Effect of 3D Projection Mapping Art: Digital Surrealism

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Abstract. This study examines the superior effect of spatialized projection mapping, also known as spatialized augmented reality or three-dimensional projection mapping, compared to projection on the screen. Specifically, to examine the effect of this modality, other variables are limited, such as sound effects or any other contents. The stimuli have little representative meaning with moving geometric patterns. The results show that spatialized projection mapping has been positively evaluated and that it elicits greater spatial presence.

Keywords: Augmented reality · Spatialized projection mapping · Three dimensional projection mapping · Psychological effect · Spatial memory

1 Introduction

Physical three-dimensional projection mapping involved projecting images (light) and augmented objects in the physical environment with digital imagery. Typically the imagery conforms to the physical object. The image embodied visual information in the physical space. Then audiences perceive synesthetic information, the merging of virtual information and the 3D physical object without a head-mounted display (HMD) or smartphone display. According to Bimber and Rasker, this medium is defined as spatialized augmented reality or 3D projection mapping (2005). The key difference between this medium and a single-user augmented reality interface is the multiple-user experience since it projects an image on the physical object directly.

This study examines how virtual information and environments are perceived and evaluated when they are experienced on project conformed objects as opposed to the standard flat screen environment. Therefore, we examine the perceived psychological effect of this spatialized augmented reality.

2 Project Mapped Augmented Reality

2.1 Introduction Transforming the Perception of Space

The main difference between two stimuli (3D mixed reality and 2D surface) is the tangibility, which was allowed form real 3D object. This study examines the effect of a

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form of augmented or mixed reality called projection mapping and its conceptualization a class of displays on reality-virtually continuum (Milgram and et al., 1995). Three-dimensional (3D) projection mapping. The technology projects a virtual image on real world surfaces which has potential tangibility (Jung, Lee, and Biocca, 2014). Figure 1 shows that the spatial 3D mapping is a form of augmented reality, especially when mapped to 3D objects and surfaces.

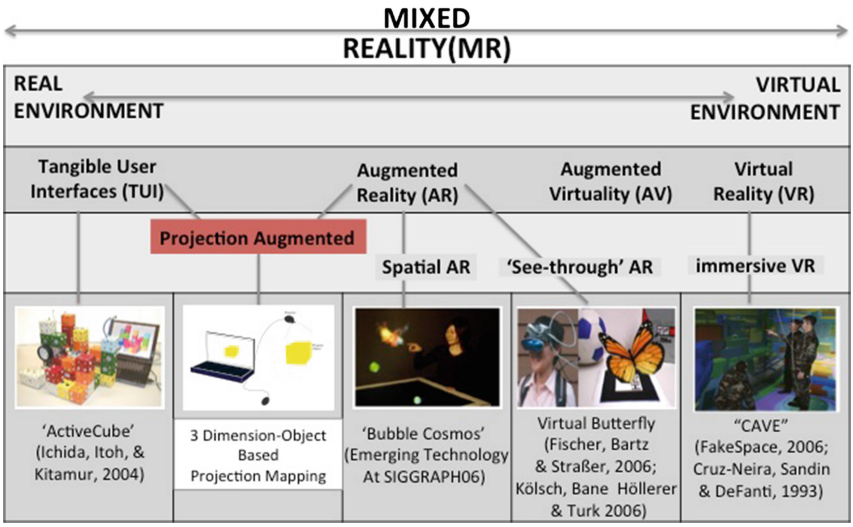

Fig. 1. Projection augmented or 3D projection mapping among milgram and kashion's "continuum of display" (1994).

The technology is frequently used in large scale and small-scale performance applications. However, the 3D mapping technology has not been well defined. There is a sense of that the projection mapping affects user experience and perception, but this has not been studied.

2.2 Production, Advertisement, and Art

At the level of performance spatialized projection mapping related technology has been widely used as stage design for musicals, concerts, promotion events, advertisements, media façade art, etc. For example, the Atlantis Resort and palm Island in Dubai held its grand opening with 3D hi-definition video projection (2011) mapping on buildings to animate and perceptually distort the buildings.

