Tactile Mouse Wheel

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Introduction: Tactile mouse wheel is a handheld device related to Virtual Reality (VR). The device uses an actuated wheel underneath the fingertip that moves up and down to render touch contact with a virtual surface and spins to render motion as the user slides along virtual surface.

Background and Objectives

- **Background Information**

  Haptic communication refers to the ways in which people communicate and interact via the sense of touch, offering an extra dimension to a VR or 3D environment, which is essential to the feeling of true immersion in those environments. Today's VR devices are capable of rendering realistic visual, audio content and tracking. Despite these advances, the ability of such devices to render the sense of touch is lacking.

- **Objectives**

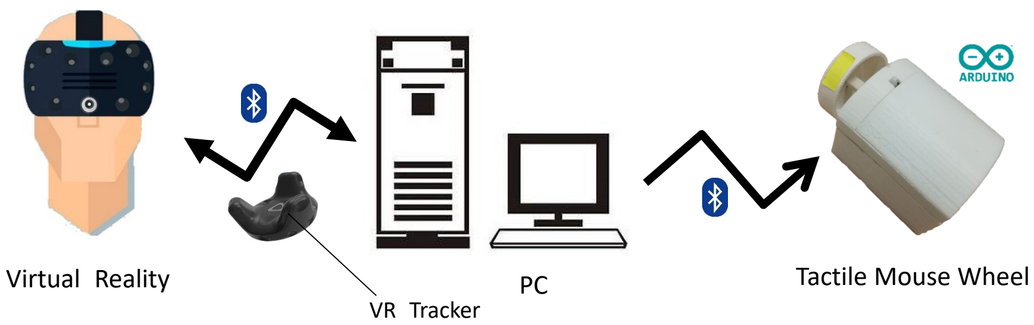
  Thus, a tactile mouse wheel is introduced to create haptic feedback to user's finger, which aims to enhance VR players' experience. To achieve this tactile mouse wheel, developers need:

  1. Design algorithm and logic for stepper motor, servo, buttons
  2. Communicate between Unity and Arduino
  3. Combine software with hardware.

Materials and Methodology

1. Materials

In general, the whole project was to achieve synchronous communication between VR device and the mouse wheel via PC by Bluetooth technology.



- Two Arduinos: DFR0305, Nano
- PLA materials for 3D printing.
- Stepper motor & Servo
- Lithium battery 14.8V
- Two non-self-locking push switches
- Virtual Reality devices: Tracker, Eye mask

2. Methodology

In general, the overall process of data followed dimensionality reduction, converting 3D movement into 1D rotation.

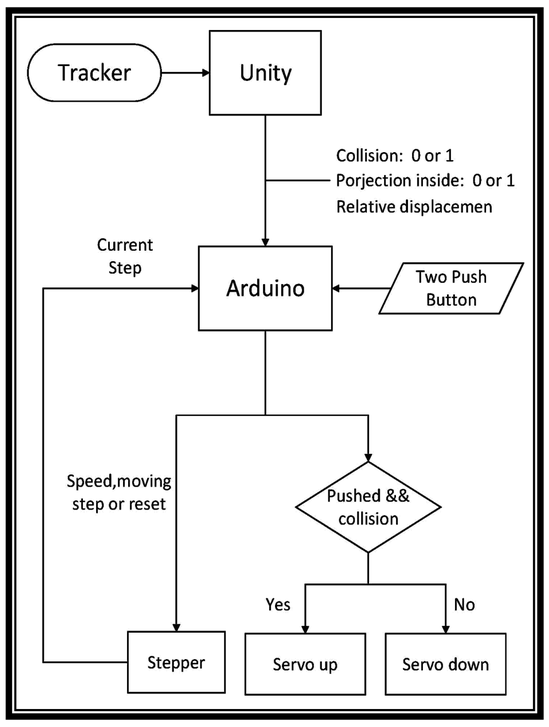


Figure 1: Control Process

(1) Unity

- Unity detect and output the interaction of finger with virtual surfaces(which related to y-coordinate) as well as the horizontal position of finger(x and z) with movement of tracker.
- To minimize the amount of transmitted data, the horizontal surface is divided into eight regions where the location of finger will be represented by two variables differently.

(2) Arduino

Rotating Steps: Input distances were all firstly measured in steps by:

$$Steps = -\frac{2048}{2\pi} \cdot \frac{dis}{Ratio \times Radius}$$

- Radius of wheel was 4cm and the virtual-to-real displacement ratio were 4.
- The rotating direction and steps were determined by current state of the wheel.
- Moving steps were always accumulated until reset.

Rotating Speed:

① The speed of motor was controlled by input frequency f. There is a linear relationship between real angular speed (steps/ms) and f.

② The updating time was 150 ms also determining the corresponding speed of each moving steps.

