Chirality: Smart Glove
The Problem
Possible Applications
Behavioral Spec

- Measure rotational position of each finger within 1° of error
- Communicate this data at high frequency via Bluetooth
Block Diagram
Parts on Hand

Microcontroller

Flex Sensor
PCB Layout (Main Board)
PCB Layout (IMU_TIP)

1.6cm

1.3cm
PCB Layout (IMU_BASE)

1.6cm

1.9cm
Components - List

- Bosch BMI323 IMU
- Spectra Symbol Flex Sensor
- NUCLEO-WB55RG STM32 Board
  - STM325WB55RG
- Texas Instruments ADS1115 external ADC
- Antistatic Glove
Components - Microcontroller

STM32WB55RG

- Dual core Arm Cortex-M4 MCU 64 MHz
  - Built-in Bluetooth Low Energy and Wifi stack
  - 1 Mbyte of flash memory, 256 KB of SRAM
  - 2 SPI, 2 I2C, 1 ADC
Components - Inertial Measurement Unit

Bosch Sensortec BMI 323

- 16-bit Triaxial Accelerometer
  - Range: 2g, 4g, 8g, and 16g
- 16-bit Triaxial Gyroscope
  - Range: 125°/s, 250°/s, 500°/s, 1000°/s, and 2000°/s
Components - Flex Sensors

FS-L-055-253-MP Flex Sensor

- Angle Displacement Measurement
- Flat Resistance: 10K Ohms ±30%
- Bend Resistance: minimum 2 times greater than the flat resistance at 180° pinch bend
- Power Rating: 0.5 Watts continuous, 1 Watt Peak
Components - ADC

**ADS1115**

- Delta-sigma (ΔΣ) ADCs
- 4-Channel, 16-bit, I2C
- 860 samples per second
- Ultra-Small X2QFN Package
  - 2 mm × 1.5 mm × 0.4 mm
- Low current consumption and supply voltage
  - 2V, 150μA
Software Development

- Represent finger with bend, curl, wag angles
Software Development

- Represent finger with bend, curl, wag angles
- Thumb is same as a finger, but with palm bend as bend
Software Development

- Represent finger with bend, curl, wag angles
- Thumb is same as a finger, but with palm bend as bend
- Hand is collection of fingers and thumb
- Use BLE stack to send real-time data
## Data Sources

<table>
<thead>
<tr>
<th>Gyroscope:</th>
<th>Accelerometer:</th>
</tr>
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<tbody>
<tr>
<td><strong>Pros:</strong></td>
<td><strong>Pros:</strong></td>
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<tr>
<td>- 3-axis rotation data</td>
<td>- Accurate positional data based on gravity</td>
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<tr>
<td>- Accurate regardless of motion</td>
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<tr>
<td><strong>Cons:</strong></td>
<td><strong>Cons:</strong></td>
</tr>
<tr>
<td>- Rate data $\rightarrow$ discrete integral $\rightarrow$ positional drift</td>
<td>- Can only give 2-axis rotation data</td>
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<td></td>
<td>- Less accurate for rotation during movement</td>
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Sensor Fusion

- Derive rotation data from gyroscope and accelerometer
- Combine gyroscope and accelerometer rotation with dynamically weighted average
- Three tunable hyperparameters:
  - Peak constant
  - Gyroscope bias
  - Gravity magnitude offset (set to 9.8)
Relevant Finger Data

Bend:
- Gyroscope: Palm, Base
- Accelerometer: Palm, Base

Curl:
- Gyroscope: Base, Tip
- Accelerometer: Base, Tip

Wag:
- Gyroscope: Palm, Base
- Accelerometer: Palm, Base
Software Flow (Finger Measurement)

- Gyro change 1
- Gyro change 2
- Accel vector 1
- Accel vector 2

Gyro angle change

Accel angle position

Sensor Fusion

Low Pass Filter

Finger Measurement
Software Flow (Thumb Bend)

Flex Sensor Data \rightarrow Onboard ADC \rightarrow Recontextualize \rightarrow Finger Measurement
Application Development

- Virtual Model rendered from real-time positional data generated by smart glove
- Each joint in virtual model utilizes relative rotational data from nearby IMU and its reference position given by IMU on palm.
Development Team

- Diego Jerez
  - Team Lead
  - Data Parsing & Hardware Processing
- Ananth Pilaka
  - Software Development & Visualization
- Jonathan Wilcox
  - Bluetooth & Communication Protocol Development
- Phil Wang
  - Hardware Testing & PCB Development
- Yusheng Su
  - Hardware Testing & PCB Development
Demo Video
Acknowledgements

Special thanks to:

- Dr. Yogananda Isukapalli, CE Capstone Project Instructor
- Eric Hsieh, Lead TA
- Alex Lai, TA
- Brian Li, TA
Thank you

Q&A