FLORIDA INTERNATIONAL UNIVERSITY

FIU | Knight Foundation School of Computing and Information Sciences

Using AI with a Low-Cost Camera to Detect Harmful Algae in Natural Water

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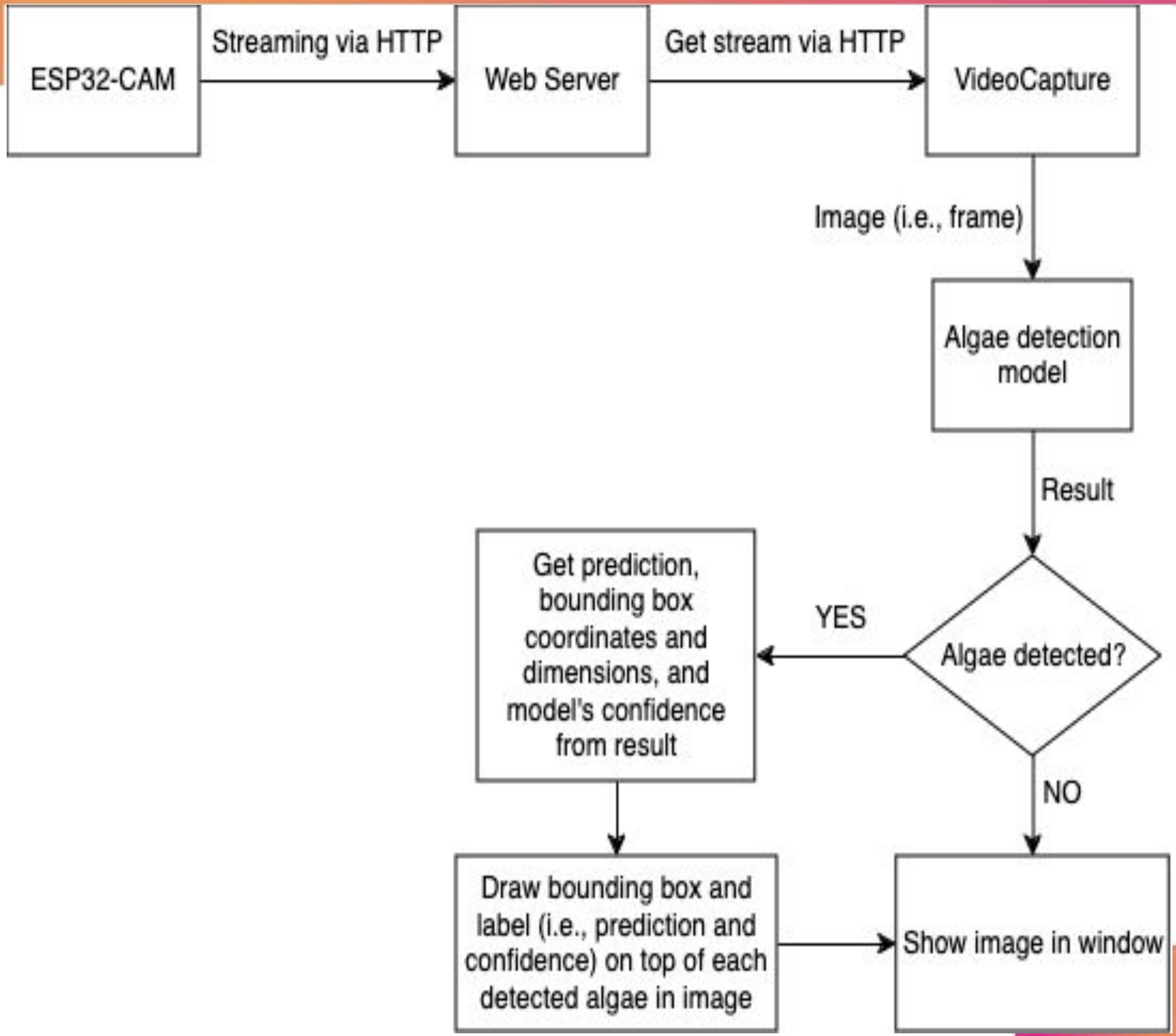
Motivation

- Harmful algae blooms can be detrimental to the environment when undergoing uncontrolled population growth
- These blooms deplete environments of oxygen, killing fish, harming humans, and disrupting local economies
- With an easier means to locate and detect some of these classes of algae, it would alleviate the burden of classifying algae when trying to search for the appropriate solution

