Assessing Contextual Mood in Public Transport: a Pilot Study

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Abstract
In recent years, the technological developments in mobile and communication networks have paved the way for smart environments, whose final goal is to provide users with enhanced experiences. The measure of user experience satisfaction, or quality of experience, may be defined as an affective state in response to a service. Thus, an experiment was devised to explore the relationship between users' affective state and their context, for assessing quality of experience in urban public transport services. A pilot study, conducted to evaluate the feasibility and requirements of such an experiment is presented, leading to a large scale field study.

Author Keywords
Quality of User Experience, Affective Pervasive Computing, Experience Sampling, Smart Systems, Pilot Study

ACM Classification Keywords
H.1.2 [Information Systems]: Models and Principles—*User/Machine Systems*; H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

General Terms
Human Factors; Design; Measurement.

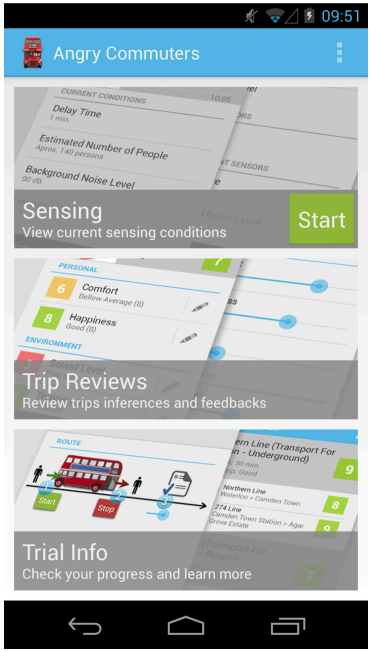

Figure 1: Mobile Application, Home Screen

Introduction

In recent years, miniaturisation of computerised devices and ubiquitous communication networks have paved the way for an increasingly pervasive computing environment [16]. This context has caused a shift in the paradigm of Human Computer Interaction (HCI), resulting in a number of new opportunities to interact with users [15]. Smart systems emerge as a by-product of this pervasive context and are capable of perceiving an environment with the final goal of enhancing users' experience [4].

The measure of user experience, or Quality of Experience (QoE), has been defined as an affective state that is the users' emotional reaction to a product or service [17]. A causal relationship was observed between affective state and satisfaction in relation to a product or service in both utilitarian and hedonic dimensions [11]. In the context of smart systems, QoE may be defined as the ability to meet users' expectations [1]. The measure of emotion is, however, complex and subjective. Extensive research has been developed in the field of Affective Computing (AC) for measuring users' affective state, with the goal of producing more empathic systems [12].

This paper presents an experiment to explore the relationship between affective state and the environment in the domain of Urban Public Transport. The study aims at acquiring insights for the development of user-centric and affective-aware services with the potential to enhance QoE. Preliminary results from from a pilot study are presented and discussed.

Related Work

Advances in the field of AC have resulted in a number of effective methods to measure emotion through physiological and cognitive methods, ranging from healthcare [9] to education [8]. Some affective devices have reached a commercial status, such as the Q Sensor[1], mainly for controlled environments. An alternative for naturalistic environments is the Experience Sampling Method (ESM), a technique from the field of psychology [3]. The ESM allows for the collection of data in a real-usage context and has been used in a number of domains. In the domain of mobile privacy, as an example, an experiment was carried out, based on a hybrid technique involving ESM and contextual interviews [10]. This project studied privacy habits when using mobile devices. Users were requested to fill a form using the device, that was later discussed on a semi-structured contextual interview.

Domain of Application

The potential in smart environments for perceiving users and adapting to their wants and needs is advantageous in different contexts, from smart homes to urban mobility [14]. Public transport in particular is a desirable domain of application, due to the resulting benefits for passengers and service providers as well as its role in the sustainable development of urban environments. In UPT there is an increasing need for delivering personalised information services that go beyond the traditional cost and duration [2]. Providing at-stop real-time information, as an example, results in an increased satisfaction, travel behaviour and psychological effects [7]. Perceiving and providing for passenger needs and wants, in this context, has the potential to increase satisfaction and positively impact usage of UPT services.

