SMART MOBILE SENSING FOR MEASURING QUALITY OF EXPERIENCE (QOE) IN URBAN PUBLIC TRANSPORT

João Miguel Guerra Vieira

Project/Dissertation developed under orientation of *Prof. Teresa Galvão Dias*
at *Faculdade de Engenharia da Universidade do Porto*

1. Motivation

In our current society which is characterized by mobility, individuality and comfort requirements, there is a need for real-time information and services that make people's life easier. In Public Transportation (PT), such data is crucial for enhancing the travelling experience. Lately, the number of smartphone applications for trip planning, mobile ticketing and validation has grown considerably, but they do not take into account the user's affective state or his Quality of Experience (QoE). Today's choosing criteria is objective (e.g. duration, cost, number of changes) and does not attend the customer's individuality, i.e. preferences.

The motivation of this project then relies on serving commuters more efficiently by adding real-time information on service's conditions providing the user with a better informed decision.

2. Objectives

This project, more than the implementation, tries to create a solid proof of concept for a new ubiquitous way of collecting affective and context data from the customer's that will help to identify his mobility patterns and preferences. The project then tries to build a smart mobile application for everyday urban use, based on the recent advances in technology.

The main objectives for this project are:

- development of a prototype of a mobile application that allows the collection of affective data in public transportation;
- assist in the collection of experimental data using the developed prototype in a controlled environment;
- research related to improving the prototype through the use of new information and communication technologies.

3. Conducted Work

This section covers all the work done during the last year timelapse. Following a systematic approach, the project can be divided in four separate steps: study, analysis and design of the solution, implementation, and testing. The order was fundamental to create a solid yet innovative solution based on the early research to define what is possible and what are the technology tendencies. The result was a scalable architecture, an ubiquitous solution and a very accurate prototype that efficiently helped on the implementation. The tests validated the features and improved the solution.

Two publications were submitted and accepted in international workshops and are listed in Section 4.

The structure of this section is the same of the final report. Section 3.1 discusses the previous work and the state of the art, while Section 3.2, 3.3 and 3.4 use those insights to create and architecture the solution. Section 3.5 covers in detail the PTSense mobile application and Section 3.6 the tests made.

3.1. Related Work

This project is part of a partnership between the Imperial College London, where a cloud computing platform was already being developed for this purpose - the Cloud2Bubble (C2B) Platform. The idea is to collect data from the user (the bubble) and provide him with personalized services, in this case PT.

From the research conducted, it was perceived that sensor networks provide an environment for collecting huge amounts of data autonomously, and also that it is able to user user collected data to help serve other users - called opportunistic sensing. Wearable sensors that read physiological signals, i.e. affective data, are getting small, stylish and finally useful for casual sensing (and not only related to health or fitness). The study of identifying emotional states based on this data is undergoing, but there are already some models, such as the Valence-arousal model. Finally, smartphones are proving to be powerful sensor nodes with internet connectivity and portability.

3.2. The Solution

The solution to assess and enhance the QoE of users in PT is based on three simple steps:

- **Collection of Context and Affective Data** – multimodal sensorial data from the user and the environement;
- **Aggregation of Data** – training models with machine learning to identify the patterns between the affective and context data - the user profiles;

- **Delivery of Service** – accessing real-time information from webservices, users and profiles, and suggest individual alternatives.

3.3. Architecture

The overall solution lies in a distributed application with two main platforms: the mobile application and the cloud platform (see Fig. 1). This is based on Cloud Computing with SOA Web Services to allow scalability, processing and storage capabilities and access to web services. The communication is done through a REST interface that enables easy access from every device with internet connectivity. Also this method allows the transmission of JSON object to pass sensor data, feedbacks and inferences between both platforms.

3.4. The Mobile Sensing Platform

The MSP collects data from a set of sensors wirelessly connected to the smartphone, including itself. This data is then transmitted to the cloud, following the process described in Section 3.2. Environment sensors are static sensors installed in the vehicle and User sensors are wearable sensors from the user. When the trip finishes, the user is also asked to insert direct input to validate the sensor readings.