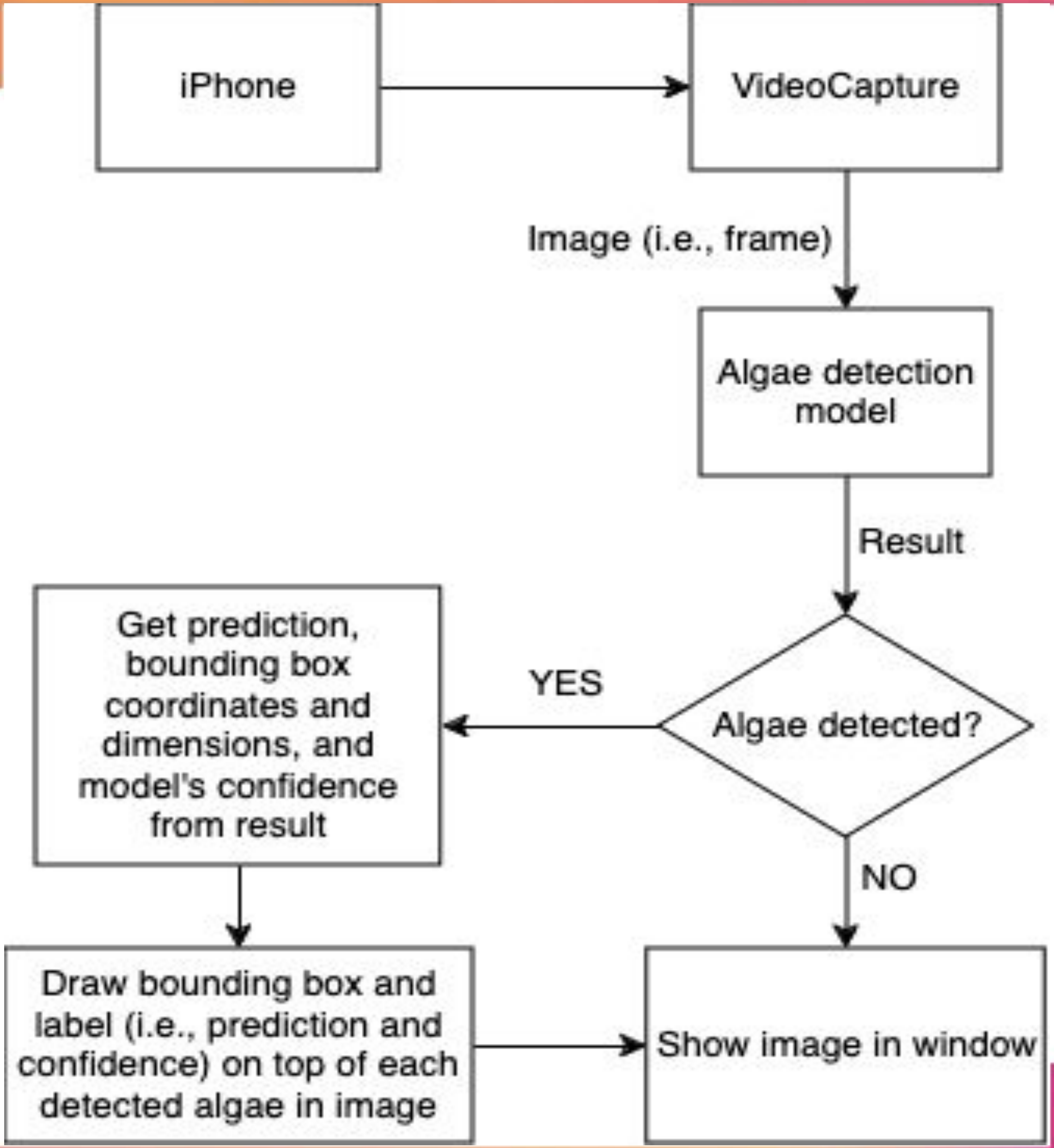
Solution

- Using the inexpensive and accessible ESP32-CAM, a microscope, and our product, different types of algal blooms can be detected rapidly and dealt with accordingly
- The AI models were trained using the YOLOv8 and PyTorch framework, and implemented using Python

