VRone: 3-Dimensional Force Feedback in VR using a Personal and Commercial Drone

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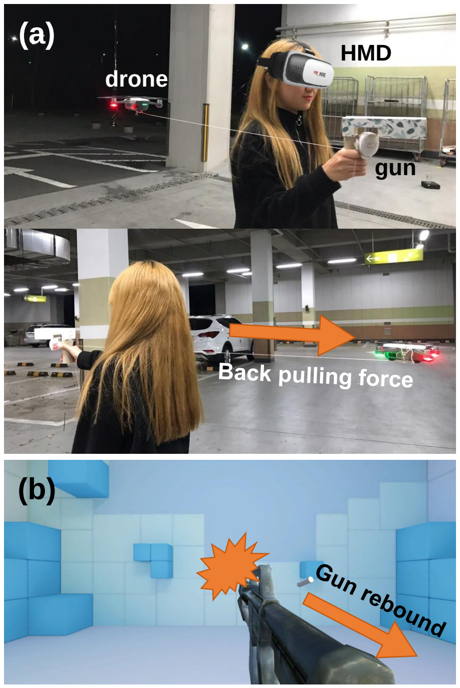

Figure 1: The concept images of this paper. (a) A user interacting with drone. (b) What the user is seeing in a virtual environment.

ABSTRACT

We present an ungrounded and portable force feedback technology in Virtual Reality (VR) using a personal and commercial drone. This system has three structure that is VR display, force feedback drone and interacting object. Our research uses a personal drone and cardboard VR and leads a user to easily implement force-haptic feedback in virtual space.

KEYWORDS

Haptic feedback; Virtual reality; Force feedback; Drone

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INTRODUCTION

Virtual reality (VR) devices leads users to compelling visual and audio experience. The commodity hardware and cardboard with mobile devices are still limited to audiovisual information and haptic feedback is not universally available as audiovisual feedback. The grounded force feedback devices can solve this problem using mechanical links [3] but still limited to possible scenarios at fixed locations and do not cover whole directions.

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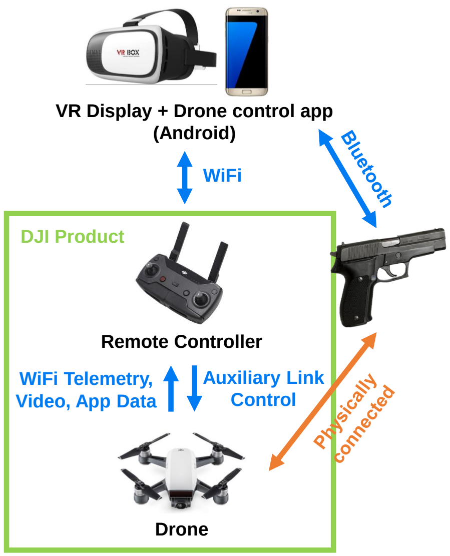

Figure 2: Overall drone-display networking implementation

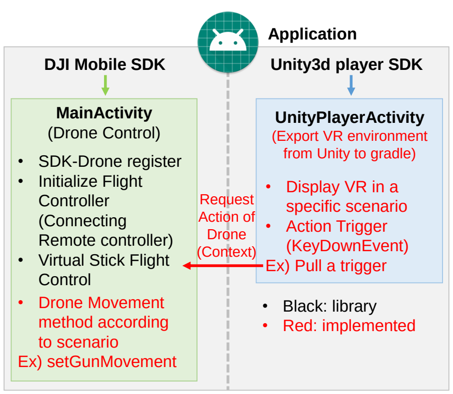

Figure 3: Application implementation

Giving haptic feedback in VR is on going study. A wearable haptic device is designed to simulate grip forces and weight through asymmetric skin deformation[5]. A hand-liftable and ungrounded device provide force feedback using thrust of air [6]. Drone can simulate the weight of virtual objects [4] and conduct levitating haptic feedback proxy [7]. Researchers have implemented virtual force based on human illusory sensations using thermal modules bonding on the two side of the wrist [8].

With the recent proliferation of drone technology, the use of drones as a haptic device is emerging. As personal drones come into existence [2], it is becoming widespread that the drones are not confined to the field of industry or research. A drone enables force feedback in all directions and can deal user moving scenarios because it is portable and ungrounded. Therefore, we want to increase the reality such as force or tactile sense by linking the movement of VR space with the movement of drones. Figure 1 shows a case of the shooting gun game. The object interacting with user is physically connected to drone and the drone simulate the gun rebound by pulling it.

In the remainder of the paper describe the implementation, present the interaction scenarios and describe the demo applications. Finally, we discuss limitations in the conclusion.

