The Golden Guardian: Multi-Sensory Immersive Gaming Through Multi-sensory Spatial Cues

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ABSTRACT

We present The Golden Guardian, a Virtual Reality (VR) game using multiple senses for spatial cue for creating an immersive game experience. We implemented visual feedback, audio feedback, and haptic feedback that delivering different cues in different situations in the virtual world.

CCS CONCEPTS

• **Computing methodologies** → **Virtual reality**;

KEYWORDS

Virtual Reality, Multi-sensory spatial cue, Haptic feedback

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1 INTRODUCTION

The recent development of head-mounted display (HMD) offered a type of immersive virtual-reality (VR) experience with high-quality spatial graphics and sounds, to simulate what we see and hear in the real world. In addition, wearable haptic devices, such as vibrotactile headbands and belts, have been incorporated peripherally with the HMDs, to provide haptic feedback of virtual objects and improve the experience of presence in the immersive VR environment. Moreover, VR is defined as an experience that user is effectively immersed in a responsive virtual world [Brooks 1999]. With these emerging VR technologies, a psychological question could be asked specially: How would different types of sensations affect people's perception and performance in immersive VR?

We present The Golden Guardian (Fig. 1), a VR game using multiple senses for spatial cue attempting to create an immersive game experience. In The Golden Guardian, the player wears the HMD (Oculus Rift DK2), the spatial auditory earphone, and the Arduino-controlled tactile headband with an array of vibration motors and peltier heating elements, with a Bluetooth mouse in his/her hand. (Fig. 2)The player is immersed as an archer to protect his/her gold as long as he/she can. The player needs to defeat the randomly appearing attacks, including the enemy archers, small dragons, and large dragons. The player needs to move his/her head to aim and click the mouse to launch the arrows.

Figure 1: The Golden Guardian

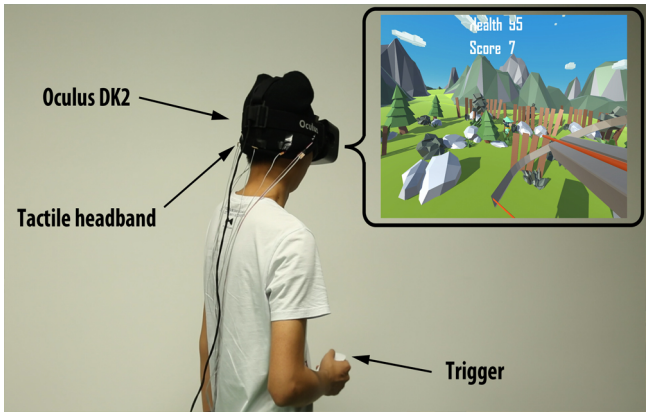

Figure 2: Player's gameplay

2 RELATED WORKS

There are many previous researches that made foundation to our system design. Oliveira et al.[Oliveira et al. 2016] found that vibration motors coverage of 45 degrees allows the user to be fast but not accurate in terms of following the haptic cue. Dobrzynski et al.[Dobrzynski et al. 2012] strongly suggests to avoid multipoint stimulation active at the same time since multipoint stimulation will decrease the accuracy rate. Menelas et al.[Menelas et al. 2014] claimed that the audio feedback allowed subjects to easily locate and

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distinguish each target in the 3D space and therefore to approach the area of the desired target as desired.

3 SYSTEM DESIGN

In case of creating an immersive experience for players, we implement three types of feedback using different senses for gaming. We designed an intuitive feedback system that maps different situations. Haptic feedback was used for warning the player being attacked. A tactile headband which receives real-time signal from the game will provide tactile feedback for different in-game events. Players are able to feel a vibration from a specific direction if enemies hit the player from that direction. Visual feedback and audio feedback are used for special enemies appearing cue. An obvious arrow that point to left or right direction will be displayed while there is a small dragon appears. Accordingly, players will hear a special dragon roar while there is a huge dragon approaching. Beating the small dragon will get a recovering for the players' health. The huge dragon will be more difficult to beat but worth more score. Players need to make their decisions according to different feedback in different situations for surviving.

4 TECHNICAL DETAILS

4.1 Software

The game was developed using Blender for modelling and Unity 3D for programming. We used Oculus DK2 SDK in Unity 3D for the VR development. For the game system, we developed a physical system to control the arrows' behaviours. Gravity, acceleration, and friction will affect the arrow's flying path and rotation for each arrow. Moreover, we developed an AI system for controlling enemies behaviours, including a waypoints system. Enemies will find their own ways under control of the waypoint system that leads them bypass the barrier. Each enemy will make a new decision while they get to one waypoint according to the decision tree. While they launch the arrow, the aiming process will generate several random factors that will affect the arrows behaviours: initial shooting power, vertical aiming angle, and horizontal aiming angle. In case of game balance, the random range of these value will be changed according to the distance between the player and the enemy.

4.2 Hardware

The tactile headband that we used for providing haptic feedback was built using Arduino and an array of vibration motors. A vibration motor was installed per 45 degrees, therefore, eight motors represent eight directions around the head. Moreover, three peltier heating elements were installed on the headband that can cover the user's forehead. Furthermore, a Bluetooth module was used for wireless communication between the tactile headband and the computer. (Fig. 3)

5 USER EXPERIENCE

The Golden Guardian provides a unique experience for most of the participants. The cues that we provided in the game performs intuitively for the user experience. After entering the game, players can rotate their head to see around before pressing the shooting button to start the game. The avatar in the game, who is an anchor

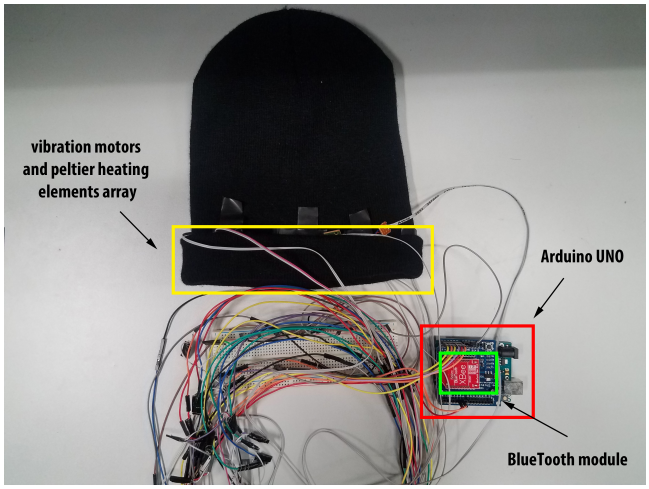

Figure 3: Tactile headband

holding a crossbow, is standing in the center of the scene preventing from being attacked by the enemies that appear in around and keep attacking him. Since the behavior of the arrows was calculated according to the physical rule in the real word, participants need to calculate the shooting angle, aiming point, and determine when to shooting by themselves. Specific vibration motor on the tactile headband will be activated while the avatar was hit by the enemy according to the attack direction. The avatar's health value will decrease by 1 if he is hit by the enemy anchor, but his health can be recovered while beating a small dragon that appeared with an arrow as the visual cue that pointed to the relative direction between the avatar's currently viewing field and the small dragon's position. There will be a directional dragon howl sound when approaching a huge dragon who have more health value, high hit damage but slower flying speed. Huge dragons will spit a fireball for attacking while they get to the avatar, the user will feel heating and all vibration motors will be activated for being attacked warning.

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