3DAthlon: 3D Gestural Interfaces to Support a 3-Stage Contest in VR

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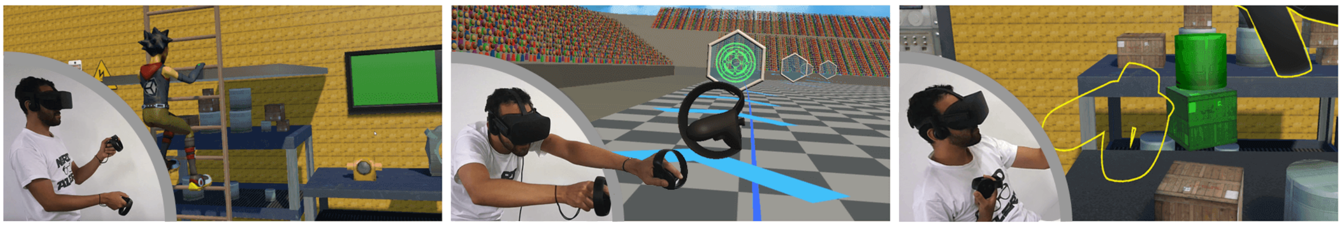

Figure 1: Overview of the three forms of control that we propose for completing the VR circuit, all of them based on gestural interaction.

Abstract

In the context of the 3DUI Contest promoted by the IEEE VR 2018, we propose 3D interaction techniques that address three distinct tasks in a virtual environment setup: climbing a ladder, controlling a quadcopter in a first-person view flight, and building a tower by stacking a series of objects. The interaction techniques were developed so the player, our 3D-athlete, has control over the events in each task, following metaphors that facilitate the use of the interface, and having status and spatial awareness supported by clear feedback cues. Thus, the player should be able to execute the tasks with precision and agility.

Index Terms: H.5.2. [Information Interfaces and Presentation]: User Interfaces—Input devices and strategies

1 Introduction

The interaction with 3D Virtual Environments (VE) usually demands multidimensional input that cannot be intuitively mapped to conventional User Interfaces (UI). Varied input and output devices for 3D interaction opens the door for new guidelines and approaches. Some strategies for designing 3D UIs are commonplace. For instance, the use of real-world metaphors to increase the usability of the 3D UI. At the same time, the development of 3D UI also allows for the creativity and the use of "magic" so users can go beyond the perceptual, cognitive, or physical limitations of the real world [3].

The standard means of input for 3D interaction in immersive VEs seems well consolidated by the pose tracked controllers that are sold with most consumer Virtual Reality (VR) headsets. Such controllers provide the tracking of hands in space (position and orientation) allowing gestural interaction and, therefore, a natural and direct mean to interact within VEs.

In this paper, we describe the design of three techniques for interaction in an immersive virtual setup: climbing a virtual ladder, controlling a quadcopter in a circuit, and building a tower by stacking a series of objects. These tasks compose a three-stage tournament circuit proposed by the IEEE VR 3DUI Contest and illustrated in Figure 2. For the design of each technique, we used a commercially available set of controllers and VR headset. We focused on different metaphors and "magical" mechanisms so that the 3D UI could allow the player (our 3D-athlete) to execute the whole circuit with precision and agility.

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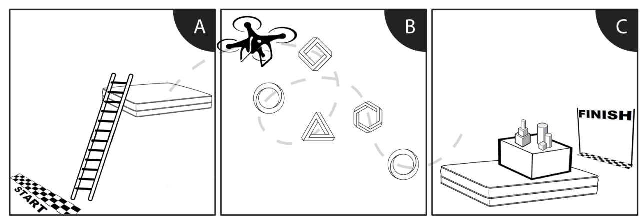

Figure 2: The player starts by climbing a ladder (a), then controlling a quadcopter in first-person passing through a number of targets (b) until, finally, finishing the circuit with a stacking task (c).

2 Techniques Design

For all the tasks, no additional hardware was used besides the Oculus Rift CV1 and the Oculus Touch controllers. The techniques were implemented using the Unity3D Game Engine (v.5.6.3) with the addition of the SteamVR library, thus the solution can easily run with other commercial headsets.

Bellow, we describe how each technique was designed.

2.1 Ladder Climbing

A multitude of VR interactions requires the control of limbs and objects other than the hands. For instance, the natural control of an avatar action such as walking or climbing a ladder (see Figure 2a). The successful completion of these interactions requires an unnatural mapping of controls, preferably adopting easy to learn metaphors that remind the real-life situations to reduce the cognitive effort and thus the learning curve of the interface.

