Observing the Context of Use of a Media Player on Mobile Phones using Embedded and Virtual Sensors

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ABSTRACT

In this paper, we discuss how contextual data acquired from multiple embedded mobile phone sensors can provide insights into the mobile user experience. We report from two field studies where contextual information were obtained from N=21 mobile phone users in a 2–8 week duration, to derive information about participant context. In the second study our focus was on observing mobile interaction with a media player application over time and we discuss how the captured contextual data can lead to a better understanding of the context in which mobile applications and devices are used. We argue that this information can provide valuable insights to the design of mobile applications and user interfaces.

INTRODUCTION

Mobile phones have become ubiquitous and an integrated part of our everyday life. In the last couple of years smart phones have gotten increased attention with the availability of several new platforms enabling easy distribution of mobile applications. Present smart phones typically have a number of embedded sensors, which have been combined and utilized in interesting ways to create novel mobile applications. In particular the sensors enable location and context-aware mobile applications that are increasingly aware of the situation the user is in.

Designing and evaluating mobile applications introduce additional challenges compared to traditional desktop and web application development and evaluation. There is a set of design constraints due to limited size of the device, limited display size and resolution, and limited input-output capabilities compared to traditional computer form factors. Additionally the situations of use are inherently mobile, which makes testing actual use more difficult. Evaluations carried out in a laboratory setting might not be sufficient for applications where the use of the application is highly dependent on the context of use. However, obtaining data when carrying out "in-the-wild" studies of actual mobile application use can turn out to be difficult and resource demanding. This calls for methods and techniques to acquire information about actual mobile use in context to obtain a better understanding of the mobile user experience.

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In this paper we describe a software framework, which enable acquiring contextual data from the mobile phone embedded sensors during daily life use by a mobile phone user. The software runs silently in the background and is logging activities including data acquired from multiple embedded sensors, to describe and understand information about people and places, as well as application and media usage. Our focus here is on studying mobile phone use, which involves using the media player on the mobile device for music playback. The emphasis is on understanding the mobile user experience in the particular context in which it takes place. We hypothesize that contextual information obtained from a mobile device can offer useful information in terms of understanding the situations of mobile use involving the media player application. Furthermore, we suggest that such information can offer valuable insights for designers of mobile applications, where user interfaces for music recommendation is the present focus.

RELATED WORK

Kjeldskov et al. [7] discussed laboratory versus field evaluation of mobile applications, and discussed the issue of how much value field evaluation would add over laboratory evaluation. In their study of a specific mobile context-aware application it was found that not much was added by the field experiments and in [6] it was suggested that similar usability problems could be identified in a laboratory setting if the right use context is recreated there. On contrary, in a usability evaluation of a mobile application Duh et al. [2] found that significant more (and more severe) usability problems were identified in field experiments compared to laboratory experiments.

Bernard et al. [1] studied how users' performance changed under different contextual conditions, including varying the motion, lighting and task types. They found that the contextual changes had a strong impact on behavior and performance. Froehlich et al. [3] combined quantitative and qualitative methods for in-the-field collection of data about usage, including device logging of user context and environmental sensor readings, and in-the-field subjective user experience sampling (prompting for feedback on the mobile phone). Several field studies were carried out in order to study different mobile phone usage patterns.

Several studies of actual mobile phone use have been carried out, both in laboratory and “in-the-wild” settings. A recent example of a study of user experience evaluation of mobile TV was carried out by Obrist et al. [9] where the importance of studies within mobile context was emphasized in order to support the mobile user experience. Another example is Roto and Olasvirta [12] that studied mobile users on the move using web-browsers on mobile phones. The experiments were performed in a controlled manner by employing multiple cameras worn by the test participants to observe the use of the mobile application in a real-world environment. A moderator had to stay in proximity of the test participant to monitor the experiment. Interesting results were acquired in the study, such as the observation of shorter attention span when using mobile applications on the move compared to a laboratory setting [11]. Although the test participants are testing the applications in a real-world setting the setup is still artificial and does not necessarily reveal how the mobile user experience would be in a natural setting, which argues for a stronger emphasis on field experiments in HCI [10].

