Developing a Smart Service System to Enrich Bike Riders' Experience

Robin G Qiu, Youakim Badr, Jianling Wang, Shan Li

Developing a Smart Service System to Enrich Bike Riders' Experience

Robin G. Qiu[1,2,*], Youakim Badr[3], Jianling Wang[2], and Shan Li[2]

[1]Big Data Lab, Engineering Division, Penn State University, Malvern, U.S.A.

[2]NUAA-IBM Logistics and Service Science Lab, NUAA, Nanjing, China

[3] University of Lyon, CNRS, INSA-Lyon, LIRIS, UMR5205, F-69621, France

*Corresponding author

Keywords: Social sensing, big data, IoT, smart city, citibike, rider biking experience.

Abstract. Social sensing via mobile apps complements physical sensing (e.g., IoT) by substantially extending the horizon we know about our daily life in real time. This paper discusses how we can integrate physical and social sensing to enable better and smarter services, focusing on enriching riders' experience of using bike sharing services in New York City. We show how we real time collect, process, and model data on riders' profiles and mobility needs, and from citibike and social media. With the support of big data technologies, we conduct data integration and aggregation to develop a smart service system by focusing on meeting the needs of riders in real time. The developed prototype in support of city mobility management and operations reveals the great potential of providing riders enriched user experience.

Introduction

Cities have been evolving as socio-technical and digital service systems, in which people as active actors are the core of all city constituents. Typically, people do not care about how and where the products and services were made or enabled, by whom, and how delivered. But people surely care about whether their socio-psychological (i.e., in the social aspects of) and functional (i.e., in the technical aspects of) needs are met in a satisfactory manner [3, 4].

Regardless of being small and simple like a comfort control management system at home, or large and complex like a city's public transportation control and management system, a service system focuses on enabling and delivering services using all available means to realize respective values for both the service provider and the service consumer. Because a city is a service system on a large scale, it would not be sustainable unless intelligent city management and smart city services could be enabled to overcome the increasing urbanization pressures and challenges [5]. For example, city mobility services play an important role in city inhabitants' daily life. Smarter and greener city mobility services can thus substantially contribute to the process of improving sustainability of populous cities.

Physical sensing by relying on IoT and other various network-based sensors makes possible the collection, processing, and computing of a variety of physical and environmental data and information. Jin et al. [6] illustrate an information framework for developing IoT based smart city's information and communication technologies (ICT) applications. They particularly emphasize that the progress in social networking with the support of smartphone technology has enabled a new sensing paradigm, called participatory or social sensing [3, 4, 7]. Indeed, social sensing complements physical sensing by substantially extending the horizon we know about the world in a timely manner.

As for mobility management in a smart city, transporting city inhabitants by meeting their daily mobility needs is the city's ultimate goal. Operating public transportation systems in a safe, punctual, efficient, and cost-effective manner is essential. Nevertheless, to promote and enable smart and green mobility in cities plays an important role in making cities financially and environmentally sustainable. Over the years, we have witnessed that energy overconsumption and greenhouse gas emission have been the main culprits accelerating air pollutions in the cities. Hence, we have the responsibility to reduce our individual carbon footprint whenever possible. A smart and green city mobility example is to promote and encourage more people to ride on bikes [1].

For example, Citi Bike that was launched in May 2013 is an NYC bike share system or citibike. “On average, there were 50,763 rides per day in October [of 2016], with each bike used 5.36 times per day.” [2] With the help of the fast advanced mobile computing and telecommunication technologies, if bike riders’ mobility patterns, social interaction and activities, and service consuming behaviour and satisfaction can be captured, analyzed, and deciphered in real time, then bike sharing systems can be substantially enhanced in terms of meeting riders’ various expectations.

In this paper, we show how integrating physical and social sensing would help enable such smart bike riding services in the context of city mobility services. In Section 2, we explore how Big Data technologies can further enhance urban smart services and introduce our PSU-INSA smart city big data platform. Section 3 we illustrate the developed prototype platform with enabled service scenarios based New York’s Citi Bike program, focusing on considerably enriching riders’ experience. At last, we conclude our work and highlight future work.

Big Data Technologies to enhance Bike Sharing Service Systems

Physical sensing helps capture, understand, and build solutions to enhance services to meet customers’ functional needs. Social (or people-centric) sensing then help capture and interpret customers’ socio-psychological requirements, including daily social and work activities, interaction, behaviour, and attitudes [9]. Because of the availability of massive data, an array of advanced analytical methods and techniques come into being, making possible extracting insights from big data and understanding customers’ socio-psychological needs with previously unachievable levels of sophistication, accuracy, efficiency, and effectiveness [9]. In the context of operating and managing smart bike sharing services, Fig. 2 shows how a service system platform prototype that has been developed at Penn State can get smarter with the support of big data technologies.

