VR Disability Accessibility Proposal

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1.0 Introduction

1.1 Objective

As the world keeps progressing, virtual reality (VR) devices are becoming more and more sophisticated. There are full body capture devices being released on the market, as well as haptic feedback. As VR becomes more high powered and consumer friendly, there is a good potential for developers to make more gaming, resource, and teaching applications. As it stands right now, however, VR is inhospitable for people with disabilities. This is especially true of people with disabilities of the arms or hands.

The issue of accessibility for people with disabilities is something that can be solved through multiple avenues. The way that we are proposing specifically tackles this issue for people with the disabilities of the arms or hands. A controller will be made for feet that are controlled by using pressure sensors to allow for both continuous and quick inputs. A USB driver will be necessary for parsing and identification of signals, and saving and normalizing a person's weight and pressure can be done via software to allow for calibration. The sensors will have their own battery pack(s) to provide power and reduce cord tangle, and potentially a single Bluetooth device will be used to wirelessly send the data, at the cost of power. To gather and send the signals, an ATMega32 microcontroller and a USB-to-Serial adapter will be used, and if Bluetooth is used, then a Bluetooth-to-Serial adapter will be used, however the project will continue under the assumption of the former. There are multiple approaches to adjustability and accessibility for users that are explained further in the subsystems section of the proposal. Testing is necessary to know what is most accessible, but either a station to keep the feet in the same place that acts as a hub for the electronics and power, a strapped on sensors/battery packs combination, or a fusion of both with a set of sensors on a pad (like the pad for the game *Dance Dance Revolution*) that has physical markers to allow a user to guide them while using the controller will be developed for user input. For this project, we will be testing and making designs for the first and third input options.

1.2 Background

There are a number of disability related controllers on the market like the QuadStick FPS game controller, and the Microsoft Adaptive Controller, however they are expensive and not developed to be used in a VR environment [1][2]. There is, however, only one foot controller for VR, the 3D Rudder Foot Motion Controller. There are a number of complaints about it, namely that it is hard to control and slides around on the ground, which we intend to address with this design. It should also be noted that there is praise, largely from people with upper body disabilities, but this support can be attributed to the fact that it is the only device that addresses their issues on the market [3].

Developing for VR also comes with it's own issues, which helps explain the lack of suitable controllers. One issue is that VR controllers have a different SDK than other controllers that exist for well established systems (PS4, XBox, etc.), so when a controller is made, it has to be compatible with the headset. On the hardware side, the controller has to be designed so that someone can use it without being able to see it, and should be stable and comfortable for prolonged use. If someone cannot navigate the controller without sight then it is unusable, due to them having the headset strapped to their face. There are also some general issues with developing for VR, such as keeping things feeling natural for users to increase immersion, and keeping peripherals strong in the case of excess movement on the part of the user due to getting too engrossed, which includes paying attention to how wires and other parts of the peripheral can get caught or hit other things.

