The living wall display: Physical augmentation of interactive content using an autonomous mobile display

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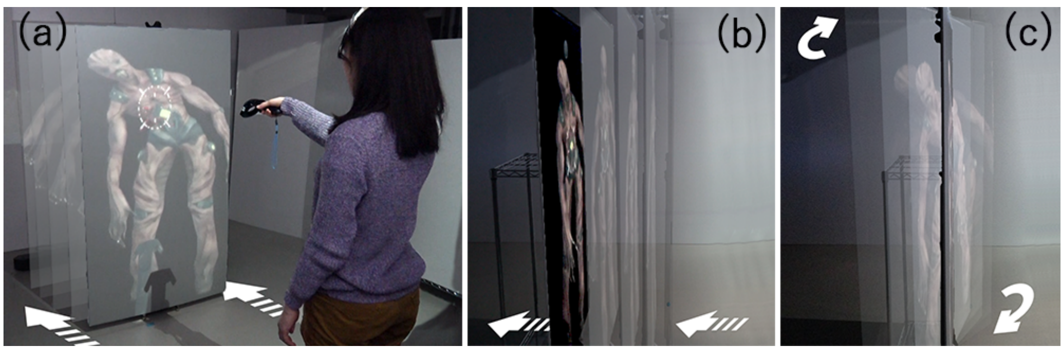

Figure 1: (a) FPS Shooting Game (b) display drives off backward when user kills zombie. (c) hitting the zombie's shoulder quickly rotates the display.

ABSTRACT

The Living Wall Display displays interactive content on a mobile wall screen that moves in concert with content animation. To augment the interaction experience, the display dynamically changes its position and orientation, responding to the content animation triggered by user interactions. We implement three proof of concept prototypes that represent pseudo force impact of the interactive content using physical screen movement. Pilot studies show that the Living Wall augments content expressiveness, and increases the sense of presence of the screen content.

CCS CONCEPTS

• **Human-centered computing → Augmented reality**;

KEYWORDS

VR, robotic display, multi-modal display

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1 LIVING WALL DISPLAY

Current 3D display technologies add depth to interactive content, but they remain cumbersome. We still mainly rely on conventional flat 2D displays to view interactive content such as video games. This limits the immersion, because the content does not feel present in our environment; instead, it is locked inside the display. Recent innovations allow us to view 3D information via stereoscopic holograms. Yet, these approaches rely on head-mounted glasses, and the content lacks a physical embodiment in the real world.

Recent work has begun to explore enhancing immersion with virtual content by using actuated displays. For example, Shape-shifting wall display[Takashima et al. 2016] can change its shape and position depending on the screen content being displayed and spatial relations of its users. The entertainment industry has also developed quite sophisticated shape-changing multi-display systems to support interactive performances[Bot and Dolly 2013]. Several shape-changing multi-display systems explore increasing the sense of spatial information of screen content: Tilt Displays [Alexander et al. 2012] is an attempt to augment 3D information of the screen

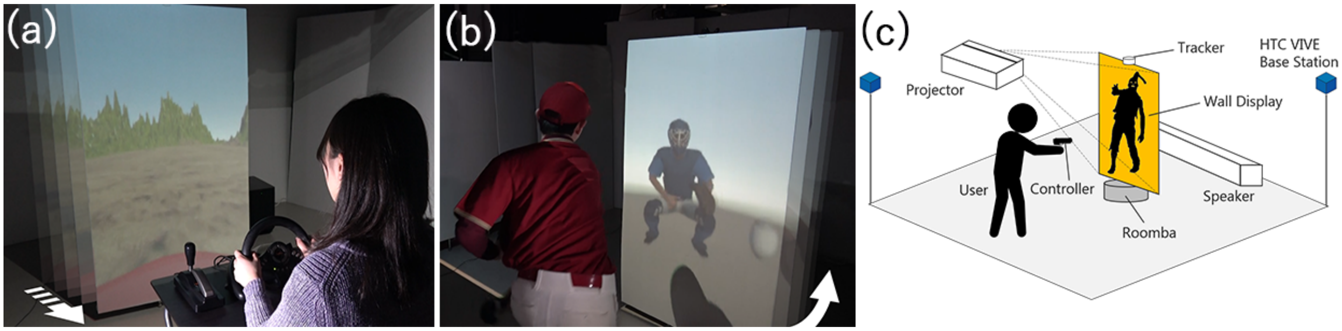

Figure 2: From left side;(a) Drive Simulation (b) Baseball Pitching Simulation (c) System overview

content by physically tilting small piece of displays. However, these movements of display are not synchronized with player's input.