Generally such studies underline that although experiments in a laboratory setting might identify for instance user interface issues, it does not account for “in-the-wild” study of actual use in everyday life in context. The experimental setup might suffer from the fact that test participants are typically instructed to use an application they are not familiar with. This means that it might be the “learning to use” of an application, rather than “actual use” that is being studied. Such studies typically only capture use over a short period of time and only reveal little about actual use or use patterns over an extended time period where learning and habituation has taken place.

MOBILE CONTEXT TOOLBOX

In order to observe users while using mobile devices and applications in real-world settings we have created a context logging software framework for mobile phones. The Mobile Context Toolbox (MCT) framework for Symbian S60 mobile phones [8] aims to facilitate the process of developing context-aware applications as well as carry out “in-the-wild” experiments where acquiring data from multiple embedded mobile phone sensors is required in order to establish information about the context of use. The generic framework can obtain information from embedded sensors including accelerometer, GPS, Bluetooth, WLAN, microphone, call logs, calendar, and additional sensors can be added to the framework for specific experiments. The architecture of the framework is shown in Fig. 1.

EXPERIMENTS

We have carried out several experiments involving test participants carrying a mobile phone with our Mobile Context Toolbox software installed and report our findings from two of those experiments.

In our first experiment 14 participants were provided with a Nokia N95 mobile phone with our software framework installed. They were instructed to carry and use the mobile phone as they would normally use their own mobile phone. The software would silently and continuously acquire data from the embedded mobile phone sensors for the duration of the experiment. In addition to collecting mobile sensor data the framework can prompt the user for textual input on the mobile device, similar to the approach reported by Froehlich et al. [3]. Further details on this study is available in [8], and detailed analysis of the datasets acquired are provided in [4] and [5], but not discussed further here as that is beyond the scope of this paper.

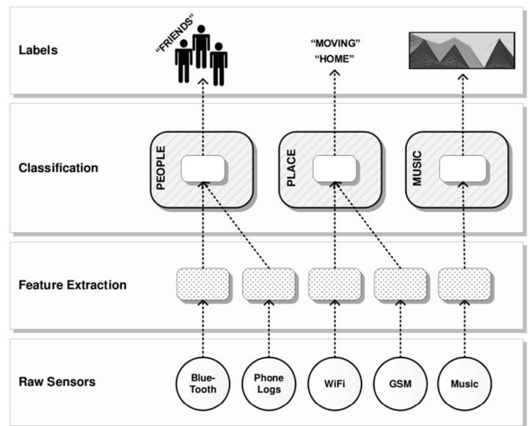

Fig. 1. Mobile Context Toolbox System Architecture

We extended the toolbox with a virtual sensor component capable of acquiring data from the embedded media player application on the mobile device. The component was capable of obtaining data including whether a music track was being played, the duration of the song, and current playback position. In addition we were able to acquire metadata from the particular song, including the artist and title. This was used in the second experiment where we focused on obtaining contextual information about people, places, and music [13]. As shown in Fig. 1, information was obtained from the Bluetooth sensor and phone log in order to extract features describing people related to the mobile phone user. Features describing places were extracted from information acquired from Wi-Fi and GSM cellular network information. Each of these features were translated into meaningful labels. From an application development perspective the intention is that applications built on top of the framework can utilize the contextual information inferred from the underlying system by means of the contextual labels acquired.

The experiment was carried out similar to the first experiment described above. This experiment involved 7 participants that were in a similar way provided with a Nokia N95 mobile phone with our software installed. They were instructed to use the mobile phone as their own on a daily basis for a two week duration. In addition they were told to use the mobile phone as their MP3 player device. The participants were also encouraged to upload their own music collection to the mobile phone, so that they could listen to the music that they liked and they would typically listen to on a daily basis.

ANALYSIS AND FINDINGS

An overview of the data acquired during the two week duration for the 7 participants in the experiment is shown in Table 1. As can be seen from the table the participants were fairly active in terms of using the media player on the mobile phone for music playback. In between 94 and 292 songs were listened to, which corresponds to 7—21 songs listened to on a daily basis on average. Also interesting to see is how many unique music tracks were listened to, indicating that some participants listened to a smaller set of tracks repeatedly. Each track played was logged with a time-stamp meaning that we could analyze the time of day where the media player was being used.

Participant	Tracks listened to	Unique tracks
1	160	85
2	153	100
3	190	48
4	292	68
5	110	58
6	167	124
7	94	65

Table 1. Overview of music listening for the 7 participants

Fig. 2 shows when music tracks were listened to by the 7 participants over two 3.5 hour durations on a random day in the experiments.