1.3 Physical Design

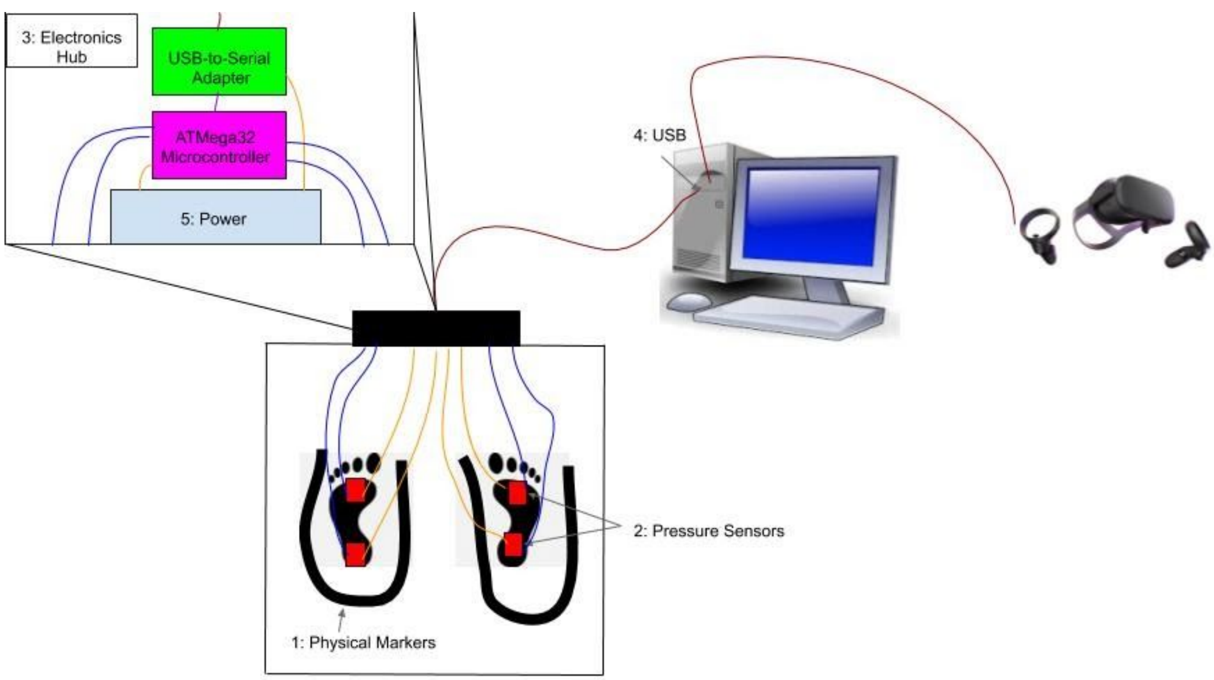

Figure 1: Representation of a sensor pad based approach to controller design with location of subsystems. Each wire has its own type defined by color: Blue - Pressure sensor output, Orange - Power Supply, Purple - Serial data from microcontroller, Maroon - USB data.

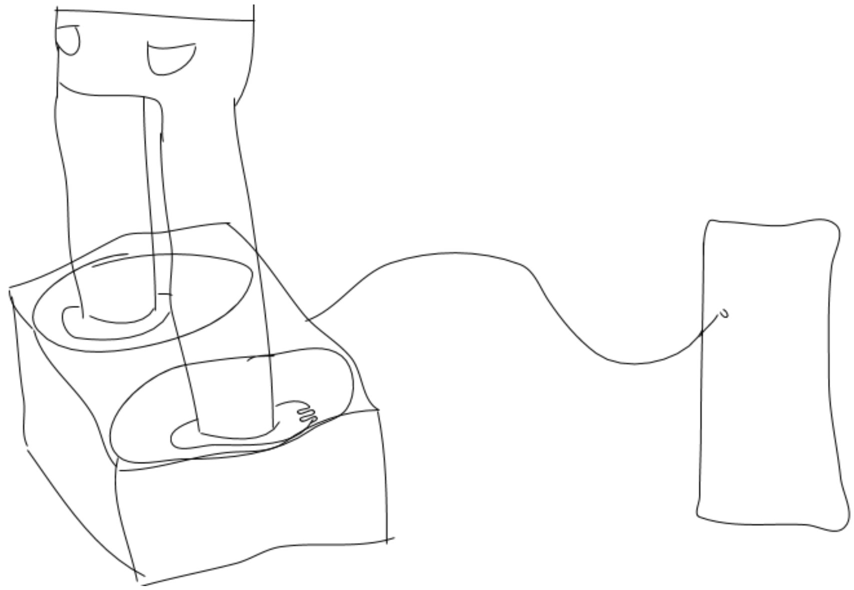

Figure 2: Artist's rendition of a hub based approach.

1.4 High Level Requirements

The high level requirements for this project are as follows:

- The pressure sensors relay their signals to a computer.
- The computer has a driver capable of reading, interpreting the signals (i.e. assigning the left foot heel signal to a left_foot_heel variable), and presenting these signals to the rest of the computer for other programs to use.
- The controller design can be navigated by users with upper body disabilities while wearing a VR headset.

