Thumbs Up

Development of a Thumb-Mounted Wireless Controller

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Abstract

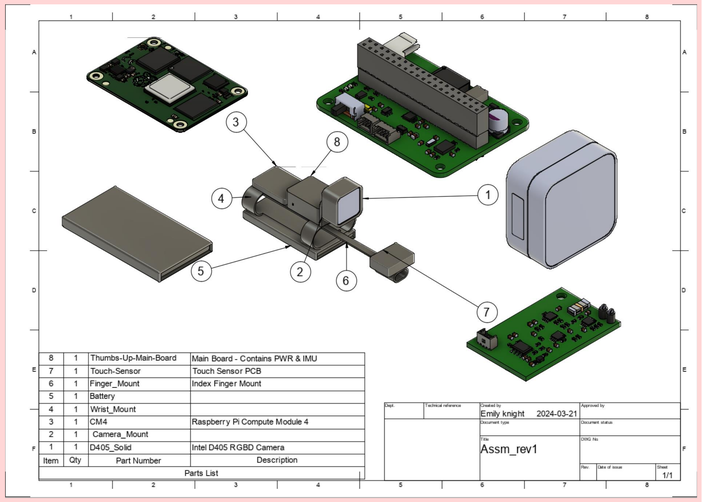
Virtual reality has become increasingly popular over the years, as more people seek efficient ways to interact with their devices. Various devices have been developed to recognize specific hand movements, enhancing user interaction. However, new developments often emerge without integrating multiple design techniques. This research project aims to combine several sensing techniques into one prototype capable of collecting data. This data can then be fed into a machine learning model to recognize gestures. Research was conducted to select the different techniques that will be incorporated into the final design. A PCB was designed to sense touch, while IMUs were incorporated to capture valuable coordinates. A depth camera was added to obtain static images that can be used to identify gestures.

Introduction

- Mixed reality (MR) is a growing industry that allows users to venture into an intersection between the physical and digital worlds. The applications of this technology range from video games to healthcare. Advanced input methods and environmental perception drive user immersion; thus, effective hardware is crucial [1].
- The project is motivated by the disadvantages of existing MR controllers; they are not user-friendly because they are physically cumbersome due to wired connections, and often rely on external cameras. Furthermore, micro-gestures, such as thumb pinching, are often unsupported, limiting applicability.
- Thumbs Up represents a uniquely lightweight, wireless MR device that allows users to interact effortlessly with applications through single-hand micro-gestures and implementation of pinch detection. Taking inspiration from previous work seen in Electroring [3], this device is the first of its kind, integrating advanced sensor technologies to enable precise detection.

Discussion

- The prototype has 3 main components: The Touch Sensor, 2 IMUs, and the Depth Camera. The GUI allows the user to see the data from the IMUs, when touch is detected, the camera's input is also displayed alongside the output of the touch sensor.
- The IMU is used to collect x, y, z coordinates of the index finger and wrist when a gesture is being made.
- The camera is used to capture static images of the hand which is an important component for identifying gestures.
- The touch sensor allows the prototype to identify when a gesture that involves touch occurs .



Conclusions

- The prototype can be used to work with a sophisticated machine learning model for gesture recognition. The prototype currently identifies touch and can classify five unique static gestures and five dynamic movements.

Results

The device successfully combines 3 sensor systems to capture user data. The device communicates with an external computer to display the collected data via a graphical user interface (GUI).

- The IMU collects three-dimensional acceleration and rotational data and displays the use input as a vector on the GUI.
- The camera captures static images of the user's hand and maps the hand anatomy to identify gestures. This data is displayed as a simulated video feed on the GUI.
- The touch sensor identifies the user's fingers making contact in a "pinching" gesture, allowing for increased MR interaction.
- The GUI displays real-time data allowing the user to understand what the device is sensing. In addition, the GUI is used for collecting gestures for the ML pipeline.
- The wireless communication is achieved through the microcontroller via Wifi connection to an external computer.
- The single cell Lithium Ion 4.2V battery allows the device to have a battery life of 3+ hours, with an average recharge time of 0.5 hours.

Methods and Materials

All device components are mounted on the user's thumb and wrist using a soft, form fitting, custom 3D printed TPA sleeve.

- The IMUs in our device are BNO 055 IMUs by Bosch, mounted on Adafruit's breakout board.
- The camera is Intel's RealSense d405 RGBD camera. The camera is mounted on the underside of the user's wrist.
- The touch sensor couples a signal to the user's finger and receives it back with copper electrodes. When the user pinches, the changed signal is detected, enabling touch detection.
- The Raspberry Pi CM4 microcontroller allows for sensor integration and device communication.

References

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