User Behaviour in Web-Based Interactive Virtual Tours

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***Abstract**. In this work, user behaviour characteristics were investigated for a web-based virtual tour application in which 360º panoramic images were used. There exist several options for the user to navigate in the museum (interactive floor plan, links in the images and pull-down menu). Written and audio information about the sections visited, detailed information for some artworks and several control functions are provided at the webpage. 15 participants undertook the usability test and they filled a post-experiment questionnaire. The main research questions were: Which option of navigation is preferred? At what rate are the written information area, audio information option and extra artwork information used? Which way of control (mouse, keyboard, panel buttons) is preferred? Results showed that the floor plan is the most preferred way for changing the location and pull-down menu is the least preferred. Another finding is that the mouse is the most preferred way for control functions.*

Keywords. web-based virtual tour, panoramic image, usability, user behaviour, think-aloud protocol, navigation.

1. Introduction

Web-based virtual tour applications constructed by 360º panoramic images are used extensively all over the world. The main item in such a tour is a viewing window that the user can control. Using Java Applet technology is one way of creating such web applications[1]. Ipix and QuickTime are other popular tools that can be used. Adding links to the images to pass the other images of the place makes possible to use the window as a navigation tool. Providing a floor plan helps user to navigate through the environment. Louvre Museum Virtual Tour[2] can be given as an example to such usage. A step further is making this floor plan interactive and integrated with the viewing window. In this way, photos and floor plan can be used together for wandering in the visited place. Additional items such as pull-down menus and links to artworks may be preferred for some applications.

Interactive virtual tours improve the visual presentation and spatial understanding of the place being visited. Day by day, providing such tours is becoming crucial for the websites that present a place having visual importance. It is also an effective tool for advertising the galleries, shopping centers etc. Therefore, evaluating the usability of these virtual tours is meaningful and findings are important to designers of similar applications.

Usability issues of these virtual tours are hardly studied. Villaneuva, Moore and Wong [10] performed a study with virtual tours using 360º panoramic photos, which they call photo-realistic virtual environments. They investigated the proper usability evaluation methodology for this kind of application. Two qualitative methods are compared: think-aloud protocol and heuristics. Their conclusion was that think-aloud protocol is more convenient. They also proposed to group the usability issues into four categories: Functionality, Interaction, Appearance and extra Comments/Suggestions by the user.

Karat, Pinhanez, Karat, Arora and Vergo [3] conducted research for design concerns of web tour interfaces. They worked with cultural information tours rather than spatial navigation tours. They proposed to design those kinds of applications with a "less clicking, more watching" approach. But, it is also mentioned that in game-like applications, control is a critical factor. They did not work on which ways of interaction would be effective.

Although not directly applied for virtual tour applications, Nielsen [5] studied web applications that use Flash. The main finding was that web-based applications must be immediately understandable because people spend less time for these applications and they have less motivation to understand advanced features.

[1] Example Applet in the website of 0-360 panoramic camera manufacturer: http://www.0-360.com/index.asp
[2] Louvre Museum: http://www.louvre.fr/

Research conducted by Gude [2] aims to find an efficient and intuitive solution for navigation in 3D virtual reality (VR) applications. The study concentrated mouse and keyboard interaction techniques, 3D format of virtual environment (VE) and navigation modes such as walk, fly etc.

Sayers, Wilson and McNeill [6] worked on the navigational issues in the usability of desktop virtual environments. Since the discussed environment is 3D, navigational issues are broader than the described photo-based virtual tour scheme. They conducted some tests to find out what kind of functions will increase navigation performance such that, using map, speed control, location marking etc. Finding for map usage is that users did not need to use the map much but in post-study questionnaire they mentioned that map would be useful for large-scale 3D environments.

Sutcliffe and Kaur [7] proposed VE-specific principles for evaluating 3D virtual reality applications. Later they combined this study with a heuristic VE evaluation method [8].

Main research questions in our study are: Which option of navigation is preferred and for what purposes? At what rate are the written information area, audio information option and extra artwork information used? What extra functions are used? Which way of control (mouse, keyboard, panel buttons) is preferred?

In Section 2, we explained our virtual tour application and usability evaluation experiment. Section 3 summarizes the results of experiment and finally Section 4 discusses these results.

