Exploring the opportunities and challenges of using mobile sensing for gamification

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ABSTRACT
Gamified services delivered on smart phones, such as *Foursquare*, are able to utilise the sensors on the phone to capture user contexts as a means of triggering game elements. This paper identifies and discusses opportunities and challenges that exist when using mobile sensors as input for game elements. We present initial findings from a field study of a gamified mobile application made to support the university orientation event for new students using game achievements. The study showed that overall the use of context was well received by participants when compared to game elements that required no context to complete. It was also found that using context could help validate that an activity was completed however there were still technical challenges when using sensors that led to exploits in the game elements, or cheating.

Author Keywords
Mobile sensing, gamification, video game achievements, ubiquitous computing.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): User-Centered Design

General Terms
Design, Human Factors

INTRODUCTION

The term *gamification* has recently been coined to explain the phenomenon of using game elements in non-game contexts [3]. Over the last few years there has been a growing interest into how the engaging and playful interactions found in video games can be applied to non-game applications as a means to engage users and enhance the user experience of products. Today we can see elements of play dispersed and interwoven with everyday tasks; video game achievement systems rewarding players for checking into physical locations have appeared in *Foursquare*, entire role playing games based around a to-do list in the iPhone app *Epic Win!*, and even a dungeon and dragons style game created around household chores in the online application *Chore Wars*. Gamification is a design strategy primarily employed to drive engagement with a service. This strategy relies on capturing behaviour when a user interacts with a system, interpreting it and determining if it should trigger game elements. By using the sensors found in consumer smart phones a range of different user inputs can be captured and used to power gamified services delivered in mobile environments.

In this paper, we discuss the use of mobile sensing as input for an achievement system embedded into a social non-game service that aims to introduce students to university. First we discuss how context can be captured using smartphones and used to trigger achievements, then we present some results from a field trial of gamified university orientation application and discuss the findings.

UbiComp' 11, Sep 17 – Sep 21, 2011, Beijing, China.

RELATED WORK

Games at orientation

Orientation games, like scavenger hunts, can be a good way to introduce new students to university [5] with technology providing a way to support different aspects of the games [7, 8]. Schwabe and Göth [7] explored the use of mobile technologies to create the scavenger hunt game *MobiGame* on a PDA (Personal Digital Assistant) for new students at university. This game provided a location aware map to help students navigate the campus, a scavenger hunt and a competitive game revolving around hunting and avoiding other teams. This game was found to lead to excitement and fun. Talton et al. [8] created a similar application *Scavenger Hunt* which delivered a hunt via a mobile device. However, both games only used input via a touch screen (e.g., Text or multiple choice) to answer scavenger hunt questions. These days consumer smart phones allow us to sense a range of different contexts, such as location or movement, and this context can be used as input for game elements in mobile applications. This provides an opportunity to explore how sensors can be used as input for orientation games and how they compare with traditional forms of input for scavenger hunts that require text-based answers.

Using context to drive game interactions

Foursquare is a good example of a gamified service that uses location sensors found in smart phones to allow users to check in to locations such as businesses, shops, parks and buildings. The application uses this check-in information as a means to power game elements that rewards particular

user behaviours. For example, users can receive points for each check in and unlock badges for completing certain location-based tasks, such as checking into thirty different coffee shops.

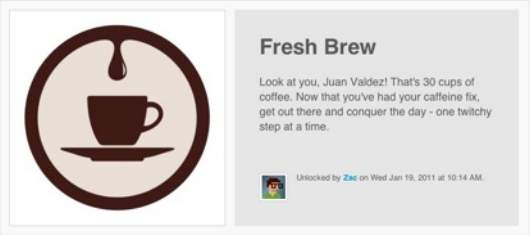

Figure 1. Foursquare badge rewarded for location based check-ins at coffee shops.

In order to use this contextual information as input the mobile application must implement a context system that can successfully capture specific user behaviour, analyse it and compare it to the game rewards defined by the system designer.

