Automating the Detection of Breaks in Continuous User Experience with Computer Games

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Abstract
This paper describes an approach towards automating the identification of design problems with three-dimensional mediated or gaming environments through the capture and query of user-player behavior represented as a data schema that we have termed "immersidata". Analysis of data from a study of an educational computer game that we are developing shows that this approach is an effective way to pinpoint potential usability or design problems occurring in unfolding situational and episodic events that can interrupt or break user experience. As well as informing redesign, a key advantage of this cost-effective approach is that it considerably reduces the time evaluators spend analyzing hours of videoed study material.

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H5.2 [Information Interfaces and Presentation]: User Interfaces - Evaluation/methodology; H3.3 [Information Storage and Retrieval]: Information Search and Retrieval
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INTRODUCTION
The non-linear, continuous and real-time interactive nature of three-dimensional mediated or computer/digital gaming environments presents novel challenges to human-computer interaction. As academia and research enthusiastically adopt and develop computer games for areas such as education, training and entertainment, the need for more considered design and evaluation methods becomes apparent.

While evaluation work in HCI has begun to address this imbalance, we are still some way off formulating a methodology appropriate for the design and evaluation of a range of digital games genres (e.g. role-playing, action-adventure, educational, etc.) and configurations (i.e. supporting platform or enabling technologies). While the focus of this paper is on the evaluation of an educational game, an important goal of our research is to develop ways to design, evaluate and inform redesign of games appropriate not only to education per se, but also to a range of digital games genres. In this paper we describe an approach to detect problematic aspects of design in the unfolding of situational and episodic events that can interrupt or break user experience with computer games.

Continuous and Unobtrusive Evaluation Techniques
Stimulating experience engages users, encouraging them to continue their encounter pursuing activities and continue to experience the mediated or gaming environment. Conversely, un-stimulating experience or disruptive interaction can interrupt or break users' encounters [2]. Furthermore, while some design aspects and genres of three-dimensional mediated or gaming environments allow for asynchronous interaction, in general they are continuous time-based interactive systems [8]. Therefore, it is argued that evaluation or assessment techniques should be continuous and unobtrusive.

Techniques used to assess or evaluate three-dimensional mediated environments other than computer games (e.g. virtual reality, virtual environments) have been developed. For example, techniques that attempt to assess user's feelings of a sense of "presence" (commonly described as a sense of "being there") in a virtual environment include getting users to verbalize [6] or press a button [7] to indicate "breaks in presence" and having users continuously reposition a sliding potentiometer to reflect their sense of "presence" [1]. While these techniques are continuous, they are problematic because they require the user to divide their attention between the mediated experience and the operation of the button or slider, or keep in mind the verbalization. Hence, the data collection methods (i.e. button, slider, verbalization) may confound the actual thing that we are trying to measure or detect (i.e. presence, experience or breaks).

Alternative schemes that are continuous and do not require the user to perform any additional operations are for example, objective physiological measures such as alpha brain waves, skin resistance or temperature and heart rate. Correlations between physiological data and events within a mediated environment provide a means of assessing design and experience [4]. However, besides the potentially high

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costs, it is questionable whether the probes and sensors attached to a user are disruptive or encumbering.

Finally, while Sykes and Brown's (2003) work in [9] on computer games shows correlations between rapidity and pressure of button presses and arousal, and is both continuous and unobtrusive, we have found this approach to be inappropriate in the development of our educational computer game and other genres where aspects of design are not intended to produce rapid and excitable button presses.

In the next section we describe our approach that is continuous and non-intrusive to users. This approach works towards automating the identification of design problems with three-dimensional mediated or gaming environments through the capture and query of user-player behavior represented as "immersidata" [5].

OUTLINE OF IMMERSIDATA SYSTEM

In the 2020Classroom project at the Integrated Media Systems Center (IMSC), University of Southern California (USC), we are developing an educational gaming environment using the Torque game engine (GarageGames®) for undergraduate students to interact and explore the physiological and biological processes of human organs.