At the personal and interactive space, Microsoft Research has demonstrated the concept of "RoomAlive: Magical Experience Enabled by Scalable, Adaptive Projector-Camera Units" (2015). Figure 2 show the image of RoomAlive. In this demostration the virtual environment is distorted to conform to spatial configuration of room. This is then used to guide animated spaces, characters, and interactivity features.

By conforming the physical space of the room the virtual environment appears integrated and more tangible and "real." The very core concept of Room Alive and projection mapping in general is that the virtual appears to be more present in the physical space. In previous studies we have demonstrated an augmented reality information produces superior performance in users when attached and embedded in objects (Tang, Owen, Biocca, & Mou, 2003 and Jung et al. 2014). Virtual objects appear to be embodied.

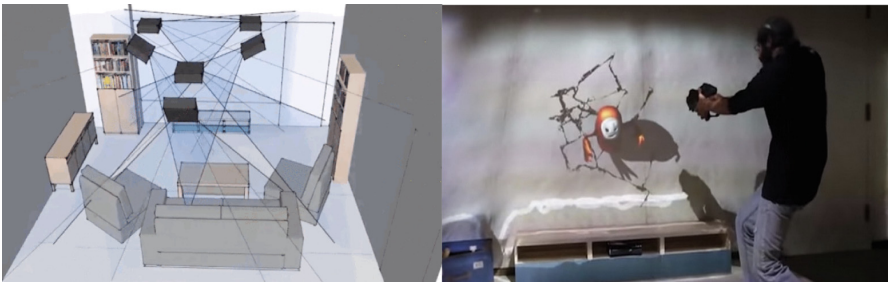

Fig. 2. RoomAlive: magical experiences enabled by scalable, adaptive projector-camera units. Users can experience immersive, augmented reality in the real room without a head mounted display so that realistic visual information is perceived.

2.3 Spatial Presence

Without any screens or lenses, the projection mapping presents the virtual layer directly onto the physical object. Spatialized projection-mapped objects provide viewers with a greater sense of spatial presence (Tang, Owen, Biocca, & Mou, 2003 and Tang, Biocca, & Lim, 2004).

The unique trait of projection mapping is that the virtual representation is perceived to be part of the physical object and environment. Jung and et al. mentioned that "the sense of 'thingness' may be stronger than that created by the ghostly overlays of some head-mounted augmented reality and hologram technology." Compared to spatialized projection mapping, the low fidelity of hologram images reduces the sense of realism (Satoshi and et al. 1994). The virtual images in projection mapping are embodied by the real object, which has its own physical presence; therefore, projection mapping has provided spatial presence and perceived reality of environment.

Therefore, this study examines the effect of spatialized projection mapping (3D) comparing with 2-dimensional (2D) flat screens.

3 Method

The simulations of Fig. 3 show that the sizes of projected images are same and the distance from medium to audience are same as well for the experiment purpose. The images of Fig. 1 show that real image from experiment.

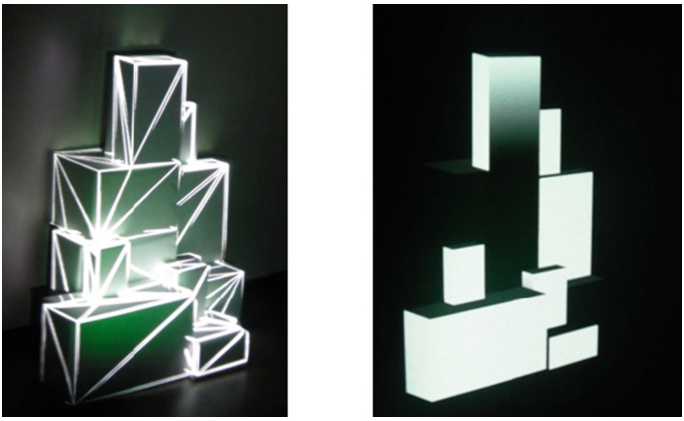

Fig. 3. Stimuli: (left) spatialized 3D augmented reality projection mapping onto physical object' surfaces; (right) the same augmented reality projection on a flat surface.

For the experimental purpose, this study compares same abstract content on same size of physical object or flat screens. The images of Fig. 4 shows how the two mediums are differently projected images on the physical object or on the flat screen.