2. Methodology

2.1. Tool

The virtual tour application that was used for this study is the Isparta Museum Virtual Tour. This tour is a part of the information system developed for Isparta Museum, Turkey [1]. It was prepared using Java Applet technology and includes interactive floor plan which is integrated with viewing window. In other words, section of the museum that is currently presented in the viewing window, field of view (FOV) and direction of view are indicated in the floor plan. It is updated accordingly as the user changes these controls.

In Fig. 1, a snapshot of the virtual tour page is shown. At top-right, the viewing window exists under which the pull-down menu and written information area are located. On the left, a short description of the museum, interactive floor plan and audio information button exist from top to bottom. The displayed area covers 755x550 pixel area in the web browser window. Currently, site is available only in Turkish and can be visited at http://edmer.ii.metu.edu.tr/isparta

Figure 1. A screenshot from the Isparta Museum Virtual Tour Page

Three functions are available for the user to navigate through the sections in the museum:

- Clicking on the navigation arrows located in the viewing window takes the user to the related section of the museum.
- Users can click on the sections in the floor plan to change the viewed section.
- Users can select the desired section of the museum from pull-down menu and the image in the viewing window changes accordingly.

Additional capabilities/properties are:

- It provides written information of the section, which is being visited. Written information is directly available in the textbox.
- It provides audio information (spoken form of the written info) of the section, which is being visited. Users have to press a button to start audio and press another button to stop it.
- Some artworks have blue circular signs on them. Clicking those signs opens a new window with detailed artwork information.
- Help page for the controls and available functions is available when users press the help button at the panel of viewing window.
- Zoom in / zoom out is available with buttons or using keyboard.
- Changing the viewing direction is possible by using mouse, panel buttons and keyboard.
- Viewed direction and angle of field of view (FOV) is shown on the floor plan with a light blue region. This region can be dragged as well to change the viewing direction.

2.2. Experiment

15 people participated in the usability evaluation experiment. Nielsen [4] mentioned that 15 participants are enough to find all the errors that can be found by usability tests. In our experiment all the participants were the graduate students in METU and three of them were female. They were graduated from either positive sciences or engineering departments (no social science graduates). All of them were using the internet at their work. Before the experiment, participants were not visually introduced to the application. The users were asked to "think aloud" as they perform the tasks. At first, they were asked to visit the museum freely to discover the navigation tools and functions as much as they wish. After this free tour, the participants were asked to perform three tasks, all of which were finding specific information related to a certain artwork in the museum. In one of them, this information is available only if the user clicks the blue spot on the artwork. In the other two, required information is available in the already available textbox and on-demand available audio information. While evaluating the task performance, the emphasis was not on the completion time but on the functions and options the participants preferred.

The usability evaluation was performed in two ways. First, verbal data gathered during the experiment (think-aloud protocol) and post-experiment questionnaire were analyzed. Second, eye-tracking data (fixation points) recorded by the equipment provided in the Human-Computer Interaction (HCI) Laboratory of the Middle East Technical University (METU) was used.

The post-experiment questionnaire provides subjective information for user's behaviour. Briefly, it investigates:

- Which options of navigation through the sections were used?
- How do the participants rate the effectiveness of these navigation options?
- What other capabilities and functions were used and at what rate?
- Which way of control (mouse, keyboard, panel buttons) is mostly preferred?
- Were the navigational aids adequate? Problems with determining the location?
- What additional controls, functions might be?
- What additional problems encountered? Any suggested improvements?
- General ideas about the application?

3. Results

As mentioned, 15 participants performed a free tour by themselves first. The mean duration for this free tour is calculated as 9'14'' varying from 3'40'' to 21'30''. After the tour, they were given three tasks. The mean durations for these tasks are calculated as 42'', 32'' and 17'' in the order given in the experiment.

Table 1. Result of which options are used for navigation through the sections

	Not recognized	Recognized but not used	Seldom used	Frequently used
Floor map	3	0	2	10
Viewing window	0	1	6	8
Pull-down menu	0	5	9	1

Table 2. Result of how the participants rate the effectiveness of the navigation options

	Not needed	Can be used seldom	Effective
Floor map	0	0	15
Viewing window	5	4	6
Pull-down menu	4	11	0

Table 1 shows which options the users utilized for navigation through the sections of the museum. Values indicate the number of people in that category. Three people did not realize that they were able to click on the floor map to change their location. From the rest, two of them seldom used and ten people frequently used the floor map. The other option of navigating in the museum is using the arrows located in the viewing window. There is one person who did not prefer to use it. From the rest, six people seldom used and eight people frequently used the arrows. It can be observed that the third option, pull-down menu, is the least preferred. Only one person used it often, nine people used seldom and five people did not use it.

