Tutorial on Location-Based Social Networks

Yu Zheng
Microsoft Research Asia
Building 2, NO.5 Danling Street, Haidian District, Beijing 100080, P. R. China
yuzheng@microsoft.com

ABSTRACT
This paper is an abstract of a tutorial on location-based social networks (LBSNs), introducing the concept, unique features, and research philosophy of LBSNs. The slide deck of this tutorial can be found on http://research.microsoft.com/apps/pubs/?id=163521. The homepage of LBSN is http://research.microsoft.com/en-us/projects/lbsn/default.aspx.

Keywords
Location-based social networks, mobile social networks.

1. CONCEPTS AND DEFINITION
The advances in location-acquisition and mobile communication technologies empower people to use location data with existing online social networks in a variety of ways. People can upload location-tagged photos to Flickr, comment on an event at the exact place where the event is happening in Twitter, share their present location on Foursquare, record travel routes with GPS trajectories to share travel experiences in GeoLife [13][19], or log bicycle trails for sports analysis and experience sharing in Bikely.

The dimension of location helps bridge the gap between the physical world and online social networking services. For example, a user with a mobile phone can leave her comments with respect to a restaurant in an online social site (after finishing dinner) so that the people from her social structure can reference her comments when they later visit the restaurant. In this example, users create their own location-related stories in the physical world and browse other people's information as well. An online social site becomes a platform for facilitating the sharing and understanding of people's experiences.

Furthermore, people in an existing social network can expand their social structure with the new interdependency derived from their locations. As location is one of the most important components of user context, extensive knowledge about an individual's interests, behaviors, and relationships with others can be learned from her locations [2][11]. For instance, people who enjoy the same restaurant can connect with each other. Individuals constantly hiking the same mountain can be put in contact with each other to share their travel experiences.

These kinds of location-embedded and location-driven social structures are known as location-based social networks, formally defined as follows [9][20]:

A location-based social network (LBSN) does not only mean adding a location to an existing social network so that people in the social structure can share location-embedded information, but also consists of the new social structure made up of individuals connected by the interdependency derived from their locations in the physical world as well as their location-tagged media content, such as photos, video, and texts. Here, the physical location consists of the instant location of an individual at a given timestamp and the location history that an individual has accumulated in a certain period. Further, the interdependency includes not only that two persons co-occur in the same physical location or share similar location histories but also the knowledge, e.g., common interests, behavior, and activities, inferred from an individual's location (history) and location-tagged data.

WWW 2012, April 16–20, 2012, Lyon, France.
ACM 978-1-4503-1229-5/12/04.

2. RESEARCH PHILOSOPHY OF LBSN
The second part of the tutorial discusses the research philosophy of LBSNs from the perspective of users and locations, and analyzes the unique features of LBSNs beyond traditional social networks.

User and location are two major subjects closely associated with each other in a location-based social network. As illustrated in Figure 1, users visit some locations in the physical world, leaving their location histories and generating location-tagged media content. If we connect these locations chronologically, a trajectory will be formulated for each user. Based on these trajectories, we can build three graphs: a location-location graph, a user-location graph, and a user-user graph. Based on the three graphs, we can understand users and locations respectively, and explore the relationship between them. Though the research topics are listed individually from the perspective of users and locations as follows, these two subjects have a mutually reinforcing relationship that cannot be studied alone. In summary, the research points include the following three folds:

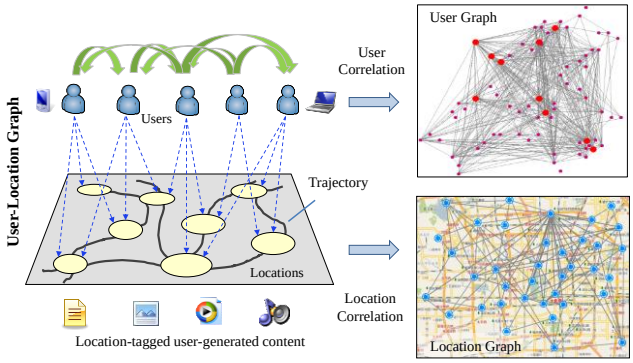

Figure 1: Research philosophy of location-based social networks

- Understanding users based upon their locations, for example, estimating user similarity according to their location history, finding local experts in a region, and community discovery.
- Understanding locations via user mobility. One is generic travel recommendations including mining the most interesting locations, Itinerary planning, and location-activity recommender. The other is personalized travel

recommendations comprised of user-based and location-based collaborative filtering.

- Events discovery from social media, for instance, anomalous events like a natural disaster or a celebration.

Actually, the problems that traditional social networks have exist in location-based social networks, and become more challenging due to the following reasons:

- The graph representing a location-based social network is heterogeneous, consisting of at least two types of nodes (user and location) and three kinds of links (user-user, location-location, and user-location).
- Location-based social networks are constantly evolving at a faster pace than traditional social networks, in both social structure and properties of nodes and links.
- A location has unique features beyond that of other objects in a social network. Besides general linking relationship between locations, the hierarchical and sequential properties of locations are unique.

3. REPRESENTATIVE RESEARCH

The third part of the tutorial presents some representative research publications with a proper balance between coverage and depth. The major content is from the chapter 8 and 9 of the book [20].