In Citi Bike, citibike mobile apps based on physical object sensing can real time provide the needed information on the statuses of bike stations and the availabilities of bikes and docks at individual stations, which can help bike riders utilize bike sharing systems in an extremely convenient and efficient manner. As shown in Fig. 1, if riders’ activities, social interactions, and service consuming behaviours and attitudes in real time can also be well captured, then bike sharing systems can be enhanced, providing riders much richer experience than ever before.

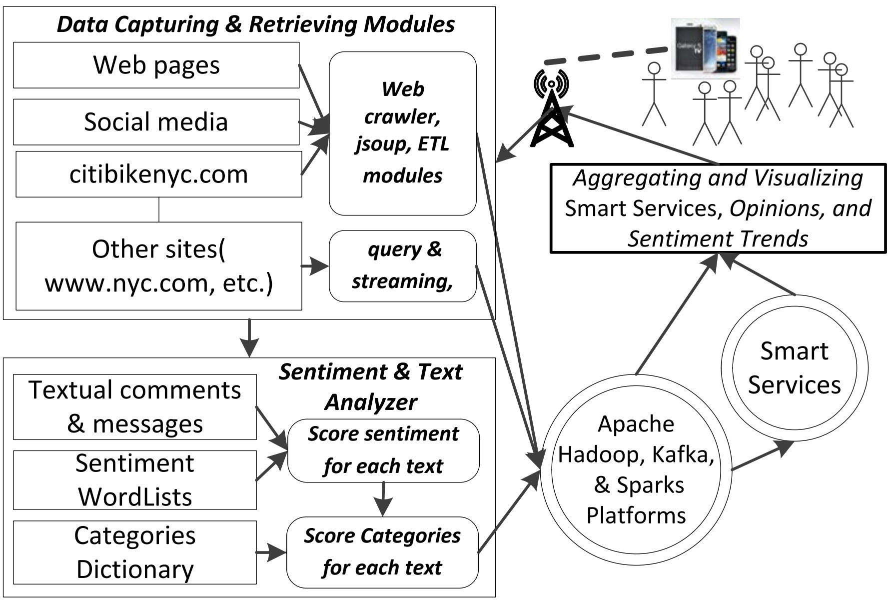

Figure 1. PSU-INSA big data platform prototype of enabling smart services [1]

Based on the citibike program, we have developed a big data platform prototype to test and validate the applicability of the proposed framework, enabling and supporting smart bike sharing services. As shown in Fig. 1, core computing components [1, 2] in support of smart bike sharing services are 1) data capturing and retrieving supports, 2) sentiment and text analyzer, 3) big data computing cluster platforms, 4) citizens' mobility smart services, and 5) visualization modules (please check out our demo website hosted by IBM Bluemix - http://pennstatetest.mybluemix.net/).

Service Scenarios to Show Enriched User Experience

Typically, to a bike rider, he/she is quite satisfied as long as he/she can get a good bike at the point of need or quickly return it once he/she arrives at his/her destination. To the service provider, in addition to maintaining stations and bikes well, bike rebalancing operations to maximally meet the needs of the bike availability across all bike stations is critical but challenging. According to citibike's monthly report in Oct. 2016 [2], Citi Bike staff rebalanced about 4000 bike daily. Preisler et al. [11] find that for a bike share system the number of empty stations is typically higher than the number of full stations despite the redistribution efforts that are already carried out.

Without question, both the empty and the full station problems should be addressed. Empty stations would result in "loss of sales and unsatisfaction" as bike riders could not get a bike at the point of need, while full stations would result in "unsatisfaction" as bike riders could not return a bike at his/her destination. In this paper, how to solve the empty stations problem will be explained. When the demand is switched from "bike" to "dock", the full station problem can be easily solved. In addition, typically a service provider can easily add capacities (i.e. docks) at stations. However, rebalancing bikes across a crowded and busy city is costly and extremely challenging.

From the perspective of enabling smart city mobility services, traditional analytic approaches work well with historical data. For example, New York City weather and citibike's daily trip and bike usage data for October, 2016 [2] can be easily analyzed using IBM SPSS Modeler [8] or other data mining tools. It is common sense that the better weather the more riders who used the citibike services. Note that riders are surely more interested in the real time availability information of bikes or docks at the point of need than their histories.

