E7
The Wand Makers Proposal

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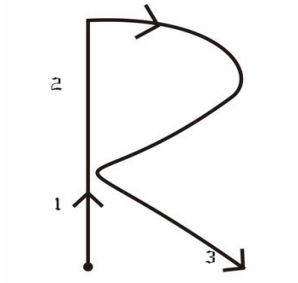
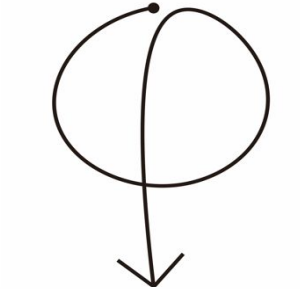
Use Case

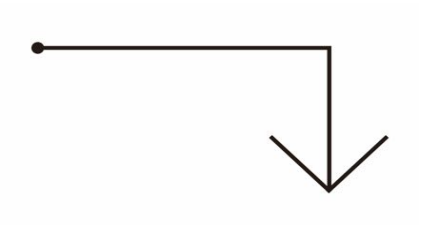
- Gesture controlled remote control + receiver, targeting all ages
  - Different gestures are meant to control different devices
- A more capable wand compared to Universal Studios' retroreflector
- Areas: Software, Embedded System, IOT

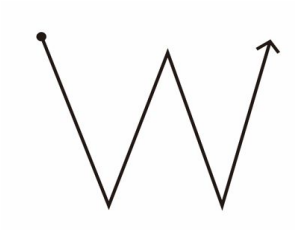
Use-Case Requirements

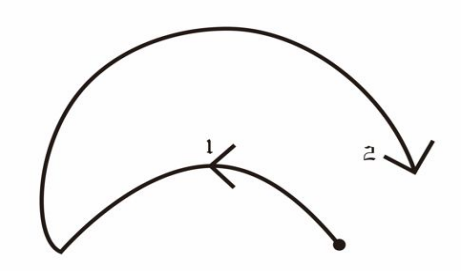
CNN should recognize 6 gestures with 90% accuracy on sensing random user's gesture

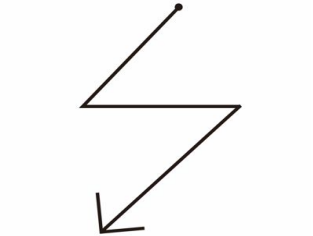












Use-Case Requirements

- Transmitter module should be able to send out IR signals with specific patterns
- Receiver module should recognize signals with 80% accuracy
- Support two types of receivers: existing IR devices, custom receivers

Safety Considerations

- Safe to use for all ages: form factor should be safe to handle
- Indoor device: The range of motion when waving the wand should not be large
- Use lightweight, non-toxic to minimize injury risks if the wand is dropped or hits an object.