Within the 2020Classroom gaming environment, players pick up and put items (abstractions of real objects e.g. acids, glands) in specific places to activate biological processes such as digestion, using keyboard and mouse.

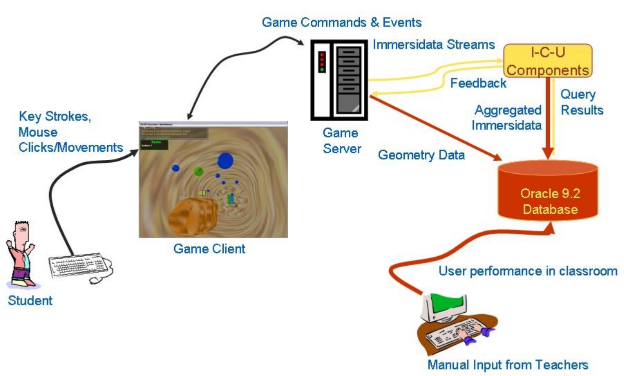

Figure 1. Schematic of the 2020Classroom and immersidata database architecture

While in the environment, we trace a player's position (directional and angular movement three times a second) and any events (keyboard and mouse button presses as soon as they occur) and store this data in a database; we have termed this type of data "immersidata".

Data collection is performed non-intrusively between the gaming environment and the database without using any cumbersome or disruptive devices attached to the user, and without getting the user to perform any additional operations. Refer to Figure 1 for schematic of the 2020Classroom and the immersidata system.

In order to store the player position and the events in the database, we utilized the following schema:

"[User ID, position (x, y, z), view point (rx, ry, rz), view angle, time]" for the player position and "[User ID, event ID, trigger, status, object, (x, y, z), (rx, ry, rz), view angle, time]" for the events.

An example tuple of the player position would be [1, (103.121, 201,032, 100.110), (0, 0, 1), 1.00221, 2004 /1/10 04:10:09], and an example of the event would be [5, place, selection, no_organ_selected, Muscles, (305.943, 296.373, 225.375), (0, 0, 1), 3.65967, 2004/04/30 12:48:16] which describes that user 5 failed to place an object on to a receptor for the Muscles because the user had no object to place.

Method: Detection of Breaks in User Experience

In order to detect breaks in user experience from the immersidata, we queried how much a user moved and the number of events between a user and the environment within a one second time interval.

We hypothesised that if a user does not move or/and there are no interactions between a user and the environment for a certain period of time (determined through experimentation), then an interruption or break in user experience may have occurred, potentially highlighting a design problem.

Plots of the movement and the number of events were drawn as shown for example in Figure 2, and corresponding numerical data produced. Subsequently, through visual inspection we identified the intervals where the movement and the number of events are near-zero. In an attempt to validate our hypothesis, we viewed video recordings made of study sessions with ten participants. This involved going directly to the identified near-zero time intervals and viewing video segments to identify the cause of a break or make sense of the circumstances surrounding a break.