Solution Architecture: ESP32-CAM



Solution Architecture: iPhone



Dataset

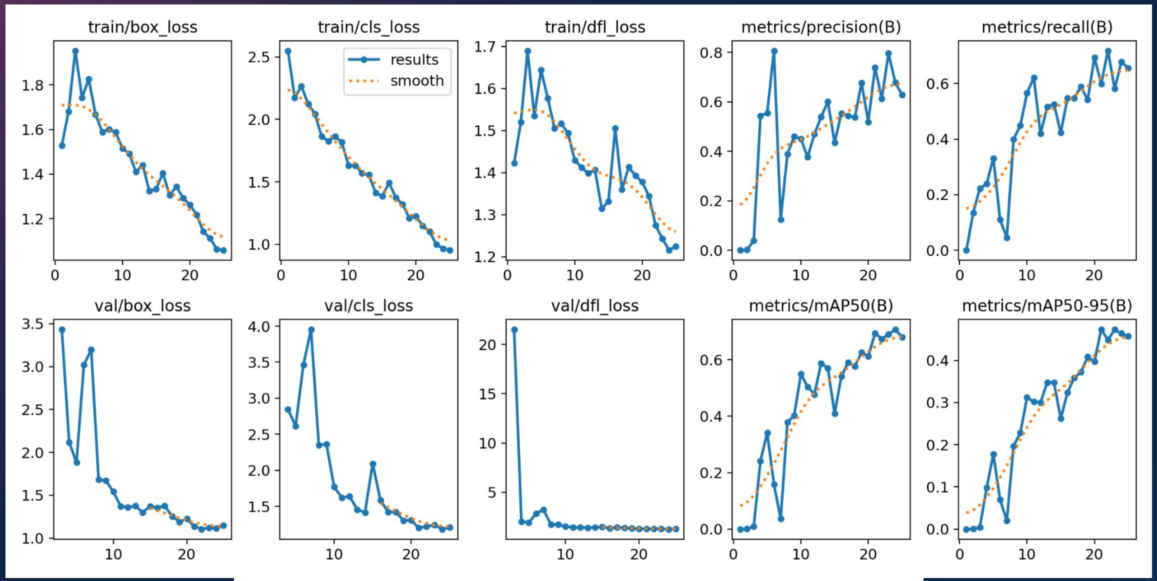
- Images
  - Around 2000
  - Downscaled to 256 x 256
  - Subset used for training
- Classes
  - Closterium
  - Nitzschia
  - Microcystis
  - Oscillatoria
  - Non Algae