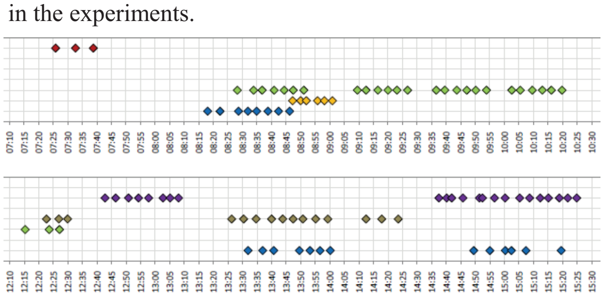

Fig. 2. Music listening patterns shown for the 7 participants on a random day of the experiments in two 3.5 hour periods. A dot corresponds to a music track played by the participant.

This information was coupled with the analysis of the contextual labels acquired from the logs of embedded sensor data. The GSM cellular information and Wi-Fi access points were analyzed in order to determine locations. Based on the analysis it was possible to determine the places in which the participants spend the most time. Thus it was possible to determine if a participant was at home, in a known place (a place where time was spent repeatedly), an unknown place, or in a transition between places (continuous changes in GSM and Wi-Fi data in minute size time windows).

The social relations were mapped based on the data acquired from correspondence logs (phone calls and SMS messages) in terms of who was calling and sending messages to whom. Based on Bluetooth device discoveries (of mobile phones) it was possible to map out when the participants were in physical proximity of each other. Furthermore it was possible to discover patterns in terms of the participants being in proximity of other people repeatedly. The inter-relations of the participants based on the mapping of the Bluetooth data is shown in Fig. 3. Participant 2 and 3 were not in physical proximity during the experiment, but we know they were related, as the correspondence logs showed that they called each other during the experiment. The numbers on the edges denote the number of Bluetooth discoveries indicating the time spent in proximity.

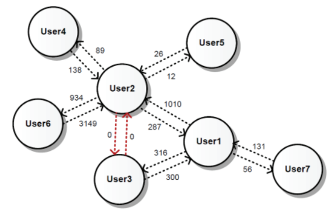

Fig. 3. Social relations of the 7 participants mapped based on Bluetooth device discoveries (physical proximity)

Based on this data it was possible to establish the context of use of the mobile media player on the mobile phone. It was possible to determine the time and places in which the music was being played. Furthermore it was possible to determine the people present when the media player was being used for music playback.

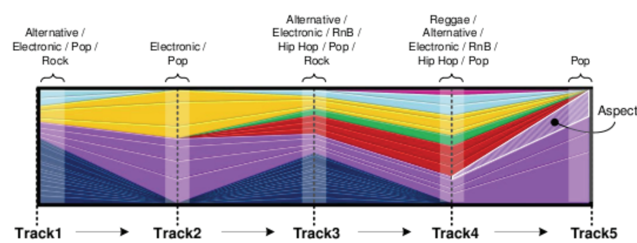

Fig. 4. Example five track sequence genre signature. Each color corresponds to a unique genre (obtained via last.fm)

The analysis of the music used the track metadata that was acquired from the media player during playback as the starting point. Based on the artist and song title the collaborative tagging of music tracks available from Last.fm was used to establish the music genres for each track being played (a genre signature). Furthermore we considered at least three songs played in a row to belong to a track sequence. In a similar manner a genre signature for these track sequences was calculated based on the individual genre signatures of each song, as illustrated in Fig. 4. This allowed us to consider and compare which genres of music were being played over time by the participants and the particular context in which they were played.

DISCUSSION

When studying the usage patterns we found that the genres of music that were listened to over time highly depended on the context of the user. In some places one set of genres were typically played, whereas in other places or in transition between places a different set of genres were being played. Furthermore, the level of interaction (such as skipping songs) also depended highly on the context in which the mobile application was being used. Transitions between places were characterized by frequent interaction (skipping and choosing songs) on the media player, whereas in known places the interaction was less frequent (less skipping of songs), meaning that participants would play a longer sequence of songs uninterrupted. An example of being in transition between places could be riding a bus, where the participant could have time to interact more frequently with the media player application, which could explain our findings from the data acquired in the experiment. However, it must be underlined that our findings are based on only two weeks of data acquired from 7 participants. Thus further experiments must be carried out in order to establish whether the findings mentioned above can be generalized. Nevertheless, we find that studying the mobile user experience in context has the potential to be a valuable source of inspiration for designers. For instance in terms of suggesting alternative user interfaces for navigating and selecting the content in the media player. Thus the mobile context could potentially play a much more prominent role in mobile applications, such as the media player. An obvious example is for recommendation systems that not only recommend music based on music similarity, but also contextual similarity.