When we asked the participants to rate the effectiveness of these three options (Table 2), we see that all have the idea that using floor map is an effective way. Five people think that arrows in the viewing window are not needed, four participants consider that they can be used seldom and six of them think that they are effective. For the pull-down menu, none of the participants think that it is an effective way to navigate through the sections. Four of them think that it is not needed at all, the rest (11 people) mentioned that it is better to keep the option available than removing it.

We should also take into account the verbal expressions of the users. Two participants mentioned that they preferred using arrows in the viewing window, because it gives a feeling of more natural visit (going to the neighbouring section each time). Five participants mentioned that it makes sense to use the pull-down menu only to reach a specific location, like the finding information tasks given to the participants.

Table 3 shows what screen/mouse/keyboard functions were used by the participants. Written information area was frequently read by five people and seldom read by five people. Four people used this area only when the required information to accomplish the task given to them is there. One of the participants did not recognize it until the related task was given.

Audio information was used frequently by only one participant. Six participants did not recognize this function. Two of these six people mentioned that they recognized the function button but did not realize that they can listen the related information if they press it, because the word on the button was not descriptive enough.

Zoom function can be controlled either by panel buttons below the viewing window or using keyboard. Two people used the buttons to zoom frequently, eight used seldom and five people did not use even they recognized. However, we should mention that resolution of the pictures was not high, which was also indicated by nine of the participants. If high resolution pictures were used we could expect more usage of zoom function.

Four possibilities exist to change the viewing direction: 1) dragging view with mouse 2) using panel buttons 3) using keyboard 4) dragging viewed area in map. Dragging the view with mouse was not recognized by three people, but from the rest, 10 participants used it frequently. All the people realized the function of panel buttons, but only one used it frequently and four of them did not use at all. Changing viewing direction by keyboard was not recognized by 11 participants and the rest (4) did not use it. Changing viewing direction by dragging it in map was not recognized by nine participants, from the rest five people used it seldom and one participant did not use it.

Links (blue circles) opening the artwork information window were frequently used by nine people. One person used this area only when the required information to accomplish the task was there. One of the participants did not recognize that the blue links can be clicked until the related task was given.

Help page can be opened by clicking a link that is located at the panel below the viewing window. In our experiment, only one participant read the help page from the beginning to the end. Six participants opened the help page but did not read the full page. Two of these six participants mentioned that they would read the full page if they recognized and opened it at the beginning. Since they had already discovered most of the functions, they did not want to read the text. Two participants did not recognize the help page link and the rest (six people) did not open the page although they had recognized.

Concerning the navigational aids, participants were generally satisfied with the available tools and they were able to determine their location during the visit. One participant needed to know the 'geographical north' since he was paying attention from which direction the sunlight was coming. Since the visited museum is mostly an indoor environment, we reckon that the geographical direction information may become a critical factor in outdoor applications. It was also mentioned that if a 3D model of the museum (indicating the current location) was available at the page it might help the navigation.

Other mentioned problems and suggested improvements are given below:

- Two participants mentioned that viewing window might be larger.
- Four participants suggested to control zoom function by mouse (using mouse wheel).
- Two participants suggested to indicate that the contents of audio and written information are same.
- Two participants mentioned that the squares on the floor map that indicates the user can click on them were not recognizable. Highlighting them with appealing colours or using camera icons are suggested improvements.
- One participant needed to control the audio information by pause-resume buttons in order to make it synchronized with his own watching/visiting speed.

Although, the participants had suggested aesthetic and functional improvements, they mentioned that the website can be used to obtain information about the museum and artworks in it.

Table 3. Result of what screen/mouse/keyboard functions are used by the participants

	Not recognized	Recognized but not preferred	Seldom used	Frequently used
Written information area	1	4	5	5
Audio information button	6	3	5	1
Zoom (changing field of view) by buttons	0	5	8	2
Zoom using keyboard	12	2	0	1
Changing viewing direction by dragging view by mouse	3	1	1	10
Changing viewing direction by buttons	0	4	10	1
Changing viewing direction using keyboard	11	4	0	0
Changing viewing direction by dragging it in map	9	1	5	0
Links opening artwork information window	1	1	4	9
Help page link	2	6	6	1

