Team A4: TeleTouch

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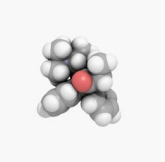
Use Case/Application

- 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

Two components: glove and compute module

Glove: 5 flex sensors + IMU connected to a Microcontroller

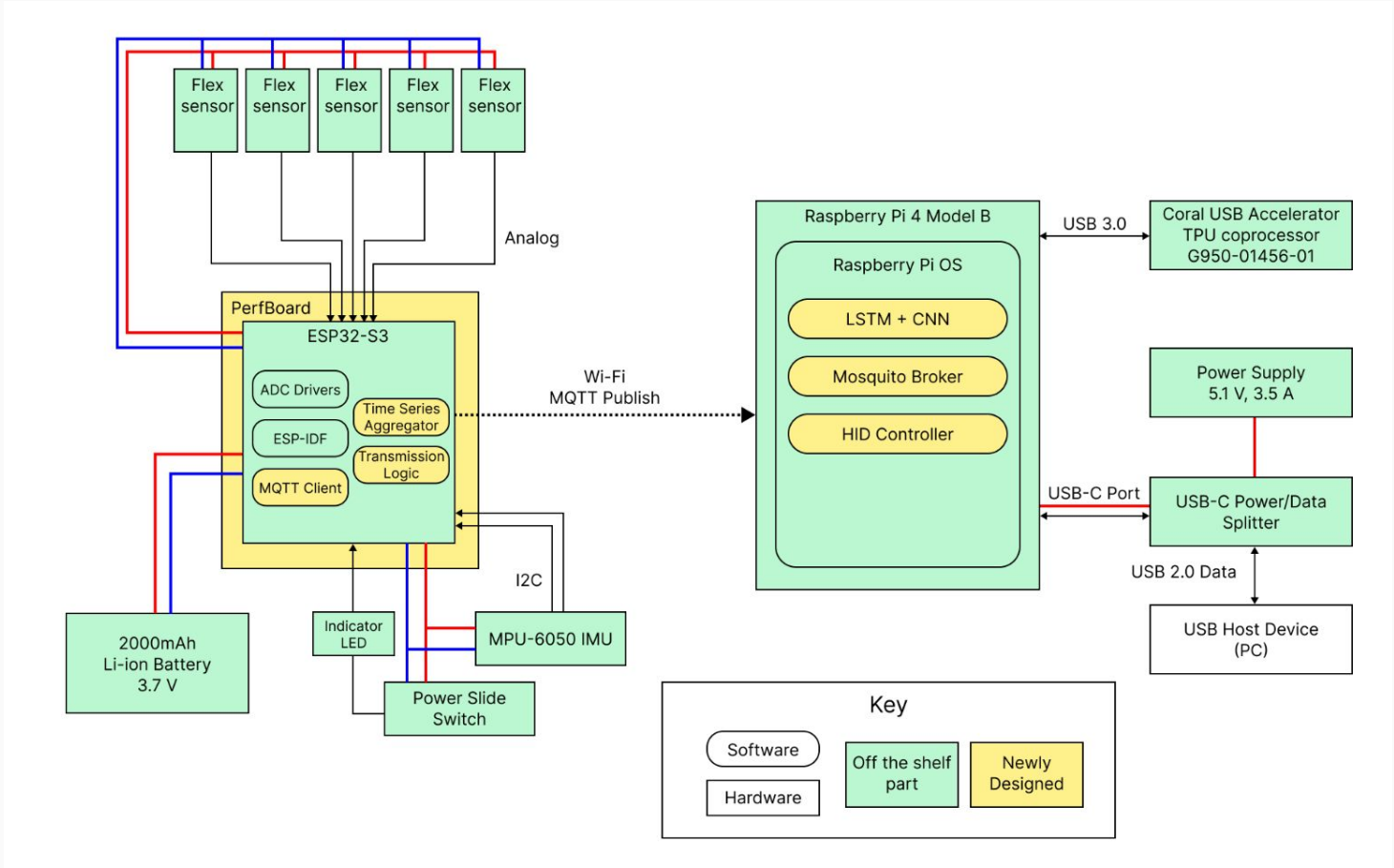
Compute: Single-board computer connected to PC via USB

Gloves are the most portable and accurate choice to collect data.

Addressing this issue will help education which has trickle-down effects on the rest of society.

Chosen parts are also more economical to make the glove more accessible to educators around the world

