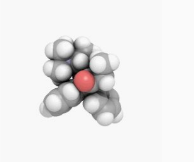
Team A4: TeleTouch

David Hwang, Gram Liu, Xuanye Li

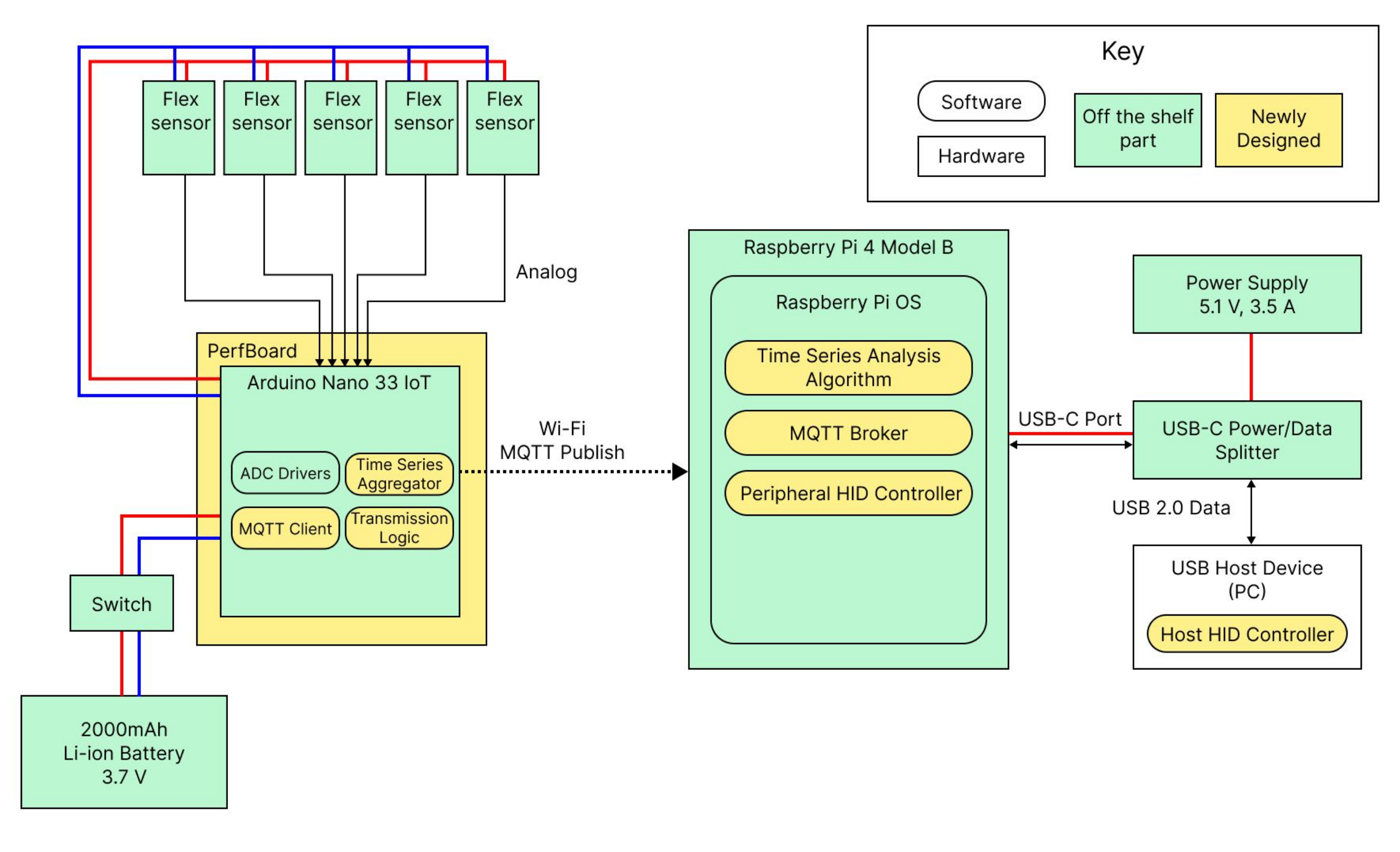
Use Case/Application

- Remotely interact with 3D models using gestures
- Support panning, zooming, and rotating gestures
- Have an on-board battery to last an entire presentation