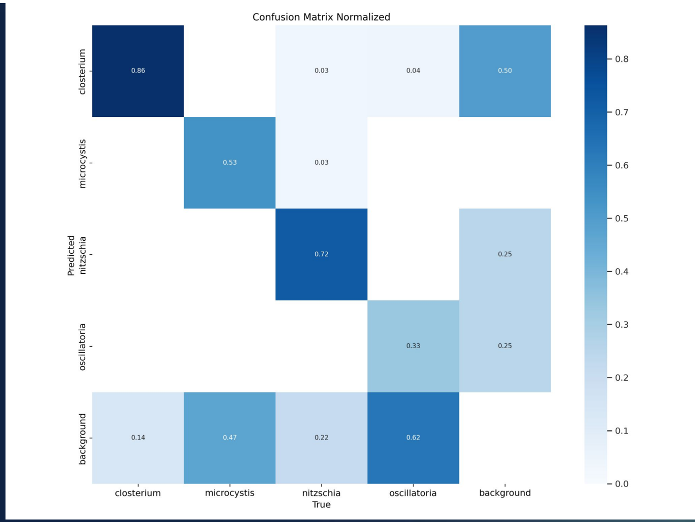
Figure 1. Image of Closterium

Figure 2. Image of Microcystis

Model Development: YOLOv8x

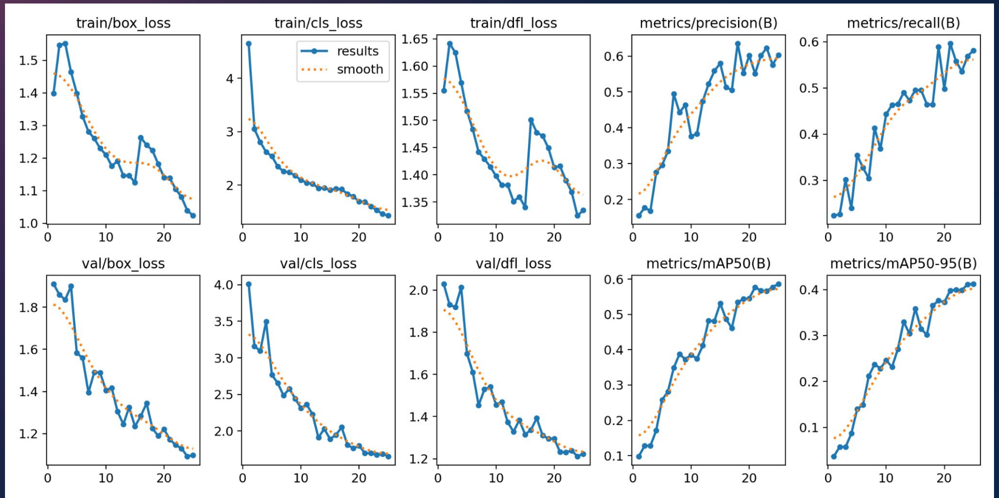
- Split
  - Training: 0.88
  - Validation: 0.08
  - Testing: 0.04
- Epochs: 25
- Optimizer: Adam

