## **Purdue ECE Senior Design Semester Report**

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| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Fall 2017 |
| **Advisors** | Prof. Thottethodi, George Hadley |
| **Team Number** | 3 |
| **Project Title** | Virtual Sport |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Chia-Hua Peng | Comp E | Software | December 2017 |
| Hengyi Lin | Comp E | Software | May 2018 |
| Lingke Yu | Comp E | PCB Layout | December 2017 |
| Yutao Hu | Comp E | Software, Soldering | December 2018 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Summary of the project, including customer, purpose, specifications, and a summary of the approach.

## Virtual Sport is a VR appliance which allows the users to play sports from the comfort of a living room. The project features a Kendo sport VR app and a haptic handheld controller. User may wear on a VR headset and enjoy playing the Kendo sport in a virtual environment. The handheld controller recreates unique touch feelings when the user is interacting with the digital objects. This launches a novel experience in Virtual Reality.

## The VR application and the handheld controller are communicated over a Bluetooth protocol. The project utilizes an accelerometer embedded inside the haptic controller to detect the hand tilting movement and to compute the rotating angles. The haptic handheld controller then sends the information to the VR app over Bluetooth and the VR application visualizes the digital sword movement in the virtual environment. Meanwhile, the app also uses a physics engine to track the collision events and to send feedback instructions back to the handheld controller. The embedded device decodes the command and utilizes vibration and servo motors to recreate unique touch feelings. By sliding the contact handle, users may perceive a shear and friction feedback while sparing a digital sword toward a virtual opponent.

1. Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

## The Virtual Sport project required basic understanding of microprocessor architecture, communication protocols, and embedded programing skills from a previous microprocessor interfacing class. Moreover, the project required interfacing the microcontroller with external modules and motor devices to achieve the specifications. Additionally, the team also applied knowledge from the circuitry coursework and selected proper electrical components to design the schematic layout. Finally, our software engineers also applied various data structures, object-oriented programming concept, and other skillset adopted from the earlier software coursework, on top of the VR app development work.

1. Description of what new technical knowledge and skills, if any, were acquired in doing the project.

## One technical skill acquired in doing the project was to design a customized Printed Circuit Board (PCB). This was the area of expertise in which members of the team had no experience. Throughout the semester, the team had acquired knowledge and skills about how to properly arrange the electrical components on a circuit board and how to design a PCB layout that best optimized the area. The project also necessitated skills to solder the microcontroller, the peripheral modules, the decoupling capacitors, and other electrical components on the final PCB. In building the device and the mechanical structure for the haptic feedback mechanism, the use of 3D printing was also a brand-new experience as well. Additionally, the team also learned how to use Unity Engine, Google VR SDK, a mobile Bluetooth protocol, and C# scripting, to design a Virtual Reality application that communicates with an embedded device.

1. Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

## At the start of the project, the team formulated a problem-solution statement, established the objectives, and defined the specific criteria of our design. The team took careful concerns on the electrical constraints, mechanical constraints, as well as the computational constraints during the design planning phase. After analyzing the pros and cons of various components, the team selected the candidates that best meet the design specifications. In analysis and synthesis, the team constructed prototypes to test the individual components, reported issues found on the prototype simulation, and determined if a modification needed to be made to achieve a specification. In synthesis and constructions stages, the raw components were put together on the PCB while the embedded program and the VR app were built up. The final package design was also being 3D printed at this stage. After ensuring the basic functionalities were achieved, the project went through an iterative of testing and modification stages. Some minor adjustments, such as the vibration intensity level, were made in this stage. Finally, the team evaluated the design with the original objective and the specific criterion.

1. Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

## **Economic:** Because there is a limited amount of budget, the Virtual Sport project chooses to use cheaper components and mechanical materials. Our hardware engineer also optimized the PCB area which significantly reduced the cost.

## **Environmental:** The design has a low environmental impact. The final end product complied with the RoHS standards and avoided the use of environmental harmful materials.

## **Ethical:** The project used Bluetooth to communicate the handheld controller with a VR app on a mobile device. Unfortunately, the controller did not have a device paring passcode. Other people could intentionally interfere the user from connecting the device. The final end product prior to manufacturing needs to include a pin code so only the owner can have access to the device.

## **Health & Safety:** The circuit and electrical components used in this project operated under low current and had low probability to overheat. The product should have low probability of hurting users.

## **Social:** The product will potentially increase the number of nearsighted young people in the society due to the close distance between the cell phone screen and the user’s eyes.

## **Political:** This project does not have any realistic political design constraints.

## **Sustainability:** The handheld controller device interfaced with a customized virtual reality application that was designed in Unity. Users may not use it directly with a general VR application downloaded from the app store. However, the project also included a customized Unity package which enables VR developers to easily access the information on the handheld controller. It should be fairly easy to create additional VR scenarios that uses this haptic controller device.

## **Manufacturability:** Assuming that all the chips and passive components can be automatically soldered onto the PCB, the manufacturability of the device should be fairly simple. The mechanical structures and the handheld controller cases can all be 3D printed. Once a complete PCB, the motor devices, and the mechanical parts are available, the rest are really just routing and soldering the motor wires to the PCB and assembling the individual parts with screws and super glues.

1. Description of engineering standards utilized in the project

## The project followed the IEEE 2048.5 Standard (Standard for Virtual Reality and Augmented Reality: Environment Safety). The engineering standard stated that the digital overlay in Virtual Reality technology can impact the user’s perception. The Virtual Sport project took serious concern on the safety issues that could potentially happen. The project originally included a component which required the user to balance the hip-body while wearing the VR headset. However, because the lack of visual perception could lead to potential risk and danger, this component was removed during the early design planning phase.

## The project also utilized an FCC certified Bluetooth module. This component provided reasonable protection against harmful interference in a residential installation. However, to fully comply with the FCC standards, the product still needs to go through additional compliance requirement testing to ensure that the high frequency clock utilized in the project would not hinder the user.

1. Description of the multidisciplinary nature of the project.

## The project required electrical and computer engineering knowledge. It necessitated the skills in choosing the proper electrical components, designing circuitry, interfacing the peripheral modules, programming a microprocessor, and integrating hardware and software for an embedded system. It also utilized Computer-Aided Design (CAD) software to design the schematic and the PCB layout and to create 3D printed models for packaging the design. In addition, the project also provided practical experience to interconnect a digital system design with the virtual reality and haptic technologies. Through completing the project, the team members have utilized the VR engine and related SDK tools, along with the object-oriented programming knowledge acquired in the earlier course work, to design an application that communicates with an embedded device.

1. Description of project deliverables and their final status.

The final prototype was able to achieve all the design specifications. The haptic handheld controller was able to communicate with the Virtual Reality app smoothly via Bluetooth. The app was able to log the correct hand tilting information and user input from the pushbutton. It also successfully utilized the data to visualize and to manipulate the virtual environment. The handheld controller received correct commands sending from the app and responded to the given instruction under an acceptable latency. The handheld controller was able to vibrate and the sliding contact handle was able to move smoothly when the user drew a virtual contact with the digital object. Overall, the haptic mechanism provided a novel experience in a virtual reality world.