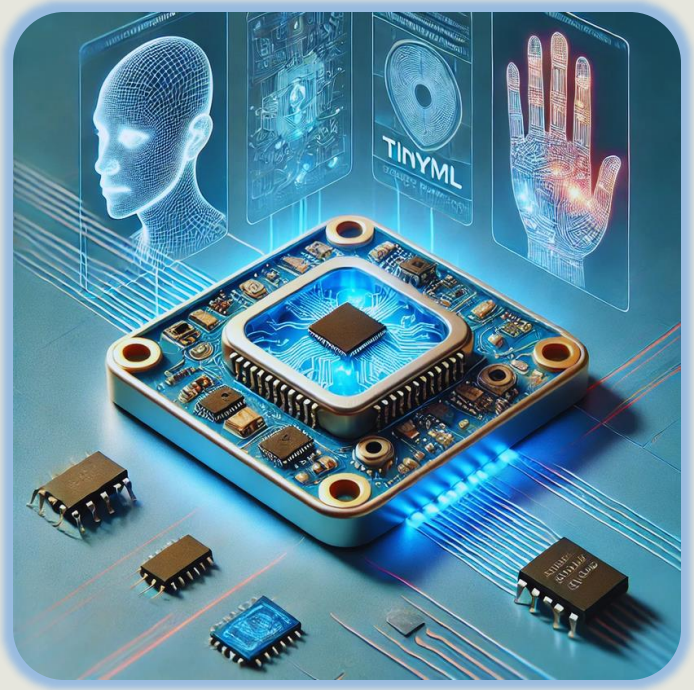
Introducing

FaceSafe

On-Device Authentication & Gesture Recognition



*Embracing **TinyML for Privacy and Efficiency***

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Powered by: **XIAO ESP32S3 Sense**

Embracing TinyML for Privacy and Efficiency

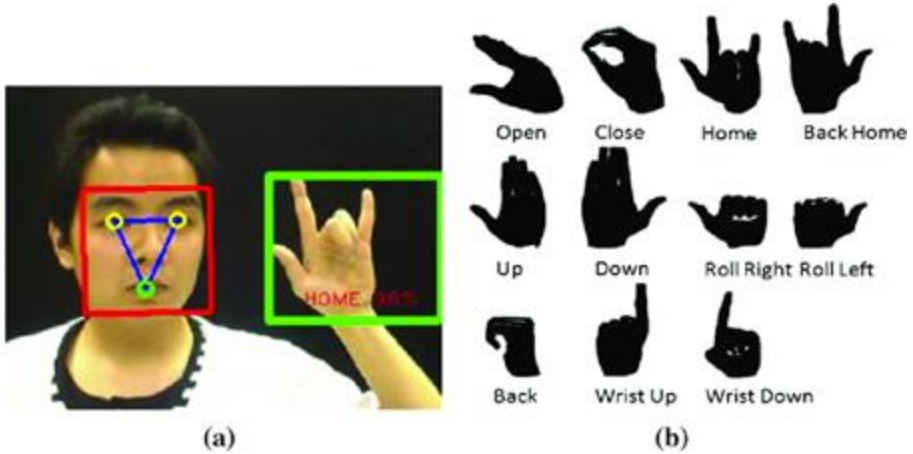
Recognize individual face for authentication and gestures for action identification.

Key Objectives:

- **Privacy**
- **Low Power & High Efficiency**
- **Real-Time Responsiveness**

Usability

- **Classroom attendance**
- **Smart Home features**



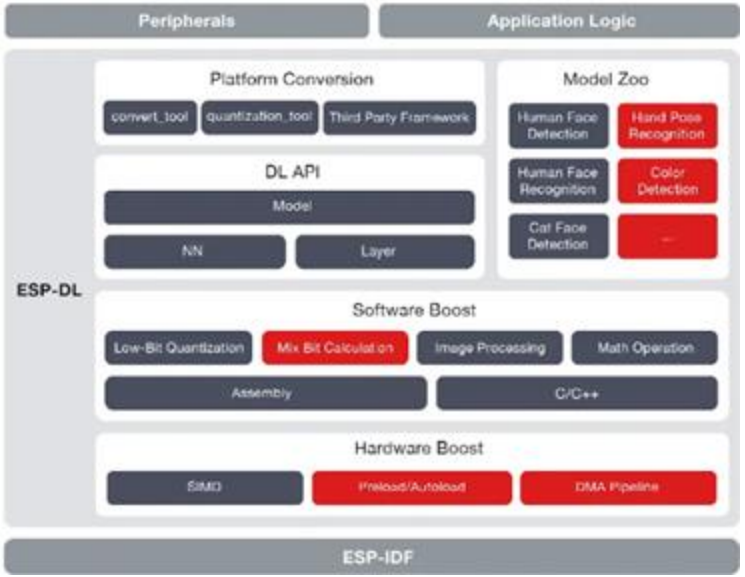
Seeed Studio XIAO ESP32S3: Powering **TinyML On-Device** Processing