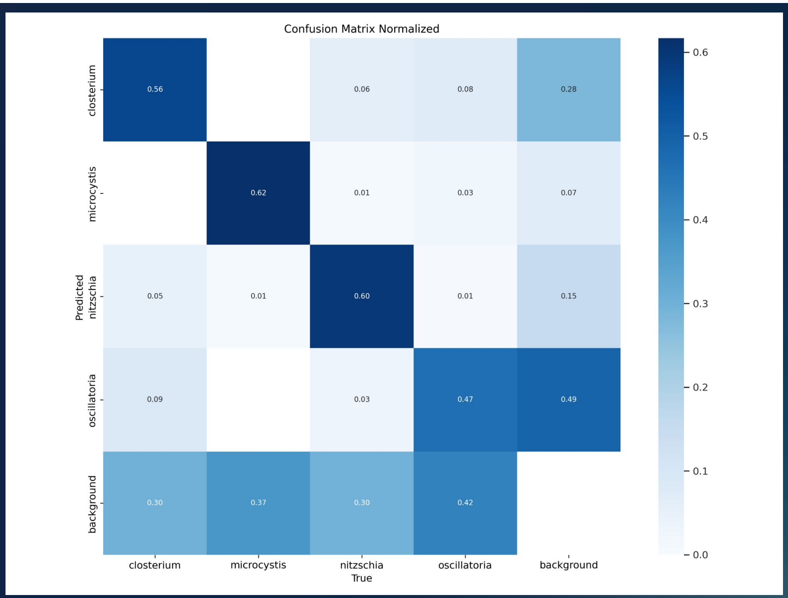




Model Development: YOLOv8n + SAHI

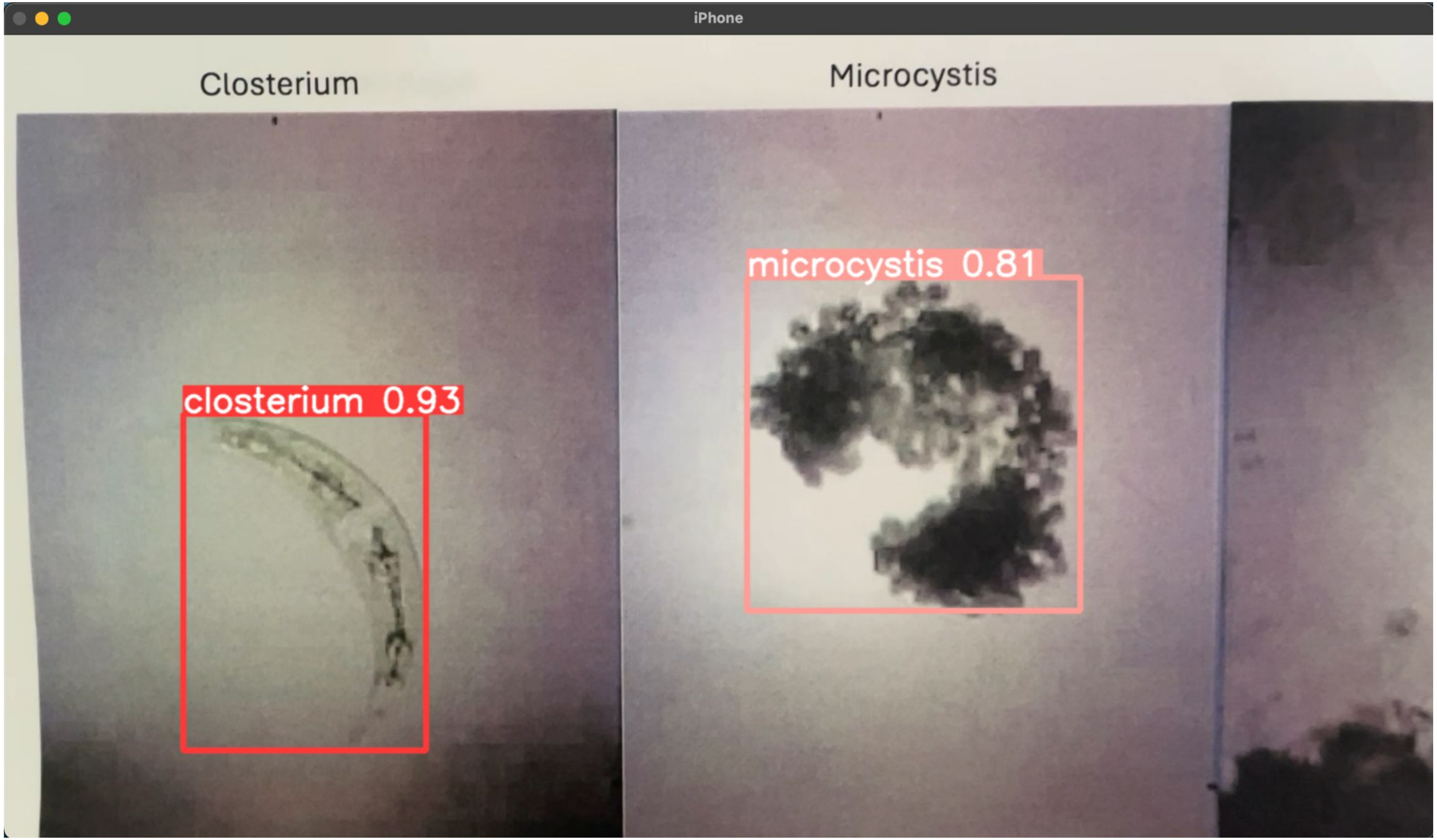
- Split
    - Training: 0.88
    - Validation: 0.08
    - Testing: 0.04
- Epochs: 25
- Optimizer: Adam





Sample Input

User Interface



ESP32-CAM AI Thinker

Press on the button below to change the settings

Change settings

ESP32

Board type:	esp32cam_ai_thinker
SDK Version:	v4.4.6-dirty
CPU model:	ESP32-D0WDQ6-V3 rev. 3
CPU speed:	240 Mhz
CPU cores:	2
RAM size:	267.08 KB
PSRAM size:	4 MB
Flash size:	4 MB

Diagnostics

Uptime:	00:18:40
RTSP sessions:	0
Free heap:	149.35 KB
Max free block:	107.99 KB

Network

Host name:	esp32-08f9e0d374b0.local
Mac address:	08:F9:E0:D3:74:B0
Wifi mode:	STA
Access point:	Jbrahma
Signal strength:	-67 dbm
IPv4 address:	10.0.0.114
IPv6 address:	0000:0000:0000:0000:0000:0000:0000:0000

Connected to the access point

Camera

Frame rate:	200 ms (5.0 f/s)
Frame size:	QVGA (320x240)
JPEG quality:	1 [1-100]
Brightness:	0 [-2,2]
Contrast:	0 [-2,2]
Saturation:	0 [-2,2]
Special effect:	Normal
White balance:	Auto
AWB gain:	Auto
WB mode:	Auto
Exposure control:	Auto
Auto exposure control (dsp):	Enabled
Auto Exposure level:	0
Manual exposure value:	300
Gain control:	Auto
AGC gain:	0
Gain ceiling:	2X
Black pixel correct:	Manual
White pixel correct:	Auto
Gamma correct:	Enabled
Lens correction:	Enabled
Horizontal mirror:	Normal
Vertical flip:	Normal
Downsize enable:	Enabled
Color bar:	Camera

