Using a Hybrid Method to Evaluate the Usability of a 3D Virtual World User Interface

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Abstract*:*

One of the current problems for Human-Computer Interaction is the limitation of methods to functionally evaluate usability in 3D virtual world applications. This paper describes a hybrid usability evaluation method which we use to conduct an expert review of the user interface of a 3D virtual world application in Second Life. With the walkthrough highlighting 'in-world' task-based problems and heuristics focusing on the user interface, the hybrid method was very effective in capturing usability problems. We therefore conclude that using a hybrid method for usability evaluation in 3D virtual world applications may be more effective than using a single-perspective method.

Keywords-Methodology; *Usability; Virtual Worlds; User Interface; Interaction*

I. INTRODUCTION

One of the current problems for Human-Computer Interaction (HCI) is the limitation of methods to evaluate usability in 3D virtual world applications. Most usability evaluation methods in use are from an era of applications that were mostly task-oriented and based on a user-system interaction model (see: [1] and [2]). However, applications such as 3D virtual worlds challenge these existing methods and demand new evaluation methods that address modern interaction models. It is possible to apply traditional HCI methods such as heuristic evaluation [3] or the cognitive walkthrough [4] to virtual world applications. But these methods were originally developed to address usability of standard graphical user interfaces (GUIs). Therefore, there are limitations in terms of the problems they are able to accommodate because they do not effectively address domain-specific issues (e.g. spatial navigation, orientation, etc.) (see: [5], [6] and [7]). A further problem is the difficulty for existing methods to capture the user experience related to interaction with 3D virtual world applications. Hence, problems with interaction may result in bias in certain types of user evaluation methods especially those that are questionnaire-based.

To address these problems, this paper describes a hybrid evaluation method that is based on extended cognitive walkthrough methods and newer virtual world heuristics which we use to conduct a usability expert review of the user interface of a 3D virtual world application in Second Life. We consider the use of a hybrid method for two main reasons. The first is to identify usability problems related to in-world interaction using a task-based approach. The second is in order to increase the means of finding usability problems in the user interface using a heuristics-based approach. The main goal of this study is to test the effectiveness of the hybrid method to evaluate the usability of a 3D virtual world user interface in an early design prototype.

II. RELATED WORK

In this section, we summarise findings on usability issues in 3D virtual worlds and review existing frameworks for evaluating usability in 3D virtual world applications. We then introduce a two-stage hybrid method which is intended to help assess usability issues in these applications.

A. Usability Issues in 3D Virtual Worlds

Firstly, the emergence of new system interaction models has redefined the boundaries of the user interface. Secondly, user interaction and user experience in 3D virtual worlds differ considerably from that of GUIs. By focusing on usability from the beginning of the development process, developers are more likely to avoid creating interaction techniques that do not match appropriate user task requirements or producing standards and principles for virtual environment user interface development that are poor [8]. A number of issues affect the use of 3D virtual world applications. We summarise a few of them as follows:

- Input device: the 'movement device' being used (e.g. mouse, keyboard, joystick, etc.) can cause navigational and interaction problems for users.
- Graphics display: being unable to meet the high memory and graphic requirements can lead to a number of distortions, environment lags, low image resolutions, and overall perceptual difficulties for users.
- Environment: users can experience unexpected effects such as moving through walls and other objects in parts of the virtual environment
- Navigation: becoming lost or disoriented in the virtual world environment is one of the most common problems users face. The lack of identifiable cues or landmarks, the cognitive load placed on the navigator and the lack of position indicators on a map for example are all factors that can contribute to navigational problems.
- Interaction: users may experience being unable to manipulate objects, tools, and controls such as floating menus and palettes.

B. A Survey of Evaluation Frameworks for 3D Virtual World Applications

Designers of virtual environment systems have limited understanding of the associated usability issues and cannot rely solely on guidelines that were developed for GUIs [9]. Therefore, several studies have been conducted in order to address usability issues in 3D virtual worlds. The outcome has been the development or proposal of a number of frameworks and tools for usability evaluation in 3D virtual world applications. Here, we consider only the most essential findings agreed upon amongst researchers.