③ Step difference larger than would lead to a rotation by 35 steps

Switch Control:

Two non-self-locking switches respectively connected to control the servo and reset of stepper.

Figure 2: Representation of Positions

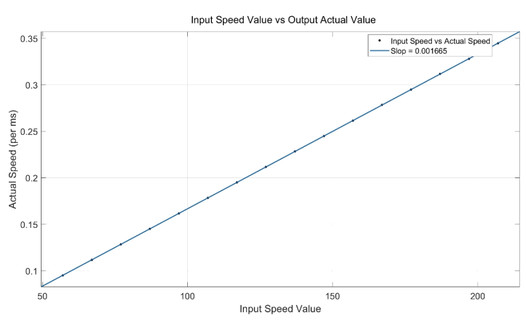


Figure 3: Actual speed versus input f

Developments and Results

1. Designing

Construction of 3D Printing model of Mouse and internal circuit connection diagram

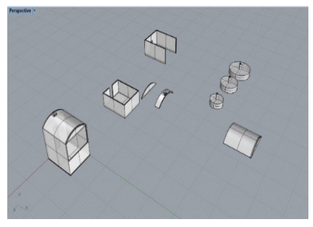


Figure 4: 3D Printing model of Mouse

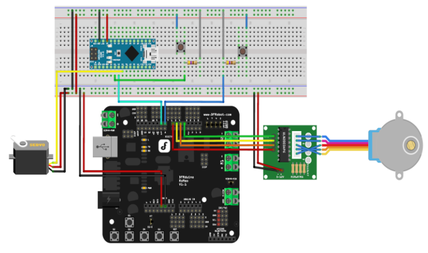


Figure 5: internal circuit

2. Hardware

Physical picture of 3D Printing model of Mouse and assembled all components

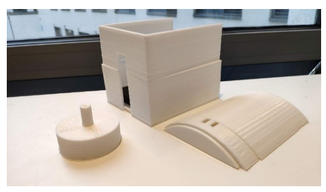


Figure 6: Physical 3D Printing model

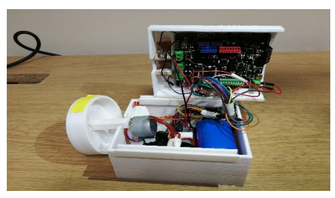


Figure 7: assembled all components

3. Software

Create a 3D virtual environment in Unity where two different materials are indicated.

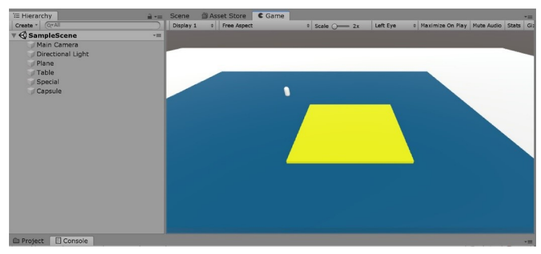


Figure 8: 3D virtual environment

4. Combination

Add the VR track to the assembled hardware device to get the final product of the tactile mouse. Connect the VR glasses and the tactile mouse separately through Bluetooth, and load the program script on the computer user can see the following scenes in the VR glasses.

Figure 9: Finished product and VR glasses

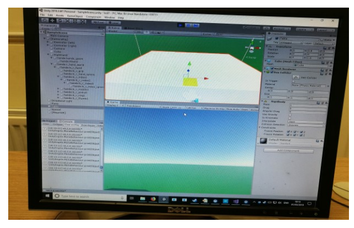


Figure 10: scenes in the VR glasses

5. Result

Tactile wheel rotates with the movement of user's hand synchronously via Bluetooth communication. When user's hand moves to the material and touch it in VR, tactile wheel will uplift rapidly so that haptic feedback generated.

Conclusions and Future Work

- **Conclusions**

  To summarize, tactile mouse wheel is a handheld device which creates haptic feedback on user's finger while wheel rotates with the movement of user's hand in Virtual Reality. Though the wheel could render touch contact and rotate under finger, there are some initial ideas the wheel has not realized. For instance, the wheel is only applied for designated scene where there are two materials. The initial ideas, however, is providing several customized scenes and wheels. Furthermore, the distance between wheel and switch is not suitable for everyone's finger, then how the haptic on fingertip is influenced. Despite wheel, the mouse box is heavier than expected.

- **Future Work**

  1. The diversity of the haptic feedback could be intensified by changing the materials of the wheel and increasing the complexity scenes in Unity. In particular, customizing wheels for users is the point if tactile mouse wheel is applied in market
  2. The function of vibration on the tactile mouse wheel could be achieved by intelligent motors and weights in the device.
  3. Tactile mouse could be made more compactible by 3D printing and it weight can be decreased by using power bank instead of 14.8V lithium battery.