Visual Indication of Interactive 3D Elements in 3D Virtual Environments

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ABSTRACT

In this paper we present the user evaluation results on the indication of interactive three dimensional elements in a virtual environment. The evaluation was conducted with a functional prototype and additional high quality images that were printed on paper sheets. The evaluation indicated that without any visual indication provided in the prototype, participants were not sure which items in the office scene are interactable when they enter to the scene. Also the indication while a user is interacting with the prototype, needs to be distinctive enough. For the visual indication of interactable elements in the virtual environment, participants preferred a glow effect in both circumstances; 1st while they enter to the virtual environment and 2nd while they are interacting with the elements. This information is useful to HCI researchers, 3D UI designers and developers to improve user experiences with virtual environments.

Categories and Subject Descriptors

H5.m. **[Information interfaces and presentation] (e.g., HCI)**: Miscellaneous.

General Terms

Design, Experimentation, Human Factors.

Keywords

3D, visual indication, virtual environments, user evaluation.

1. INTRODUCTION

Visual indication for interactive elements is used quite often in games, such as Serious Sam 3 BFE [9], where a user is moving in three dimensional (3D) virtual environments (VEs) [2]. The aim of the indication is to draw user's attention and act as a guide. Also virtual worlds, such as Second Life [6] would benefit from this kind of approach. Especially, when a user enters for the first time into the 3D virtual environment, she/he has to know which items and 3D objects she/he can interact with, to make user interaction as smooth and user friendly as possible.

In this paper we present the early development phase user experience (UX) evaluation results with an operational prototype and additional images of ways for visual indication for interactive 3D elements in VEs which were printed on paper sheets. The sets of visual indications were designed for two cases: 1st when a user enters to the VE and 2nd while she/he is interacting with the elements. This paper contributes to the 3D VE research and the designer community by presenting user experiences with the prototype and participants preferences on visuals example images.

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2. RELATED RESEARCH

Visual indication is widely used in 3D games where it is critical for fast performance in different situations, such as, finding equipment, energy or route. For example, in Serious Sam 3 BFE [9] the energy blood bottles are indicated with animated colour change from red to white-turquoise, the indication is shown on the bottle as colour overlay or as coloured edge depending on the viewing distance. It is also noted in 3D game research, that for a smooth interaction, the location of the visual indication is as important as the indication itself [4].

In current collaborative 3D VEs, such as Second Life [6], visual indication is not widely used for indicating interactive 3D elements. Also research of visual indication of 3D elements in 3D VEs is lacking. Pichler [8] studied four strategies for an anchor highlighting in a 3D scene. The strategies were bounding cube, brightness, colour code and colour edges, of which the colour code was found to be the best in a usability test. It was also the users' favourite choice for highlighting mode, whereas colour edges was the most visually appealing choice [8].

There is still not enough user experience based information about the visual indication of interactable 3D objects in VEs. ISO 9241-110:2010 [3] defines user experience as: "*a person's perceptions and responses that results from the use and/or anticipated use of a product, system or service*". As the aim of UX studies is to help in selecting the best design solution and make sure that the development is on the right track, therefore it is important to evaluate UX before, during and after the use [10].

3. USER EVALUATION

We selected a 3D virtual office scene (Figure 1) as our study example, because in prior studies we have noticed that background space has an impact on how users perceive the 3D GUI [1]. We thought that the office scene would be suitable and meaningful for all kinds of users. The scene included *non-interactable* office related 3D objects, such as a table, chairs, a calendar, a clock, file cabinets and shelves, binders, coffee mugs and a plate. In addition, we embedded 21 *interactable* 3D icons to the scene. There were: two web browsers (Firefox and Chrome), five social media icons (Twitter, Skype, Facebook, Chat, and

YouTube), three files (Word, PowerPoint and PDF), a radio, a news screen, a binder, a screen, an email, a microphone, a calculator, a camera, a video camera and a calendar. Interactable icons were located in different places in the scene; three were on the table, five were on the file cabinets and shelves, five were on the wall and seven were floating in the air at different spatial depths. For the evaluation we implemented a 3D office scene in the open source realXtend Tundra 2 virtual environment platform [7] and used a screenshot image of it as a basis for our visual indication image examples.

