Guidelines for Designing Image-based Virtual Reality Application

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Abstract—This paper presents a set of guidelines oriented to makes easier the creation of a well-designed image-based virtual reality (IBVR) application for eliciting spatial presence experience among users. These guidelines are only for cylindrical view that contributes calmness among users. We structured these guidelines considering the survey obtained feedback from a hundred users. These data were enriched by repertory grid technique. We show a guidelines-creation process and develop the aspect in IBVR prototype. The guidelines are described based on seven criterions. The criterions are hotspot, zoom in/out, panning, panoramic view, recorded natural sound, navigation in IBVR application and storyline.

Keywords—Presence, Spatial Presence, Virtual Reality, Image-based Virtual Reality, Human Computer Interaction

I. INTRODUCTION

IMAGE-BASED virtual reality (IBVR) is one of the type of virtual reality (VR). IBVR refers to the use of images stitched together to create a virtual environment [1]. It offers photographic quality realism and provides the user with 3D illusion during walkthrough despite the absence of geometric information [2]. IBVR application provide high realistic virtual environment and need low processing performance computer. Three types of realistic virtual environment in IBVR application are spherical view, cylindrical view and cubic view. The realistic virtual environment is one of the factors that elicit presence.

Presence is a major design requirement [3]–[5] and critical components [5] for virtual reality (VR) application. The system is deemed more success as the percentage level of presence experience gained by the user gets higher [1], [4], [6]. Presence and IBVR application is still lacking. It because of it limited interaction functions.

IBVR interaction functions are panning, zoom in/out, and hotspot. The navigation is only in the virtual environment. Despite the limited interaction function, it is expected users can also experience presence in IBVR environment. The concept of presence in VR application is not only due that not only considered on the high interaction function [7]. According to [8], [9] mainly important is how users mind can accept virtual environment as real environment. As such, spatial presence is most relevant in this situation. Moreover, spatial presence is based on cognitive theory [8], [10]–[12].

Spatial Presence theory is focus on user’s is certainly involved directly with the human mind [8], [13] and conjunction with human feeling [11]. Therefore, it has been stated that Spatial Presence require cognitive theories to explain the mental mechanisms that enables humans to feel presence when they use media or simulated technologies [8], [9], [14].

Spatial presence can be defined as a user’s experience to feel being located in mediated environment that not just involve application factor but the most important is about user’s expectation about the media, particularly the media characteristics [8]. Moreover, positive feeling of the content of an environment is one of the factor to elicit spatial presence [11]. Hence, we applied calmness virtual environment as the scope in this paper.

In order to contribute to previous efforts, a set of guidelines to design IBVR application is provided here.

The remaining of this paper is organized as follows: In section 2, we analyzed some related issues. Our proposal is described in section 3 including an overview of the creation process and an illustrative example. Finally section 4 states our current and future work related to this research.

II. PROBLEM OUTLINE

GBVR is most studied in research on presence because of its high interaction capabilities and dynamic panoramic virtual environment that give a deep presence to the user [15], [16].

In this section, design guideline is described. However these guidelines is not suitable for IBVR application because the characteristics of IBVR and GBVR is not similar.

Ten steps design virtual environment (VE) has proposed by [17]. This guideline stated that developer should always alert with the technology developments and always plans the advantages of using the system on a continuous basis. Developers should also identify and understand the real characteristics of VR, end users, equipments, hardware, software, development platforms and the features of the VR application to be developed.

[8] also produce a development guideline for the computer games and VE. Things that must be in consideration is detailed design planning of VR application including the interface, level of difficulties and routes for each level.
III. GUIDELINES FOR DESIGNING IBVR APPLICATION

A. The Proposed Guidelines

The proposed set of non-exhaustive guidelines is following presented. We had conducted a preliminary study to identify the IBVR characteristics that elicit spatial presence by measuring IBVR application by using Presence questionnaire (PQ).

• Hotspot: The first characteristic of IBVR is the hotspot. This navigation button allows the user to travel from one place to another. Users will use a mouse to apply the hotspot function. We also assume that the hotspot will be the function that can enable the users to feel spatial presence even though the navigation is only done by using a mouse. The user can travel easily from one visual to another just by clicking the hotspot button. If the users find it difficult to use the application, the user’s spatial presence will be distracted [18]. In addition, each hotspot button has information that allows users to understand the hotspot function button before they click on it. They can then explore the visual easily. Moreover, they can identify specific hotspot features that can enhance their spatial presence.