Core Specs of ESP32S3:

- **Dual-core Tensilica LX7**
- **240 MHz Frequency**
- **512KB SRAM & 8MB Flash**

Additional Peripherals:

- **Integrated Wi-Fi and Bluetooth**
- **Built-in Camera Support**



ESP-DL provides APIs for Neural Network (NN)ference, Image Processing, Math Operations and Deep Learning Models.

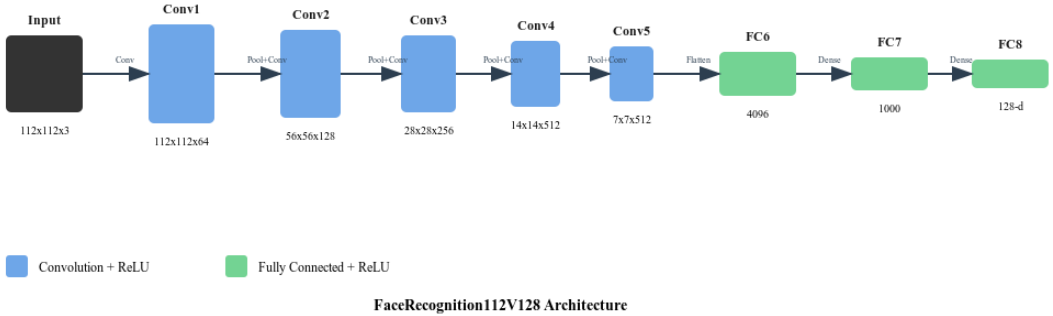
Models Deployed

- ## Face Detection Model

  At first a two -stage face detection model is identified two place a rectangular box around the face so that the input of face recognition is reduced.

- ## Face Recognition Model

  A deep neural network model employs convolutional layers and depth wise separable convolutions to extract and encode facial features into a compact, 128-dimensional embedding



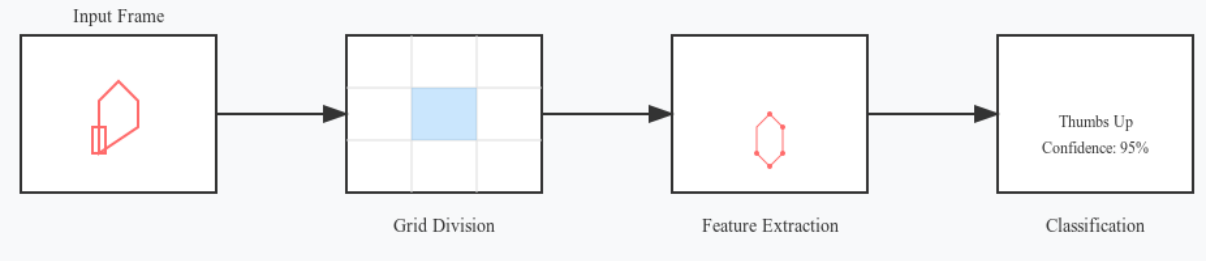
FaceRecognition112V128 Architecture

- ## Hand Gesture Detection

  For hand recognition we used Swift YOLO model which is a variation of the YOLO (You Only Look Once) object detection algorithm tailored for lightweight and efficient real-time inference.

Gesture recognition

- SenseCraft AI framework
  - Rock paper scissors
  - Left/right hand recognition
  - More compatible
- Espressif
  - Less compatible
  - Challenges in deploying, doesn't take streaming data



Path to Success: Key Steps in Project Development

1. Hardware Setup:

- Installation of **camera**, **antenna**, and **microSD card.**
- Configuration of **WiFi antenna**
- Verification of hardware functionality

2. Software Setup:

- Installation **Arduino IDE** for code development.
- Upload initial firmware to test the camera module functionality.
- Mapping of the GPIO pins with the camera slot for seamless communication.
- Enabling **PSRAM** to support larger images.