Usability evaluation may involve a representative user base (e.g. studies that make use of questionnaires) or in other cases it can be carried out without users being involved (e.g. an expert review). Usability evaluation mayalso take on several different forms or approaches (i.e. the difference between a questionnaire-based study and an expert review). Early work on usability evaluation includes an investigation of spatial input devices [10] and a description of basic methods for evaluating general usability components of virtual environments [11]. Bowman, Koller and Hughes [12] conducted a user-based evaluation of navigation which resulted in a framework for evaluating different virtual environment travel techniques. Likewise, Salzman, Dede, and Loftin [13] also took a user-based approach to conduct formative usability evaluations of an educational virtual world.

Several more usability evaluation methods and tools have been developed by others. For example there are checklists of criteria for assessing virtual environment design [14], adapted methods for evaluating usability of standard user interfaces for virtual environments [15], and questionnaire-based audits for virtual environment features [16]. Focusing on usability alone does not ensure the development of functional virtual world user interfaces. In fact, designers of 3D virtual world systems need ample guidelines and not just a rudimentary selection of methods.

Bowman, Gabbard, and Hix [8] indicate that evaluations based solely on heuristics and performed by usability experts have been very difficult in virtual environments because of a lack of published and verified guidelines for virtual environment user interface design. Despite this, a few works have developed usability methods that also integrated guidelines for virtual environment design. Examples are the model of interaction integrated with design guidelines for virtual environments found in [17] and design guidelines (see: [18]) which were further refined in [19]. Nevertheless, it remains true that the need for a set of guidelines for interface design has been insufficiently addressed.

C. A Two-Stage Hybrid Usability Evaluation Method

Long established methods such as formal evaluations and post-hoc questionnaires remain relevant to the standard GUI. However, newer types of interfaces like those of 3D virtual worlds introduce a new set of usability issues which need to be managed. With a collection of well-established usability evaluation methods that have a solid foundation within the field of HCI, research trends are moving towards further adaptation of these existing methods for use with newer types of systems and we have already identified the important ones in the last section. However, there are key questions that need to be addressed by current usability research. Firstly, extensive testing needs to be carried out with newer evaluation methods in order to verify the framework and the proposed guidelines. Secondly, literature suggests that most studies collect data by a single means. Therefore consideration should be given as to why single-perspective usability evaluation methods have endured for as long as they have in HCI research.

III. CASE STUDY: SECOND LIFE

The hybrid method is illustrated by a case study evaluation of the ‘Chaotic Science Lab’, a virtual world application (shown in Fig. 1) that aims to provide support for trainee science teachers in developing health and safety skills [20]. The Chaotic Science Lab virtual application enables trainee science teachers to carry out health and safety audits, develop their awareness of potential hazards, and assess the possible risks involved either individually or in groups. They are then able to discuss the discovered issues ‘in-world’ or later in a real classroom.

Figure 1: The Chaotic Science Lab – A virtual simulation of a real science laboratory

The application creates sessions that map on to real-world classroom teaching sessions. One of the in-world session scenarios is to prepare the virtual classroom for a new teaching session at the end of a session while following basic health and safety procedures. This involves putting a number of items that were used in the classroom back into their correct places. Using this scenario, we provide the details of our usability inspection starting with the cognitive walkthrough. This is then followed by details of the heuristics evaluation of the Second Life user interface.

A. Stage I – Cognitive Walkthrough

The classic cognitive walkthrough is an inspection method that is used to identify usability issues in an application and places emphasis on tasks. In this study, we used an extended cognitive walkthrough [21] developed for 3D virtual environment systems. The method is composed of three cycles of interaction: task action, navigation, and system initiative. Therefore within a given scenario, the user forms an intention to achieve a task goal and proceeds to find his or her way around the virtual environment. System initiative may then occur. In this phase, the system interrupts task action and navigation in order to provide some guidance or help. As such, the user is able to decline system initiative and resume navigation.