Figure 1. A 3D virtual office scene used in the user evaluation.

3.1 Interactable Prototype

The idea was to implement the prototype to a touch screen tablet device, but it was impossible to get any tablet to work with the Linux operating system and realXtend Tundra 2 [7]. Therefore we chose the next best solution, which was a laptop computer with a 12 inch touch screen. In the evaluation, the screen was twisted on the backside, so that users could interact with it like they would with a tablet device (Figure 2). The actual implementation of the prototype was done similarly as our earlier prototype [5], where all the actions were the same, but the 3D space and icons were different. In the prototype it was possible to drag 3D items on 3D icons, which launched, for example, a search from the Internet and showed results on the news screen on the wall. We did not implement any visual difference between static elements and interactive elements in the scene when a user is not interacting with it, because we wanted to study if users know which elements are interactable and which are not. When the user starts to interact with the prototype, a yellow overlay colour was used to indicate targets for the dragged items (Figure 2).

Figure 2. Yellow colour overlay indication is showing the possible target 3D icons while user is dragging a song object.

3.2 Example Images on Paper

In addition to operational prototype, we decided to use picture examples which were printed on paper. We have found picture examples useful in early development phase user evaluations to get user feedback for the visual design of elements with easy and cost effective manner [1]. Creation of evaluation examples was done by utilizing the "research through design"- method [11].

To study how interactive elements should be presented to the user, we made evaluation example images in the Photoshop by adding different visual effects on the interarctable icons. 1st we added them on an image representing a view to the office when a user enters to the VE (Figure 1) and 2nd on image representing view when a user is interacting with the elements, e.g. indicating targets objects for dragged items (Figure 2 & 4). We based our designs on indications that we had seen in 3D games, such as Serious Sam 3 BFE [9] and we wanted to extend the visual indications used in prior research [8]. Therefore we decided to use seven types of effects: brightness, drop shadow, inner shadow, stroke, colour overlay, inner bevel and glow, either independently or as a combination of many effects to represent interactivity. We used a uniform colour theme in all options, to make them easily comparable with each other's. For the 1st case, we made eight different examples to represent interactive elements (Figure 3). For the 2nd case, we made seven examples (Figure 4). We printed each example image on a paper sized 28,5x16 centimetres which were almost in equal in screen size to the interactable prototype.

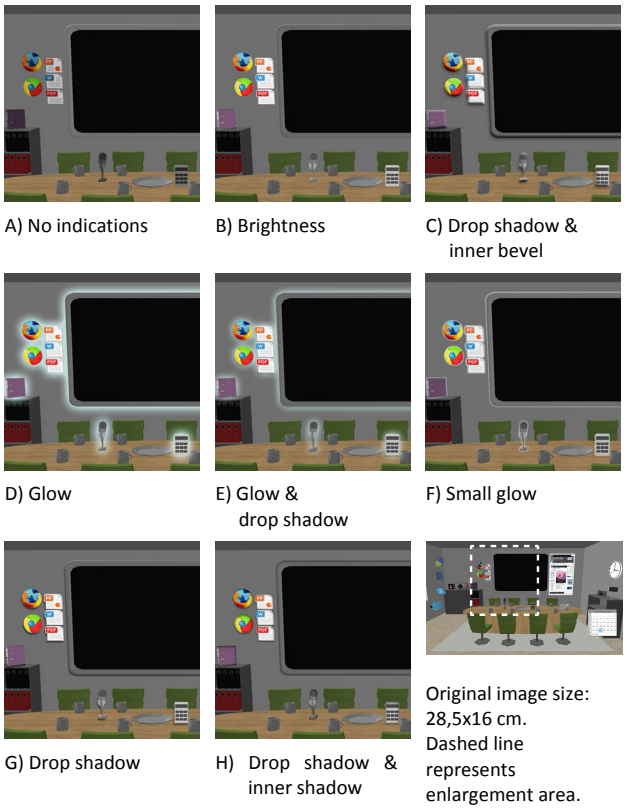

Figure 3. Enlargements of the visual indication effects used in the example images (A-H) in the 1st case. Below an example of the original image with the enlargement area indicated with dashed white line.

