These applications were designed for browsing/sharing photos via the Internet in a mobile environment but were not designed for navigation assistance or continuous activity recording.

Rekimoto et al. proposed a method of summarizing user activities with reverse geocoding [18]. They also provided lists that are more descriptive by labeling the user descriptions of street addresses (e.g., the street address for a user's home is labeled "home"). These methods are related in terms of extracting information from people-contributed media. Moreover, our methods provide the labels dug out from social tagging. Sellen et al. reported that the automatic way in which SenseCam captures these images results in cues which are as effective in triggering memory as images which people capture on their own initiative [19]. Kalnikaite et al. showed that there are multiple types of data that we might collect about our pasts, as well as multiple ways of presenting this data [9]. These previous works intended to enhance user's memory using the life logs that were recorded by the user itself. Additionally, our approach focused on the user's environmental understanding based on their public image, which we compared with social tagging on the Internet.

6 Discussion and Future work

6.1 Comments and Request Feedback from Users

Our proposed mobile applications aim to encourage users to assist navigation/activity recording by using geotagged photos/tags from Flickr as descriptions of the user's path. In order to confirm whether the system enhances the users' life logs, we conducted interviews about our application. Seven males and seven females (22–51 years old iPhone users) participated in the evaluation for 1–4 weeks. After the evaluation, we received comments and requests and we found possibilities that the system encourages users to recollect memories by using geo-tagged photos/tags from Flickr as descriptions of the user's path. According to comments such as "I was watching the timeline on the way to work in a train. That stimulated my recollections and helped me rediscover what I've missed in my daily life." by providing activity records enhanced by the life logs described by others' photos/tags, the participants experienced rediscovery of their environmental understanding. In addition, comments like "It (augmented life logging) is pretty close/ keeps the motivation of recording my life." imply that collective geotagged objects can be used for augmented life logging. At the same time, there were several requests. (More than two participants made requests.) According to requests "Viewing nearby photos by my friends through our group trip, will help talk up a storm." Participants in the system should be connected with multiple social network systems (SNSs) they use daily or with their buddies. This comment points out how this project would provide ordinary users with a sustainable life-log system.

6.2 Tag Clustering and Optimization

Social Geoscape is proposed for providing users with an easier way to grasp the public image of cities using Flickr's user tags (Fig.8). In our proposed application Kioku Hacker, we use the Flickr API (flickr.place.findByLatLon) that provides the searching functionality and sorting geotagged photos from their users. Kioku Hacker collects and processes these photos from Flickr APIs (maximum 200 photos within a 32km radius) to complement the periodic records in the user's life log. At the same time, the user tags included in these tags are created and ordered according their frequency. This system totals up the nearby tags to create a tag list, although this method sometimes produces the problem of outputting irrelevant tag clusters. For instance, many photos taken at (or nearby) the University of Tokyo (located in the Hongo district in Tokyo) are tagged "Hongo" and "University," but when the system indicates the tag clusters at the campus, the system outputs "Ueno" (next to Hongo district) because the number of photos taken at Ueno are more than that at Hongo. To solve the problem, this system optimizes tag clustering. Fig.8 shows the conceptual model of tag clustering optimization. As shown in the figure, this system multiplies a coefficient value (C) that is in inversely proportional to the distance (D) from the photo shooting point. As a result, "Hongo" tagged clusters are biased even if the number of tags is less than that for "Ueno." In addition, this system excludes tags that are unrelated to geographical or environmental factors (e.g., geotagged, Eye-Fi, Kodak) to indicate a more semantic tag description or recommendation.

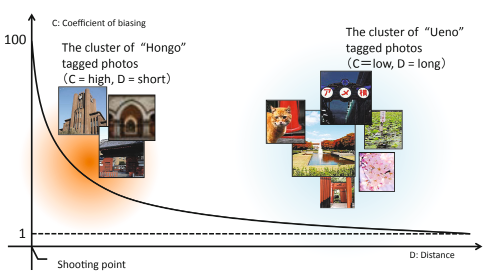

Fig. 8. Conceptual model of tag clustering optimization: "Hongo" tagged clusters are biased even if the number of tags is less than that for "Ueno"

Additionally, we observed several trends of image tagging between the each segment of the photos such as day/night, inhabitants/tourists, and recent/old days. For instance, in the case of Shinbashi area (A downtown area in Tokyo. Nearby this station, the area has a lot of bars and restaurants for businesspeople.), some sets of photos tagged "shinbashi" are also tagged "night", include the sceneries of nightspots such as nearby restaurants or bars. The cluster of night tagged photos spreads to the Ginza area (nearby district of Shinbashi also famous for night spot). We can guess that the users took these photos, and understood these areas as nightspot including bars and restaurants. On the other hand, we observe that the set of photos tagged "shinbashi" but not "night", include the sceneries of buildings, business persons, and billboards, in addition to many of these photos taken nearby Shinbashi station. The result indicates the area can be recognized through different perspectives, and there is a possibility of grasping the further aspects of the cities from user generated geotagged objects. We should consider this fact, however, our proposed method flattens out those different perspectives because the objects are not sufficient to cluster each other at present. To solve the problems, it is important to provide a user interface and user experience that encourages the motivation to contribute to developing social tagging.

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