Participatory Sensing for Improving Urban Mobility

Miguel Angel Ylizaliturri-Salcedo, Saul Delgadillo-Rodriguez,
J. Antonio Garcia-Macias, and Monica Tentori

Departamento de Ciencias de la Computación
Centro de Investigación Científica y de Educación Superior de Ensenada
Carretera Ensenada-Tijuana No. 3918,
Zona Playitas, C.P. 22860, Ensenada, B.C. México
{mylizali,sdelgadi,jagm,mtentori}@cicese.edu.mx

Abstract. Urban computing leverages mobile participatory and opportunistic sensing to monitor and provide continuous awareness of urban cities. CICESE Research Center offers students and staff an intra-campus transportation service called *CICEMóvil* to help them get around campus. However this service lacks of formality as trips are constantly being cancelled without previous notification and it's hard to discover when the vehicle is going to be available for the next trip. We present the design and development of a mobile augmented reality system using participatory and opportunistic sensing to empower users to track and share the location and status of *CICEMóvil* via their smartphones. We concluded discussing directions for future work, as we aim to study how participatory sensing could be used to promote self-reflection at a collective level through the design and evaluation of mobile sensing campaigns in public transportation.

Keywords: urban sensing, participatory sensing, smartphones, supervision, transportation, mobile applications.

1 Introduction

Participatory sensing has its origin in sensor networks showing how sensing has evolved from a paradigm centered in technologies to a one centered in people. Increasingly, individuals are using mobile devices to create "sensing campaigns" gathering, analyzing, and sharing knowledge. These campaigns empower individuals to reveal and share personal data about their lifestyle or environment status [1]. The deployment of sensing campaigns in urban areas, proving feasible the use of pervasive computing [2], enables the collective gathering of data and uses it as a monitoring tool to provide awareness and support decision-making at individual and collective levels.

An interesting area to study participatory sensing as a reflection tool in cities is the monitoring of public transportation. In [3] authors describe a combination of data from cell towers and GPS devices installed in buses and taxis to represent urban mobility captured in real-time. Urban mobility metrics include road congestion and pedestrian movement in Rome.

G. Urzaiz et al. (Eds.): UCAmI 2013, LNCS 8276, pp. 378–381, 2013.

As identifying bus arrival time is a concern from urban citizens, in [4] authors describe the use of smartphones passengers data to identify the location of cell towers and discover the routes of public transportation. This information is used to predict the waiting time for other users querying the system using their smartphones. Although, sensing campaigns have been widely used for monitoring road conditions (e.g., [5,6,7]) or providing continuous awareness [3,8] of "big data", little has been said about how individuals could use this data to reflect on their habits and change behavior at a collective level. In contrast with the literature in this area, in this paper we study how participatory sensing could be used to promote self-reflection in a concrete scenario of public transportation.

2 System Design and Implementation

The research center CICESE implemented a local transportation service called *CICEMóvil* consist in a small shuttle van with 7 passenger seats, working every weekday from 8:00 to 15:00 hrs, transporting students and staff around campus. However, there isn't a formal schedule and it is very hard to plan trips with this service. The driver usually takes long breaks and suspends the service without public notification. This system aims to supervise the driver's behavior, but more importantly to make the driver aware on his data and promote behavior change trough reflection.

Following an interactive user-centered design methodology we iteratively designed several low-fidelity prototypes and design scenarios envisioning how participatory sensing could help to both monitor *CICEMóvil* and promote self-reflection.

2.1 Architecture

The system has an architecture similar to [4] composed by three elements (Figure 1). One of the advantages of our approach is the simplicity of implementation, allowing to instrument vehicles at a low cost.

- **Monitor.** This is a mobile application for Android smartphones that allows sensing location and speed of the *CICEMóvil* trough GPS, and its proximity to known Wi-Fi hotspots placed throughout the campus, sending data to a cloud server. Monitor shows a map of the campus and the current location of *CICEMóvil* (Figure 2 a), and also offers the option of sending an "away" notification (Figure 2 b).
- **Visor.** This augmented reality application for Android smartphones shows the information about prominent landmarks within the campus, and other available services, like transportation (Figure 2 c). When requested, a screen with more details and a request service button are presented (Figure 2 d)
- **Application Server.** This server application has been deployed and hosted in the Heroku cloud. It offers a RESTful representation of the resources (*i.e.,* location of the vehicle, driver notifications and users requests of service), working as a proxy between both smartphone applications.