• Zoom in/out: In our preliminary study, the result showed that users are unconcerned with the zoom in/out feature. They felt this feature can either be necessary or unnecessary in the IBVR environment [19]. In this study, we still consider zoom in/out because we may obtain a different result by using the Repertory Grid technique [19].

• Panning: The third navigation button is panning, which allows users to see 360 degrees of panoramic view in the IBVR environment. Two types of panning are provided in an IBVR application, panning with mouse and auto-panning [19]. In our preliminary study, users preferred auto-panning. In the current study, both types of panning are still considered in this hypothesis because we use the Repertory Grid.

• Visual realism and recorded natural sound: The scope of this paper is on the cylindrical view. Based on our preliminary study, participants were satisfied with the cylindrical image when they use a mouse [19]. The second element of visual realism, is animation and addition object. The majority of the participants agreed that the visual object or animation is unnecessary in viewing the IBVR environment [19]. They assumed that a panoramic view in the IBVR environment is enough to elicit presence. The result was based on PQ. A different result may be obtained by using the Repertory Grid. Recorded natural sound is also considered to have an impact on enhancing user presence.

B. The Guidelines-Creation Process

Previous guidelines were confirmed by the experiences of 100 participants using repertory grid technique. Three IBVR prototypes are developed the technique requirement.

1) Participants

A total of 100 participants have been involved in this study. The ages of the respondents are between 23 years old and 40 years old. We choose this age range based on the results of our preliminary study [19] because people within this age range are interested in using IBVR application walkthroughs.

The respondents must also be employed and part-time students. They are chosen because they are busy working on weekdays. This study develops an IBVR prototype for the respondents. They can use this application to feel calm.

2) Equipment

We develop a non-immersive IBVR application to allow respondents to use this application without expensive VR equipment. In this study, a 21-inch LCD screen is used with headphones. However, if the IBVR application is used with a HMD and a “big screen,” then the user will experience higher spatial presence. This statement is based on our preliminary study.

3) Materials

Three IBVR prototypes are used in this experiment: forest, field, and island. The three prototypes that applied IBVR characteristics as described in table 1.

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<thead>
<tr>
<th>IBVR characteristics</th>
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<td>Field (3)</td>
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4) Method

This study involves three steps: familiarization, constructs elicitation/grid completion, and constructs exploration.

In familiarization, the objectives of the experiment are explained to the users. The objective is for users to list the features found in the IBVR application that can generate spatial presence. However, we have not mentioned that the purpose of the development of the application is to elicit calmness among users. Next, we show the IBVR application. The respondents are allowed to explore the application, but the system is not the one that will be used in the experiment.
In construct elicitation/grid completion, a respondent is left in the room. Respondents have seen the repertory grid form in advance. They have also read the description of the three locations in the form. Then, they open the IBVR applications one by one. After looking at and exploring the three locations, the respondents fill in the repertory grid form. Majority of the respondents who do not have an IT background have reopened the locations.

The last step is construct exploration. After the user exits the room, we check the list of characteristics written in the repertory grid. We conduct a short interview to determine the details of the written characteristics. The interview allows us to perform quantitative analysis based on our clear understanding of the list provided by the respondents.

5) Analysis

The data obtained from the respondents were analyzed using Web Grid II software in the form of hierarchical cluster analysis. Analysis in this software uses FOCUS algorithms that employ distance measures to reorder the grid. The grid is sorted based on the rating scale on the IBVR application. The related dendrogram produced by clustering is a simple way to obtain an overall impression of the mental model of each participant in the area of investigation.

C. Illustrative Example

From the result, we identified seven criterion of IBVR application that could elicit spatial presence. Thus, we described the criterion in the guideline to design IBVR application in this section. We divide this section into four guidelines: user interface for selecting scenes, visual in IBVR application, audio in IBVR application, story line in IBVR application and navigation in the IBVR application.

1) Selection Interface

A wide variety of panoramic views based on spatial presence theory as highlighted by Wirth et al. [8]. According to the authors, the users will experience spatial presence if domain-specific interest exits among them.