We propose the Living Wall Display, a new way of physically augmenting animated interactive visual content on the screen using an autonomous mobile interactive display. The Living Wall Display has 2-DoF, and we use these to dynamically change its position and orientation, coupling this movement with the underlying content animation via interactions. In addition to the audio-visual information of traditional flat screen, the display movements can provide users with a stronger depth perception effect. For instance, in a first-person shooting game scenario, it physically expresses the force exerted by the impact of a virtual bullet by moving in the Z dimension. This kind of display helps enhance a designer's expressive ability beyond a static 2D display without the bulkiness of a HMD, helping to enhance the sense of presence.

2 APPLICATIONS AND PILOT STUDY

To explore how we can use the Living Wall Display to increase a user's subjective sense of presence, we designed three proof of concept prototype demonstrations. Each uses the physical movements of the Living Wall Display to enhance depth perception and express pseudo force impact in three different 3D game experiences: a first person shooting game, a driving simulator and a baseball pitching simulator (Figure 1, 2(a,b)).

To evaluate our approach, we conducted a pilot study with eight participants (male:5, female:3; 21-26 years old; mean: 22.8). Each participant played each game with both a conventional flat wall display and Living Wall Display. We then asked them about their subjective impression about each scenario + display condition. Overall, our participants suggests that Living Wall Display helps increase the content representation qualities. The following describes features and summary of the pilot study of each demonstrations.

FPS Shooting Game. (Figure1). The Living Wall display is used to represent an enemy zombie, where the user can shoot at the zombie using a controller. Depending on where the zombie is hit, it turns quickly (e.g. hitting the zombie's left shoulder quickly rotates the wall counter-clockwise and back), and couples this with enemy's "hit" animation. Once the user kills the zombie with enough bullets, the animation shows the zombie falling away from the player, and it drives off backward. The pilot study showed that there were significant differences between how users perceived the static and Living Wall Display: namely, that the zombie feels "more real" when shown in the Living Wall Display. The study also showed that it enhanced the impression of a 3D appearance, and aggressiveness of the zombie. We also found users felt higher levels of exhilaration.

Driving Simulation. (Figure2(a)). The Living Wall Display moves to show inertial forces exerted on the car and driver during driving. When the user steps on the accelerator, the wall moves backward to enhance the feeling of acceleration. In contrast, when the user presses on the brake, it moves forward, as if the user's momentum is carrying him/her toward the front dashboard. Our study showed that the Living Wall Display seems to could enhance illusion of depth. The result showed that Living Wall Display could enhance the space of driver's seat wider by back and forward movement.

Baseball Pitching Simulation. (Figure2(b)). The Living Wall Dispay moves to show impact of catching ball and movement of catcher. When the catcher catches the ball thrown by user, it moves like the catcher's glove–i.e. backward and then forward when the ball is caught. The user study showed that Living Wall made the catcher and the result of the throwing action more real, helping to express the lively atmosphere of baseball pitching.

3 SETTING AND DEMONSTRATION

Figure 2(c) shows an overview of the system. The whole system consists of mobile interactive display, HTC VIVE Tracker and projector. Living Wall Display is autonomous mobile display moved using 2-DoF robot, Roomba. Roomba is connected with PC through serial communication using Bluetooth. The interactive display can move back and forward, and rotate physically. The position of display is tracked using VIVE Tracker in real time for dynamic interactive projection mapping above the wall display.

Our demonstrations will provide audiences with playful experiences regarding sense of presence and pseudo force feedback of interactive content and show new content representation possibilities in the venue.

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