2.0 Design

2.1 Block Diagram

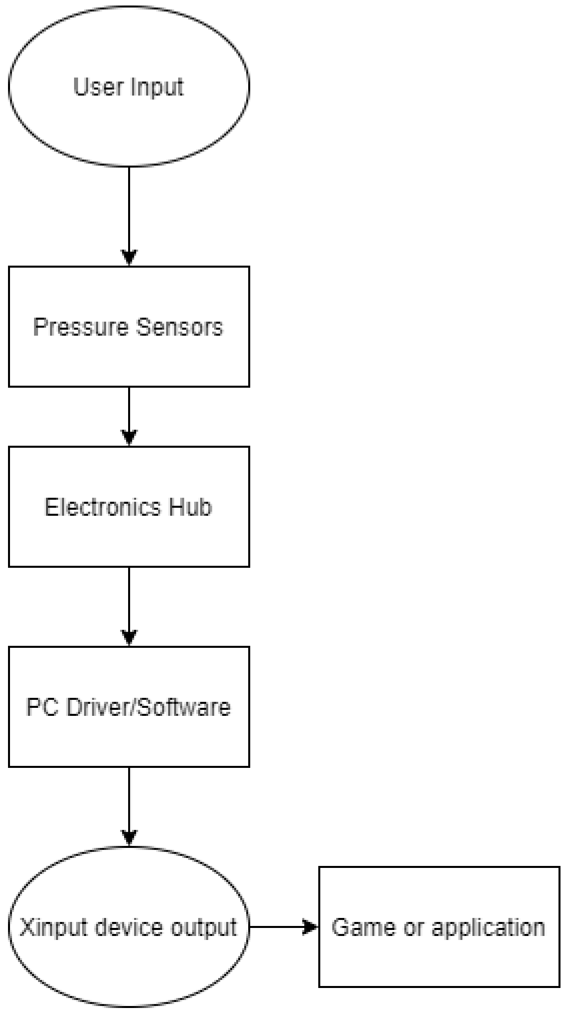

Figure 3: High-level block diagram

This block diagram is a high-level overview of the device. It takes input from the user stepping on a pressure sensor, which sends a signal to the electronics hub, then to the PC driver and software where it is processed into a usable xInput device signal for other programs to use. This block diagram satisfies all the high-level requirements because it is able to detect a user's input and process it into a signal that can be used as an input to a game or program.

2.2 Functional Overview and Block Requirements

- Pressure Sensors
  - This subsystem consists of four load cells and four HX711 24-bit analog to digital (AD) converters. There are two cells assigned to each foot, giving the user four distinct inputs using the balls or the heels of his/her feet. Each load cell is connected to an HX711 24-bit AD converter which converts the analog load cell signals to digital signals which can be processed by the ATmega32 Microcontroller. This subsystem is connected to the ATmega32 Microcontroller via wires.
  - Specific Requirements:
    - Operating voltage of HX711: 2.6-5.5V
    - HX711 AD converter must convert the signals with a delay of no more than 5ms
    - Load cells must support up to 100kg
- Electronics Hub
  - This subsystem consists of an ATmega32 Microcontroller and a Serial-to-USB adapter. The microcontroller takes inputs from the HX711 AD converters and processes the signals to be sent to the Serial-to-USB adapter. The microcontroller is then connected to a computer via USB where the processed signals can then be read by a driver or other software.
  - Specific Requirements:
    - ATmega32 Operating voltage of 4.5-5.5V
    - ATmega32 must process and send the signals to the Serial-to-USB adapter within 5ms
- Power Supply
  - This subsystem can either be integrated with the Serial-to-USB adapter, or it can be a separate battery. This subsystem will supply power to all other electronic components in the device and must operate within the given voltages. The Serial-to-USB adapter is able to supply 5V as given by the USB standard, but that requires the device to be tethered to a PC. If there is enough time, the device may be changed to a wireless device, connecting to a PC via bluetooth. This would then require a battery or other power supply that would be able to power the device at the given voltages.
  - Specific Requirements:
    - Must continuously supply 500mA at 5V +/- 0.5V
    - (If battery-operated) Must have enough power to last at least 5 hours