Wirth et al. [7], [8] and Heeter [7], [8] state that user presence exists if the visual mechanism displays the virtual environment that the user is comfortable with. Thus, we categorize the IBVR environment into two parts: panoramic without people and panoramic with people. “Panoramic without people” indicates scenes without people, animation, and object involved in the view, whereas “panoramic with people” involves various human activities added with objects and animations.

Figure 1 illustrates the first interface. A is the name of this application, which is called IBVR stress therapy. B represents users of the application. C shows that space can be used by the users in selecting the environment. Each category contains a variety of panoramic views. Thus, for the D part, the users can choose suitable locations. We provide a variety of locations that the users can choose from.

Fig. 1 User interface for selecting scenes

2) Visual in IBVR application

Each of the visual in the IBVR application should provide beautiful, consistent, clear, natural panoramic view, calm color and end-start panoramic view.

Beautiful location is subjective between users. Hence, various panoramic views are needed in IBVR application. We suggest that the beautiful panoramic view is about the view of a place that the most visit among tourists. The collection of the panoramic view should be consistent in terms of the light of parameter or color. Calm color refers to the light parameter of the visual color. In our visual, the light parameter is the center of the bright and warm colors. Respondents also indicated that this color calmed them.

The panoramic views have to be clear and not blur. Moreover, make sure that the display of the panoramic view is not jerky. Users highlighted that there must be a link between one visual to another so that the user will feel he/she is watching a story. Natural panoramic view is defined as the calm content of the virtual environment. We combined a calm virtual environment, animations, and additional objects as the contents of the virtual environment.

Additional objects refer to static images pasted on the virtual environment to make the visual more realistic. Animation is also need to be realistic. Environment on visual display is a combination of pictures. Therefore, visual displays only the real views. With the advent of parallel animation is in the visual environment, this could create more sense of presence to users. Additional object such as human being is provided in the panoramic virtual environment. The presence of suitable additional object in the suitable panoramic view will enhance user’s feel located in that panoramic place.

3) Audio in IBVR application

Recorded natural sound is defined as the sound which is mimic to real environment.

The most important criterion in natural sound is being able to describe the virtual sound environment, which includes additional objects and animation found in VE. For example the sound will play bird sound when there is a bird in the panoramic. Natural sound should be smooth and should not be repeated within a short period of time. Furthermore, clear sound plays an important role in creating the feeling of being in a virtual location. Calm sound refers to recorded natural sound that describes the virtual environment. Recorded natural sounds used in this study were taken from meditation sounds.
4) **Story Line in IBVR application**

Story line can be defined as the story from start until end in each location.

- **Accepted story line** is the story that is always made when the user is in the area. For example, climbing up the hill and taking the steps to the hill are similar to the actions of a mountaineer. The story line is accepted by the user’s mind as normal activity that usually occurs when the user is in the real location [20].

- **Clear Story Line**: Respondents also thought the story line should have a clear narrative and be easy to understand. The story line from start until the end is easy to understand [20].

- **Synchronized Story Line**

From start until the end, the virtual tour shows the sequence of scenes that are related to each other [1].

- **End-start panoramic view**: IBVR application is a simple virtual tour (walkthrough) application. A ‘start’ panoramic view shows that the virtual tour is start and ‘end’ visual shows that the virtual tour is end.

![Fig. 3 Star visual of island location](image)

Figure 2 provides an example of a starting point for users in an island virtual environment. A is the starting visual point. B is the hotspot, which enables users to shuttle to the next view. C is the list of icons found on the IBVR application. The icon is for panning (left, right, up, and down), zoom (in and out), home (to return to the first visual), and enlarging the visual to screen size. D is for users to adjust auto-panning (from a speed scale of 1 to 7). E allows users to coordinate the volume level on the IBVR environment. F enables users to view the entire picture to be displayed on the site.

**End-start hotspot**: In addition to these features, End–start hotspot describes the “reverse plot.” The purpose of the reverse plot is to allow users to feel like they can return to their original place (i.e., the beach) before they start exploring the cave. Example of reverse plot is described in figure 3. If the user is in plot B in location A; “beach” visual; when the user next clicks the button “hotspot” for the cave visual, they will enjoy a 360-degree view of the cave; when the user clicks on the button “hotspot,” it will return to the location A; “beach” visual again that display plot B.

