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Measuring the effect of distractions on mobile users' performance

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Abstract
Users of mobile applications in everyday life are required to be aware of their surroundings yet evaluations of such applications often allow the participants to focus entirely on the evaluation task. This is largely due to practical considerations, as the undertaking of an evaluation in an uncontrolled environment - such as a busy street - is fraught with difficulty. These difficulties may be logistical - it may be hard to control the environment and capture data - and ethical – participants may be exposed to injury if being asked to perform a complicated task in a real life environment. This paper describes the usability lab our group has built which will allow us to investigate the effect different forms of distraction have on mobile users performing different tasks under different conditions.

Keywords
Human-Computer Interaction, usability, mobility, distractions

1 Introduction
The use of mobile computing devices - such as handheld computers and next generation mobile phones - is becoming increasingly popular. Mobile Human-Computer Interaction (HCI) is the research field related to the design and evaluation of the interaction between users and mobile computing devices. The nature of these devices, however, implies that a different approach is required for the evaluation of applications running on mobile devices as compared to those running on standard, desktop devices.

A desktop application is typically run in a reasonably quiet environment with few distractions meaning the user is able to pay full attention to the task at hand. A mobile application, on the other hand, is run in a variable environment where there maybe multiple distractions meaning that the user's attention on the task at hand is limited.

The evaluation of mobile applications, however, has typically not reflected this change in usage environment. A recent survey showed that only 41% of research in Mobile HCI evaluated the system being researched [2]. Furthermore, the majority of these evaluations (71%) were undertaken in a laboratory setting with very few of these using special evaluation techniques designed for a mobile application. The authors suggested that this was for two reasons: the background of most practitioners is computer science and so this is the most familiar technique and; the laboratory environment is the easiest to manage.

This paper outlines the design of a Mobile HCI lab designed to allow the evaluation of mobile applications in the most realistic environment. In particular, the paper concentrates on the features of the lab that are designed to distract the experimental participants in a controlled fashion.

2 Background
Kjeldskov & Sage developed a framework which described mobility in terms of physical motion and the amount of attention required to navigate [4]. Using this framework five techniques for simulating mobility in a laboratory environment were developed and evaluated. A sixth technique – which divided the users attention between conscious actions and the use of a mobile system while stationary - was also evaluated. In all six cases the techniques were compared with the results achieved by participants walking in a pedestrian street. The participants reported the highest workload when walking in the pedestrian street but uncovered most usability problems when sitting. The nature of the problems discovered when sitting, however, were mostly cosmetic indicating that mobility is a significant factor in the evaluation process. The authors attempted to mimic a real-life scenario by forcing the participants to follow a continuously differing path through the lab but this had no effect on the results obtained. This may have been due to the nature of the evaluation where the participants followed an evaluator. This meant that the participants were only required to maintain their position behind the evaluator who set the speed and was watching for obstacles.

There are some other examples of evaluation design which consider the mobility of users. Mustonen *et al.* found that reading speed is affected by walking speed although the reading task also has an effect [5]. It was found that the walking speed had a greater impact on the participants' performance when they were reading the text rather than searching the text for a particular pattern. Similarly, Brewster found that users' abilities to enter numeric codes on a graphical user interface was significantly reduced when in a real-life environment as compared to a laboratory environment [1]. Pirhonen *et al.* used a step machine to simulate a user walking when evaluating a gesturally controlled media player [6]. The use of the step machine had the advantage of simulating movement while keeping the user stationary to allow for easy video capture.

An investigation into where evaluations should take place surprisingly showed that there is little or no benefit in undertaking evaluations in the field compared with in the lab [3]. In the study the laboratory evaluation uncovered more usability issues than the equivalent field study; and the field study only uncovered one issue that the lab study did not. This issue concerned the validity of the data entered in a safety critical situation and reflected the fact that the laboratory environment was not as realistic as the field environment. Furthermore, it was found that the lab environment allowed for more control and easier data capture than when in the field. It was also found that the participants in the lab environment uncovered as many context-aware related problems as in the field. This is surprising as it would be expected that the richness of the context in the field compared to the lab would enable participants to uncover more of these types of problems.

3 Lab Design

The previous section outlined research that has been undertaken on mobile evaluation. This research showed that while laboratory based studies are suitable, mobility is a significant factor when evaluating mobile applications. At first glance, this would imply that an open space with scope for participant movement would be sufficient but as Kjeldskov & Sage reported this does not necessarily force the participant to monitor their surroundings to any great extent [4].

It is necessary, therefore, to design the lab in such a way that evaluators are able to distract participants in a controlled fashion. There are three main types of distraction that need to be supported:

Passive Distractions distract the participants but require no active response. An example of such a distraction in real-life is a billboard on a wall.

Active Distractions require the user to respond in some way. The required response will vary on the distraction. A mobile phone ringing, for example, may require the user to answer to the phone whereas a lamp post will require the user to navigate round it.

Interfering Distractions are a third class of distraction - which may be passive or active - and interfere with the user's interaction with the mobile device. If, for example, the application provides audio feedback to the user a noise such as a passing car or ongoing conversation would interfere with that interaction.

4 Lab Implementation

The lab has been built in the basement of NRC-IIT's Fredericton site. The lab consists of a large empty space (8.65m x 17.3 m) which can be sub-divided using portable partitions. This space enables the experimental participants to be mobile during evaluations. There are two observation offices along one side of the lab, each of which has one way glass.

Visual distractions can be produced using the six roof mounted projectors in the lab. The projectors are mounted on a central rail so that they can be moved through the lab and rotated to project on the appropriate wall. The lab walls and doors are painted white and there are white blinds which can be pulled over the observation windows meaning the projectors can be used all around the lab.

Audio distractions are provided using a 7.1 surround sound system. As with the projectors, the speakers are ceiling mounted meaning the lab's floor space is obstruction free. An indoor location system [7] is used so that the presentation of the distractions can be done only when the user is in the appropriate location.

5 Future Work

The lab will enable us to develop a series of guidelines regarding the effectiveness of different forms of distraction. This will enable future evaluations of mobile applications to be performed under the most appropriate conditions.

These first of these evaluations will require the participants to monitor distractions projected onto the laboratory walls while performing their primary task. Participants will be required to acknowledge certain distractions by pressing a button on the user interface of their mobile device. The effect of different forms of distraction - and the absence of distraction – on task performance will be compared. Two different forms of distraction will be evaluated. The first form - single characters - will require the participants to look for '*'s being projected. The second form, photographs of street scenes, will require the participants to look for hazards – in this case moving vehicles. This research will indicate whether abstract distractions are as effective as realistic distractions. Future evaluations will investigate the effect of audio distractions and the different types of distraction as described in Section 3.

6 Conclusions

This paper outlines the design of a mobile HCI lab which allows evaluators to distract users in a controlled fashion. This is significant as previous research has shown that mobility on its own is insufficient to accurately simulate a real-life context while undertaking evaluations in the field is often impractical.

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