Table 4. Mean number of fixations for the defined AOIs

	Floor map	Viewing window	Written info. area	Audio info. buttons
Mean no. of fixations	236	798	148	23
Min. no. of fixations	86	244	6	0
Max. no. of fixations	423	1559	286	95

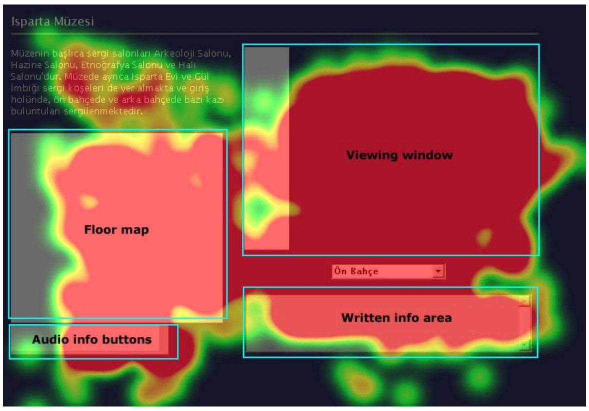

Figure 2. Accumulation of the occurred fixation points of the participants

Using the eye-tracker data, the locations in the page that the participants' eyes fixated were analyzed. Four areas of interest (AOI) were defined in the main virtual tour screen: viewing window, floor map, written information area and audio information buttons area. Number of fixations occurred in these areas are counted (Fig. 2, Table 4). It is seen that participants mostly gazed the viewing window. Indeed, the number of fixations in the viewing window is greater than the sum of other three areas. Floor map is the next most gazed region. Then, comes written information area and audio information buttons.

4. Conclusion

In this study, user preferences were investigated for a web-based virtual tour application. One of the main research questions was that which option of navigation is preferred and for what purposes. Three options to navigate through the museum sections were the interactive floor plan, links (arrows) in the images and the pull-down menu. It is observed that mostly preferred way is using the floor plan, although three participants could not recognize this ability of the map. Thus, this option should be highlighted so that the users recognize it more easily. Arrows in the viewing window were also used often to change the location in the museum. Pull-down menu is the least preferred option. This can be related to the findings of Tullis and Codimer [9] who compared the data entry techniques (such as drag and drop, icons, text entry, pull-down etc.) and found out that pull-down menu is one of the less preferred ones. According to participants' verbal expressions: a) arrows in the viewing window are good for the ones who like to visit the sections by passing to the neighbouring one, they feel more natural visit, b) pull-down menu would be useful only if the user wants to find a certain section in the museum.

We observed that to obtain information for the visited sections, written information is more preferred with respect to the audio info. Links on the artworks were frequently used by most of the participants. Help page on the other hand was used for only half of the participants and not used effectively by the ones who opened it since they recognized it after discovering the functions by themselves. It should be considered to offer help at the beginning. Also areas on the floor plan that users can click on should be highlighted to be easily recognized. These findings support the result of Nielsen [5] who mentioned that the functions in web-applications should be immediately understandable.

Changing viewing direction can be controlled by mouse, keyboard and panel buttons. When we analyzed how much they were used, we saw that the mouse control was preferred most. Panel buttons were used seldom. Keyboard buttons were not used even by the users who recognized that the keyboard control is possible. Zoom in/out is possible by panel buttons and keyboard. Keyboard control was generally not recognized and some of the users looked for mouse control and they suggested using mouse wheel for zoom control. These results are in accordance with the findings of Gude [2], who also concluded that users mostly preferred mouse-based modes of navigation.

We also analyzed the eye fixations of the participants to determine the most gazed areas. As expected, the viewing window in which 360° photographs are viewed according to the direction and field of view is the most gazed area. We should mention that the results obtained from the task analysis (free tour and three finding information tasks) and answers to the post-experiment questionnaire are much more determinative than the eye-tracker data. Villaneuva, Moore and Wong [10] also found that think-aloud protocol is more convenient for the usability evaluation in photo-realistic virtual environments. They had also proposed to group the usability issues into four categories: Functionality, Interaction, Appearance and extra Comments by the user. We did not divide our results in these four strict categories but our questionnaire items cover these issues.

As a result, we analyzed the user behaviour in web-based virtual tour applications using 360° panoramic images. Research questions concerning the navigation options, control options and information related functions were answered. Tendencies such as using the floor map for navigation and mouse for control were extracted. Interactive virtual tours become popular since they enhance visual presentation and spatial understanding. Thus, findings are crucial to designers of such applications.

5. Acknowledgements

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