As for evaluating the mobile user experience we find that the point in the process where the evaluation takes place has profound implications for the method to be chosen. A mobile application under development can probably benefit from simulating different contexts of use in a laboratory setting as proposed in the literature. However, if a mobile application has already been deployed we find that contextual information as discussed in this paper can offer useful information and provide valuable insights to the use of the application. As found in the case studied here we discovered how the context of use had implications for the interaction with and the content chosen in the media player.

CONCLUSIONS

Our mobile context toolbox for mobile phones has allowed us to carry out several experiments, where we have observed mobile phone users using a mobile phone in real-world settings. Based on the logged information from multiple embedded mobile phone sensors we have been able to establish information about the time and context of use of the media player application on mobile phones and we have been able to identify how the context has implications for the use of the application. We conclude that contextual information can offer valuable insights to the where and when of mobile use and provide valuable insights on the aspects having implications for the mobile user experience.

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REFERENCES

[1] Barnard, L., Yi, J.S., Jacko, J.A. and Sears, A. (2007) Capturing the effects of context on human performance in mobile computing systems. *Personal and Ubiquitous Computing 11(2)*, 96.

[2] Duh, H.B.L., Tan, G.C.B. and Chen, V.H. (2006) *Usability evaluation for mobile device: a comparison of laboratory and field tests*. Proc. of the 8th conf. on HCI with mobile devices and services, 186

[3] Froehlich, J., Chen, M. Y., Consolvo, S. and Harrison, B. and Landay, J. A. (2007) *MyExperience: a system for in situ tracing and capturing of user feedback on mobile phones*. Proc. 5th Int. conf. on Mobile systems, applications and services, 57-70.

[4] Jensen, B. S., Larsen, J., Hansen, L. K., Larsen, J. E. and Jensen, K (2010). *Predictability of Mobile Phone Associations.* Int. Workshop on Mining Ubiquitous and Social Environments.

[5] Jensen, B. S., Larsen, J. E., Jensen, K., Larsen, J. and Hansen, L. K. (2010). *Estimating Human Predictability From Mobile Sensor Data*. IEEE Int. MLSP Workshop.

[6] Kjeldskov, J. and Skov, M.B. (2007). Studying usability in sitro: Simulating real world phenomena in controlled environments. *Int. Journal of HCI 22(1)*, 7-36.

[7] Kjeldskov, J., Skov, M.B., Als, B.S. and Høegh, R.T. (2004) *Is it worth the hassle? Exploring the added value of evaluating the usability of context-aware mobile systems in the field.* In Proc. Mobile HCI, 529-535.

[8] Larsen, J. E. and Jensen, K. (2009). *Mobile Context Toolbox: an extensible context framework for S60 mobile phones*. In Proc. EuroSSC 2009, Springer LNCS 5741, pp. 193-206.

[9] Obrist, M., Meschtscherjakov, A. and Tscheligi, M. (2010). User Experience Evaluation in the Mobile Context. *J. of Mobile TV: Customizing Content and Experience*, 195-204.

[10] Oulasvirta, A. (2009) Field experiments in HCI: promises and challenges. *Future Interaction Design II*, 1-30

[11] Oulasvirta, A., Tamminen, S. and Roto, V. and Kuorelahti, J. (2005) *Interaction in 4-second bursts: the fragmented nature of attentional resources in mobile HCI.* Proc. of the SIGCHI conference on Human factors in computing systems, 928.

[12] Roto, V. and Oulasvirta, A. (2005) *Need for non-visual feedback with long response times in mobile HCI.* Special interest tracks and posters of the 14th international conf. on World Wide Web, 775-781.

[13] Zandi, N., Handler, R., Larsen, J. E. and Petersen, M. K (2010). *People, Places and Playlists: modeling soundscapes in a mobile context*. 2nd Int. Workshop on Mobile Multimedia Processing (WMMP2010).