Corgi Defence: Building In A Virtual Reality Environment

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Abstract
This paper describes *Corgi Defence*, a puzzle-game in a three-dimensional virtual reality environment. *Corgi Defence* provides players with a set of intuitive interaction techniques and preserves their comfort in an unfamiliar virtual reality space. The resulting experience is enjoyable despite limitations of the hardware in recognizing hand postures.

Author Keywords
Game Design; Virtual Reality; Manual Interaction

ACM Classification Keywords
K.8.0. [Personal Computing]: General - Games, D.2.2 User interfaces

Introduction
Corgi Defence is an immersive puzzle-solving game played in three-dimensional virtual reality (VR). Players use their hands to construct defences to save a corgi dog from attacks by creating a defensive structure using a limited number of blocks. Unlike most existing tools for three-dimensional modeling, *Corgi Defence* allows players to easily and quickly create, destroy, and manipulate objects in three-space.

Virtual reality hardware is rapidly becoming accessible to the consumer market in the form of devices such as the Oculus Rift, the Valve/HTC Vive, Sony's Project Morpheus and Google's Cardboard [7,2,10,1]. In addition, body and motion tracking devices such as Microsoft's Kinect or the Leap Motion sensor make it possible to detect body motion including gestures [5,3].

Furthermore, there has been a surge of interest in developing games with VR hardware in mind. For instance, the Leap Motion 3D Jam [4] specifically targets the use of Leap's sensor in concert with a VR headset. In light of this, we developed *Corgi Defence* to explore the interaction between embodied input techniques and virtual space.

By leveraging technologies provided by the Oculus Rift coupled with the Leap Motion sensor in *Corgi Defense*, we challenge players to solve physics puzzles by building structures in a three-dimensional virtual world using natural hand gestures and controls.

Although the game experience has been well received by players, the ability of the leap motion sensor to consistently and accurately detect hand postures can hinder gameplay.

Gameplay

Corgi Defence is an interactive puzzle game. The eponymous spacefaring and lovable (but mischievous) corgi has found himself in trouble with territorial aliens. It is the player's task to protect our canine friend. In order to do so, the player builds a wall to divert cannon balls from their ballistic path. The wall is composed of voxels, which the player adds or removes using a pointing gesture with their index and little fingers

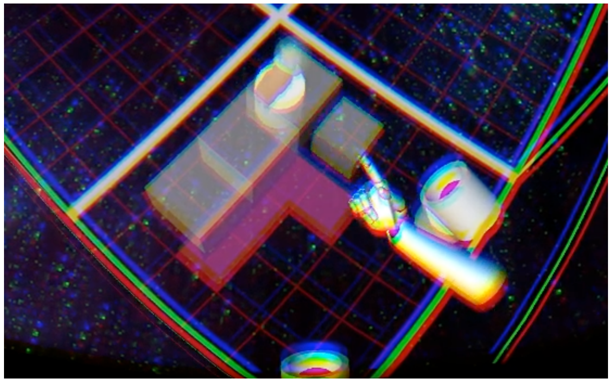

Figure 1: Typical *Corgi Defence* gameplay. The cannons are situated at the right and bottom of the level. The corgi rests near the top of the scene whilst the player prepares the wall, creating voxels by pointing with the index finger.

respectively. We restrict the wall to ten contiguous voxels to keep the puzzle challenging. Figure 1 illustrates the wall building process.

Once the player is satisfied with their construction, they activate the firing phase of the game by touching a large virtual button above the game scene. The wall drops into place, and the cannons fire. If the corgi remains unscathed, the victory condition is fulfilled.

Natural Interaction

Our goal in building *Corgi Defence* was to create a natural interface to an immersive game environment. Slater et al. finds that immersion can be achieved by involving the user's physical body to provide a sense of presence in a virtual space [9]. In accordance we have employed manual interaction techniques that we deem to be natural and intuitive.