3. Camera and Model Integration:

- Capturing images using the ESP32-S3 camera.
- Configuring the system to push captured images as inputs to the **image classification model** for face recognition.
- Tuning the system for efficient picture capture and classification.

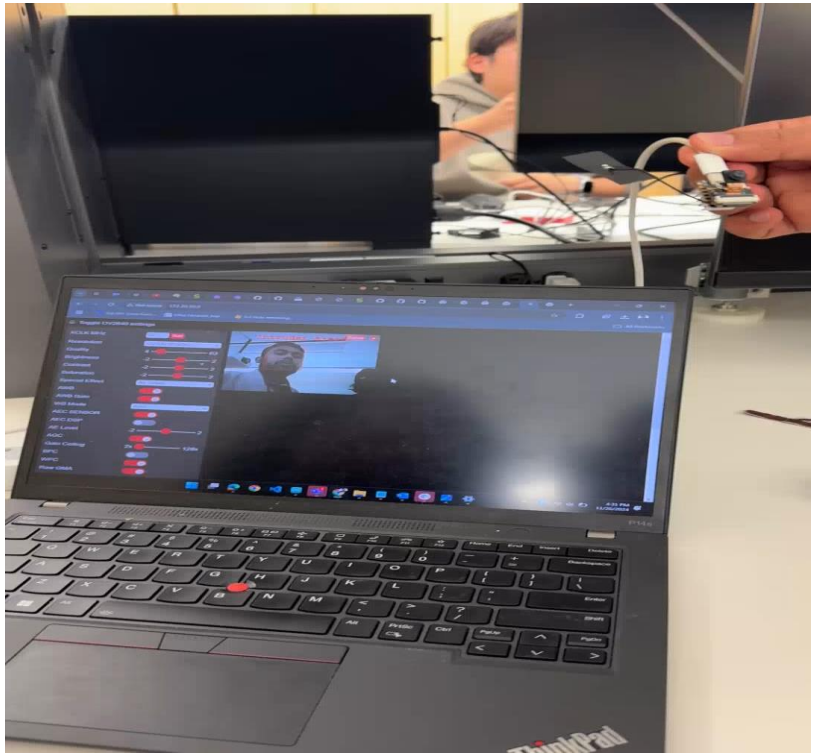
4. Deployment of User Interface:

- Deploying a **web-browser-based GUI** for a user-friendly experience.
- Live video stream enabling via the camera feed.
- GUI functionality integration over **WiFi**, allowing seamless user access.

5. Gesture Recognition Pipeline:

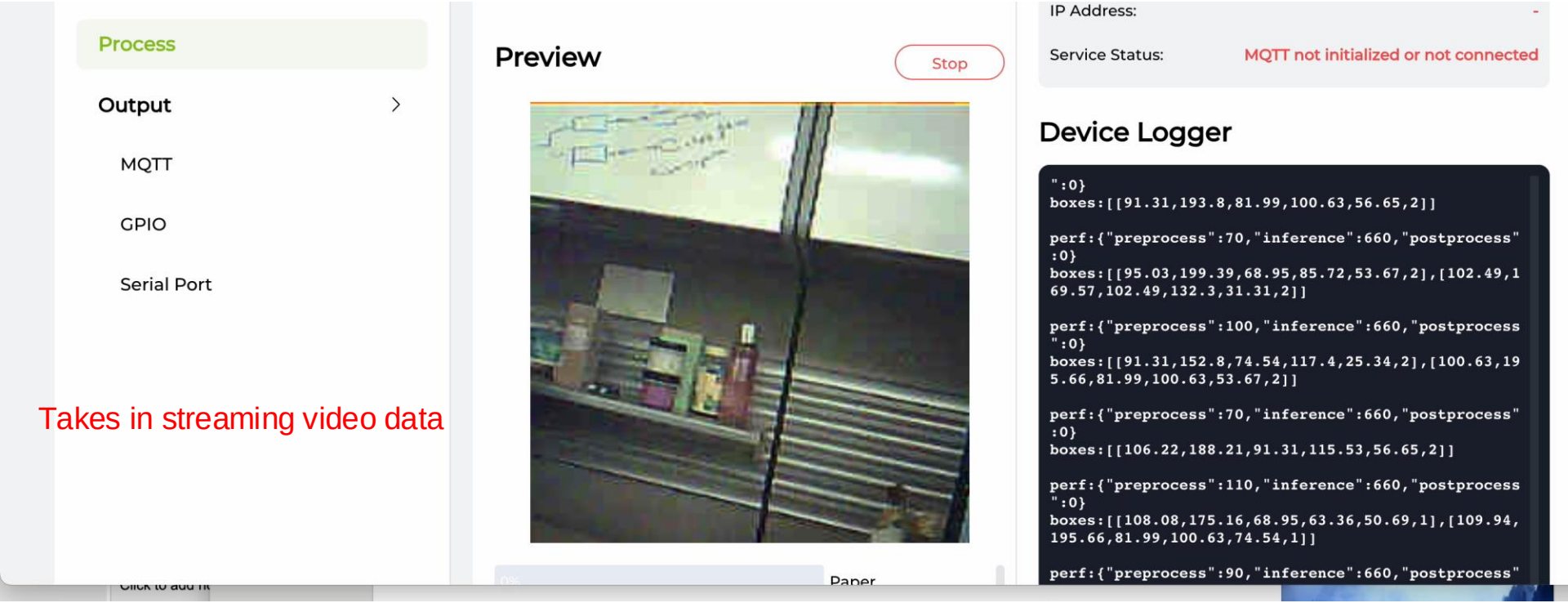
- Integration of the gesture recognition model after face recognition.
- Configuring the system to transition from face detection to gesture recognition for actionable insights.

