The Dichotomy of Presence Elements: The Where and What

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1. Introduction

One of the goals and defining characteristics of virtual reality systems is to create "presence" and fool the user into believing that one is, or is doing something "in" the synthetic environment. Most researches and papers on presence to date have been directed toward coming up with the definitions of presence, and based on them, identifying key elements that affect presence [1][2][3][6][8].

While prior research has identified many of these presence elements, it is not clear how to effectively combine them to create a VR content with the maximum presence with respect to a given hardware setup, limited computing resources, and content dynamics [5]. Along this line of thinking, this paper investigates into the relative "benefits" of the visual presence elements, such as stereoscopy, texture, geometry (shape), shading, shadow, and motion, toward the overall presence.

Hinted from the fact that our brain has two major paths for processing visual information, the "where" path for determining object locations, and "what" path for identifying objects, and judging from the location-based definition of presence (e.g. "sense of being there"), we started out with a hypothesis that the "where" cues (e.g. stereoscopy and motion) would contribute more to presence than the "what" cues. This would also explain the high level of presence obtained from seemingly low presence (i.e. with relatively low photo-realism) virtual environments.

2. Experiment

2. 1 Testbed Environment and Independent Variables

We carried out an elaborate experiment in which presence levels were measured (with subjective questionnaire) in test virtual worlds configured with different combinations of six visual presence elements. We first built a simple virtual undersea world as the testbed for the experiment. Table 1 shows the summary of the independent variables and their level design. Figure 1 shows an example of the virtual undersea world presented to the subject during the experiment.

2.2 Experimental Procedure

Subjects, in a random order, looked at each of the 32[1] virtual undersea worlds projected on a 50 inch screen from a fixed location for 90 seconds. After looking at each configuration, the subject was asked to fill out a presence questionnaire.

Table 1: Five independent variables and their levels.

Type	Variables	Levels	Explanation
Where	Stereoscopy	High	With stereo
		Low	With no stereo
	User Motion	High	Fixed user navigation
		Low	View at fixed location
	Object Motion	High	Fish moves around
		Low	Fish stays in place
What	Object Self Motion	High	With deformation
		Low	No deformation
	Geometry	High	High polygon model
		Low	Low polygon model
	Texture	High	With texture
		Low	No texture

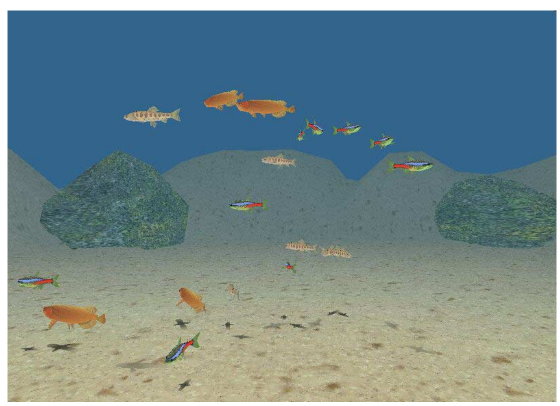

Figure 1: An example configuration of the virtual undersea world (Geometry=high, Texture=high, Stereoscopy or Motion can not be illustrated here).

[1] Although there are 64 combinations of the independent variables, the Fractional Factorial experiment design allows analysis by testing only 32 subject groups.

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2.3 Presence Questionnaire

The questionnaire comprised of four questions asking to rate the (1) visual realism of the objects, (2) one's ability to perceive locations of oneself and other objects, (2) the visual realism of the overall environment, and (4) the feeling of being in the environment, in a scale from 0 to 100. In the debriefing session at the end, subjects were asked to rank the order of importance among the five visual elements for creating the feeling of being in the undersea world.

5. Main Results

The ANOVA, simple effect tests, and regression analysis showed that the manner in which the visual presence elements played a role was significantly different for user perception of visual realism and presence (or what and where), in accordance with our initial hypothesis. In fact, results showed that "where" cues were also very important for visual realism only, but more so for presence (See Tables 2 and 3). In particular, the interactions caused by the "where" cues (with "what" cues) were very important. This is another confirmation that presence is not all about pictorial realism, especially considering that this experiment did not include other well-known presence elements such as interactivity or multi-modality. It also tells us that there is a limit to creating a compelling VR content by only working on improving model details.

6. Acknowledgement

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Table 2: Regression analysis. Dependent variable is the overall visual realism of the environment and R^2 = 0.97.

Types (Relative Wts.)	Variable	Pr>|t|	Par. Est.	Std. Estimate	Relative Weights
What (37.41)	Geometry	<.0001	**5.61**	**0.202**	**10.10**
	Texture	<.0001	**15.2**	**0.547**	**27.31**
Where (29.87)	Stereoscopy	<.0001	**3.74**	**0.138**	**6.72**
	Object Motion	0.0044	**9.05**	**0.326**	**16.26**
	User Motion	<.0001	**3.83**	**0.138**	**6.89**
Interaction (23.07)	Geometry x Object Motion	0.0055	**4.29**	**0.134**	**6.68**
	Texture x Object Motion	<.0001	**6.89**	**0.215**	**10.72**
	Texture x User Motion	0.0159	**3.63**	**0.113**	**5.67**

Table 3: Regression analysis. Dependent variable is presence and R^2 = 0.95.

Types (Relative Wts.)	Variable	Pr>|t|	Par. Est.	Std. Est.	Relative Weights
What (32.0)	Geometry	<.0001	**4.76**	**0.171**	**9.14**
	Texture	<.0001	**11.91**	**0.428**	**22.86**
Where (30.54)	Stereoscopy	<.0001	**5.41**	**0.195**	**10.39**
	Object Motion	<.0001	**7.52**	**0.271**	**14.44**
	User Motion	<.0064	**2.97**	**0.107**	**5.71**
Interaction (30.12)	Geometry x Object Motion	0.0001	**5.28**	**0.165**	**8.78**
	Texture x Object Motion	<.0001	**8.49**	**0.265**	**14.11**
	Texture x User Motion	0.0051	**4.35**	**0.136**	**7.23**

7. References

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