PathS: Enhancing Geographical Maps with Environmental Sensed Data

Armir Bujari
Department of Mathematics
University of Padua
Padua, Italy
abujari@math.unipd.it

Matteo Ciman
Department of Mathematics
University of Padua
Padua, Italy
mciman@math.unipd.it

Ombretta Gaggi
Department of Mathematics
University of Padua
Padua, Italy
gaggi@math.unipd.it

Gustavo Marfia
Department of Computer Science
University of Bologna
Bologna, Italy
gustavo.marfia@unibo.it

Claudio E. Palazzi*
Department of Mathematics
University of Padua
Padua, Italy
cpalazzi@math.unipd.it

ABSTRACT

The widespread adoption of mobile technology has opened the door to a new era for the public health sector. The ability to collect, share and access community health related data are key factors that have made mobile health an appealing addon to medicine practitioners and researchers. Mobile sensing and wireless communications can be exploited to create new information and services that could help prevent health risks, benefiting the community as a whole. As a proof of concept, we have developed an augmented reality application offering an enhanced pedestrian route navigation system, while at the same time gathering quality data through the devices. Thanks to this application we are able to enrich geographical maps on the web with historical data about brightness and noise levels, and to provide pedestrians with an improved navigation.

Categories and Subject Descriptors

H.3.5 [**Information Storage and Retrieval**]: Online Information Services - data sharing, web-based services

General Terms

Experimentation, Human Factors, Measurement

Keywords

Health, Human Factors, Mobile, Navigation.

*Corresponding author

MobileHealth'15, June 22-25, 2015, Hangzhou, China
 ISBN 978-1-4503-3525-6/15/06 ...$15.00
DOI: http://dx.doi.org/10.1145/2757290.2757292.

1. INTRODUCTION

In our daily routines we are subject to a variety of phenomena that could have a slow progressive impact in deteriorating our health. Exposure to periodic loud noise can create physical and psychological stress, interfere with communication and concentration, and contribute to hearing impairments. Continous sunlight exposure or the lack thereof could cause skin cancer or vitamin D defficiency both severily impacting our health. A lot of research efforts have been devoted to addressing these and other environmental risks; however, with the advent of mobile and wireless technology many new complementary possibilities have arisen [10].

Mobile technology is becoming more and more pervasive; device sensors can be monitored in a manner transparent to the user, thus collecting information about the environment, e.g., brightness, noise, GPS position [15], accessibility, etc., or the user, e.g., physical activity, stress condition, etc. [12, 2, 14]. All these data can be exploited to generate new content on the Web giving rise to enhanced information and services which could help prevent unnecessary exposures to risks.

This is indeed called the *Web Squared* (or Web^2) era, since the amount of available information collected by sensors, in an autonomous and distributed way, grows exponentially with respect to data actively generated by users in Web 2.0 [9, 11]. In this context, the contribution of our work is *PathS*, i.e., Path Squared, a project aimed to provide pedestrians with an Augmented Reality (AR) navigation service while collecting data about brightness and noise levels. These data are then used to enrich geographical maps on the web (e.g., Google Maps) with historical values about these parameters and guide pedestrian route generation. The objective is to provide the end user with an attractive, enhanced route generation solution that transparently senses the sorrounding environments while the smartphone is handheld, thus collecting unbiased and more reliable data.

The rest of the paper is organized as follows: in Sec. 2 we discuss related works similar in spirit to our goals. In Sec. 3 we describe the functional components of the application outlining their overall *modus operandi.* Next, in Sec. 4 we provide some preliminary results obtained from a data sensing campaign undertaken in Padua, Italy. In Sec. 5 concluding remarks are discussed and future research directions are outlined.

2. RELATED WORKS

The pervasive coverage of mobile sesing technology and the ubiquity of network connectivity are key factors that have boosted the capability to acquire and monitor data regarding the environment we are immersed in. The people-centric sensing paradigm has been around for some years and many research effort has been devoted ranging from algorithms and techniques proposed to measure specific environmental properties to hierachical system architectures and communication paradigms [5, 3].

In [1] the authors describe an application that determines pollution exposure indexes for people carrying mobile devices. The authors in [4] propose a pattern recognition method employing smartphones that could transparently and automatically detect crossroads accessible to blind people.

Aram *et al.* [13] propose a system for data acquisition using smartphones and speciailized sensors. In particular, they show how it is possible to acquire temperature and humidity values using low cost sensors and how these data could be forwarded through Bluetooth connectivity to a smartphone. In this way, it is possible to monitor conditions about a room or a particular environment, and alert when specific unhealthy conditions are reached.