Using context cues to define game triggers

Context can be acquired either explicitly by requiring the user to specify it, or implicitly by monitoring the user and computer-based activity using sensors [6]. A combination of context sources can be used to attain a higher level of abstraction [2]. Indulska & Sutton [4] divide sensors into three groups; physical, virtual and logical sensors. Physical sensors are hardware sensors in devices that can attain physical data regarding the user and their environment, such as location, movement or temperature. Virtual sensors source context data from software applications or services such as current computer logins or search history. Logical sensors use multiple information sources and combine physical and virtual sensors to solve higher tasks. These sensors can be used to provide cues for contexts [6]. *Cues* provide an abstraction from physical and logical sensors taking values from a single sensor and providing symbolic or sub-symbolic output. The table below shows examples of contexts drawn from cues.

Context	Cues
In the office	Artificial light, stationary or walking, room temperature, dry
Jogging	Natural light (cloudy or sunny), walking or running, dry or raining, high pulse

Table 1. Describing contexts in terms of cues from Schmidt, Beigl and Gellerson [6]

Cues can be used to define context and context semantics that covers *entering a context, leaving a context* or *while in a context.* Using this understanding of cues and contexts an achievement context system can define particular contexts using available cues from sensors that in turn can trigger game rewards, e.g., A user can trigger a game reward for attending university orientation. To determine this context we can use two cues, university location and event date to confirm the context and award an achievement for attending the event. These can be measured using physical sensors such as global-positioning system (GPS) sensors and internal clock and matching it with virtual sensors such as the university campus co-ordinates and the time of the event.

SYSTEM DESIGN

Overview

Orientation passport is a prototype mobile application built for the iPhone that provides a digital copy of a student's orientation schedule tailored for mobile interaction. The *schedule* replaces the traditional paper schedule for the event and is accompanied by a number of helpful additions including a *campus map* based on Google Maps which lists building names and shows the student's current location; a *friend page* where new contacts can be added by 'bumping' phones together using the Third Party Bump API which connects two phones to each other; a *profile page* where the user can edit their personal information sent to other users. As well as these features a *list of achievements* is included in the application. Each achievement can be unlocked by completing a particular activity within the application, such as answering a text question, checking into an event using the phone or adding new friends using the phone.

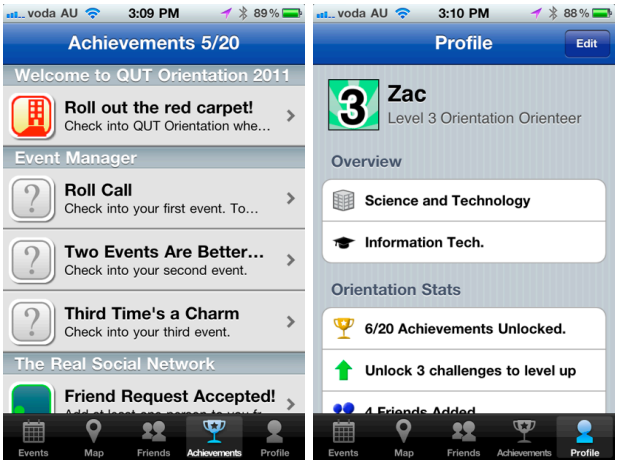

Figure 2. Screenshots of a student's achievements and profile

Achievement System

The achievement system is a concept that has evolved over the last decade to become a very popular way to add extra challenges and play time to video games with little expense. These achievements are usually extrinsic task-reward systems generally set as external elements, unnecessary to the game's primary intrinsic goal. They usually reward the player with points, unlock bonus in-game material or simply exist as status symbols. Achievements are being utilised more and more as a way to add game rewards to non-game applications [1].