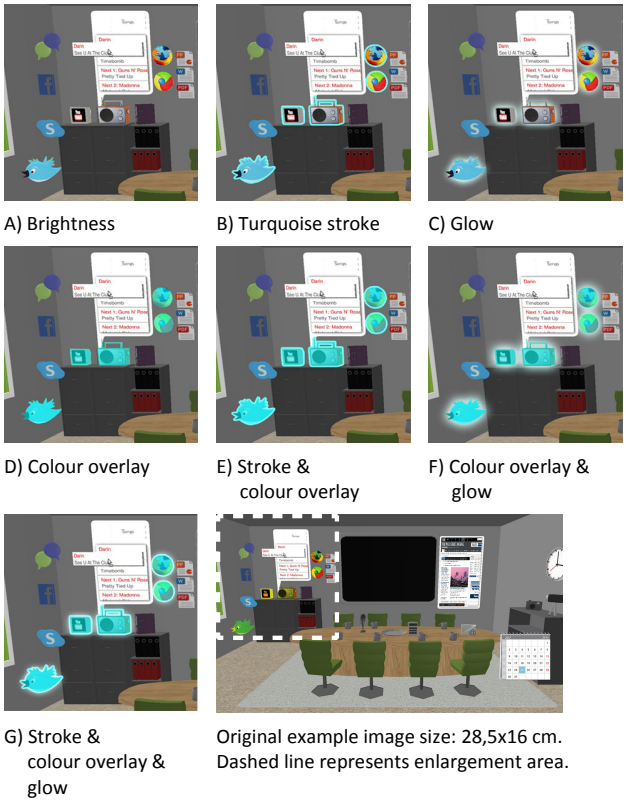

Figure 4. Enlargements of the visual indication effects used in the example images (A-G) in the 2nd case. Below an example of the original image with the enlargement area indicated with dashed white line.

3.3 Participants

We recruited 35 participants to the user evaluation. All of the participants had prior experience with touch screens. 86% of them owned a touch screen mobile phone and 97% of them had tried or used tablet devices. The participants' age varied from 20 to 52 years with a mean of 31. 69% of the participants were male. 54% of the participants used 3D virtual environments on a computer, but none of subjects used them on a tablet or a mobile phone.

3.4 Evaluation Procedure

The user evaluation had two tasks, which both had two phases. In the first phase participants evaluated the prototype and in the second phase they selected the best option from given example image alternatives. Participants' subjective experiences were gathered by observing, writing down their comments and video recording, while they were completing the following tasks:

1ST TASK:

- We showed a 3D virtual office scene from the laptop and asked participants to list which of the items in the scene they thought would be interactable (without interacting with the prototype yet).
- In the 1st selection task we placed eight example images (Figure 3) in random order on the desk in front of the subject and asked to select the best choice for indicating interactive elements in the scene when they enter to the VE or give their own example of an indication. They were also asked to explain reason for their selection.

2ND TASK:

- Then we asked subjects to interact with the prototype: specifically, move in the scene and find music (press radio icon). Then we asked them to listen to a song (drag the song object on the radio icon). After that we asked them if they could drag it to some other place too (yellow overlay colour was showed on the possible targets) (Figure 2).
- In the 2nd selection task we placed seven example images (Figure 4) in random order on the desk in front of the participant and asked to select the best choice for indicating target icons in the scene while interacting with it or give their own example of an indication. They were also asked to explain reason for their selection.

4. FINDINGS

In the 1st task, it was not clear to the participants which items in the office scene are interactable and which are not. It was easier to notice icons which did not look like they are part of the scene, such as Firefox, Chrome, Twitter, Facebook, Skype, Chat, Word, PowerPoint, PDF and news screen. These were noticed because participants knew them from other contexts or because they were floating in the air. The interactivity of the items on the table and on the shelves was not that clear to the participants. The binder, microphone and video camera were listed as interactable objects by less than 25% of the participants, because they fitted visually too well in to the scene and its non-interactable objects. Also a few thought that the clock, chairs, all binders and coffee mugs are interactable items even though they were not. Therefore, it was quite obvious that participants did not notice all of the interactable items when they entered first time to the office scene.