IMPLEMENTATION

Communication System

We have three major structures: Virtual reality display, force feedback generating system using drone and force feedback delivering system to the user (An object that interacts directly with the user). Figure 2 shows overall communication system of three structures. User interacts with force feedback delivering system, in this case gun with Bluetooth mouse. The gun and the mobile phone communicate via Bluetooth and the application in mobile phone receive the trigger pull. Drone controlling and VR display system are integrated in one android application. After receiving the trigger pull, the application shows gun shooting visual effect and updates movement of a drone. The mobile phone is connected the WiFi of a remote controller and the drone movement data is delivered to the remote controller.

Drone & Virtual Environment Settings

The drone control software was written in Java in android studio development environment. DJI provides DJI Mobile SDK and we built an android application using virtual stick flight method for flexible way to automate flight. DJI Mobile SDK provides registering drone, pre-built drone control methods [1] and initializing wifi connection with remote controller. There are three axes in which an aircraft rotates to make a turn in a three-dimensional space called the air: roll, pitch and yaw. The virtual stick mode simulate two sticks on remote controller. The right stick control pitch and rolls and the left stick control yaw and throttle. We combined drone control and VR display to our one

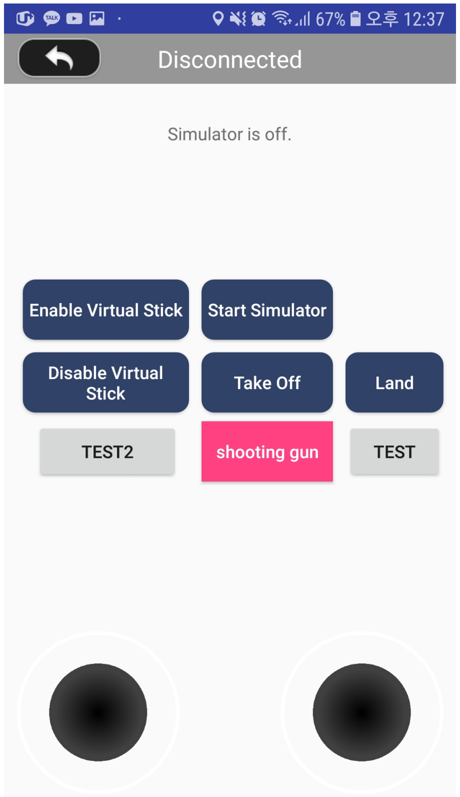

Figure 4: MainActivity: Drone controlling activity is running on background

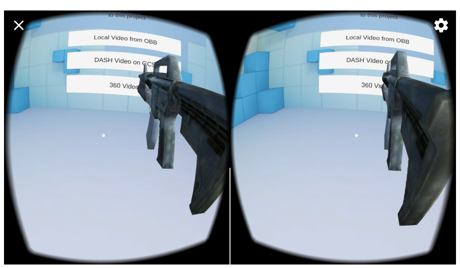

Figure 5: UnityPlayerActivity: it displays VR space and starts bullet animation when keydown

application. We developed android module which has the visual and interaction trigger information implemented in unity. We used pre-built method from DJI Mobile SDK and adjust speed of body and degree of joystick shifting. At present, it is implemented only in the direction of requesting the movement of the drones from the visual information as shown in Figure 3. The middle of the drone body delivers a force feedback to connected the object interacting with the user. The VR applications were implemented in Unity Cardboard setting. Implemented virtual space in Unity is exported and integrated to the drone controlling android application. A user see the visuals on VR BOX. You can see project source code in our github. (https://github.com/daehwa/Drone-Haptic)

VR APPLICATION SCENARIOS

We designed four VR visual applications using to demonstrate our study for a more immersive VR experience.

An umbrella in a storm. This scenario can make you feel as if your umbrella is leaning back when it rains. This effect can be achieved in a virtual space with only the umbrella handle. (Figure 6a)

Windsurfing. As the surfboard accelerates, a user will can that the handle they are holding is pulled horizontally. (Figure 6b)

Flying kite. In this scenario, a user is given the force feedback of being pulled vertically and horizontally, depending on the motion of the kite. (Figure 6c)

Shooting gun. The drones pull the gun back and create a kickback feedback when the trigger is pulled. (Figure 6d)

Demo for the shooting gun scenario is available on youtube. (https://youtu.be/NmtAUSoUl7c)

DISCUSSION & CONCLUSION

This study is classified into the ungrounded haptic device category and there is a limit to the output power like most ungrounded devices. The current system has power to lift an object of 170g. The battery time of the drones is a issue in order to provide continuous interaction to the user. This drone can fly for 16 minutes on average in non-wind conditions at a speed of 20km/h. Rotation of the propeller of the drone generates noise. The solution can be speaker of Head Mounted Display(HMD) with noise-cancelling(NC) technology. A user's tactile experience can be extended because the drones are not visualized in a virtual environment. This paper focus on interactive scenarios and use a rough concept of 1-dimensional drone haptic research [4]. Our research uses a personal drone and cardboard VR and leads a user to easily implement force-haptic feedback in virtual space.

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