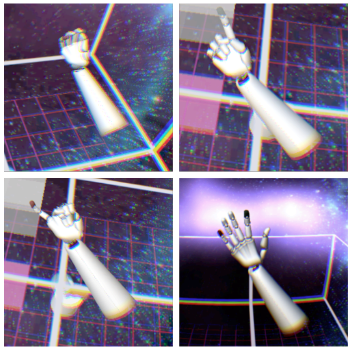

Figure 2: Hand gestures used in *Corgi Defence*. Clockwise starting from top-left: Grasp for level rotation; index point for block creation; little-finger point for block deletion; neutral open hand (notice the colour coded fingertips).

To create a voxel, the player makes a pointing gesture with their index finger. Pointing with the little finger erases an existing voxel. To help the player understand the effect of their actions, the virtual fingertips on the relevant fingers are colour-coded blue and red, indicating their function (as seen in figure 2 in the sidebar). To allow the player to access the far side of a level, a virtual turntable is implemented allowing the puzzle area to rotate about its centre. The player uses a grasped fist to activate this feature, as if grabbing and pulling an invisible turntable under the level.

Throughout we have avoided the use of artificial constructs such as menus and dials. Selecting a virtual paintbrush and eraser were avoided in favour of direct manual manipulation of the game scene by the player. Our adherence to this principle can be seen in the placement of level selection and firing phase buttons; the player need not navigate menus, but rather can find the appropriate functions in their surroundings.

Player Comfort in a VR Environment

VR environments may cause a number of discomforts such as virtual sickness and neck strain [6]. To combat the need for frequent head movements, we restrict gameplay to a small area, allowing the player to complete each level without adjusting their gaze.

Motion sickness arises from dissonance between the visual and balance senses and is a known issue when using virtual reality hardware. Although not entirely avoidable [11], we attempt to reduce any disorientation experienced by our players. A space-themed skybox provides an independent visual background against which players can orient themselves as recommended by Oculus's best practices guidelines [8]. In *Corgi Defence*, the player is never required to move within the virtual environment and is anchored in location. The turntable mechanism allows players to view occluded parts of the puzzle area without moving the camera. The intent is to reduce motion sickness by keeping the player stationary both physically and in game. The use of repeated patterns is avoided in the interface, which can cause nausea in virtual environments [6].

Initially the puzzle area was placed in front of players at eye level. Play testing revealed that players experience fatigue when required to raise their arms for extended periods. This discomfort is addressed by placing the puzzle area at waist height, allowing for a comfortable angle for both the player's head and arms when working in the virtual environment. The player's posture is as if they were standing at a workbench.

Implementation

We use the Oculus Rift DK2 headset to display the virtual environment in stereoscopic vision. A Leap Motion sensor is used to detect users' hand positions and gestures. It is mounted onto the front of the headset such that when the player moves their head the sensor's range follows their field of vision. However, the Leap Motion sensor is designed to work as a desktop device that tracks the hand above a fixed surface. We suspect that because the sensor is being used outside of its intended configuration, its ability to recognize gestures is significantly reduced.

Corgi Defence's game environment is built in the Unity 3D game engine using C# to script behaviors. We use existing Unity 3D packages to interface with the Oculus Rift and the Leap Motion hardware. The Oculus Rift package includes an in game camera whose movements in the scene correspond to those of the headset as measured by an accelerometer in the Oculus Rift hardware. The Leap Motion package provides a pair of virtual hands that mimic the movements of the player's hands when tracked by the Leap sensor. We use the Leap Motion API to detect hand pose. The corgi model was acquired from the Unity asset store.

Experience

Corgi Defence was showcased at Queen's University's Creative Computing Show. Attendees were introduced to the game, their objectives as the player, and given a brief description of the gesture controls before donning the headset. As discussed earlier, Leap Motion's sensor struggles to consistently and reliably detect hand postures and at times gestures were poorly recognized. However, with practice, most users were able to successfully complete the game. Feedback was positive despite the controls: players reported enjoying building with their hands in three-dimensions. We received no negative feedback regarding discomfort or motion sickness.

Figure 3: Showcasing Corgi Defense at the Queen's University Creative Computing Showcase.

Conclusion

Corgi Defence demonstrates that using manual gestures to interact in a virtual reality environment can be entertaining, despite not being as easy and intuitive as we had initially hoped. The mostly positive reception encourages us to further explore similar systems in the future, especially when the technology matures to consistently recognize hand-gestures with accuracy.

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