For the orientation passport achievement system we surveyed a number of different achievement systems currently on the market including iPhone Game Center, Xbox Live, Playstation Trophies, Steam Achievements and

World of Warcraft Achievements to influence the achievement design, language and anatomy. We created a list of twenty achievements that allowed students to find and unlock information about the university as each achievement was completed. The twenty achievements were created with input from student engagement staff and from a focus group discussion with orientation staff around three important student orientation aspects; *participation, exploration of services and campus* and *social networking*.

We then determined the various contexts we could attain from physical and virtual sensors available. In terms of physical sensors we had access to location context through the use of the phone's Global Positioning System (GPS) sensor or by scanning a Quick Response (QR) code at a specific location, time context from the phone's internal clock and movement context from the phone's accelerometer sensor. In terms of virtual sensors we had access to student information including their orientation event schedule and student number. Using these cues we then created a number of achievement types that used triggers that could be used to reward achievements. In order to trial a number of different inputs the achievements were set up to use varying types of contexts as triggers for completion. This ranged from using no sensors, where a user would simply have to answer a numerical question, similar to previous orientation scavenger hunts, e.g., [7], to using a number of combined sensors, as shown in the table below.

Type	Context
Answer a question	*No sensors:* numerical input via touch screen (e.g., Phone number, bus route or floor number).
Find an object	*Object* context: Scanning an object with a barcode (e.g., A Book or Student Card)
Find a university location	*Location* context: Comparing the phone's GPS location with university co-ordinates or scanning QR Code placed somewhere on campus with the phone's camera.
Check into an event	*Location* and *time* context: Comparing the event schedule and event location with the phone's clock and phone's GPS location.
Add a friend	*Location*, *time* and *movement* context: Using accelerometer data to trigger a connection that compares two user's location and time to connect them with each other.

Table 2. Achievement types and context triggers for completing the achievement

This provided us with a range of different contexts that could potentially be used as triggers for achievements that we add to the system, e.g., check in to one event, add three friends.

Compensating for location sensor limitations

Location information could be accessed via GPS sensors on the phone however because a number of the events took place indoors, location could be hard to obtain. In order to compensate for this, as long as the phone registered that the user was in a 1000m radius of the event then the user could still check into the event. Alternatively for some achievements QR codes were also used to define locations by printing a unique code and placing it at a location to be scanned by the student using the iPhone camera.

STUDY DESIGN

Participants

26 first year university students were recruited (17 males, 9 females) to trial the application with achievements during university orientation. Participants were recruited via a news article posted on the university's orientation website a month before orientation started. We attempted to create as realistic a setting as possible for the study and had two requirements for recruiting participants: (1) the participant had to be a first year student attending university orientation, and (2) they had to own and use a smart phone or similar device (iPhone or iPod touch in this case) on which to test the application. Participants received two free movie tickets for their participation in the field study after they completed a questionnaire and their log data was collected.

Evaluation

Participants were provided with the application when they arrived at orientation. The mobile application included twenty achievements that could be unlocked over the course of the day. These achievements ranged from easy achievements (e.g., checking into the orientation event, adding one friend) to harder ones (e.g., Checking into three separate events, adding three friends). Participants were asked to return at the end of the day and fill out a questionnaire detailing their experience. Usage data was captured on the device and sent to the researcher, which recorded the achievements completed by the participant. A questionnaire was also completed by the participant on completion of the field study which contained both quantitative questions in the form of 5-point Likert scales (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree) complemented by a number of open-ended qualitative questions. The design of the questionnaire focused on providing feedback on the usability and experience of the prototype and the game achievements.

RESULTS

Twenty different achievements were added to the orientation application that could be completed by participants while they used the application at university orientation. 22 sets of data were successfully captured from participants' phones, 4 sets could not be captured. This data reported on how many achievements were completed by each participant. It was found that every single participant completed at least 4 or more achievements with the

majority of participants (90.9%) completing at least 8 or more achievements and (81.8%) completing 10 or more.