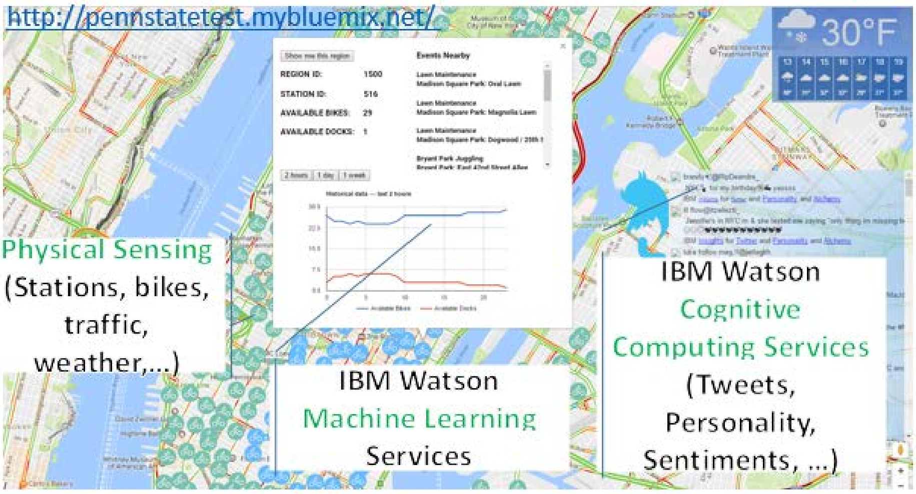

Figure 2. Services enhanced through real time cognitive computing and machine learning

To real time predict reliable new trends, behaviors and attitudes on a large scale, a big data based platform of collecting and aggregating real time, voluminous, and heterogeneous data from heterogeneous data sources should be developed. To enrich rider experience, for example, using a rider's location data or profile to predict the number of available bikes of nearby or preferred bike stations can be a very promising smart service. However, the availability of bikes or docks can be considerably impacted by daily events that are adjacent to the stations close to the rider. In general, varying with local weather, traffic, public transportations, on-going activities, and demographics, the demand on bikes or docks fluctuate, also changing very rapidly from time to time and location to location.

Fig. 2 highlights how integrating and aggregating physical and social sensing can be applied to such a big data based platform, which fully leverages the state-of-the-art network-based sensor and social media technologies. As illustrated in Fig. 2, physical sensing data include real time information on bikes, docks, and stations, local weather conditions, and traffic. Social sensing data includes daily events in New York City and relevant riders, city, and citibike program information in social media. As illustrated in Fig. 2, all heterogeneous data are streaming in real time. Streamed data are essentially integrated and aggregated as inputs into analytics modules using mathematical modelling with the support of IBM Watson cognitive computing services [10].

Let's explain how real time predicting the availability of bikes and docks for individual stations as one of citibike's smart service examples can be well enabled and supported in our PSU-INSA big data platform. A service scenario that surely enrich riders' experience is as follows:

- To a bike rider, at the point of need he/she has the confidence of getting a bike or returning his/her bike before the rider heads for a bike station he/she chooses (Fig. 3); If one station has a low number, the rider can easily pinpoint an adjacent station to make sure that sufficient bikes or docks are available before heading for the chosen station.
- To Citi Bike as the service provider, the deployed prediction model can be effectively applied to controlling and managing bike inventories in a timely manner (Fig. 3). The best scenario will be that either the number of bikes or the number of available docks at each station will be always maintained at the levels necessary for making riders happy and satisfactory (i.e., no need for a rider to looking around at the point of need).

