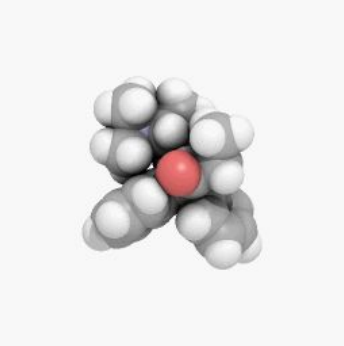
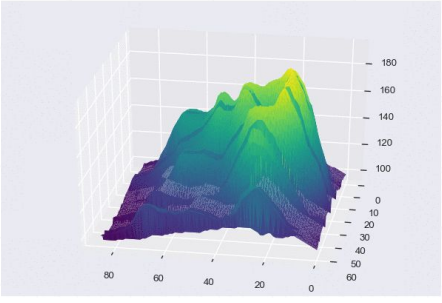
Team A4: TeleTouch

David Hwang, Gram Liu, Xuanye Li

Overview

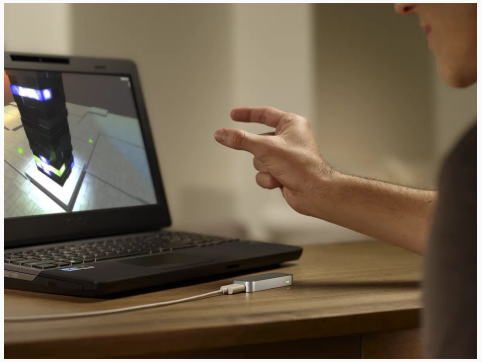
- Live presentations of 3D diagrams and schematics is difficult
- Existing solutions are expensive, not intuitive for 3D space





Use Case and Project Scope

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



ECE Areas: Software Systems, Signals and Systems, Hardware Systems

Requirement	Metric
Use sensor data to recognize when user is making gestures	3 gestures (zooming, panning, rotating)
Reliable gesture detection	> 80% 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

