Space Profile-based Reverse Geocoding Service using Cloud Platform

A case study of Tokyo Metropolitan Area

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***Abstract*— Reverse geocoding has raised potential privacy concerns, especially regarding the ability to reverse engineer geographical location to obtain the street address of an individual. In most cases, direct reference to the geography of the area mapped that elucidates sensitive information isn't of much interest than having the knowledge of what we can do or find there. Rather than raising a flag, this paper presents a design framework of the space profile-based reverse geocoding service that creates an abstract space on which explains the area characteristic as well as probable activities that individuals can be engaged in the area.**

Keywords: Reverse geocoding, Location based, Space profiles, GPS, Activity map

I. INTRODUCTION

Many popular web applications allow the user to type in an address to receive a map with a geocoded result. Geocoding enables the user to find a geographic coordinate on earth using a descriptive text, for example, a postal address, city name, or any other phrases referring to places on earth. Reverse geocoding, on the other hand, is the process of converting geographic coordinates into a human-readable address. However, a reverse geocoding result, such as town or city name doesn't say much about the characteristics of the place. In this paper we describe our on-going work on a web service that allow the user to reverse geocode and obtain the area profile.

A traditional reverse geocoding process, long conversion time and low conversion accuracy are the main issues. Tajima et al. [1] suggested the image-based conversion methods to pre-process the longitude and latitude into a color code. Xu et al. [2] utilized a cloud-based 25-node Hadoop cluster setup on Amazon AWS to geocode over one billion addresses. It was found that the processing time and cost were less than any of the commercial services.

At the forefront of emerging trends in social networking sites is the concept of "real-time web," in which many sites offer services that leverage the GPS in phones to create a location-based user experience [3]. To achieve this, there is an increasing use of geographic identifier in various domains and wide variety of disciplines, including public health, economics, ecology, and sociology [4]. Many popular sites use it to tag, cluster and find digital photo [5,6], perform business analytics [7], and many mapping applications can benefit tremendously from geo-tagging capabilities.

What is common to all existing services is that it typically advocates an ad-hoc reverse geocoding approach and none of them describes the reverse geocoded location as the context of geographical space. This work goes beyond the traditional concept and gives a new approach to identify the area characteristics, which can consequently be analyzed to benefit urban planning and business intelligence among a variety of operational and analytical dimensions.

II. SYSTEM ARCHITECTURE

A. Location information retrieval and space profile concept

This section presents a specific approach that was developed for space profile inference processes. First, we built an automatic geo-location collection framework using Google Places API (Fig. 1). The Google Places API is a service that returns a list of 'places' along with information about each place. The collected places were then clustered into 12 categories using predefined classes. Note that these 12 categories were derived from 96 original types according to the Radar Search Service (Table 1). The space profile was then inferred according to a collection of places that was statistically significant in the area.

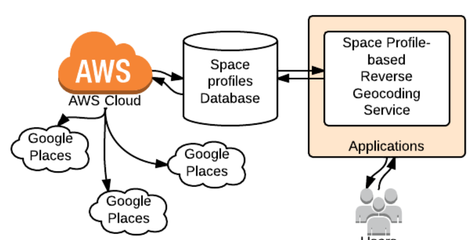

Figure 1. System architecture of space profile-based reverse geocoding service platform.

We build a modular reference system using 0.005-degree rectangular grids to represent real world space profiles. An initial location was chosen at latitude 90 and longitude 180, and then the remaining sampling locations were defined so that all locations were at regular intervals across the globe.

There is a limitation that the Google Places API Radar Search Service allows the user to search up to 200 places in each query. Therefore, in the dense urban area, the Radar Search would fail to return the entire places due to the over limit issue. To cope with this drawback, we calculated the road density as a proxy for dense and loose urban area. The total length of the street network in each predefined grid was used as the threshold parameter. For the dense area, the grid size was reduced to 0.0025-degrees in longitude and latitude. Due to the data availability of the area, more specifically, the availability of open street network data and places information in each country, a dynamic threshold is highly suggested for development of a more adaptive system.