PRISM [6] is a framework that supports the participatory data acquisition of environmental data using off the shelf mobile device. This framework provides both an infrastructural component that orchestrates the mobile nodes participating in the data acquisition process, and a mobile component deployed on smartphones that automatically collects data from the environment.

Benjamin Gotow *et al.* in [7] explore the challenges faced when developing Augmented Reality (AR) applications for smarpthones. They investigate and tackle three main problems: data acquisition, i.e. how to manage raw data coming from smartphone sensor, the implementation of the *magic lens* that adds the overlay to the simple underlying environment, and finally how to fetch the points of interest from an online server.

Kanhere in [8] presents several future research directions for data acquisition using smartphones in urban environments. For example, using GPS sensor, a real-time map of traffic jam in cities could be developed, analyzing moving patterns and building traffic statistics. Alternatively, audio samples of streets could be collected by pedestrians to generate a noise map.

PathS objective is to provide end-users with an attractive, enhanced route guidance system while at the same time transparently gathering environmental data. These data could be then exploited by the system to provide users with alternate route options depending on their preferences and needs.

3. THE PATHS PROJECT

PathS is a complex system that gathers environmental data from smartphone sensors and uses them to provide new Web services such as heatmaps about specific urban parameters that could aid end-users in chosing their path based

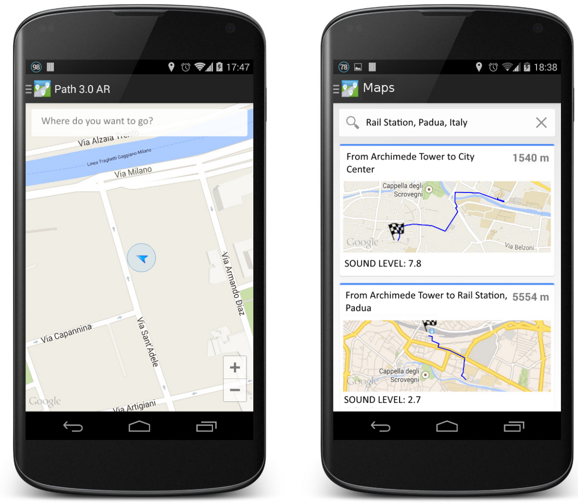


Figure 1: *PathS* screenshots with destination/route search.

on preferred criteria. Clearly, these data can also be used for many other purposes, including but not limited to planning smart city development. To this end, let us consider a person that has to walk between two locations at a certain time. The Google Maps service (as well as other similar ones) suggests routes generally based on either the shortest or the fastest path. However, a user could prefer less polluted and noisy routes or more shadowy routes in hotter days over the shortest ones. In the general case the user should be presented with the possibility to select a weighted combination of the available criterias and the system presents a ranked list of available paths and their characteristics.

To be effective, *PathS* needs a smart way to gather the data, possibly with no (or very limited) human intervention. Furthermore, collected data should be of good quality; this means that if we consider brightness or noise, the sensor (the smartphone) should be exposed to the phenomena. Once having the data, we also want to be able to offer a web service to users and municipalities. To this end, we have already developed a Google Maps based service that enriches maps with historical values about sensed data.

3.1 Data Acquisition

The first component of the system is intended for data acquisition and for this we have developed a smartphone application for the Android platform. Our application acquires information using the sensors about environmental light (through the light sensor) and noise (through the microphone). Clearly, light and noise data would result inaccurate with the smartphone hidden in a pocket, or a purse, as the actual values of brightness and noise would be significantly underestimated.

To address this, we have embedded the data sensing functionality into an Augmented Reality (AR) application for pedestrian navigation and Points of Interest (POIs) display. In this way, we incentivize the user to have the smartphone in his hand while walking around, which is perfect for our purpose. Clearly, the user is informed by an initial disclaimer about the anonymous data sensing that will be performed. Every time environmental data are acquired, a GPS location is attached. Once collected, the data are sent to the server that is responsible for staging and processing them.

