Using Social Media Data to Study People's Perception and Knowledge of Environments

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Abstract. Increasing availability of online social network and media-sharing services (e.g. Facebook, Foursquare and Flickr) has led to the accumulation of large volumes of social media data, such as text-based messages, check-ins, reviews/ratings, images, videos, and so on. Many of these data are tagged with geographic location information, e.g. latitude/longitude, and often reflect how people perceive, experience and behave in various environments. This paper explores the potential of geotagged social media data for understanding people's perception and knowledge of environments, especially urban environments.

Keywords: Social Media Data, Spatial Knowledge, Data Analysis

1. Introduction

As acting in space, people perceive the environment and acquire knowledge to build mental representations of the external world. These mental representations (or mental maps) can be considered as our spatial knowledge about the environment. This knowledge is crucial in our daily life. It helps to organize our experiences, as well as to fulfill spatial tasks, such as orienting and wayfinding (Lynch 1960, Siegel and White 1975, Golledge 1999). Therefore, understanding people's perception and knowledge of environments is fundamental to many research disciplines, such as geography (e.g. human geography and GIScience) and environmental psychology. It also enables many applications such as location-based services (LBS), urban planning, and policy making.

Conventionally, research on this aspect often employs empirical experiments in labs or in fields (Maceachren 1991, Montello et al. 2003), which are often very expensive and time-consuming, and hard to apply for large-scale studies. Recently, with the impetus of social media, such as Twitter (http://www.twitter.com/), Foursquare (http://www.foursquare.com/), and Flickr (http://www.flickr.com/), large volumes of social media data have been continually created. Many of these data are tagged with geographic location information, e.g. latitude/longitude, and reflect how people perceive, experience, and behave in various environments. Therefore, they might be a new and significant source for studying people's perception and knowledge of these environments.

This paper aims at using social media data for studying people's perception and knowledge of environments. We implement three case studies to illustrate the potentials of geotagged social media data in studying people's spatial knowledge of various environments.

2. "Where is the City Center of Vienna?"

In daily life, people often use vague concepts like "city center" and "area around train station" to conceptualize and communicate about space. Existing research on this aspect often employs empirical experiments (see Montello et al. 2003). In recent years, the highly available social media data have enabled us to access information about how people use vague concepts in daily life. This information can be used to model humans' conceptualization of space, e.g. modeling their perceived boundaries of city center.

This case study illustrates how photo metadata (i.e. title, descriptions, tags, and location) on Flickr can be used to study humans' perceived boundaries of city center in Vienna (Austria). A similar research was done by Hollenstein and Purves (2010), who used Flickr photo tags to describe the borders of city center in many cities, such as Zurich and Chicago. In this paper, we extend their approach, and investigate whether the perceived boundaries of city center for local residents are the same as for tourists.

By looking at the Flickr website, one might find many photos having some terms like "city center", "downtown", and "innenstadt" in their titles, descriptions, or tags. The geographic locations of these photos (i.e. where these photos were taken) might reflect their users' implicit feedback and perception about where the city center is located. Therefore, by aggregating the geographic locations of these photos, the perceived boundaries of city center can be modeled for the users who took the photos. In this case study, by carefully studying the terms used for describing city center in both German and English (UK and US) languages, we use the list of "city center", "city

centre", "downtown", "inner city", "stadtzentrum", "innenstadt", "stadtmitte", "stadtinneres", and "stadtkern" for identifying these photos. More specifically, for each photo within the administrative boundary of Vienna, if one of these words appears in its title, descriptions, or tags, we consider this photo being taken in the city center. Instead of modeling each individual's city center, we are interested in comparing the collective city center for the group of local residents and that for tourists.

Similar to De Choudhury et al. (2010), we differentiate tourists and residents by checking the span of the taken times between their first and last photos. If the span is bigger than 21 days, we consider the user as a local resident. After photos of Vienna city center for local residents and tourists are identified, we then use kernel density estimation (available in ArcGIS 10.1) to derive the perceived boundaries of Vienna city center for local residents and for tourists. Figure 1 shows the results.

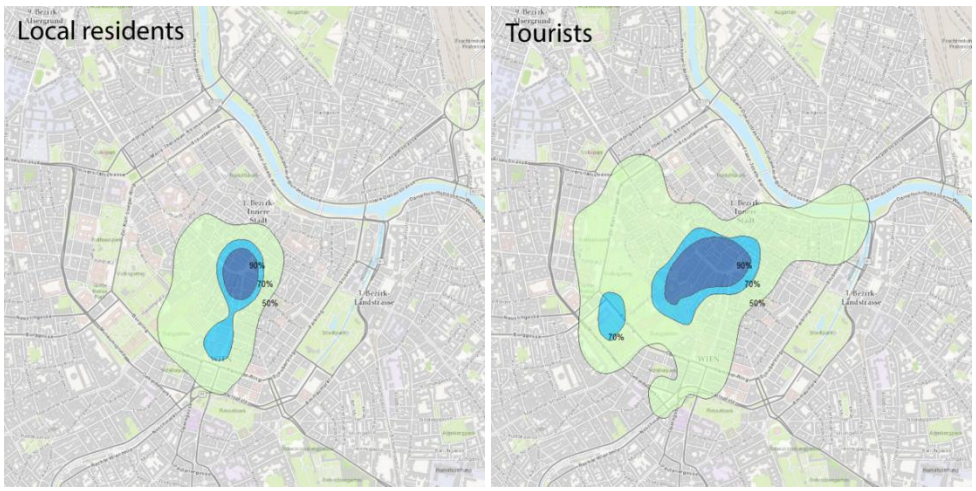

Figure 1. The perceived boundaries of Vienna city center for local residents (left) and for tourists (right). These results are generated using the photos that were taken during January 2007 and January 2011.

