PathS: Enhancing Geographical Maps with Environmental Sensed Data

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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 (mHealth) 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

Theory

Keywords

Health, Human Factors, Mobile, Navigation.

1. INTRODUCTION

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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 vitamine D defficiency both severily impacting our health. A lot of research effort has been devoted to addressing these and other environmental risks, however, with the rise and advent of mobile and wireless technology many new complementary possibilities have come into spur [12].

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. [4, 7, 8]. 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 [11, 3]. In this context, we propose and discuss *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 rest of the paper is organized as follows: in Sec. 2 we discuss realted 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. Section 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 our 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 [1, 2].

In [5] the authors describe an application that determines pollution exposure indexes for people carrying mobile devices. A microblogging service is discussed in [13] that uses mobile devices to record multimedia content *in-situ* and shares this content in real-time.

Aram *et al.* [6] 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 costs sensors, and in turn exploit Bluetooth connectivity to forward this data to a smartphone. In this way, it is possible to use data to monitor conditions about a room or a particular environment, and alert when particular unhealthy conditions are reached.

PRISM [14] 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 to be used with the smartphones that automatically collects data from the environment.

Benjamin Gotow *et al.* in [9] explore the challenges once faces 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 and catch the points of interest from an online server.

Kanhere in [10] presented several research future directions for data acquisition using user 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. This data could be in turn 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 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.

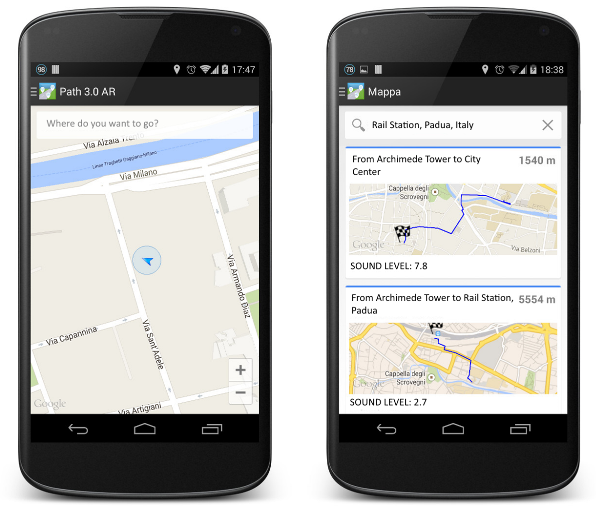

Figure 1: *PathS* screenshots with destination/route search.

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

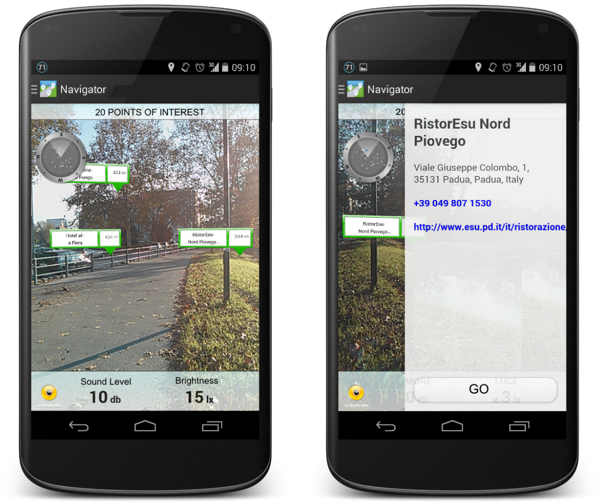

Figure 2: *PathS* pedestrian navigation mode.

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.

When starting the application, a Google Map view is offered to the user (Figure 3.1, 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 3.1, 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 3.2, 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 be aware of the different values of these parameters recorded in different days, hours and locations. In Figure 3.3 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.

Figure 3: Web heatmap service visualizing collected data.

Figure 4: Heatmap service showing the average between four independent measurements of light and noise parameters.

4. RESULTS

In Fig. 4 are shown the histograms for brightness and noise levels acquired through PathS in the sorroundings of our the Department of Mathematics in Padua, Italy. The results shown belong to a larger sensing campaign involving bachelor students of our department.

5. CONSLUSION AND FUTURE WORK

We have developed an augmented reality application for pedestrian navigation in order to gather quality environmental data from smartphones and enhance pedestrian route generation. We have also created a web service providing a heatmap of collected historical values about brightness and noise levels. The application could be employed

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.

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