B. *Cloud-based location profiling*

In our big data retrieval process, we used the Amazon AWS to create a simple web front-end to our queries. Our web application made RESTful calls to the Radar Search service which in turn used Java to invoke queries on the data to store in our application back-end. We broke the query into chunks of 1,000 requests per instance since this is the limitation of free service of Google places API per day. Each query process sent the query results back to analysis engine and returned place category as space profiles.

III. Service Application

The main contribution of our work is to demonstrate the feasibility and benefits of space profile-based reverse geocoding service. We built a web service application prototype based on the statistical results from Amazon AWS. The developed interface offers the user an easy way to access the query area from a map. It allows the users to select the country then city name from the drop down list. The application then connects to the cloud based location profiling to generate the space profiles. A snapshot of the service application is illustrated in Fig. 2.

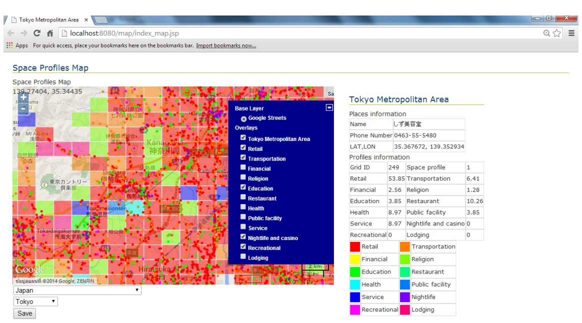

Figure 2. A snapshot of our developed web service application that provides the space profile-based reverse geocoding service. Nearly one million places were retrieved by our sytem to create space profile map (for Tokyo Metropolitan area).

The rectangular grids were shaded with 12 distinct colors to represent different space profiles, which can also be used to infer probable activities related to these categories that are likely to be engaged by people in the areas [8]. The reverse geocoding process was fired every time the mouse was clicked on the map canvas. The details information of the area, percentage of possible profile as well as the shop names and summary information were displayed on the information panel (Fig. 2).

IV. Conclusions

In this work-in-progress paper, we describe our approach in an ongoing research that suggests a unique opportunity to develop a global database of geographical space profiles in a cost-effective manner from the available online data, geo-referenced services, and cloud platform. The outcome of the development provides reverse geocoding capabilities not only the place names or address information but also the profiles, particularly fruitful paradigm for identifying space activities related to semantic meaning of the area.

TABLE I. Space Profiles

Category	*Space profiles*	*Types*
1	Retail	Food, liquor store, …
2	Transportation	Airport, subway station, …
3	Financial	Accounting, bank, …
4	Religion	Church, mosque, …
5	Education	School, university, …
6	Restaurant	Café, restaurant, …
7	Health	Hospital, dentist, …
8	Public facility	City hall, library, …
9	Services	Beauty salon, car wash, …
10	Nightlife	Bar, night club, …
11	Recreational	Bowling, aquarium, …
12	Lodging	Lodging, hotel, …

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References

[1] K. Tajima, K. Ando, K. Ohshima and M. Terada, “A high speed geocoding method for location-based service with coloring map images, ” Information Networking, 2009. ICOIN 2009. International Conference on , vol., no., pp.1,5, 21-24 Jan. 2009.

[2] S. Xu, S. Flexner, and V. Carvalho, “Geocoding Billions of Addresses: Toward a Spatial Record Linkage System with Big Data,” GIScience Big Data Age, no. 98004, 2012.

[3] N. Kumar, J. Chen, and D. Liang, “Reverse Geocoding–A New Method of Enumeration Listing,” Available at SSRN: http://ssrn.com/abstract=1808962

[4] A. Sashima, N. Izumi, K. Kurumatani, "Location-mediated Web services coordination in ubiquitous computing," Services Computing, 2004. (SCC 2004). vol. 109, no.114, pp.15-18 Sept. 2004.

[5] https://www.facebook.com/

[6] https://www.flickr.com/

[7] Y. Qu and J. Zhang, “Trade area analysis using user generated mobile location data,” Proc. the 22nd international conference on World Wide Web companion, pp. 1053–1063, 2013.

[8] S. Phithakkitnukoon, T. Horanont, G. Di Lorenzo, R. Shibasaki, C. Ratti, “Activity-Aware Map: Identifying Human Daily Activity Pattern using Mobile Phone Data,” Human Behavior Understanding, pp. 14-25, 2010.