Figure 1 shows that both local residents and tourists perceive the area around "Stephansdom", which is the 'symbol' of Vienna, as the city center. However, compared to tourists, local residents have greater consensus with each other in defining the boundaries of city center. This is consistent with the findings of Beguin and Romero (1996), which showed that differences in individual cognition decrease over time (or with increased familiarity).

3. Modelling People's Affective Responses to Environments

Humans perceive and evaluate environments affectively. Some places are experienced as pleasing, while some others as disgusting and unsafe. These affective responses to environments form our spatial knowledge about environments, and influence our daily behavior and decision-making in space, e.g. choosing which places to visit. In this case study, we are interested in extracting affective responses evoked by environments from social media data, particularly geotagged photos in Flickr.

According to the observation of Kisilevich et al. (2010), the language pattern adjective-noun is the simplest and most popular example in English language to describe the characteristics of an object. For example, "a beautiful place" and "a dirty street". Therefore, to extract affective responses to environments from geotagged photos in Flickr, we propose a lexicon-based sentiment analysis method. Firstly, for each geotagged photo, we use Stanford CoreNLP 1.3.4 library to tokenize, split, and lemmatise its title and description. A part-of-speech (POS) tagging process is also applied. Results of these steps are a list of words and their lexical category (e.g., noun, verb and adjective). Secondly, we extract adjective-noun sets, such as "interesting building". Again, Stanford CoreNLP library is applied. Results of this step is a list of adjective-noun sets. Thirdly, we filter out adjective-noun sets that are not place-related. To achieve this aim, a list of place nouns is created, which consists of English place nouns (e.g., "building", "restaurant", ...) and study-area specific place-names from GeoNames (e.g., "Stephansdom", "Karlskirche"). Finally, for each adjective within the remaining adjective-noun sets, we check whether it is in the ANEW (Affective Norms for English Words) or AFINN (Finn Arup Nielsen's word list) affective lexicons. If yes, we assign the valence value to the photo. Otherwise, we use Java WordNet Library to get synonyms of the adjective, and check whether one of the synonyms is in the ANEW or AFFIN affective lexicons. If yes, the valence value is also assigned to the photo. For each photo, we then average all the valence values of its title and description, and assign the result as the valence value of this photo.

This method was applied to the Flickr photos uploaded for the city of Vienna (Austria) in the period of January 2007 and October 2011. We only focused on photos with geotags and English title/description.

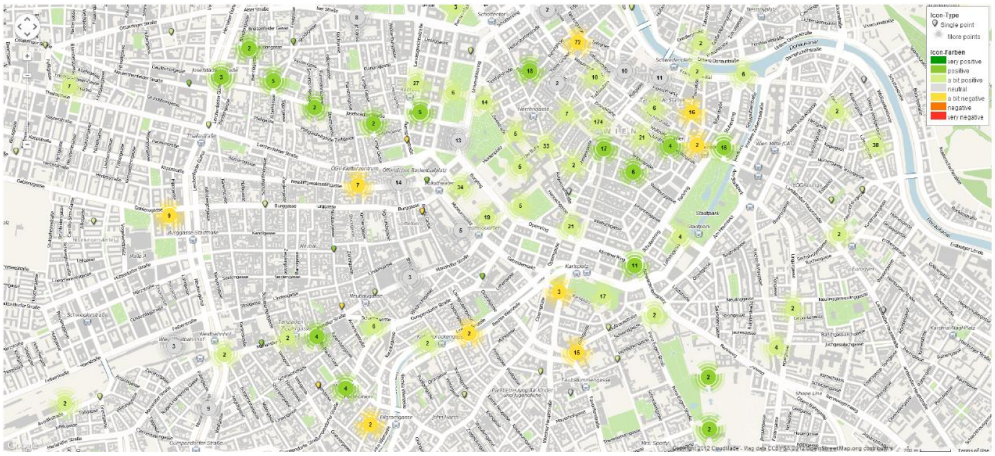

Figure 2. Affective responses to environments extracted from geotagged photos in Flickr (Map data: OpenStreetMap and Contributors, CCBY-SA). Colours of the markers indicate valence values of the responses, with green being very positive, gray being neutral, and red/yellow being very negative.