In A, a second hotspot is provided, namely, F. When the users click F, they are transferred to views under the sea, namely, I. The users can view the animation of swimming fish in plot H. Then, the users can click G to return to the same plot in A.

5) **Navigation in IBVR application**

Navigation is about the use of the overall function in IBVR application. Respondents highlighted four key characteristics in exploration that can create spatial presence. The features are easy to use, free to explore, develops excitement, and like a virtual tour.

- **Easy to use** means the system is easy and simple to use without the need for a thorough reference for the user. Interface design was to keep the user’s interface simple through the tour so that user’s easy to learn and use the system [21]. No difficulties in using navigation button to interact with IBVR [21].

- **Free to explore**: The second feature is free to explore, which means the respondents do not have to follow certain conditions to make explorations in the IBVR application. For example, users can adjust auto-panning according to their own desires and can zoom in/out an image in any of the plots.

- **Develop excitement**: Experience the sensation of shuttle from one visual to another visual with hotspot [1]. Experience the sensation of spinning around in a virtual 360 degrees environment [1]. The users want to explore more when they like the story line in the mediated environment [7].

- **Hotspot**: Hotspots are stored in 8-bit images and can be done on each visual or object in the picture. Hotspots allow users to shuttle from one scene to another within the same environment. Developers can also add more than one hotspot on an IBVR visual. Hotspot and visual refer to the hotspot function that enables the user to shuttle from one visual to another in a narrative. The respondents feel that a simple hotspot is suited to this application because a hotspot is easy to use. To enable users to feel they are in a narrative, a form of consistent hotspot is required. Once they see the simple “hotspot” button, they will recognize the button. If the shape of the hotspot is uneven, users will feel odd and will be unable to experience as if they are in the narrative. Incorporate hotspot and text into the virtual tour to provide descriptions about the panoramic virtual environment [1]. In addition, meaningful hotspot means every hotspot icon should have information about the function of the hotspot itself [1]. The aim is to enable users to acknowledge the functions of the hotspot icon before they click on the icon. This is because the hotspot function on the IBVR application not only shuttles from one
visual to another, but also plays the video and the audio. Respondents also highlight the combination between “hotspot, sound, and addition object” in the visual as requirements that will enable them to feel spatial presence.

- **Panning** is a view that can be seen in a certain degree rotation. Panning function in a cylindrical image is the degree of left and right rotation. Panning and visual allows users to see a visual with 360-degree rotation [1]. Panning enables them to feel they are at that location rather than just being shown a visual of a still image, an opinion derived from a short interview conducted with the respondents during the exploratory study. Panning consists of two techniques: auto-panning, and mouse click. Adjustable panning refers to auto-panning. Auto-panning features required by the user include the capability to adjust the rate of rotation and the smooth presentation of the visual display that uses auto-panning techniques. Flexible panning refers to both types of panning. For the function of panning using the mouse click, what the user wants is to freely start panning at any plot they like. Similar with auto-panning, the users also prefer to start at any plot they want.

- **Zoom in/out**: The second feature is zoom in/out. Zoom in enlarges the image or focuses on an object or area of the image more clearly. Zoom out shrinks the field of view of the visual. Zoom in/out and visual refer to the visual zoom in and zoom out functions visual. Zoom in/out can be done at any plot of the visual, which is described by respondents as flexible zoom in and zoom out. The function of zoom in and zoom out can be done easily because this application uses standard icons of zoom in and zoom out. The zoom in icon is “+” and the zoom out icon is “−.”

IV. CURRENT AND FUTURE WORK

Based on our comprehensive study on IBVR characteristics that can enhance spatial presence, we proposed design guidelines for IBVR. The design guideline is based on spatial presence theory proposed by [11]. Positive feeling can elicit spatial presence [11]. Hence, we proposed design guidelines which adapt calm criteria to IBVR application. Four guidelines are proposed: user interface for selecting scenes, visual in IBVR application, audio in IBVR application, story line in IBVR application and navigation in the IBVR application. However, these guidelines are for general IBVR application. In the future, a specific study on each guideline should be studied. Thus, more thorough IBVR characteristics can be obtained.

REFERENCES