To conduct the walkthrough we first prepared a scenario (discussed in the previous section) to represent the user's task which dictates the goals and actions to be performed. Next we registered a session using a control panel within the application. The session allowed 10 minutes to move science apparatus scattered about the lab back to their correct places. Once the time was up, the system then showed the user's score. Session details (time, date, locations, and score) were also available via a web interface.

B. Stage II – Heuristiscs

Standard heuristics evaluation involves having experts review an interface against a set of guidelines or principles. However, we used a newer usability heuristics (see: [22] and [23]) developed for virtual world applications. The approach includes 16 specific usability heuristics and an associated usability checklist of 53 items that are grouped into three categories (i.e. Design and Aesthetics, Control and Navigation, and Errors and Help). The inspection was individually carried out by a group of three evaluators. The number of problems foundwas first aggregated into a single list of usability problems. Each evaluator then separately assigned scores to each problem's severity and frequency (on a scale of 0 to 4 with 0 being no problem/less frequent to 4 being a catastrophic problem/more recurrent) The mean severity and frequency were summed in order to determine the criticality of the problems.

IV. EVALUATION

The first stage of the evaluation was carried out in order to identify usability problems relating to in-world interaction using a task-based approach. Given the scenario to prepare the virtual classroom for another teaching session, a goal-directed mode of exploration was presumed. Therefore the walkthrough was conducted by using two cycles of interaction (i.e. task action and navigation). The third cycle, system initiative, did not occur within our scenario and therefore was not used. Each cycle consisted of action stages numbered from 1 – 9 (Task action) and 1 – 5 (Navigation), and a list of specified walkthrough questions that guided our group of evaluators during each stage. The following is a summary of the two cycles of interaction along with any problems we encountered:

A. Task action

1) Form goal

a) Can the user form or remember the task goal?

The task knowledge required for this stage was simple and it was therefore concluded that the user is able to determine and remember what to do. In case the user has poor task knowledge, the application provided features that include help tips and a main interactive signpost about the task and how to complete it. One of the problems found at this stage is related to navigation within the application (see: Navigation cycle B.1.a).

b) Can the user form an intention of what to do?

Besides the hints given at the start about what to do, the application did not suggest the best course of action. This is in part due to the nature of the application in that it provides results of the user's try at the end. However, it was expected that trying to put objects in obviously incorrect locations (e.g. placing a conical flask on a laptop as its final destination) will generate some sort of feedback response.

2) Locate active environment

a) Are the appropriate objects or parts of the environment visible?

The environment was highly detailed with very good graphical content producing realistic imagery. Also most of the objects that were necessary to locate in order to carry out the task action were visible. However, some of the objects that were made of glass material rendered poorly. Their low contrast against the environment of the virtual lab made them a bit difficult to see.

3) Locate objects

a) Can the necessary objects be located?

As mentioned in A.2.a there were problems with correctly rendering glass-made objects within the application. Low contrast of these objects made them difficult to see and because of this they were also difficult to find. Nonetheless, the objects were still discernible and with a bit of effort the user is able to locate them.

4) Approach and orient

a) Can the user approach and orient themselves to carry out the necessary action?

Here no problems were encountered in terms of approaching and orientation. However, with regards to missing generic design properties, the user's navigation could be guided in this action stage by providing hints within the application (see: Navigation cycle B.1.a).

5) Specific action

a) Can the user decide what action to take and how?

Within the given task scenario the user follows a goal-directed mode of exploration. Therefore task knowledge determines what actions the user should take.

6) Manipulate object

a) Can the user carry out the manipulation easily?

The user is able to carry out the manipulation easily as there are no complicated virtual tools required to handle the objects.

7) Recognise feedback

a) Is the consequence of action visible?