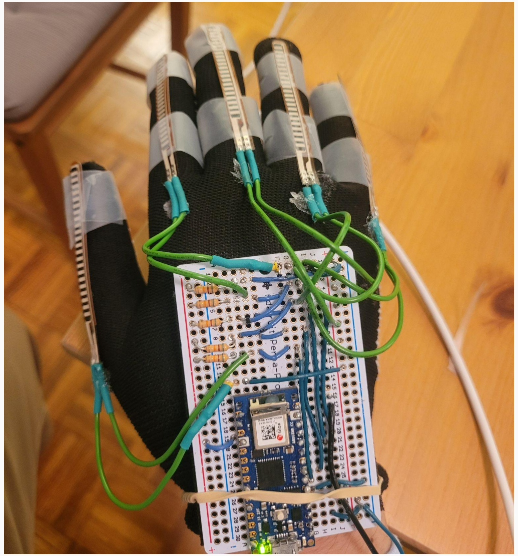
Requirement	Metric
Use sensor data to recognize when user is making gestures	6 gestures (enable/disable transmission, zoom in, zoom out, pan, rotate)
Reliable gesture detection	> 90% gesture recognition accuracy
Smooth user experience when using gesture manipulating objects	Gestures must be recognized and the correct controls should be dispatched to the computer within 1 second
Device should be lightweight and portable	Total mass is at most 1 kg Battery life is up to 1 hour of continuous use
User is able to move freely while using the device	Supports up to 50 m away from the computer