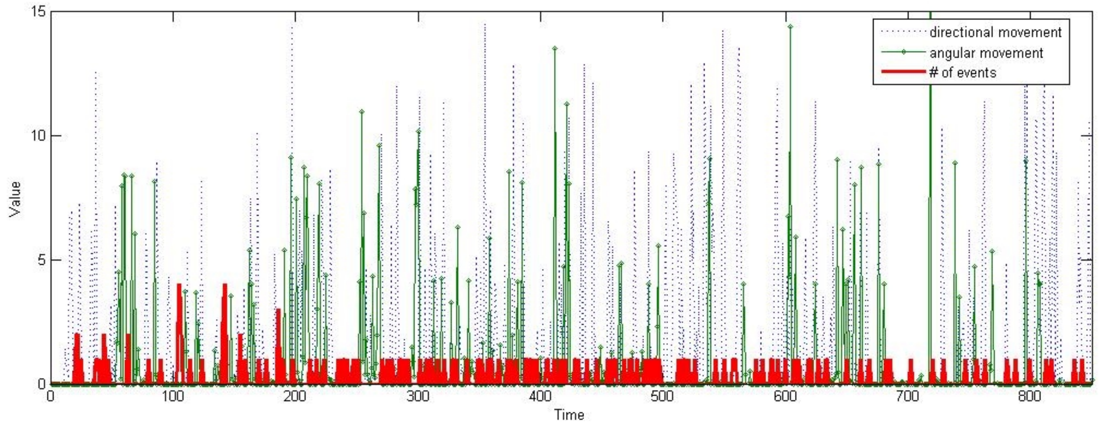

Figure 2. Example of superimposed plots of angular and directional movement, and number of events for user '1' showing no movement and no events between 680 and 700 seconds. Analysis of videoed study material revealed a design problem as shown in Table 1.

Table 1. Design concerns captured in a study with the 2020Classroom educational gaming environment following analysis of the immersidata. The numbers indicate the time or range of times in seconds, in or between which, a design concern occurred. The letters d, a, and e denote the types of immersidata (directional and angular movement, and events) through which design concerns were identified.

design concerns	**Users**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
audio and text mismatch	680-700 d, a, e									
confused as to what to do in the first room							0-700 d, a			
not knowing how to place tissue that absorbs nutrients		1350-1450 d, a, e								
problem scene: "intestinal cell"		1650-1700 d, a, e		1450-1550 d	600-650 1600-1800 d, a	650 750 d, a	2000-2075 d	2200-2350 d	1070-1100 1200-1990 d, a	1080-1600 d
unsure how to complete task		1750 d, a, e								
cell phone rings			950 d, a, e							
frustrated		1800 d, a, e	1650 d, a, e				1700 d, a	1600-1950 d, a, e		
disorientated							1200-1700 d, a			
Total	1	4	2	1	1	1	4	2	1	1

Results

In reference to Table 1, of the identified intervals from immersidata plots and numerical printouts where the movement (directional and angular) and events (keyboard and mouse button presses) are near-zero, eight breaks in user experience were identified. These results exclude the situations in which users were appropriately contemplating the educational content of the 2020Classroom. Of the eight breaks in experience, the cause of one was from an external source (i.e. cell phone) and the remaining seven were identified as design concerns of varying occurrence and severity. Low occurrence and severity design concerns were invariably identified as users' errors (e.g. not knowing what to do or how to complete a task). High occurrence and severity design concerns, for example, identifying problematic scenes or segments (e.g. the "intestinal cell" scene and those prompting cries of frustration) were identified as seriously undermining the playability and user experience of the computer game.

DISCUSSION

In this paper, we have proposed a continuous and unobtrusive technique towards automating the detection of breaks in user experience with three-dimensional computer games. Our hypothesis is that based on how much a user moved, and the number of interactions between a user and the environment, we can expedite the process of detecting breaks in the user experience. Analysis of data from a study of the 2020Classroom educational computer game that we are developing shows that this approach is an effective way to pinpoint potential usability and design problems occurring in unfolding situational and episodic events that can interrupt or break user experience. As well as informing redesign, a key advantage of this cost-effective approach is that it considerably reduces the time evaluators spend analyzing hours of videoed computer games study material.

FUTURE WORK

Extending the research described herein we are working towards the development of an assessment technique to capture the actual experience that is induced and evoked in, or witnessed by users of mediated or gaming environments. Utilizing the "immersidata" system, this technique will enable the capture and query of user-player behavior (e.g. gestures, directional and angular movement, mouse and keyboard events, etc.) in a manner that is unobtrusive and thus allows users to pursue their activities and continue to experience a mediated or gaming environment. In addition, this technique will allow assessment to be carried out continuously so that fluctuations in user experience can be captured and linked to situational and episodic events, and design features. Preliminary steps have already been taken in this direction [3].

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