[1] affectiva Q Sensor *http://www.affectiva.com*

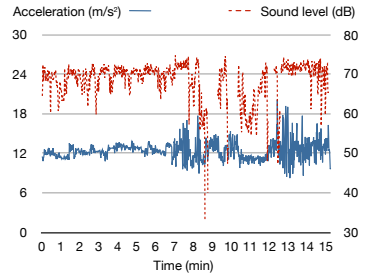

Figure 2: Journey Sample, Acceleration and Sound Levels

Figure 3: Journey Sample, Route

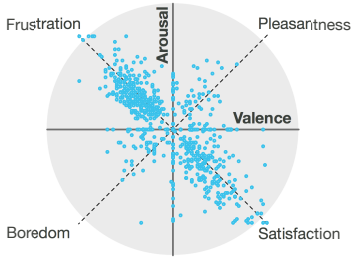

Figure 4: Travelling Mood, based on Russell's Circumplex [13]

Contextual Mood in Public Transport

The experiment was designed to collect personal data in-situ and non-intrusively, with the goal of investigating the relationship between affective states and the surrounding environment.

Procedure

The study is divided in two steps: collection of personal and environment data; and a debriefing session with the participants. The collection of data is based on a mobile application, in Figure 1, that uses the sensors available on the device (see Figures 2 and 3), and personal data through a short feedback form. These support the investigation of the relationship between user and the travelling environment in different dimensions: user mood and environmental context; and the variability of reported conditions in relation to sensed ones. A debriefing session, conducted after the data collection period, aims at investigating these aspects further based on interviews with the participants.

Mobile Application

The mobile application was developed for the Android platform and enables users to record and report their daily journeys anonymously. Furthermore, a secure cloud-based platform stores the collected data, taking advantage of the ubiquitous connectivity and protection against unauthorised access. Environment sensing occurs in-vehicle, throughout the journey, and samples the sensors available on the device, such as ambient sensors (air temperature, pressure and relative humidity), motion (accelerometer and gyroscope), position (orientation and proximity), geolocation and microphone. The application was subjected to usability testing sessions, which demonstrated that users were able to successfully use the application as intended [18]. Moreover, the feedback form used to collect personal and environment data proved to be intelligible, relevant and a convenient solution overall [6].

The feedback form is divided into affective state and environment perception. The collection of affective state is based on the Russell's circumplex of emotion (see Figure 4) and is divided into two dimensions: cognitive valence and physical arousal [13]. In addition to an open text entry for additional comments, the feedback form requests users for an evaluation of their journeys, using a colloquial tone to facilitate interaction and comprehension.

Cloud-based Platform

The collection of data is supported by a cloud-based software platform, Cloud2Bubble, which allows for the collection and processing of multiple sources of data. Moreover, this platform aims at leveraging the affective loop of interaction to measure and enhance QoE in smart systems [5].

Pilot Study

A pilot study was conducted to evaluate the feasibility of the experiment on a small scale, including statistical variability and design, prior to a more extensive one. The study was conducted in the city of Porto, Portugal with a limited number of users.

Participants

Participants were selected through social networking and mailing lists, based on a short survey composed of mobile device usage and travelling habits sections. The survey was completed by a total of 172 respondents of which 10 were selected based on the following criteria: frequent passenger; located within the greater Porto area; and user of an Android-based phone. The group of participants were aged between 19 and 33 years old ($\bar{n} = 24.1$;

Feedback form contents:

- MOOD: user's affective state;
  - Valence: cognitive dimension;
  - Arousal: physical dimension;
- CONTEXT: in-vehicle environment;
  - Noise: sound level;
  - Saturation: quantity of passengers;
  - Smoothness: driving quality;
  - Ambience: environment impression;
  - Speed: speed of journey;
  - Reliability: reliability of service;

$\sigma = 4.7$); 6 male / 4 female; 3 professionals / 7 students.

Setting
The study was performed in the city of Porto, Portugal in June 2012. The participants were provided with detailed instructions about the application and were asked to install it on their personal devices. All journeys were then recorded and reported for a period of two weeks. The data was collected anonymously and stored securely, ensuring the participants' privacy. During the debriefing session however, with the participants' consent and cooperation, some individual journey reports were discussed.

All users were instructed to start recording their journeys when boarding the vehicle (pressing *Start*), and correspondingly *Stop* when leaving. The application then presented the feedback form (on the left). The period of data collection was followed by individual debriefing sessions with the users. The goal of the interviews was to explore users' perspectives on the experiment, including ease of interaction with the mobile application, suitability to describe the travelling context and convenience in relation to their daily habits.

Results

The experiment ran for a period of two weeks and resulted in 110 valid journeys reported from 7 different subjects (Figure 5). Even though 10 subjects were initially selected to take part in the experiment, 3 of them reported a low number of journeys or were unable to commit to the entire two week period. The reported journeys originated over 26 hours of data, with durations varying between 1 and 60 minutes approximately.