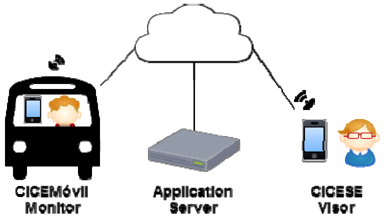

Fig. 1. System components

2.2 Use Scenario

Luis is the driver of the *CICEMóvil*. When he starts his journey, the Monitor starts running in a smartphone. As he gets into the vehicle, the application shows a map with the current location of *CICEMóvil*, making him aware of what data is being shared. Later, after driving for two hours, Luis needs to take a break, and decides to stop the vehicle. He then selects the notification icon on top of the map, and a screen for publishing an "away" notification appears. He announces that the service is suspended for 15 minutes. After 20 minutes, Rosa, a student using the augmented reality visor application searches for the *CICEMóvil* and identifies its location, noticing that the vehicle is already late; that's why she announces her request of service pressing a Request Stop button in the application. Luis gets a notification and he realizes that he's already late because there are some students waiting for transportation and gets back to work.

3 Future Work

We conducted a proof of concept using both applications touring the circuit as a passenger inside the *CICEMóvil*. This prototype is going to be scaled into production, following some technical adaptations. This Visor augmented reality application works well but it's limited to Android devices, in consequence a mobile website is also going to be deployed. More interesting it's to explore how this community campaign could promote a change behavior in the driver as the users employing their own smartphones are empowered to demand availability change in the quality of the transportation service.

More important to remark, this work is also our first approach to monitoring transport services. Our investigation is aimed to include a service with multiple vehicles, willing to detect which are the habits of a driver that can be sensed, in consequence the driver's application is going to get more important as it can work as a window into collective data (i.e. the statistics of the other drivers and their personal behaviors) in order to reinforce and to promote the adoption of better driving practices.

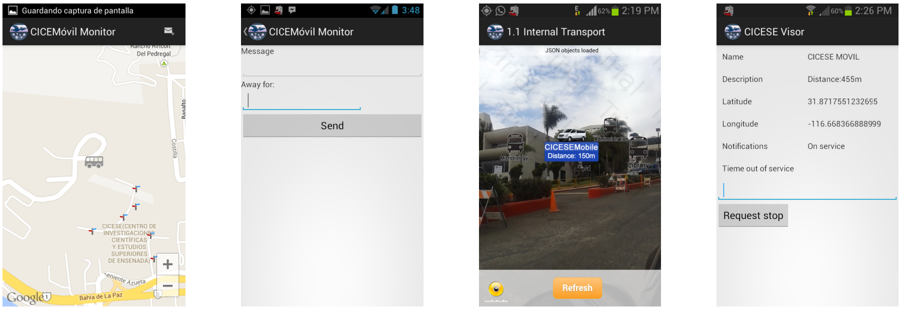

Fig. 2. From left to rigth: a) Monitor showing the location of CICEMóvil, b) Monitor screen for sending away notifications, c) Visor main screen showing the augmented reality view and d) Visor screen for details about CICEMóvil

4 Conclusions

A system composed by two Android smartphone applications and a web server has been developed and tested as concept. Our approach shows a simple and economic way to monitor vehicles in confined environments. More important, it's the precedent for our future investigation in exploring ways to employ participatory sensing as a tool for improving urban mobility and how to persuade and promote better driving behaviors. Our future work aims to reach an evaluation in a public transportation system and to use the produced data as constructs of the pulse of the city.

References

1. Burke, J.A., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., Srivastava, M.B.: Participatory sensing (May 2006)
2. Cuff, D., Hansen, M., Kang, J.: Urban sensing. Communications of the ACM 51(3), 24–33 (2008)
3. Calabrese, F., Colonna, M., Lovisolo, P., Parata, D., Ratti, C.: Real-Time Urban Monitoring Using Cell Phones: A Case Study in Rome. IEEE Transactions on Intelligent Transportation System 12(1), 141–151 (2011)
4. Zhou, P., Zheng, Y., Li, M.: How long to wait? In: Proceedings of the 10th International Conference on Mobile Systems, Applications, and Services, MobiSys 2012, p. 379 (2012)
5. Mohan, P., Padmanabhan, V.N., Ramjee, R.: Nericell. In: Proceedings of the 6th ACM Conference on Embedded Network Sensor Systems, SenSys 2008, p. 323 (2008)
6. Bhoraskar, R., Vankadhara, N., Raman, B., Kulkarni, P.: Wolverine: Traffic and road condition estimation using smartphone sensors. In: 2012 Fourth International Conference on Communication Systems and Networks (COMSNETS 2012), pp. 1–6 (January 2012)
7. Yoon, J., Noble, B., Liu, M.: Surface street traffic estimation. In: Proceedings of the 5th International Conference on Mobile Systems, Applications and Services, MobiSys 2007, p. 220 (2007)
8. Zheng, Y., Liu, Y., Yuan, J., Xie, X.: Urban computing with taxicabs. In: Proceedings of the 13th International Conference on Ubiquitous Computing, UbiComp 2011, p. 89 (2011)