Technical Challenges

Latency

Transmission of sensor data to a Machine Learning model

Gesture recognition must be performant

Accuracy

Machine Learning model should adapt to the specific user's gestures

HID input needs to closely match user's intention

Usability

User must not feel inhibited by the device

System should have enough power for entire presentation

Calibration system may be required to make device usable to all people

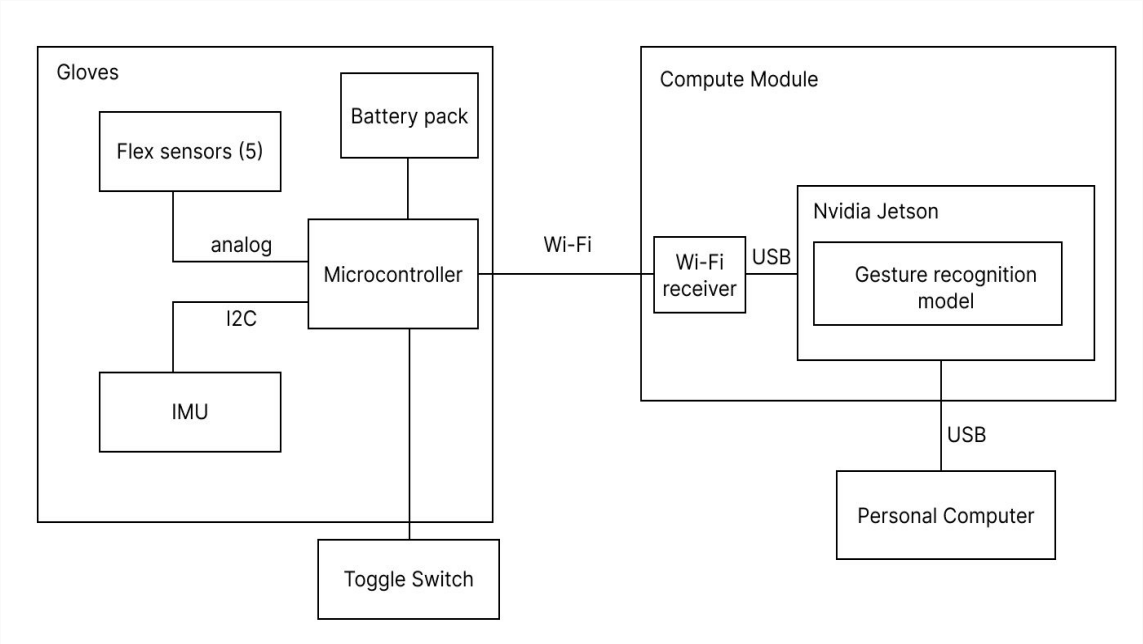
Solution Approach - Hardware

Two components: glove and compute module

Glove: 5 flex sensors + IMU connected to a ESP32

Toggle switch to enable gesture detection mode

Compute: Nvidia Jetson Nano with Wi-Fi Module



Solution - Hardware Alternatives

Rings

Sensor Rings instead of entire glove

Hall effect sensors to measure finger position

Trade-off: unable to detect degrees of freedom on hand gestures; requires a magnet to be attached to center of hand

Camera + CV

Camera pointed at user then use CV for gesture detection

Trade-off: requires dedicated camera mount and user has to face towards camera at all times

Solution Approach - Software

- Flex sensor (analog) for the 5 fingers, acceleration (3-axis), and rotation (3-axis) data will be passed in as a vector to a deep neural network over WiFi
- The model will identify if a gesture is actively being performed and classify it into one of the known gesture classes
- The gesture class is translated into an associated HID input and dispatched to the connected computer

Testing, Verification and Metrics

Latency

Oscilloscope measurement of Jetson GPIO pin and sensor detection output

Model classification time

Wi-Fi transmission delay with ping tests

Accuracy

Train/test split evaluation.