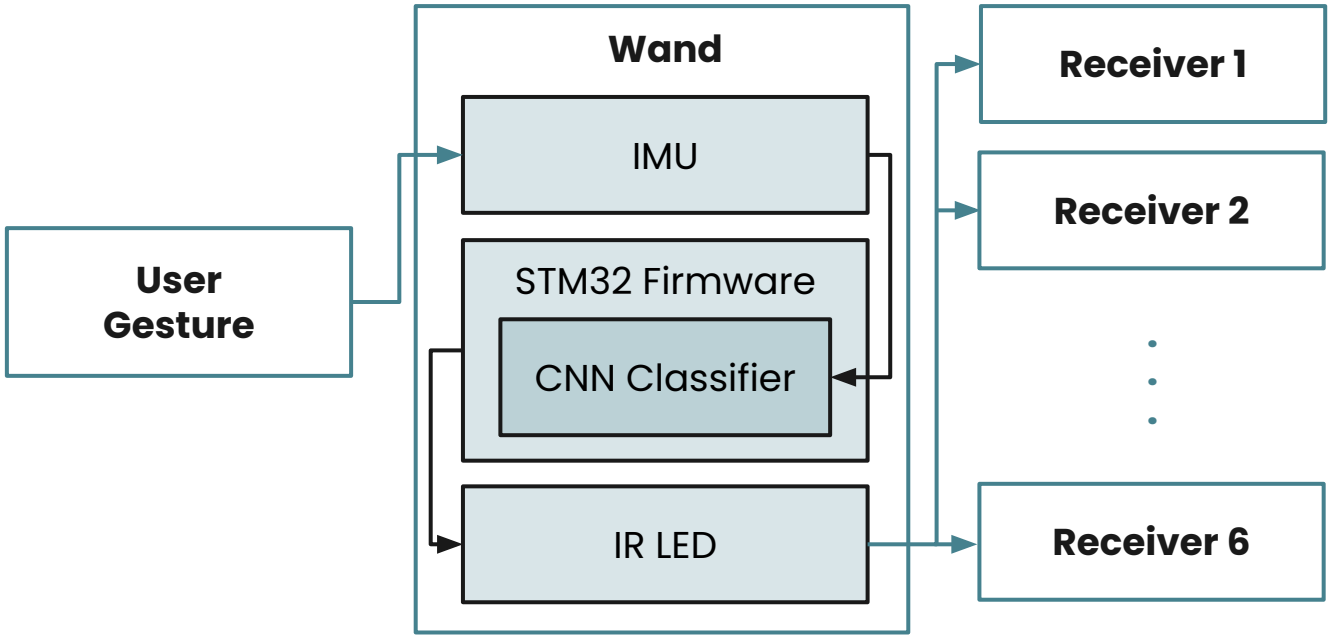
Technical Challenges - Hardware

- **Custom PCB**:
  - Circuitry must accommodate a small form factor to fit inside the wand
  - Wand must be physically robust and motion-resistant
- **Energy Efficiency**:
  - Wand should be able to operate for extended periods from the internal battery
  - Form factor limits maximum capacity of battery

Technical Challenges - Software

- **Robust CNN**: The wand can distinguish intended gesture and random movement
- **Consistency**: Ensuring consistent performance with IR signals over varying distances; no false-triggers
- **Usability**: The wand should be intuitive and easy to use

Solution Approach



Solution Approach

Hardware

Custom PCB:

- Test the modules to be used on development board before designing into the PCB and getting it manufactured

Energy Efficiency:

- Use power system that chooses between battery power and USB power
- Leverage low power mode and smart wake-up to minimize power consumption when idle

Software

Robust CNN:

- Use custom-collected IMU gesture data to enhance model robustness across different users
- Apply quantization and model pruning to reduce the computational load

Consistency:

- Use external flash memory to store IR signal patterns

Usability:

- RGB LED for user feedback

Testing, Validation, and Metrics

PCB

Post-reflow board validation; transmit debugging signals using USART

Firmware

Test firmware on development board testbed before merging to PCB

IR Recognition: Accuracy

≥80% successful transmissions over 50 trials with 6 different IR signals

IR Recognition: Distance

≥80% successful transmissions over 50 trials at 1m, 2m, 5m, 10m distances

Gesture Recognition

Evaluate the model using confusion matrix and cross validation with data from multiple user performing gestures.

Useability + Reliability

Get feedback from users about user experience; test the wand under different gesture speeds and environments.

Division of Labor

- **Sharon**: PCB design; 3D model and printing; manufacturing; hardware test
- **Olina**: CNN model development; data preprocessing and training; model optimization, testing and validation
- **Nadia**: STM32 firmware; sensor integration; IR protocol; software test

TASK TITLE	TASK OWNER	PROGRESS	JAN WK 1	JAN WK 2	JAN WK 3	FEB WK 4	FEB WK 5	FEB WK 6	FEB WK 7	MAR WK 8	MAR WK 9	MAR WK 10	APR WK 11	APR WK 12	APR WK 13	APR WK 14	APR FINAL
Deliverables																	
Abstract	All	100%															
Website Initial Setup	All	100%															
Project Proposal Slides	All	100%															
Design Presentation Slides	All	0%															
Design Document	All	0%															
Ethics Assignment	All	0%															
Interim Demo	All	0%															
Final Presentation Slides	All	0%															
Poster PDF	All	0%															
Final Video	All	0%															
PCB & 3D Modelling																	
PCB Update (V1) Design and Manufacture	Sharon	80%															
PCB V1 Verification	Sharon	0%															
3D Model for Wand Design and Print	Sharon	80%															
PCB Upadate (V2) Design and Manufacture	Sharon	0%															
PCB V2 Verification	Sharon	0%															
3D Model for Mechanical Structures	Sharon	0%															
Final Deliverable Setup	All	0%															
Slack	Sharon																
CNN																	
Data Collection	Olina	0%															
CNN Model Development	Olina	0%															
Model Training & Tuning	Olina	0%															
Integration & Testing	All	0%															
Usability Testing	All	0%															
Reliability Testing	All	0%															
Slack	Olina																
STM32																	
Buy and Research Hardware	Nadia	0%															
Codebase Setup	Nadia Sharon	0%															
IR Setup	Nadia	0%															
User-facing Firmware	Nadia	0%															
CNN Integration	Nadia	0%															
System Integration & Test	All	0%															
Slack	Nadia																