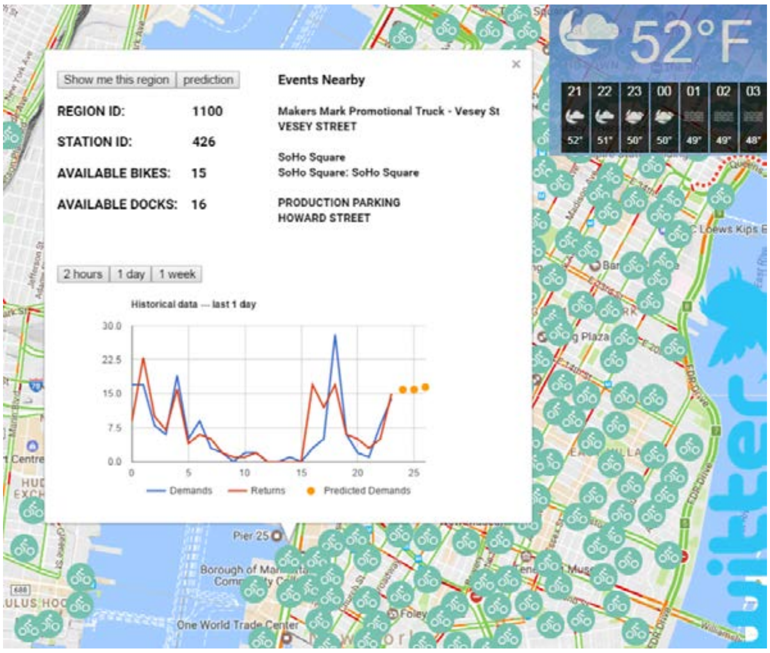

Figure 3. Machine learning in support of demand prediction

Furthermore, to enhance the above-discussed smart city mobility services, public opinions from social media, including twitter.com and facebook, can be aggregated and incorporated into our prediction modelling and enabling other intelligent services in real time, Citi Bike thus could know their customers and citizens' real issues and needs from time to time, so better and improved services could be developed as time goes. Promisingly, in the long run, by implementing effective service referrals and beneficial action resources for generating positive social changes, bike sharing systems can be made smarter and thus being utilized in a more effective and satisfactory manner, contributing to building healthy and strong cities.

Conclusions and Future Research Highlights

The intention of this paper is to show a framework for integrating physical and social sensing that facilitates enhancing and empowering service systems in general. In particular, we showed how PSU-INSA big data platform could be adopted in enhancing citibike mobility services in a smarter and greener manner. With the support of social interactions, citibike services are further enhanced, resulting significantly enriched riders' experience. In the future work we will further explore how to promote and develop crowd sensing or social sensing based platforms by capturing and deciphering the market trends and social dynamics in real time, so better policies or regulations could be proposed and implemented in influencing the public to promote the maximum use of a variety of environment-friendly transport modes including bikes and electric vehicles.

Acknowledgment

This work was done with great support and help from the Big Data Lab at Penn State and LIRIS at INSA-Lyon. The project of *Big Data Platform (Massive Data) for Proactive Analyses of Behaviors of Users in Urban Worlds* is financially supported by the Rhône-Alpes Region, France. This project was partially supported by IBM Faculty Award (RDP-Qiu2016) and IBM Grant (IBM-NUAA-SU: Customer Behaviour Analytics in Multi-channel Scenario) the Penn State Faculty Development Research Funds (*Building a Showcase for IoT/Big Data Based Smart Services* – 2016-17; *Building a Foundation to Showcase Potential of an IoT Based "Sense and Respond" Framework* – 2015-16).

References

[1] Qiu, R., Qiu, L., and Badr, Y., "Integrating physical and social sensing to enable smart city mobility services," *2016 IEEE INDIN*, France, July 18-21, 2016, pp. 909-915.

[2] Citi Bike, citibike services, https://www.citibikenyc.com/

[3] R.G. Qiu, "Computational thinking of service systems: dynamics and adaptiveness modeling," *Service Science*, vol. 1, no. 1, pp. 42-55, 2009.

[4] R.G. Qiu, *Service Science: The Foundations of Service Engineering and Management*. John Wiley & Sons, 2014.

[5] M. de Jong, S. Joss, D. Schraven, C. Zhan, and M. Weijnen, "Sustainable-smart-resilient-low carbon-eco-knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization," *Journal of Cleaner Production*, vol. 30, p.1-14, 2015.

[6] J. Jin, J. Gubbi, S. Marusic, and M. Palaniswami, "An information framework for creating a smart city through internet of things," *IEEE Internet of Things Journal*, vol. 1, no. 2, pp.112-121, 2014.

[7] J.A. Burke, D. Estrin, M. Hansen, A. Parker, N. Ramanathan, S. Reddy, and M.B. Srivastava, *Participatory Sensing*. Center for Embedded Network Sensing, 2006.

[8] IBM SPSS Modeler, https://www.ibm.com/us-en/marketplace/spss-modeler

[9] M. Schroeck, R. Shockley, J. Smart, D. Romero-Morales, and P. Tufano, "Analytics: The real-world use of big data," *IBM Global Business Services Business Analytics and Optimization Executive Report*, 2012

[10] IBM Bluemix, https://console.ng.bluemix.net/

[11] Preisler, T., Dethlefs,T., and Renz, W., "Self-organizing redistribution of bicycles in a bike-sharing system based on decentralized control." *Computer Science and Information Systems (FedCSIS), 2016 Federated Conference on*. IEEE, 2016.