Accuracy of dispatched HID controls

Testing, Verification and Metrics

Usability

Ease-of-use: User study measuring comfort, setup time, and responsiveness

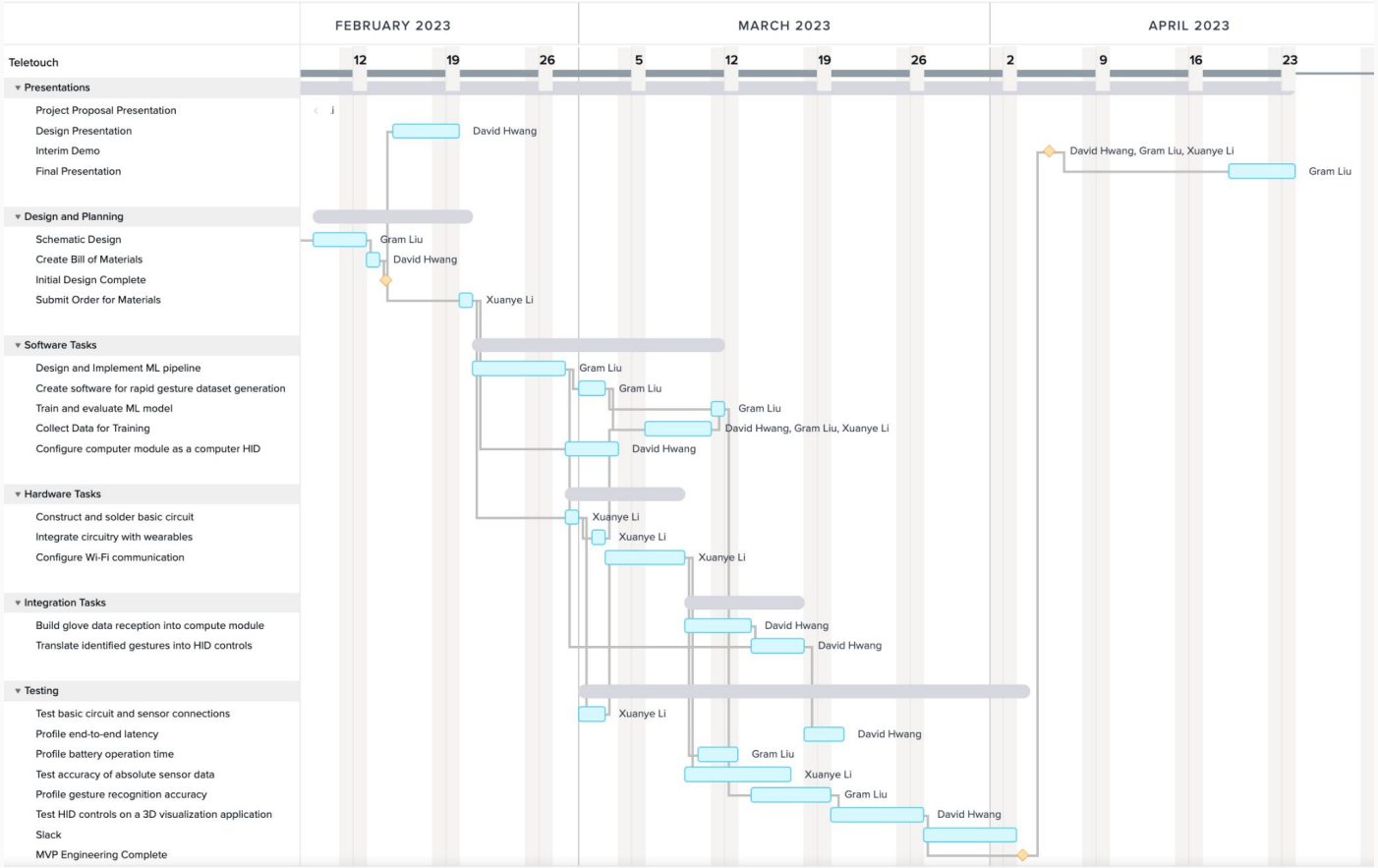
Portability: Measure weight with a scale. Test wireless communication across measured distances up to and over 50 m.

Battery Life: Run sensors and Wi-Fi communication on gloves continuously until connection is lost

Tasks and Division of Labor

Task	Gram	Xuan	David
Implement and train ML model	x		
Collect training and test data	x	x	x
Build and assemble wearable circuit		x	
Configure compute module as HID and identify controls			x
Integration of hardware and software	x	x	x

Schedule


FEBRUARY 2023
MARCH 2023
APRIL 2023
12
19
26
5
12
19
26
2
9
16
23
Teletouch
Presentations
Project Proposal Presentation
Design Presentation
Interim Demo
Final Presentation
Design and Planning
Schematic Design
Create Bill of Materials
Initial Design Complete
Submit Order for Materials
Software Tasks
Design and Implement ML pipeline
Create software for rapid gesture dataset generation
Train and evaluate ML model
Collect Data for Training
Configure computer module as a computer HID
Hardware Tasks
Construct and solder basic circuit
Integrate circuitry with wearables
Configure Wi-Fi communication
Integration Tasks
Build glove data reception into compute module
Translate identified gestures into HID controls
Testing
Test basic circuit and sensor connections
Profile end-to-end latency
Profile battery operation time
Test accuracy of absolute sensor data
Profile gesture recognition accuracy
Test HID controls on a 3D visualization application
Slack
MVP Engineering Complete
David Hwang
David Hwang, Gram Liu, Xuanye Li
Gram Liu
Gram Liu
David Hwang
Xuanye Li
Gram Liu
Gram Liu
Gram Liu
David Hwang, Gram Liu, Xuanye Li
David Hwang
Xuanye Li
Xuanye Li
Xuanye Li
David Hwang
David Hwang
Xuanye Li
David Hwang
Gram Liu
Xuanye Li
Gram Liu
David Hwang