Figure 2 shows the results in a map view. As can be seen from the results, different places are connected with different affective responses. Some places (e.g. parks) are perceived as pleasant (positive valence), while some others (e.g. main roads with busy traffic) are perceived as rather negative (unpleasant). Therefore, it might be interesting to investigate the correlation between people's affective responses and the environmental characteristics of different places. More work should be done on this aspect.

4. Identifying Popular Landmarks in Vienna

This case study uses social media data to identify the landmarks people visited when travelling to a new city, and compares the popularity of different landmarks in summer and in winter. We understand landmarks as attractions and locations frequently visited by people. The knowledge acquired from visiting these landmarks can be considered as people's first knowledge (or the first mental image in their mind) of the new environment, and acts as anchor points for building other spatial knowledge (Maceachren 1991, Golledge 1999).

Similarly, we employ the heuristic rule proposed in De Choudhury et al. (2010) to remove photos from local residents. We then use the list of popular attractions provided by the Vienna Tourist Board (Wiener Tourismusverband) as potential or candidate landmarks. This list of attrac-

tions was compiled according to the ticket sale statistics of 2009[1]. We then associate a Flickr photo to a potential landmark *p* whenever *p* is the closest landmark to the photo, and it was taken within 100 meters of *p*. In line with Statistics Austria (http://www.statistik.at/), the period from May to October is defined as the summer season, while the rest as the winter season. After all these steps, we can order the popularity of different landmarks in both summer and winter. Figure 3 shows the results. Due to space restrictions, we only show the map view around the inner city. Therefore, some of the popular landmarks are not listed in the map view, such as "Schloss Schönbrunn" and "Donauturm".

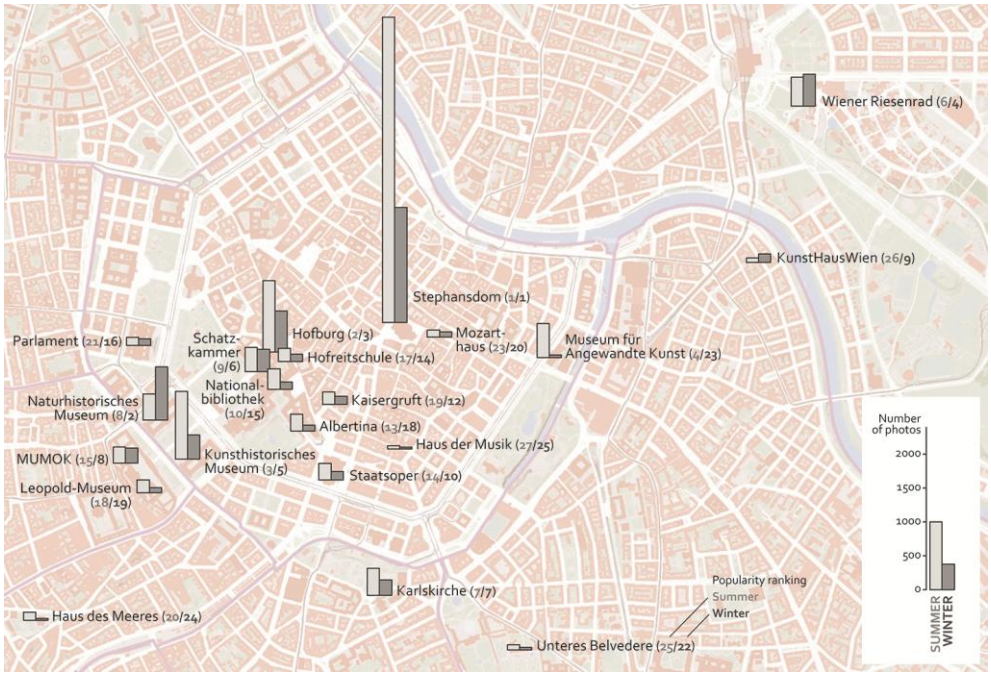

Figure 3. Popularity of landmarks in summer and in winter. The numbers attached to each landmark name denote the rankings of this landmark in summer and in winter.

Figure 3 shows that the popularity of landmarks in summer is different from that in winter. "Stephansdom" is ranked the first in both summer and winter. However, the relative orders of other landmarks differ a lot. For

[1] http://en.wikipedia.org/wiki/Tourist_attractions_in_Vienna

example, “Schloss Schönbrunn” is ranked as the fifth in summer, while as the 13th in winter. This is consistent with what we expected: Due to the weather differences of summer and winter, places tourists visited in summer might be very different from those visited in winter.

5. Summary and Challenges

This article proposed that social media data are a new and significant source for studying people’s perception and knowledge of environments. Results of the three case studies confirm this, and show that compared to the conventional methods such as empirical experiments and questionnaires which often use a small group of participants, analyzing social media data enables us to investigate these issues with large-scale studies.

Several challenges also exist when analyzing social media data, such as the digital divide (e.g., users of social media are certainly far from a representative sample of the public), poor data quality (e.g., lack of quality-ensuring mechanisms in social media platforms) and privacy. To address the above challenges, interdisciplinary approaches integrating methodologies of geography, environmental psychology, computer science and other related fields should be developed and applied.

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