Text based input vs. sensor input

Overall participants generally preferred achievements that required some kind of context trigger (e.g., location, time, event) to complete. Out of the five different types of achievement input (check in to a location, check in to an event, add a friend, scan a QR code and answer a question) half of the students (50%) picked *scanning a QR code* as their favorite type of achievement to complete. Only two people (7.7%) identified the keypad input as their favorite type of achievement input, making it the least preferred. Open-ended responses supported this finding with students reporting that the act of finding and scanning QR codes around university "made it fun", were "fun to scan" and that scanning a QR code "was genuinely challenging and satisfying to complete".

DISCUSSION

Using context to validate user behaviour

One of the advantages of using context as input means that in order to complete the achievement students must fulfill the context requirements, i.e., be in a particular location at a particular time. With questions that require text input instead of contextual input the answer could be guessed or found out through other means. By using context such as location to trigger achievements students must search for and visit a particular location in order to complete the achievement.

Figure 3. A student unlocks an achievement in the game by scanning a QR code

Participants reported that for some achievements that required numerical input (e.g. finding how many levels the library had or finding how many food shops were in the cafeteria) they could simply "guess the answer through trial and error" and another said that instead of exploring the campus they "didn't check it out and find the answer, what I did was guess". Not only did students guess but also for some this had an adverse effect on the experience of the achievements with a number of students finding these types of achievements as "useful but not fun". Achievements that required some a contextual cue as input seemingly encouraged students to explore more than those that just required an answer via touch input. In particular achievements that used context as input such as QR codes were reported as encouraging a number of students to explore the university more. Students indicated in the qualitative feedback that with these types of achievements they "got to explore different parts of the university" and "explored the library", another said that they "saw and enjoyed the art museum – otherwise (I) wouldn't have gone in". Another said they liked scanning QR codes "because it made me discover a new place" and another said that they "help you explore the campus". Another responded that "the most interesting part of this application was walking around the whole campus searching for the code, it was pretty awesome, I felt like playing a treasure hunt game" and another reported that they enjoyed "searching for the code."

Cheating by finding exploits in the sensing cues

One interesting finding from the log data was that a number of participants found that they could complete some achievements without actually undertaking a desired behaviour. One participant managed to check in to three different events within the space of two minutes unlocking three separate achievements without actually attending any. This occurred because the participant had three different events scheduled at the same time and the context system allowed him to check in to an event as long as he was positioned somewhere near it (<1000m). This larger location radius was used to compensate for the lack of GPS tracking indoors. This distance could have been lessened to minimise the exploit but possibly at the expense of some users being unable to check-in if their GPS didn't track their position inside effectively. It was chosen to allow the possibility of exploitation as a tradeoff for usability as it was preferred that students be able attain the achievement, rather than have issues unlocking it. This leaves the designer with the challenge of balancing the accuracy and limitations of the context that can be acquired, with the usability of the application. Cues that are too precise might make some achievements harder to unlock yet cues that are too relaxed might open the game elements up to exploitation, or cheating, like that found in the study.

CONCLUSIONS

The study showed that overall the use of mobile sensing can work successfully as input for a gamified achievement system. Using context to unlock achievements was well received by participants when compared to game elements that required no context to complete. Results from this study indicate that game achievements using context as input can be fun to use when compared to answering questions via text input. Using context can help validate that an activity was completed however there does exist technical challenges for system designers when balancing the accuracy of the context required to trigger game rewards. This study provides us with a foundation to explore achievement systems for mobile applications further and to look at how context can be used to create achievements that engage people at events such as university orientation.

ACKNOWLEDGEMENTS

This research was carried out as part of the activities of, and funded by, the Smart Services Cooperative Research Centre (CRC) through the Australian Government's CRC Programme (Department of Innovation, Industry, Science and Research). The authors wish to thank the QUT Student Engagement Team for their input and support, in particular Peter Gatbonton and Duyen Nguyen.

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