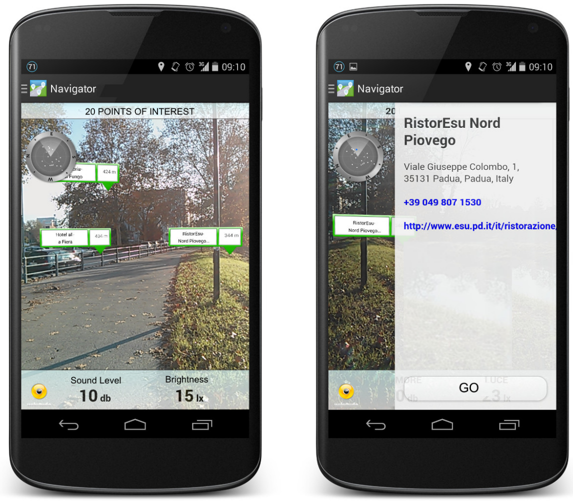


Figure 2: *PathS* pedestrian navigation mode.

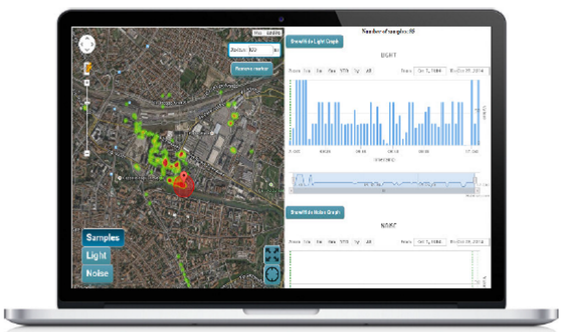


Figure 3: Web heatmap service visualizing collected data.

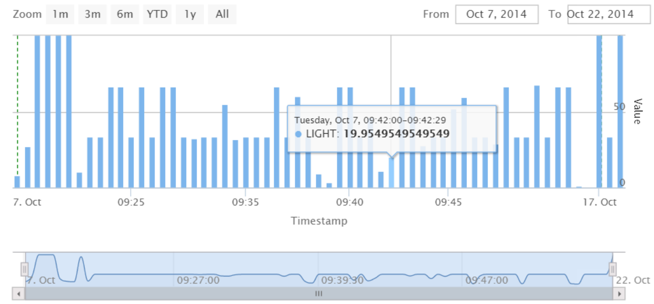
When starting the application, a Google Map view is offered to the user (Figure 1, leftmost screenshot). The user has to enter a destination in the address bar, which is then sent to the server. The server will then send back a list of possible routes (Figure 1, rightmost screenshot) including the classic shortest one and alternative routes that consider users' preferences (dedicated menu) in terms of brightness/shadow and noise. By tapping on one of the listed routes, it is possible to open the AR navigation view.

3.2 Pedestrian Navigation

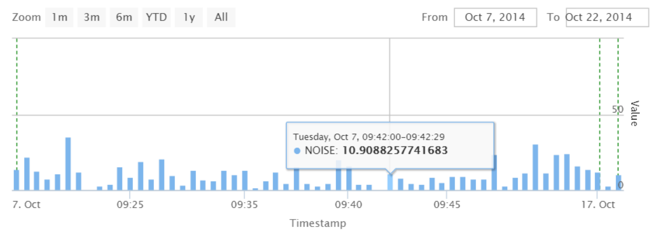
In pedestrian navigation mode, a user can be lead toward a destination by means of both textual and graphical instructions, the latter shown in AR thanks to the Wikitude library. As reported in Figure 2, the user can also choose to superimpose on screen POIs related to specific topics (e.g., bars, attractions, events) and by clicking on them a panel will appear describing related information and providing interaction modalities (e.g., opening a web site, dialing a phone number).

3.3 Data Presentation on the Web

Collected data about brightness and noise can also be made available on the web (transferred in JSON from the PathS server) so as to let citizens and municipalities to aware of the different values of these parameters recorded in different days, hours and locations. In Figure 3 we report an example of the data collected in Padua, Italy, during a trial we performed, showing values in a heatmap style made available by Google APIs. By clicking on a specific point in the map, histograms (Highcharts library) with detailed information and data evolution over time related to the chosen location are shown. Clearly, the amount of data available depends on the popularity of our application.



(a) Light



(b) Noise

Figure 4: Web heatmap service visualizing collected data.

4. PRELIMINARY RESULTS

Figure 4 shows the histograms for brightness and noise levels acquired through PathS in the sorroundings of the Department of Mathematics in Padua, Italy. The results shown belong to an on-going larger sensing campaign involving students of the bachelor courses.