Application Usage
Due to the fragmented Android ecosystem some users experienced unexpected errors and corrupted data in some versions of the platform when the application was first released. The technical difficulties were addressed rapidly, enabling users to actively participate in the study.

Subject	Journeys, n	Duration, $\bar{n}$	Duration, σ
A	8	25:51	22:04
B	7	27:24	14:37
C	45	6:29	3:05
D	15	25:13	14:40
E	18	13:36	6:19
F	8	17:34	8:12
G	9	15:33	6:40
TOTAL	110	14:11	12:18

Table 1: Distribution of Journey Reports

Users proved to be satisfied with the flow of interaction with the application. They reported ease of use and convenience in participating using their own personal phones. The collection and storage of data was performed as expected and monitored daily.

The extensive usage of sensors by the prototype revealed some difficulties. Firstly, most active devices used by the participants were not provided with all the sensors. Secondly, some of the available sensors, when running for a extensive period of time, increase battery consumption considerably. As a result, these will be limited to microphone and motion sensors in newer versions of the application.

Debriefing Session
The interviews were performed after the data collection period via telephone and were recorded with the knowledge and consent of participants. The purpose of the interviews was to explore users' perspectives on the study.

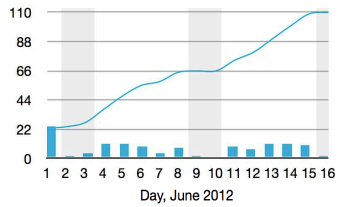

Figure 5: Cumulative Journey Reports

The first section was focused on the interaction with the mobile application. None of the users reported difficulties with installing or using the application throughout the course of the experiment, apart from the initial technical difficulties that were rapidly corrected. The method proved to be ecological valid, as well as appropriate to describe the travelling context. However, two of the users felt that the feedback became too cumbersome to answer in the final days, due to the lack of incentives.

The second stage of the interviews focused on the travelling context. There was an overall agreement that having to report journeys had the effect of making users more aware of their surroundings. However it did not seem to have a significant effect on the journey report. Some difficulties arose in expressing the relationship between mood and context and the opinions were illustrated with such examples as:

> *"Some situations have a strong effect on me. It really annoys me when I'm very tired and can't find seat."* (Subject G)

The complexity of reporting mood was also expressed in relation to the activity. All the subjects, except for subject E - who tried to report mood exclusively in relation to the journey - reported their inability to think of their mood in relation to a single activity and therefore reported their overall mood.

> *"I reported my mood in absolute terms, I don't think it's possible to dissociate [mood]."* (Subject F)

Discussion

The realisation of this pilot study enabled the assessment of the experiment feasibility and requirements. The results obtained provide valuable insights and a preliminary analysis was performed to explore different possibilities. The overall response of the participants to the pilot study supports the proposed approach for investigating QoE in UPT. The technical solution proved to be effective, enabling collection of both personal and environmental data in an ecologically valid way.

The experiment design benefited from a number of improvements, unveiled during this stage, including user interaction and quality of collected data. Such improvements include more flexible input methods and optimisation of device usage.

A preliminary analysis across travellers seems to identify shared travelling preferences for a diverse group of users, supporting a common baseline for UPT comfort or satisfaction. In addition, distinct characteristics seem to emerge for some individuals, supporting the idea of individual user profiles that allow for a more informed development of personalised services. Emotional state seems to be affected by different contextual elements. The preliminary results suggest that the cognitive component tends to be more closely related with the travelling means, *eg:* mode of transport and condition of vehicles. The arousal component, in contrast, seems to be associated with specific characteristics of a single journey, *eg:* saturation and reliability.

Our findings, albeit at an early stage, unveil a number of opportunities for empathic systems in the context of urban mobility, and smart environments in general. In the context of UPT, two main possible avenues were identified: to assist service providers in managing and planning their resources; and to provide users with a personalised empathic system with the potential of enhancing their QoE.

Conclusion

This paper presents an experiment devised to investigate the relationship between affective state and environment conditions in UPT, with the goal of facilitating the convergence of affective-aware technology and smart environments A pilot study was conducted with a limited number of users in preparation for a large-scale one, to assess its feasibility and requirements. The findings obtained at this stage will be used to improve the overall design of the experiment, as well as to determine user and environment data requirements. The preliminary findings will be used as a guidance for further investigation of the relationship between mood and context.

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