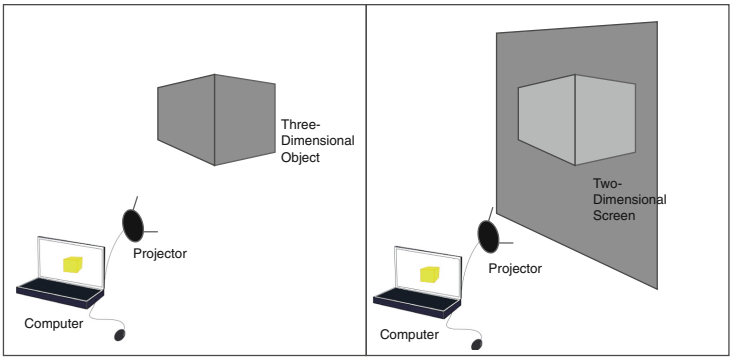

Fig. 4. Stimuli: (left) spatialized 3D augmented reality projection mapping onto mapped 3D surfaces; (right) standard 2D projection of patterns on a flat surface.

3.1 Procedure

Before the experiment, all participants (n = 24) were recruited by an online bulletin board at a university in Seoul, Korea. Upon arrival, all participants were introduced to the experiment, given the consent form, and guided to the experiment room by the experimenter. Randomly, half of the participants were assigned to watch spatialized projection mapping stimulus and the other half of the participants were assigned to watch projection mapping on the flat screen. After that, they were asked to fill out questionnaires of satisfaction, enjoyment, and presence. For the participation, they were compensated with 2000 Korean won (US $2).

First, all participants entered a dark and isolated room. After that, they were asked to watch video art work on 3D physical object or 2D screen. And then they were guided out of the dark room and asked to response to questionnaires of satisfaction, enjoyment, and presence on the PC.

Stimulus Material. For the stimulus material the objects were made with various white cubes. And its total size was approximately 97 cm x86 cm. To project the image we used Samsung SP-L300WG which has Cuboids-object with 3D projection video, flat screen with 3D modeling video.

3.2 Measurement

Presence. To measure perceived engagement, a presence questionnaire which was borrowed from Igroup Presence Questionnaire (IPQ) by Schubert et al. (2001) and Lessiter et al.'s scales (2001) and the questionnaire modified for this research was used. It was an index composed of six items. Participants answered how well the sentences, - for example, "I was completely captivated by the virtual world." - described their impression on the stimulus material, on ten-point Likert scales ranging from "Strongly Disagree" to "Strongly Agree."

Engagement, Satisfaction and Engagement. Participants indicated how well the word, "satisfied" &"enjoyable" described their impression on the stimulus material, on a ten-point Likert scale ranging from "Describes Very Poorly" to "Describes Very Well."

4 Results

Independent t-tests were carried out to measure two groups users' presence, engagement, satisfaction and enjoyment. The results of t-test show that average scores of presence and engagement measurement were significantly higher from 3D than 2D $p < 0.1$.

Presence. There was significant difference in scores for 3D projection mapping M **= 7.**66, *SD* = 2.01 and 2D projection *M* = 3.63, *SD* = 2.61; $t(22) = 4.158$, $p = .01$ (two-tailed).

Engagement. The scores of engagement for 3D projection mapping *M* = 6.91, *SD* = 2.87 and 2D projection *M* = 3.41, *SD* = 1.50 have differences significantly $t(22) = 3.73$, $p = .01$ (two- tailed).

Satisfaction. There was marginally significant difference in satisfaction scores for 3D *M* = 6.33, *SD* = 2.7 and 2D projection *M* = 6.91, *SD* = 1.31; $t(22) = 1.85$, $p = .07$ (two-tailed).

Enjoyment. The scores of engagement for 3D projection mapping *M* = 6.91, *SD* = 1.31 and 2D projection *M* = 4.9, *SD* = 2.31 have differences significantly $t(22) = 2.60$, $p = .01$ (two- tailed).

5 Discussion

The results of presence measurement include how people immerse the mixed reality; it means that the 3D projection mapping bring them to different virtual reality however, they realize the real objects as well.

According to our study, experiencing 3D projection mapping elicits more spatial presence, enjoyment, and satisfaction than a standard 2D flat screen does. Therefore, the popularity of the projection mapping modality in various usages is not just a heuristic preference by developers or any decision makers, but it can also be explained with standardized measurements.

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