Through a dedicated configuration menu the user can customize the behaviour of the sensing module by specifying the sampling frequency and duration (e.g., sound recordings). Once the data is acquired it is locally processed and ready to be fetched to a remote server. The application could be configured to deferr cellular connectivity for data communication and prefer open cost-less wireless access points for this matter.

The raw data corresponding to the charts have been collected on four parallel and independent measurements. The sampling frequency depends on the sensor; the component monitoring the light sensor is configured to sample data every 100 m while the microphone is accessed every 60 seconds of the trial. The bars show the average value between the measurements every 10 minutes of time lapse.

5. CONCLUSION AND FUTURE WORKS

We have developed an augmented reality application for pedestrian navigation in order to gather quality environmental data from smartphones and enhance pedestrian route generation. Coupled with the application we have designed a web service providing a heatmap of collected historical values about brightness and noise levels.

We plan to extend this work including information about traffic, pollution and accessibility. We also plan to exploit multiple ways to collect these data, including smartwatches, social networks and applications. An improved version of Google Maps able to generate custom routes depending on users' needs (also considering disabilities) and preferences is already under development.

ACKNOWLEDGEMENTS

Partial financial support for this work is provided by the University of Padua PRAT 2013, CPDA137314. The authors wish to thank Stefano Tombolini and Tobia Zorzan for their contributions to the project.

6. REFERENCES

[1] E. Agapie, G. Chen, D. Houston, and E. H. et. al. Seeing our signals: Combining location traces and web-based models for personal discovery. In *Proceedings of the Workshop on Mobile Computing Systems and Applications*, pages 6–10, New York, NY, USA, 2008. ACM.

[2] F. Aiolli, M. Ciman, M. Donini, and O. Gaggi. A serious game to persuade people to use stairs. In *Proceedings of Persuasive 2014*, May 2014.

[3] A. Bujari. A survey of opportunistic data gathering and dissemination techniques. In *Proceedings of IEEE International Conference on Computer Communications and Networks (ICCCN)*, pages 1–6, July 2012.

[4] A. Bujari, B. Licar, and C. E. Palazzi. Movement pattern recognition through smartphoneâĂŹs accelerometer. In *Proceedings of IEEE Communications and Networking Conference (CCNC)*, 2012.

[5] A. T. Campbell, S. Eisenman, N. Lane, E. Miluzzo, and R. Peterson. People-centric urban sensing. In *Proceedings of the Annual International Workshop on Wireless Internet*, New York, NY, USA, 2006. ACM.

[6] T. Das, P. Mohan, V. N. Padmanabhan, R. Ramjee, and A. Sharma. Prism: Platform for remote sensing using smartphones. In *Proceedings of the International Conference on Mobile Systems, Applications, and Services*, pages 63–76, 2010.

[7] J. Gotow, K. Zienkiewicz, J. White, and D. C. Schmidt. Addressing challenges with augmented reality applications on smartphones. In *Mobile Wireless Middleware, Operating Systems, and Applications*, volume 48 of *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, pages 129–143. 2010.

[8] S. S. Kanhere. Participatory sensing: Crowdsourcing data from mobile smartphones in urban spaces. In *Proceedings of IEEE International Conference on Mobile Data Management (MDM)*, pages 3–6, June 2011.

[9] T. O´Reilly and J. Battelle. Web squared: Web 2.0 five years on. April 2014.

[10] W. H. Organization. mhealth. new horizons for health through mobile technologies. Technical report, 2011.

[11] C. E. Palazzi, G. Marfia, and M. Roccetti. Combining web squared and serious games for crossroad accessibility. In *Proceedings of IEEE International Conference on Serious Games and Applications for Health (SeGAH)*, pages 174–186, New York, NY, USA, 2011. ACM.

[12] C. E. Palazzi, L. Teodori, and M. Roccetti. Path 2.0: A participatory system for the generation of accessible routes. In *Proceedings of IEEE International Conference on Multimedia and Expo (ICME)*, pages 1707–1711, July 2010.

[13] E. G. Pasero, A. Troiano, and E. Pasero. Environment sensing using smartphone. In *Proceedings of IEEE Sensors Applications Symposium (SAS)*, pages 1–4, Feb 2012.

[14] H. Wang, D. Lymberopoulos, and J. Liu. Local business ambience characterization through mobile audio sensing. In *Proceedings of WWW*, April 2014.

[15] Y. Zheng, X. Xie, and W. Ma. Geolife: A collaborative social networking service among user, location and trajectory. *IEEE Data Eng. Bull.*, 33(2):32–39, June 2010.