Demo video: Face detection & Recognition



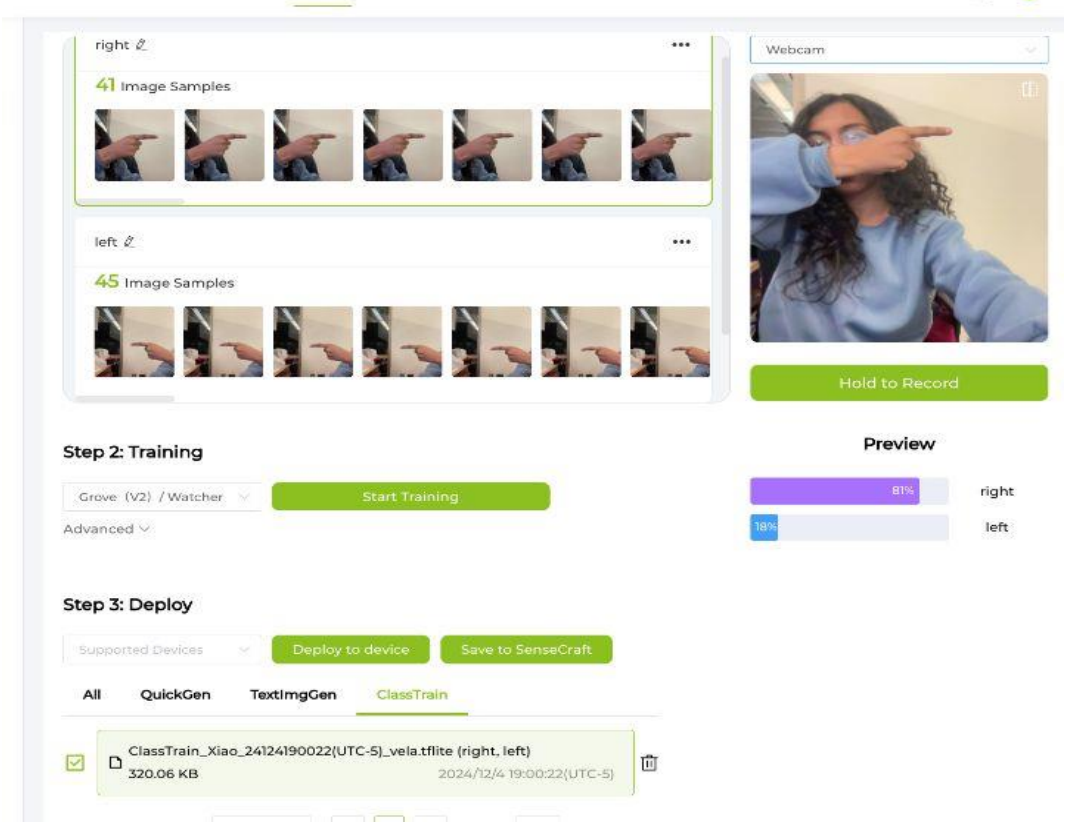
- Adds a rectangular box when face is detected.
- If the face is recognized it shows a green box with associated ID and recognition accuracy
- Category: Person ID, Intruder
- Latency of recognition: ~0.7 sec
- Current Consumption: ~341mA