One set of research publications focuses on understanding users in terms of their location histories. It starts from modeling the location history of an individual using the individual's geo-data such as GPS trajectories or check-in records, following the paradigm of "sensor data → geospatial locations (significant places) →semantic meanings (e.g., restaurants)" [2][6]. Then, the solutions for estimating the similarity between two different users according to their location histories in geographic [2] and semantic spaces [4][5] are introduced respectively. The inferred similarity represents the strength of connection between two users in a location-based social network, and can enable friend recommendations [16] and community discovery.

The other set of publications is about understanding locations by incorporating user mobility. The first is mining the most interesting locations, travel experts, and travel sequences in a city using user-generated GPS trajectories [14]. The second is some trip planning and itinerary recommendation literatures [3][7][8]. The third is a location-activity recommender that provides a user with two types of recommendations [10][17][18]: 1) The most popular activities that can be performed in a given location and 2) the most popular locations for conducting a given activity. The above three types of work are generic recommendations.

Regarding the personalized recommendation, the tutorial presents a variety of ways to enable a personalized location recommender system. This recommender starts with a user-based collaborative filtering using the user similarity inferred from their location histories [16]. This model is able to accurately model an individual's behavior, however, suffering from the increasing scale of users in a real system. To address this issue, location-based collaborative filtering is proposed further [12][15]. The model feeds the correlation learnt from user location history into an item-based CF model, having a similar effectiveness to and a much better efficiency and scalability than the user-based method.

The tutorial also introduces the books [20], conferences, and workshops (e. g, LBSN 2011 [1]) related to this research theme. Two free datasets that can be used for LBSN research are placed on http://research.microsoft.com/en-us/projects/lbsn/default.aspx.

4. CONCLUSION

LBSN is a fertile field to explore, having many interesting but challenging research problems and unprecedented wealth of knowledge about people and locations.

5. REFERENCES

[1] C. S. Jensen, W.C. Lee, Y. Zheng, M. F. Mokbel. Proceeding of the 3rd ACM SIGSPATIAL International Workshop on Location-Based Social Networks. 2011.

[2] Q. Li, Y. Zheng, X. Xie, and W.-Y. Ma, Mining user similarity based on location history, in ACM SIGSPATIAL GIS 2008, ACM.

[3] H. Liu, L.-Y. Wei, Y. Zheng, M. Schneider, W.-C. Peng, Route Discovery from Mining Uncertain Trajectories. In ICDM 2011.

[4] X. Xiao, Y. Zheng, Q. Luo, X. Xie. Finding Similar Users Using Category-Based Location History. In Proc. of .ACM SIGSPATIAL GIS 2010.

[5] X. Xiao, Y. Zheng, Q. Luo, X. Xie. Inferring Social Ties between Users with Human Location History. Journal of Ambient Intelligence and Humanized Computing, 2012.

[6] Y. Ye, Y. Zheng, Y. Chen, J. Feng, X. Xie. Mining Individual Life Pattern Based on Location History. In proc. of MDM'09. IEEE.

[7] H. Yoon, Y. Zheng, X. Xie, W. Woo. Smart Itinerary Recommendation based on User-Generated GPS Trajectories. In Proc. UIC 2010.

[8] H. Yoon, Y. Zheng, X. Xie, and W. Woo, Social Itinerary Recommendation from User-generated Digital Trails, in Personal and Ubiquitous Computing, Springer Verlag, 2011.

[9] Y. Zheng. Location-based social networks: users. In Computing with Spatial Trajectories. Y. Zheng and X. Zhou, Eds. Springer 2011. ISBN: 978-1-4614-1628-9.

[10] V. W. Zheng, B. Cao, Y. Zheng, X. Xie, and Q. Yang, Collaborative Filtering Meets Mobile Recommendation: A User-centered Approach, in AAAI 2010, ACM. 2010

[11] Y. Zheng, Q. Li, Y. Chen, X. Xie, W.-Y. Ma. Understanding Mobility Based on GPS Data. In Proc. of UbiComp'08, ACM.

[12] Y. Zheng and X. Xie, Learning travel recommendations from user-generated GPS traces, in ACM Transaction on Intelligent Systems and Technology, ACM, January 2011.

[13] Y. Zheng, X. Xie, and W.-Y. Ma, GeoLife: A Collaborative Social Networking Service among User, location and trajectory, in IEEE Data(base) Engineering Bulletin, IEEE, June 2010

[14] Y. Zheng, X. Xie, and W.-Y. Ma, Mining Interesting Locations and Travel Sequences From GPS Trajectories, in WWW 2009, ACM.

[15] Y. Zheng, X. Xie. Learning Location Correlation from GPS trajectories. In proc. of MDM 2010, IEEE press. USA.

[16] Y. Zheng, L. Zhang, Z. Ma, X. Xie, and W.-Y. Ma, Recommending friends and locations based on individual location history, in ACM Transaction on the Web, ACM, 2011

[17] V. W. Zheng, Y. Zheng, X. Xie, and Q. Yang, Learning from GPS Data for Mobile Recommendation, in Artificial Intelligence Journal, Elsevier, April 2012

[18] V. W. Zheng, Y. Zheng, X. Xie, and Q. Yang, Collaborative Location and Activity Recommendations With GPS History Data, in Proc. of WWW 2010, ACM, 2010

[19] Y. Zheng, Y. Chen, X. Xie, W.-Y. Ma. GeoLife2.0: A Location-Based Social Networking Service. In proc. of MDM 2009, IEEE.

[20] Y. Zheng, X. Zhou, Computing with spatial trajectories. Springer 2011. ISBN: 978-1-4614-1628-9