EEL4924C Electrical Engineering Design II
Project Abstract with Brief Diagrams

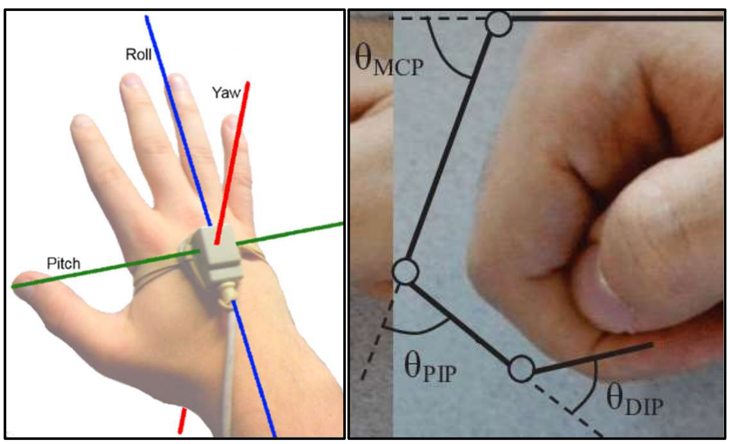
Hand Tracking Glove

Submitted by:

(Daniel Hamilton, d.hamilton@ufl.edu, 352-514-4490)

Project Abstract

The goal of this project is to build a wearable glove that will track bends in each finger and 3-dimensional hand orientation of the right hand. The glove will wirelessly transfer the data over Bluetooth to a script running on a desktop where it will be plotted and displayed live. The data that this glove will produce is shown in the figures below. Note, this device will only capture MCP and PIP joint bends since DIP joint bends can be estimated using PIP values.



Figures 1 and 2: **Hand orientation (left) and MCP/PIP finger bends (right)**

If time permits, I plan to demonstrate the Hand Tracking Glove's capabilities by controlling a virtual hand in a desktop application that I will make using the Unity 3D game engine. Additional stretch goals are to capture finger spread using bend sensors, capture hand transposition using an accelerometer sensor, and enable normal device operation while the battery is recharging.

Introduction

The Hand Tracking Glove has applications in Virtual Reality as a more immersive controller than the traditional VR controller, as a tool for interpreting sign language into a spoken language, or to control robotic arms remotely. Since the glove is a controller, it has potential use for any application that requires human guidance.

This project is inspired by the Nintendo Power Glove, which was released in 1989. Although the Power Glove gained public attention for its early VR mechanics and appearance in the 1989 film, *The*

Wizard, the glove was notoriously difficult to use due to its limited and inconsistent functionality. My Hand Tracking Glove will make the following improvements to the Nintendo Power Glove.

Hand Tracking Glove Capability	Nintendo Power Glove Capability
24-bit bend resolution per finger (12 bits for each of the 2 sensors used per finger).	2-bit bend resolution per finger (1 sensor for entire finger) = 4 possible finger positions.
Data acquisition for all 5 fingers.	Does not capture pinky finger movements to save money. Pinky mirrors ring finger.
Orientation calculation **for all axes** using accelerometer, gyroscope, and magnetometer sensor fusion.	Calculates yaw and roll (not pitch) using a triangulation calculation to determine positions of two ultrasonic speakers on the glove. The pitch does not affect the position of the 2 speakers, so it cannot be captured on this device.

Technical Objectives

Below are the core requirements for this project and my expected solutions. Additionally, I have listed some stretch goals after the core requirements are complete.

Req #	Core Requirement	Expected Solution
1	Capture finger bends for 5 fingers	I will use "stretch" or "bend" sensitive materials attached above and below each joint, which will change resistance as the joint bends. When used in a voltage divider, the output voltage can be read through the microcontroller's ADC and joint bends can be estimated. Each finger's MCP and PIP joints will be captured, and the DIP joint will be ignored on the device side.
2	Capturing analog voltages for 10 flex sensors with limited ADC pins	I will use 2 8x1 Analog multiplexer ICs to switch between finger voltages to output. There will be an MCP specific mux and a PIP (or IP) specific mux. This will allow both joints on a finger to be measured at the same time using only 2 ADC pins and 3 GPIO pins for the mux select lines.
3	Calculating orientation of the hand	I will use a sensor fusion algorithm to combine accelerometer, gyroscope, and magnetometer data into orientation values on the device. These algorithms are both memory and CPU intensive and will require a powerful FPU for floating point calculations.
4	Wireless data transmission	Establish a protocol to connect, disconnect, and transmit data to a Bluetooth device. Should also handle connection interruption or incomplete message transfers.
5	Rechargeable battery power	To support wireless operation, the device will be powered by a Li-ion battery. I will need to build a charger circuit to support "constant current, constant voltage" battery recharging steps.
6	Battery charge indicator	I will use an additional ADC pin on the microcontroller to determine the battery's remaining charge based on the Li-ion battery's discharge voltage diagram. This info will be converted to a charge percentage and displayed on the LCD. Need to experiment with circuitry required.
7	Status LCD	Outputs device info like battery charge percentage, Bluetooth connection status, and battery charging status.

8	Live data plotter script	I will make a Python or C# desktop script that connects to the glove over Bluetooth, decodes received data, and plots the data in real time. This will be useful for visualizing the glove's capabilities and will be my baseline demo.

Req #	Stretch Goal	Expected Solution
1	Capturing spread between fingers.	I will use variable resistance "bend" sensors that change resistance as the sensor bends. This could be placed between fingers and used in a voltage divider to output a voltage range that could be read in the microcontroller ADC. The Hand Demo would have to be modified as well to support finger spread.
2	Capturing hand movement	I will use accelerometer data to calculate changes in hand position. This feature could be used to create a more interesting demo.
3	Virtual hand demo (or a simple video game)	The desktop application will receive and decode data from the glove and will move a 3D hand model's joints and wrist based on the values. Each finger's DIP joint will be estimated using the PIP joint values. This goal aims to create a more interesting demo than the live data plotter.
4	Enable device operation while charging	Adding load sharing capability to the battery charging circuit ensures the battery charger and the device load are both receiving sufficient power to operate as expected.

Hardware Diagram