A VR gun controller with Recoil Adjustability

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Abstract — This paper provides the design and implementation of a VR gun controller with haptic feedback for the HTC Vive with recoil adjustability. The primary focus of this design is to provide realistic haptic feedback for games utilizing projectile launching weapons to improve gaming immersion on a level further than simply audio and visual.

I. INTRODUCTION

Virtual Reality (VR) is a growing industry providing users with interactive experiences in 3-D and has been utilized in a multitude of fields ranging from the gaming industry to military applications. It is reported that the VR gaming market is estimated to achieve $14.6 billion dollars by the end of 2023, representing 30.5% Compound Annual Growth Rate (CAGR) for the period of 2017-2023 [1]. Contemporary VR gaming utilizes Head Mounted Displays (HMDs), motion controllers, and motion tracking devices. Devices like the Oculus Rift [2] and HTC Vive [3] have adequately addressed the visual and auditory modalities, but haptics still has room for improvement. Touch is said to be ten times stronger than verbal or emotional contact [4] and haptic feedback can significantly increase immersion within VR experiences [5]. In [6], it was found that participants using realistic gun controllers experienced heightened levels of immersion and gaming realism.

Many companies have attempted to improve VR gaming with their version of a VR gun controller. There are more than five VR gun controllers on the market, but only two shall be mentioned here due to space limitations. Ilium VR, a startup company created Athena [7], using a proprietary motor system to deploy haptic feedback. Striker VR [8] uses high speed linear motors that are able to emulate various haptic effects. Although Striker VR has the most versatile haptic feedback controller, its price point is not acceptable by most consumers. In this paper, we present a changed design of a VR motion controller with recoil adjustability to vary immersion levels to suit the user’s experience. Compared to [8], the proposed method focuses on achieving varying degrees of immersion without the need of an overpowered motor. With adjustments to the haptic feedback system, our proposed system uses an ordinary motor but provides recoil adjustability. This alters the firing strength of the physical system based off the user’s need.

This paper differs from our previous design in [9] because of design changes to the firing mechanism as well as a variety of electrical design choices improving system stability. The design in [10] limits a player’s range of motion, tethering them to one spot. This design allows a player to go anywhere as long as the controller is being tracked. Although this paper utilizes software aspects similar to [11], this paper focuses on an electro-mechanical design as opposed to player interaction. The rest of this paper is organized as follows.

In Section II, a system overview is provided. In Section III, a brief description of the selected hardware components and how they interact as a system is provided. Section IV describes the prototype design of the firing system. Finally, conclusions are given in Section V.

II. SYSTEM OVERVIEW

The proposed system focuses on the design and development of a gun controller but interacts with several preexisting elements. These include the Vive’s HMD, Vive Tracker, and VR scene marked blue in Fig. 1. The proposed gun controller communicates to the scene through the Vive Tracker. The gun controller acts as a replacement to existing Vive controllers. The player uses the HMD and Vive tracker to provide HMD position and orientation, motion controller position and orientation, and motion controller buttons. As the player interacts with a scene, the haptic system activates as the trigger button is pressed. The gun controller places the Vive tracker on top for position tracking and data communication to the scene.

III. HARDWARE DESIGN

The hardware design includes seven main components integrated together: A STM32L476 Microcontroller, a L298N motor driver, a step-down converter, a step-up voltage regulator, a 12V lithium-ion battery pack, and the Vive Tracker. Fig. 2 is a component level overview of the design. A brief description of the components used in the design is as follows.

STM32L476 Microcontroller: The STM32L476 [12] is an ultra-low power microcontroller. Its main feature necessary for this project is its USB On-The-Go.

YSD-12650 Li-Ion Battery: This Li-Ion battery is a 6500mAh battery running at a nominal voltage of 12V.

TPS62172 Buck Converter: This Step Down converter [13] converts 12V to 3.3V to run the STM32L476 at an output current of 0.5A.

TPS65235 Voltage Regulator: This voltage regulator [14] is put in place to maintain a consistent output voltage of 12V even
when the battery’s voltage begins to drop. This supports the device to respond in a consistent manner.

L298N Motor Driver: The L298 [15] is a dual full bridge motor driver designed to accept and drive various inductive loads.

Haptic Feedback System: The haptic feedback system developed utilizes a 12V rated DC motor incorporating a gear train further explained in section IV.

Vive Tracker: The Vive tracker is a solution tracking device that can be placed on any accessory allowing the selected object to be tracked.

The STM32 acts as a host communicating through USB On The Go (OTG) to the Vive tracker. Every command dictated from the STM32L476 is able to be received by matching the protocol input of the Vive tracker.

IV. DEVELOPED PROTOTYPE

The focus of this design is to increase player immersion by providing haptic feedback from events within the scene. The haptic effects of the controller use a spring attached weighted shaft moving rapidly back and forth to simulate the recoil of a firearm. The developed prototype showcases four types of moving parts as well as the weighted shaft and recoil adjustment mechanism knob outlined in Fig. 4. Recoil adjustability is achieved by increasing or reducing the mass of the reciprocator tube. An adjustable recoil subassembly is located inside the reciprocator tube. The subassembly is attached to the interior of the tube with a 90° twist lock feature. To adjust the recoil amount, the user will first lock back the reciprocator to its rearmost position. The user will then twist the two protrusions 90° counter clockwise to undo the twist-lock. This will free the adjustable recoil subassembly from the tube. The user will then loosen the M3 socket screw on the rear freeing the weight carrying stem, granting access to steel weights. The user can then choose how many weights to insert up to a maximum of three. The higher weight increases the haptic feedback strength. The conical compression spring on the back will provide tension for the system regardless of the number of weights installed. The lock back mechanism consists of a swivel handle connected to the recoil tube. The handle rides in an “L” shaped channel that is mounted on the outside housing. By pulling back the handle, the user can manually cycle the recoil tube to the rearmost position. At the top edge, the user has access to the recoil adjustment mechanism.

V. CONCLUSION

In this paper, we have detailed the design and implementation of a VR gun controller with varying haptic force using a custom solution to adjust recoil strength meeting

REFERENCES