Sufficient and recognisable feedback is provided to the user as a consequence of their action. For example when the user clicks on an object to be moved, an action dialogue box helps the user complete the move. Once the move has been completed, a message is displayed informing the user that the new position has been recorded.

8) Assess feedback

a) Can the user interpret the change?

Feedback is clear and unambiguous hence the user is able to interpret the change as he or she manipulates the objects in the application.

9) Specify next action

a) Can the user decide what to do next?

Our test included a single scenario with continuous action. In this context, the user is always within procedure and relies mainly on task knowledge to carry out all the steps necessary to complete the task goal.

B. Navigation

1) Find path to target

a) Does the user know where to start looking?

The task knowledge required for the scenario was clear and simple. However, navigation towards target objects is mostly by free-form movement rather than directed or rather aided pathways. The only way the user knows where to start looking or where to locate the target is by looking everywhere.

2) Decide direction

a) Can the user determine a pathway towards the target?

The user is unable to determine an exact pathway towards the target objects – there are clues concerning what to do, but there are none as to where they might be located (e.g. a mini-map overlay with guidance to the general area an object is located or active/interactive cues leading to the targets).

3) Move navigate

a) Can the user execute movement and navigation actions?

Movement and navigation are fairly simple and mostly accomplished by intuition. Where this is not the case, Second Life provides a welcome area with basic skills and interaction tutorials for new users.

4) Interpret chance

a) Can the user recognise the search target?

Given the context of the application and the scenario, task knowledge allows the user to recognise most of the search targets as being a hazard or out of place.

5) Record/memorise location

a) Do the facilities for recording locations exist?

There are no waymarking or pathway tracing features built into the application but facilities do exist for recording object locations.The second stage of the evaluation was carried out in order to increase the means of finding usability problems in the user interface by using a heuristics-based approach that accommodates virtual worlds. A summary of the findings is shown in Table 1. A total of 36 problems were found with most of them relating to design and aesthetics of the user interface. Clarity of the user interface scored a severity average of 3.33 on our usability checklist mainly due to the poor implementation of elements (e.g. a cluttered menu system). The next problem area is control and navigation which was also found to be more critical than design and aesthetics. In particular, flexibility and efficiency of use scored a severity average of 3 on our checklist. The errors and help system was found to have the least problems. However, it was found to have the most critical of problems.

Categories	Problems Detected	Mean Severity	Mean Frequency	Mean Criticality
Design and Aesthetics	18	1.25	0.50	1.75
Control and Navigation	12	1.48	1.10	2.58
Errors and Help	6	1.88	1.25	3.13
Total	36	4.61	2.85	7.46

Figure 2: Summary of the usability heuristics evaluation

V. DISCUSSION AND CONCLUSION

The main goal of this study was to test the effectiveness of the hybrid method to evaluate the usability of a 3D virtual world user interface in an early design prototype. We found it to be highly useful especially because it is flexible enough to allow us to combine two different non-costly approaches for specific purposes within a single application. The cognitive walkthrough captured several problems that are mostly related to navigation. These findings agree with other studies such as [24] and [25] that suggest navigation is a significant problem in 3D virtual environments. On the other hand, the heuristic evaluation also revealed several problems found in the user interface. However, further comparative tests will have to be done in order to determine whether more problems are captured using heuristics for 3D virtual worlds compared to standard heuristics for GUIs.

In conducting the evaluation, we found evidence that there are no clear boundaries between the application, the virtual world, and the user interface. Thus, the user is able to interact with a standard GUI, and move between different applications and 'worlds' without realising any changes in the interface. Furthermore, what constitutes the user interface needs to be redefined. Is it the GUI? Is it the avatar and other interactive objects? With the walkthrough highlighting 'in-world' task-based problems and heuristics focusing on the user interface, the hybrid method was very effective in capturing usability problems. We therefore conclude that using a hybrid method for usability evaluation in 3D virtual world applications may be more effective than using a single-perspective method.

VI. REFERENCES

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