Solution Approach



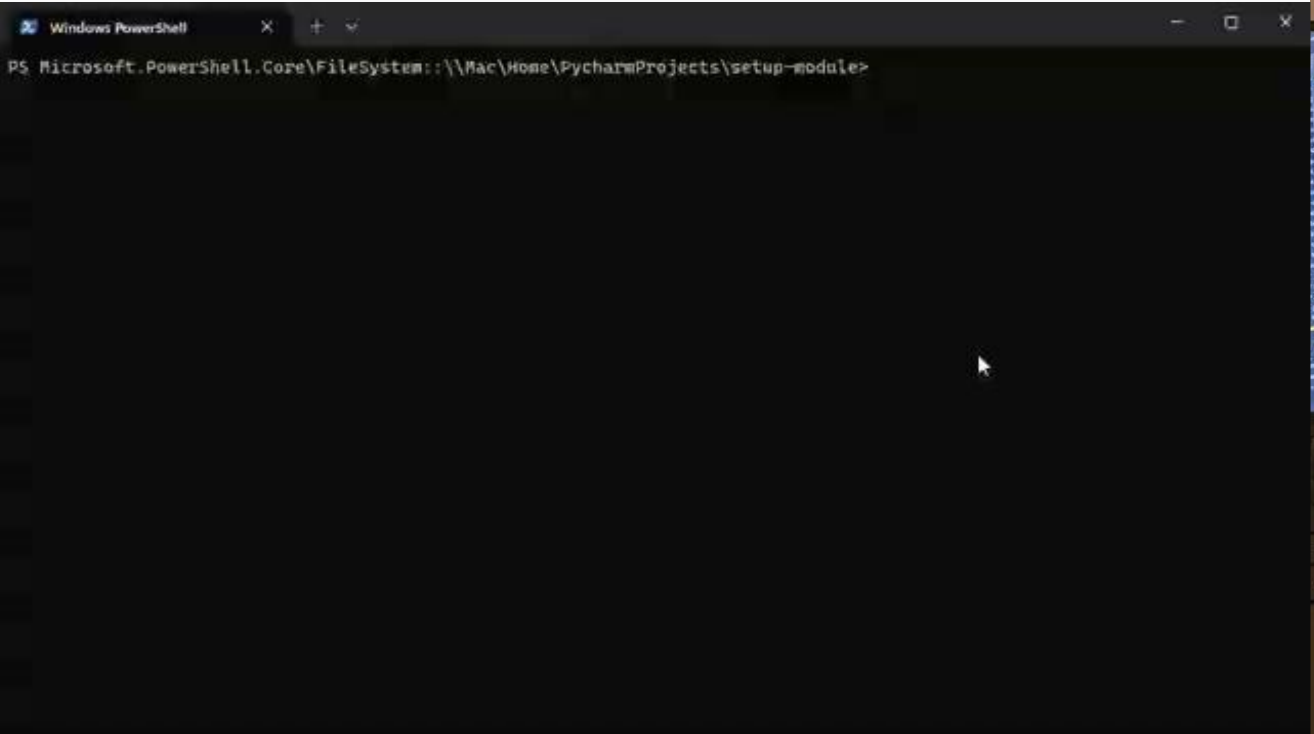
Complete Solution - Hardware

Compute Module

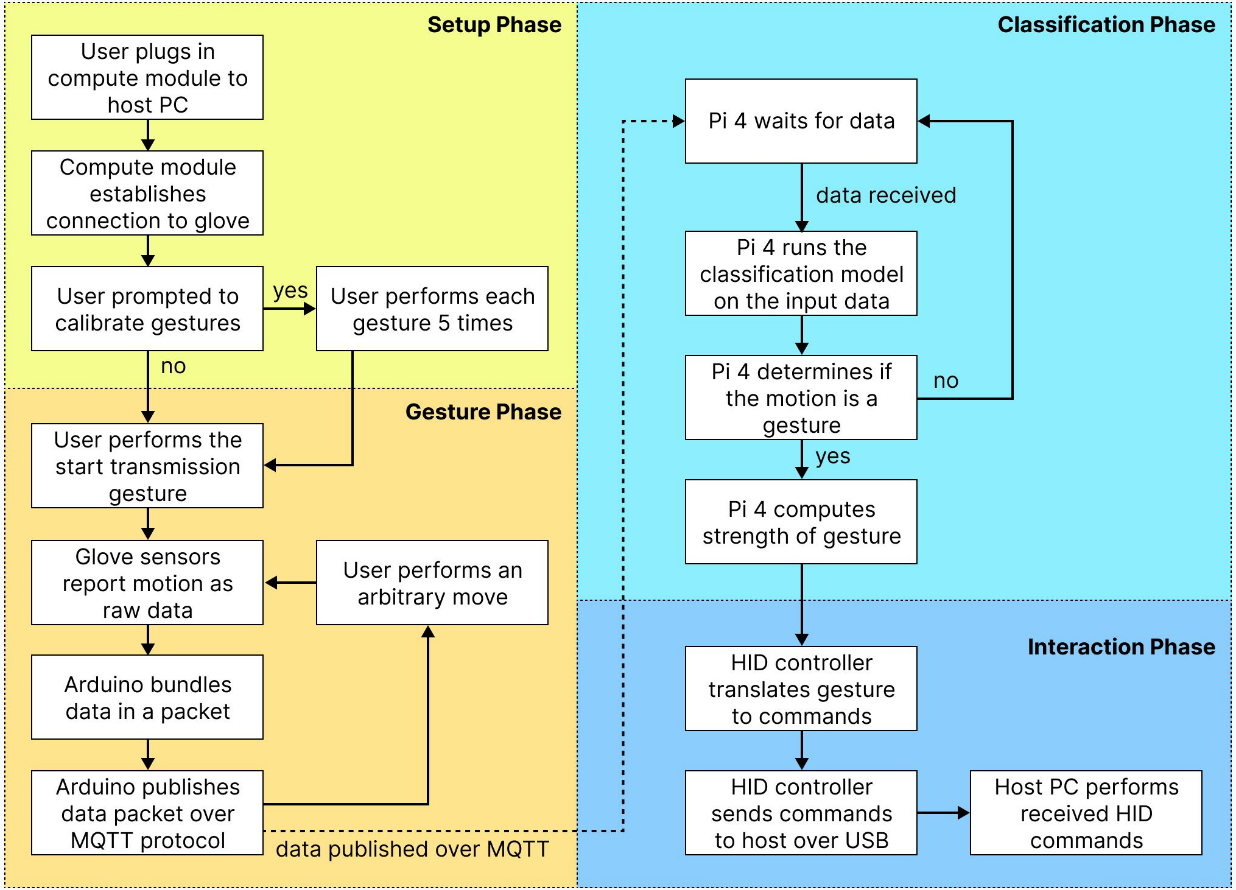


Glove Module

Complete Solution - Classification



Data Pipeline



Design Changes and Trade-offs

Issue	Solution
CNN-LSTM: Too complex for use case, time frame too short to collect enough training data	**Windowed Time Series Analysis**: Use simpler ML methods like decision trees. Requires calibration.
Stitching sensors: Does not provide enough tension. Takes too long to stitch, but is more secure.	**Use stronger, inelastic adhesives like tape and hot glue**
Flex sensor strain: Significant strain on flex sensors with existing wires	**Use more flexible wires and secure flex sensors at base**
ESP with separate IMU not compact	**Use Arduino Nano 33 IoT with WiFi and IMU for all-in-one package.** Cheaper
Difficult to pair both glove and compute to same network	**Use RPi compute module as an access point.** Shorter range.
HID controller needs size of monitor and application information	**Determine commands on PC**: Configurable to arbitrary set ups and reduces communication cost

Testing, Verification, and Validation - Latency

Measurement	Actual Value
Oscilloscope measurement of Pi 4 GPIO pin and sensor detection output (overall measurement)	~ 112ms
Sensor data collection	~ 100ms
Model classification time	~ 5ms
Wi-Fi transmission delay with ping tests	~ 5ms
Dispatch time	TBD

Original target metric: < 1s total latency
Tests were averaged over 20 trials

Testing, Verification, and Validation - Accuracy

Accuracy	Train/test split evaluation Accuracy of dispatched HID controls	> 90% gesture recognition accuracy	90% for rotation/pan Other gestures TBD Dispatch accuracy TBD

Testing, Verification, and Validation - User Experience

Requirement	Measurement Procedure	Target Metric	Actual Value
Usability	Ease-of-use: User study measuring comfort, setup time, and responsiveness	~~90% user satisfaction based on survey~~ Setup time < 5 mins	~4 minutes
Portability	Measure weight with a scale.	< 500 g	57g + 34g battery = 91g
Range	Test wireless communication across measured distances	Up to 50 m between glove and compute	10 m
Battery Life	Run glove module with all sensors and communication running and measure total power consumption	up to 1 hour of continuous use	~40 hours

Project Management