In the 1st selection task participants preferred the glow effect for representing interactable elements when they enter to the virtual office (Figure 5). 43% of the participants preferred example E which had a glow with a drop shadow. It was preferred because it clearly showed interactive elements with a small glow effect while the brightness of the glow did not cause too much irritation, unlike in option D. 33% selected option D which had only the glow effect. 13% selected option F which had the smallest glow effect. No one gave their own examples, but they selected one of the given examples and commented on the changes that they would like to have. 13% of the participants commented that the indication could be shown only for limited time after entering to the virtual environment. They also wished that they could either switch the indication off or adjust the amount of the glow.

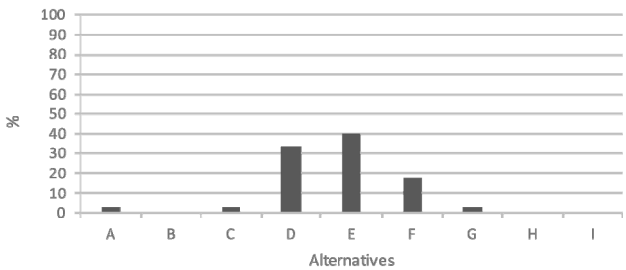

Figure 5. Participants' selections for indication of interactive 3D elements when entering to the virtual office scene.

When participants interacted with the prototype in the 2nd task, the yellow overlay colour indication for possible target objects was not perceived well enough because almost all of the participants missed it. We had to ask leading questions, such as 'are there any other possibilities where you could drag the item to'. Even after leading questions some of the participants did not notice the implemented indication. The yellow overlay colour was not distinctive enough from icons original colours, especially, if it had yellow, red or green colours.

In the 2nd selection task participants preferred the glow effect as well (Figure 6). 40% of the participants chose option C which had only a glow around the icons. It was preferred because it did not change the original colours of the icons. 37% of the participants preferred option G which had a turquoise overlay colour. Participants commented that it is clearly distinguishable from the glow indication that they selected in the 1st selection task. On the other hand for two participants the colour change made it look like it was inactive or forbidden. One participant was red-green-blinded and for him the turquoise colour was not a good choice. He wished for more warmness to the colour to make it distinct better from the background colours. For him the original yellow indication colour was better. A few participants also suggested that the colour could be something else, for example white. A few participants wished that icons could blink or the background could darken when a user starts to drag the item.

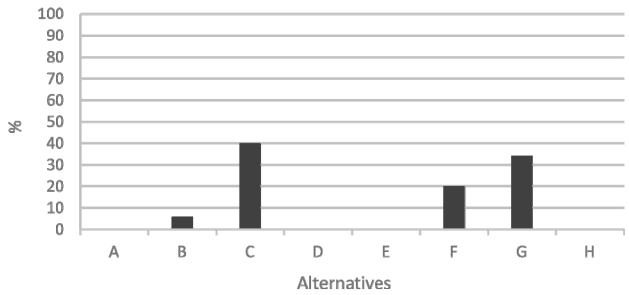

Figure 6. Participants' selections for the target object indication while dragging an item.

5. CONCLUSION

In this paper we present a preliminary user evaluation on indication of interactive elements in a 3D VE. The evaluation was conducted with a functional prototype and additional high quality images printed on paper sheets to gain information for the next iterations of the prototype. The evaluation elicited that without any visual indication provided in the prototype, participants cannot be sure which items in the scene are interactable when they enter to the VE. Also the indication while interaction for presenting possible target objects, needs to be distinctive enough from target icons original colours. From example images, participants preferred a glow effect for indicating interactable elements in the VE in both circumstances; 1st when they enter to the virtual environment and 2nd while they are interacting with the elements.

Whereas we believe that our results provide useful information for researchers and designers of the 3D VEs, we also recognize the limitations of the study. As we did not implement visual examples, we missed touch screen interaction with them. Therefore, in future studies we should focus on testing different glow effect sizes for target icons while a user is interacting with the prototype to find out if the indication is visible enough when the user's hand is blocking the view to the screen. Also it should be studied if the indication should show all the time or just briefly when a user enters to the VE.

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