Block Diagram



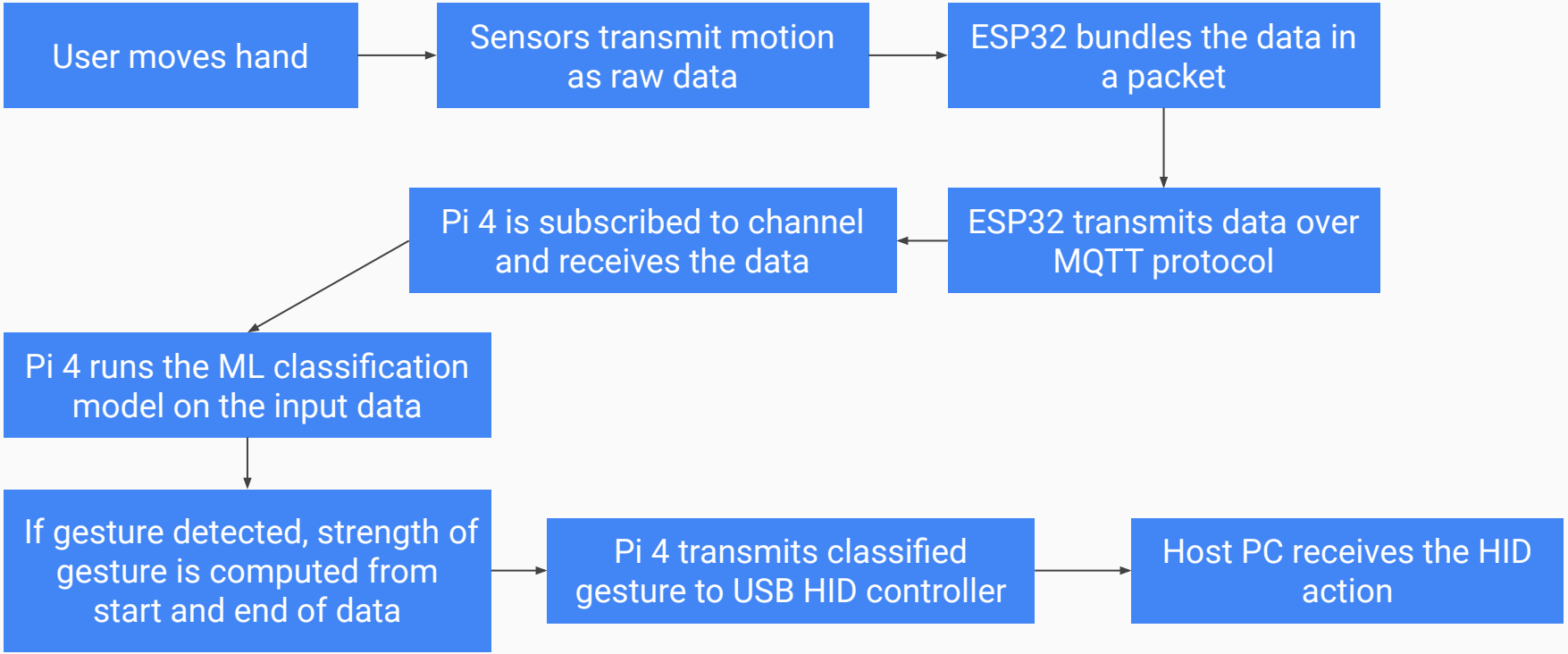
Sensors and Hardware Specifications

MCU: ESP32-S3
    Supports Wi-Fi and in stock

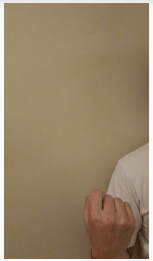
Single-board Computer: Raspberry Pi 4 (previously Jetson)
    Support for HID and Wi-Fi
    Coral TPU to extend compute

Battery: Lithium Ion Battery
    3.7V 2000mAh
Sensors: Spectra Symbol Flex Sensors
IMU: MPU-6050
LED: Adafruit LED Sequin

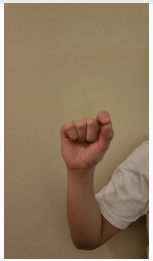
Pipeline of Data



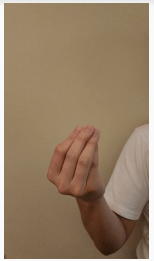
Gestures



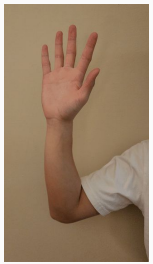
Enable recognition
Flex: all increasing
Acc: +y
Gyro: +x (roll)



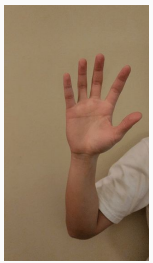
Zoom In
Flex: Thumb+Index decreasing, other fingers fully flexed
Acc - constant
Gyro - constant



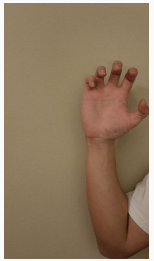
Rotate
Flex: all constant low mid
Acc: constant
Gyro: changing yaw



Disable recognition
Flex: all decreasing
Acc: -y
Gyro: -x (roll)



Zoom Out
Flex - All fingers increasing
Acc - constant
Gyro - constant



Pan
Flex: all constant mid
Acc: changing x
Gyro: constant

Described in terms of accelerometer, flex sensor, and gyroscope output

Gesture Classification

Lives in the compute module (Raspberry Pi 4)

CNN-LSTM model

- Input: time-series vector (11x1)
- Output: 1 of 6 gestures, confidence level

If a gesture is detected (confidence level above some threshold), strength of the gesture is computed based on start and end points of relevant values

Testing, Verification, and Validation

Requirement	Measurement Procedure	Target Metric
Latency	Oscilloscope measurement of Pi 4 GPIO pin and sensor detection output Evaluate Model classification time Wi-Fi transmission delay with ping tests	< 1 second total latency
Accuracy	Train/test split evaluation Accuracy of dispatched HID controls	> 90% gesture recognition accuracy

Testing, Verification, and Validation

Requirement	Measurement Procedure	Target Metric
Usability	Ease-of-use: User study measuring comfort, setup time, and responsiveness	90% user satisfaction based on survey Setup time < 5 mins
Portability	Measure weight with a scale.	< 1 kg
Range	Test wireless communication across measured distances	Up to 50 m between glove and compute
Battery Life	Run sensors and Wi-Fi communication on gloves continuously until connection is lost	up to 1 hour of continuous use

Project Management