- USB Driver
    - The purpose of the USB driver and software is to parse the incoming data from the microcontroller and sensors and process it into data which programs on the PC can use. This driver must be able to properly read the data sent by the microcontroller and it must expose it so that a secondary piece of software can use it to pass proper inputs into games or other software. This software must be able to set activation thresholds for each one of the pressure sensors so that users of all weight ranges can comfortably use the device.
    - Specific Requirements:
        - Driver must process the signal within 10ms upon receiving
        - Driver must parse separate inputs for each foot input i.e. left_heel, right_heel, left_toe, right_toe, etc.
        - Software must include ability to adjust weight thresholds
        - Software must pass xInput signals to other programs

2.3 Risk Analysis

The block which poses the greatest risk to successful completion of the project is the USB driver and accompanying software. A USB driver is difficult to write from scratch, and it must work flawlessly so that there is little to no error when communicating with the device itself. This can prove difficult given the time frame of the project. The other difficulty is in writing the software that properly sets the activation thresholds for the device. Lots of documentation must be followed to successfully implement the emulation of an xInput device, which may pose some difficulty. The rest of the subsystems should be relatively straightforward to implement since it only requires following the given datasheets for each subsystem.

3.0 Ethics and Safety

Due to the project dealing with VR, some obvious health concerns do come to mind. Virtual reality headsets are known to cause nausea and anxiety, especially after extended usage. People with disabilities might be even more at risk of being affected by these problems. In addition, VR headsets can also cause eye strain, and even anxiety from all the stress of being in the virtual environment. There are all issues we need to be aware of as we develop this technology, and make sure our project doesn't make these issues any worse through both accidental and intentional misuse. With regards to testing specifically, only the project members will be testing the technology. Since there is a low development time, we can't be certain that the project is ready for beta testing with the target audience. Before reaching that point, we will thoroughly test the product on ourselves.

With regards to ethical issues relevant to the project, IEEE Code of Ethics Section 1.1 [4] discusses the importance of safety and health of the public, and we believe that we should ensure that the project is safe for any user. Considering our target audience is people with disabilities, we need to be even more considerate of their needs to be safe and healthy while using this project. Furthermore, for testing, we need to be clear about the effects of the technology and the associated risks, and ensure we receive proper consent from testers via waivers. ACM Code of Ethics Section 2.7 [5] is also quite relevant to our project because it is important for the public to understand the technology we are using and how it works. This allows for projects like this to gain even more attention. Virtual reality has a lot of potential, and it could yet be expanded to help disabled individuals. By educating the public through proper conduct and safety precautions, as well as helping them to understand the consequences of this technology on society, we can collectively learn and continue our efforts in this field.

References

[1] "QuadStick FPS Game Controller." *quadstick.com* QuadStick, 2020, https://www.quadstick.com/shop/quadstick-fps-game-controller. September 17th, 2020.

[2] "Xbox Adaptive Controller." *microsoft.com* Microsoft, 2020, https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller. September 17th, 2020.

[3] "3D Rudder Foot Motion Controller for VR and PC Games and Applications with VR Mode, Foot Keyboard Mode, Foot Mouse Mode, Foot Joystick Mode." *amazon.com* Amazon, Dec 29, 2016, https://www.amazon.com/3dRudder-Foot-Motion-Controller-Applications/product-reviews/B01MS26PFK. September 17th, 2020.

[4] "IEEE Code of Ethics" *IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html.* September 17th, 2020.

[5] "ACM Code of Ethics and Professional Conduct" *ACM, https://www.acm.org/code-of-ethics.* September 17th, 2020.