Demo video: Rock paper scissors



Takes in streaming video data

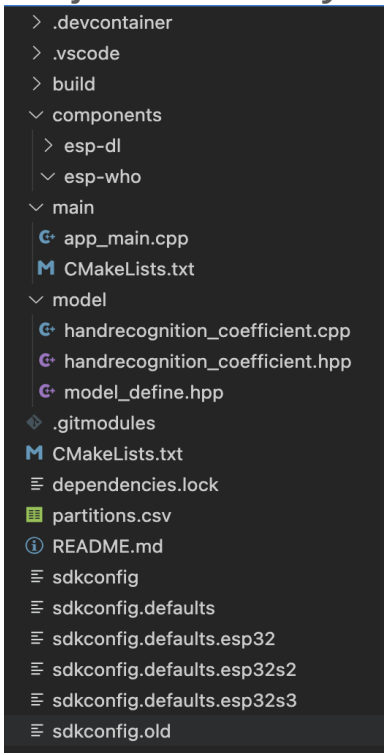
Demo: Left/right hand recognition



Train data: 86 image samples
Model: Swift-YOLO
Size: < 2MB
Latency: 700-800ms

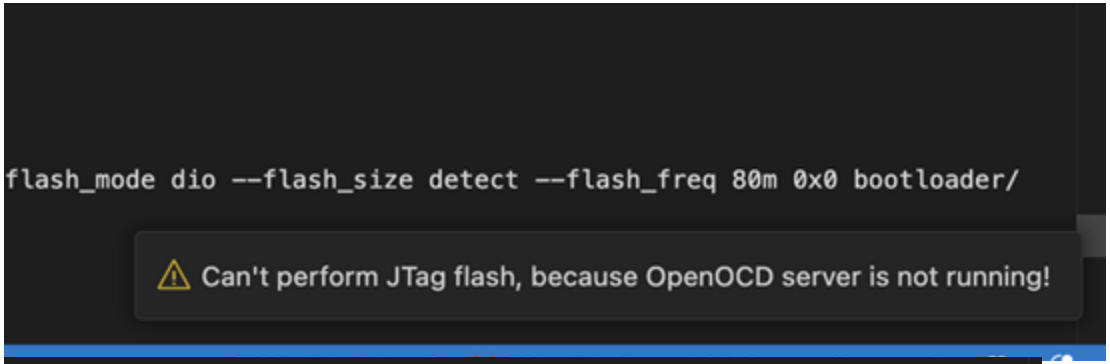
Espressif: Details and issues

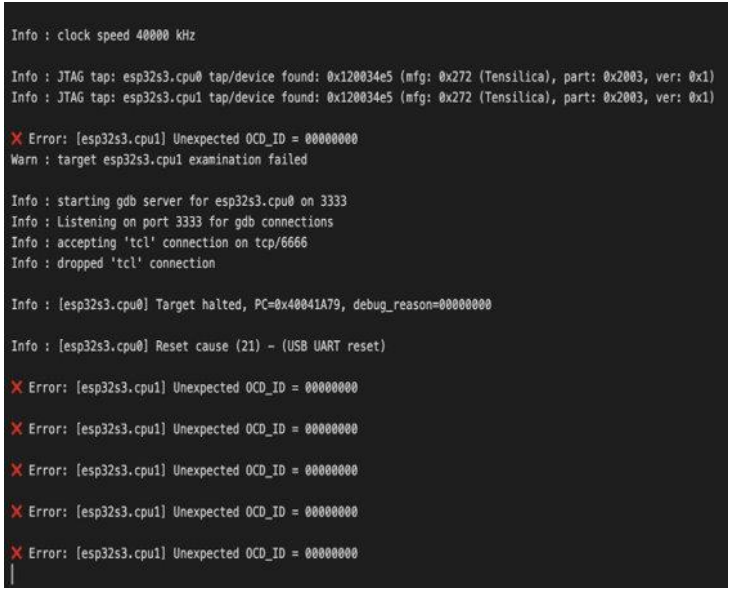
Project directory and inference:

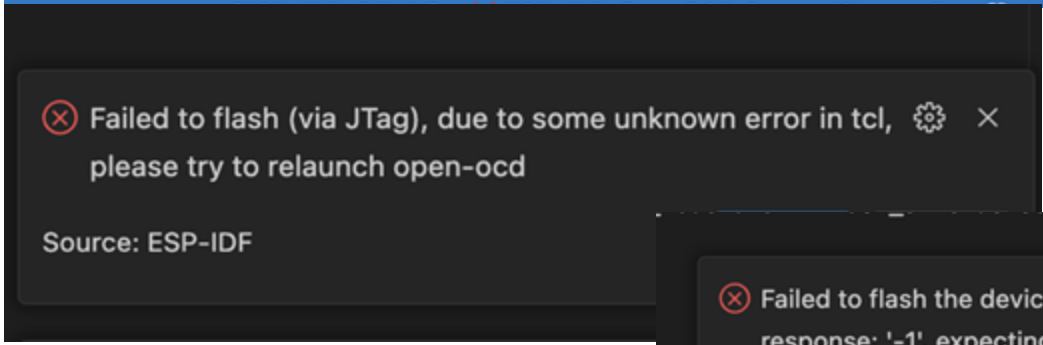


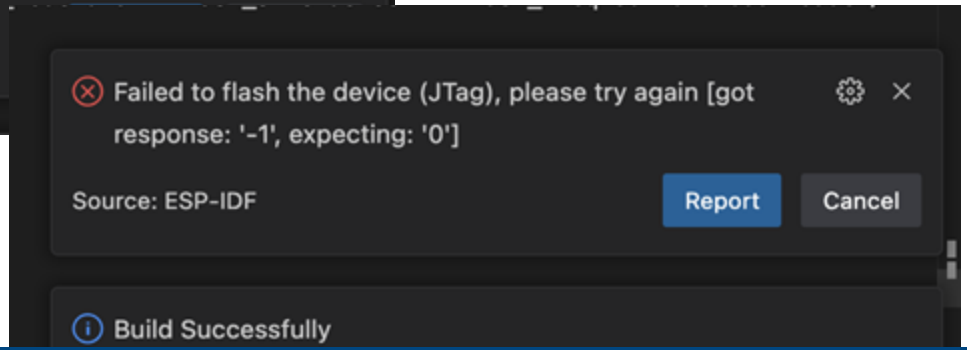

```
Message (Enter to send message to 'XIAO_ESP32S3' on '/dev/cu.usbmodem2101')

[0;32mI (852) cpu_start: Project name:     deploy [0m
[0;32mI (852) cpu_start: App version:      bb27ee3 [0m
[0;32mI (852) cpu_start: Compile time:     Dec  3 2024 18:58:19 [0m
[0;32mI (852) cpu_start: ELF file SHA256:  28fff01e28434653... [0m
[0;32mI (852) cpu_start: ESP-IDF:          v4.4.5 [0m
[0;32mI (853) cpu_start: Min chip rev:     v0.0 [0m
[0;32mI (853) cpu_start: Max chip rev:     v0.99  [0m
[0;32mI (853) cpu_start: Chip rev:         v0.2 [0m
[0;32mI (853) heap_init: Initializing. RAM available for dynamic allocation: [0m
[0;32mI (853) heap_init: At 3FC9B968 len 0004DDA8 (311 KiB): D/IRAM [0m
[0;32mI (854) heap_init: At 3FCE9710 len 00005724 (21 KiB): STACK/DIRAM [0m
[0;32mI (854) heap_init: At 600FE000 len 00002000 (8 KiB): RTCRAM [0m
[0;32mI (854) spiram: Adding pool of 8192K of external SPI memory to heap allocator [0m
[0;32mI (855) spi_flash: detected chip: gd [0m
[0;32mI (855) spi_flash: flash io: qio [0m
[0;32mI (857) sleep: Configure to isolate all GPIO pins in sleep state [0m
[0;32mI (857) sleep: Enable automatic switching of GPIO sleep configuration [0m
[0;32mI (858) cpu_start: Starting scheduler on PRO CPU. [0m
[0;32mI (0) cpu_start: Starting scheduler on APP CPU. [0m
[0;32mI (858) spiram: Reserving pool of 32K of internal memory for DMA/internal allocations [0m

SIGN::forward: 710316 us
19.410315, 17.129026, 16.344234, 15.779153, 16.601696, 14.735577,
Palm: 0
```

Challenges with Espressif: Flashing to device









Overall challenges

- Setting up WiFi
- Enabling streaming data – configuring GPIO port
- Model Deployment: memory constraint, serial port connection
  - Made different choice of models
  - Resolved after bootloading multiple times
- Thermal throttling
  - Soln: heat sink
- Issue: always need to be reset
  - Acceptable given device constraint