In Ladder Climbing task the player has to issue discrete climb commands to move an avatar up or down. To issue these commands

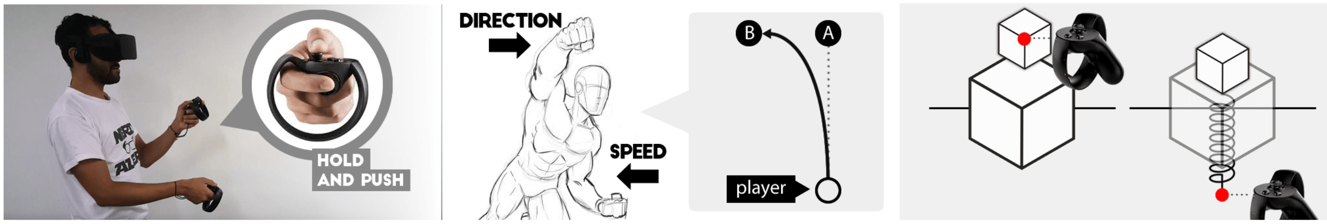

Figure 3: Interaction techniques for each task. The velocity in which the player moves the controllers defines the ladder climbing rate (left); The player's hands control heading direction and velocity during flight, and the trajectory line for path planning (center); The player manipulates the objects directly, an invisible virtual spring support a better placement of the 3D stacking (right).

the player has to press and hold the trigger button and move the controller downward or upward to climb up or down the ladder. At the end of the movement the user releases the trigger, return the controller to the starting position, and repeatedly cycle through these steps with both hands. The mapping is a metaphor to the actual movement of grasping a rung and pulling or pushing oneself up or down a ladder, as shown in Figure 3 (left).

The variation of the controller height while the trigger is hold pressed is used to determine the interval of delay between discrete climb actions of the avatar. A score is computed using the sum of all differences in vertical position between frames for the interval of 1 second. If the score is below a minimum threshold, the avatar does not move. If it is above a maximum threshold, the avatar will move without delay between climb actions. Any score between these two thresholds will make the avatar climb with a delay. The delay is maximal for scores just above the minimal threshold, and is linearly interpolated for score values within the minimal and maximal thresholds.

2.2 First-Person View Flying

To complete the second task, players need to maneuver a drone model through all of the pre-defined targets in order. In our implementation, the controls of the drone are abstracted into simpler 3D navigation control. Thus, basic driving functions (e.g. power, pitch, yaw, roll) are combined into high level directional instructions. These instructions, in turn, are applied to a more intuitive gestural vocabulary, so players can define their travel direction using their own arms in a superman-ish flight metaphor.

Our steering technique is based on a classic pointing technique [2, 3]. In our implementation, the vector defining the direction of travel is obtained from the orientation of the player's hand. Travel direction is then decoupled from gaze direction so the player has the freedom to look in any direction while moving. Our implementation also includes both hands on the interaction. Thus, the forward hand controls the heading direction while the other hand controls the speed (power) as it is moved apart from the forward hand (see Figure 3 (center-left)). However, unlike previous work [1], our technique is combined with a route-planning technique. Thus, instead of just following the direction of the forward hand, the player follows a trajectory drawn according to both heading direction and velocity parameters. As shown in Figure 3 (center-right), when the player's heading direction is changed (from point A to point B), the trajectory line is defined by a Bézier curve in which the previous heading direction and velocity defines the curve. In addition, the trajectory line allows players to plan their flight path ahead, so they can fly as precise and fast as possible through the rings without touching them.

2.3 Objects Stacking

The goal of the object-stacking task is to build a tower by stacking 3D pieces on top of each other. The tower has to remain in equilibrium after all, in a VE that simulates gravity and the physical interaction between pieces of different masses.

We mapped the controllers to the player's hands to manipulate the virtual objects directly. When a hand hovers an object, it is highlighted. Then, the selection is performed by squeezing the controller. The object remains selected while it is being held and the rotation pivot depends on the position where it was first held.

In the proposed technique, the selected 3D object is attached to the controller through an invisible spring. In this way, when the player is placing the shape on top of the structure, his/her hand can pass through the structure while the visual representation remains on top of the stack, as shown in the Figure 3 (right). As soon as the object is released, the spring is removed, and the 3D shape stays in the position and orientation defined by the player. By doing so, our technique avoids collision problems during the manipulation and allows a precise stacking.

It is possible to manipulate a group of stacked objects. For that, the player selects and manipulates a shape that has other shapes above, all objects are grouped by joints and manipulated simultaneously. We also implemented a bi-manual stacking, where in one hand the user holds the stack while the other hand selects and places new objects on top of the 3D structure. In this way, it is possible to control position and orientation of both single objects or stacked objects at the same time. When the player releases an object or the assemblage, all fixed joint are removed and physics are applied in order to conclude the task.

3 Final Comments

In this paper, we presented three different techniques for a virtual triathlon. Even though the proposed solutions are meant to support different tasks, all the techniques are based on the use of understandable metaphors, useful feedback, and controlling mechanisms. These attributes should then allow for our 3D-athlete to have an enjoyable experience while performing the circuit with agility and precision.

Additional features are still going to be implemented in the proposed techniques. For instance, the first-person view flying task should also incorporate a tunneling feedback. Thus, any discomfort during first-person navigation in the VE should be minimized by dynamically blocking the peripheral vision of the player. In addition, the stacking task should also include an "equilibrium guidance" feedback, so players can better choose the position to drop objects to minimize the chance of objects falling from the stack.

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