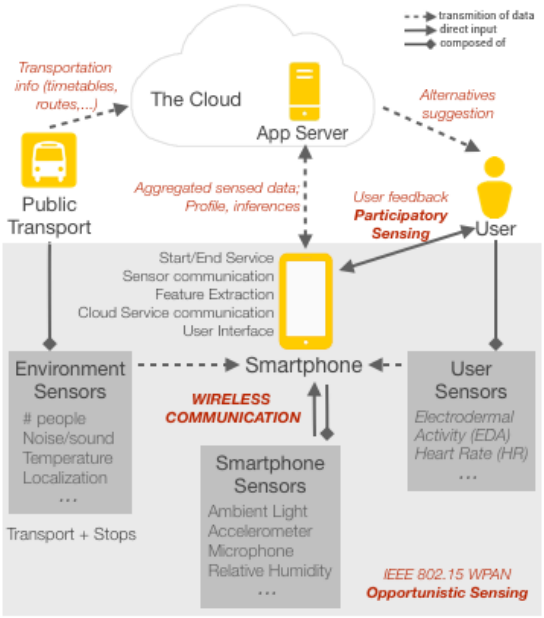

Fig. 1 – Conceptual architecture of the application

3.5. PTSense App

The PTSense was developed for Android 2.1+ (including ICS). It followed the strong guidelines and interactive PDF prototype developed that was tested and improved. It relies on usability and efficiency, with special focus on the notification system and background services. The first lets the user interact with the application whenever he wants through notifications and letting him focus on his primary activities. The second keeps collecting the sensor data in the background. This data is stored on the database and sent to the C2B only when there is internet. Efficiency concerns were addressed, which covers aspects like battery, storage and processing.

Classification is made and shown to the user quantitatively, qualitatively and with colors while the input is done through dragging sliders to classify stimulus which helps to understand the relation between the emotional state and environment conditions. This serves to proactively suggest alternatives to the users based on their routines or when asked directly. See Fig. 2.

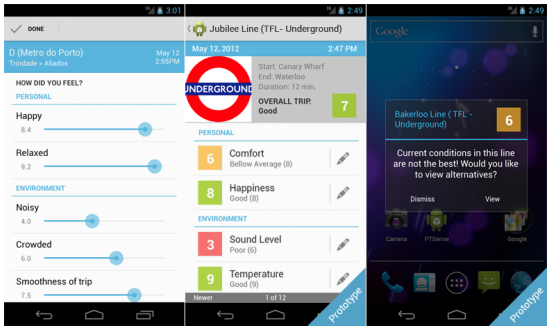

Fig. 2 – Feedback, Prediction and Pop-up in PTSense

3.6. User Testing

There were two tests: a Usability Test in London, with the functional prototype; and a Feature Test in Porto for the duration of two week with the Android application. Results show moderate correlations between variables sensed and from the feedbacks.

4. Conclusions

Aside from the moderate correlation in the testing phase, we can conclude that the PTSense application is not yet finished, but has a solid architecture to support future work. The solution designed achieve the goals on collecting affective and emotional data and the research led to an innovative smart application based on new and powerful fields of technology such as the Internet of Things, Affective Computing and Pervasive Computing.

Publications

- J. G. Vieira, P. M. Costa, T. Galvao, J. Pitt and J. F. e. Cunha. “Smart Mobile Sensing for Measuring Quality of Experience in Urban Public Transports”. Paper presented at The Second International Workshop on Smart Mobile Applications (SmartApps’12), Newcastle, UK, June 19, 2012

- P. M. Costa, J. Pitt, J. G. Vieira, T. Galvao and J. F. e Cunha. “Investigating Mobile Quality of Experience in Public Transport”. Poster to be presented at The 14th Edition of ACM SIGCHI’s International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI), San Francisco, USA, September 21-24, 2012.