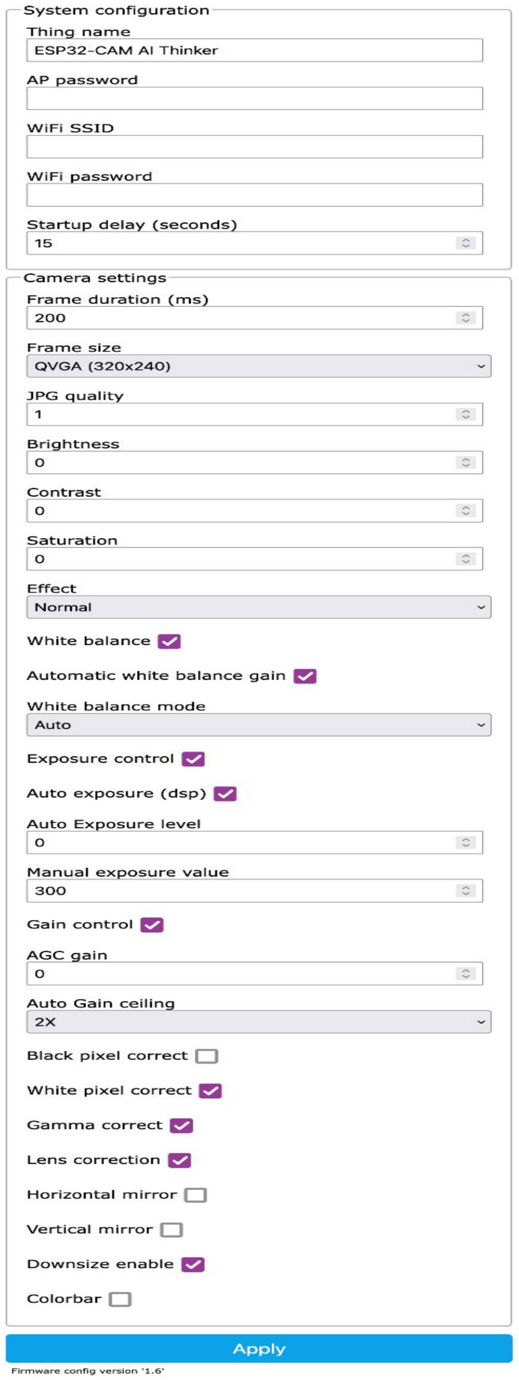
Camera was initialized successfully!

Special URLs / API

RTSP camera stream:	rtsp://10.0.0.114:554/mjpeg/1
JPEG Motion stream:	http://10.0.0.114/stream
Snapshot of the camera:	http://10.0.0.114/snapshot

User Interface: ESP32-CAM

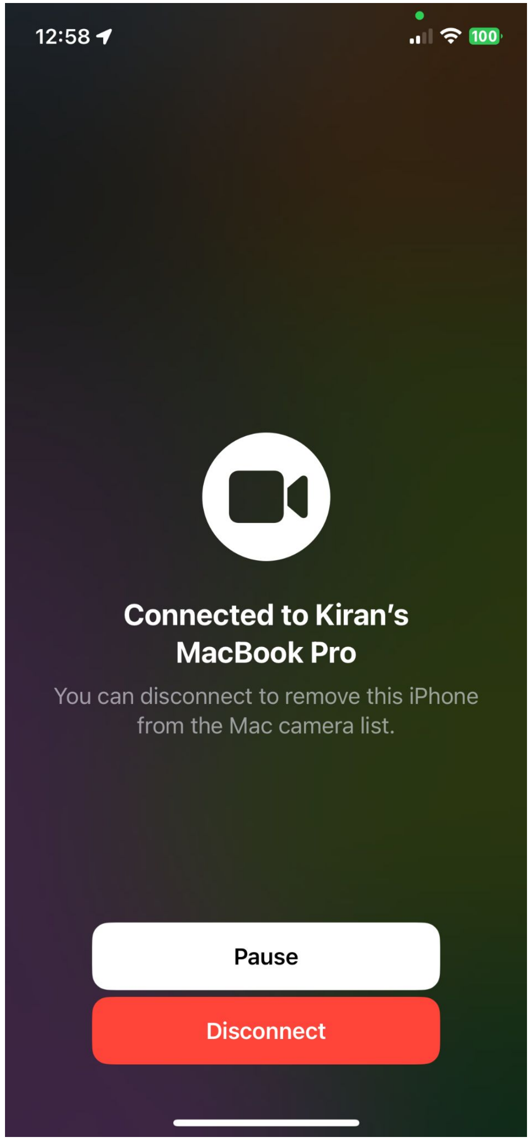
- Web streaming server’s home page
- Includes hardware, diagnostics, network, and camera information
- Includes links to HTTP server, RTSP server, and snapshot

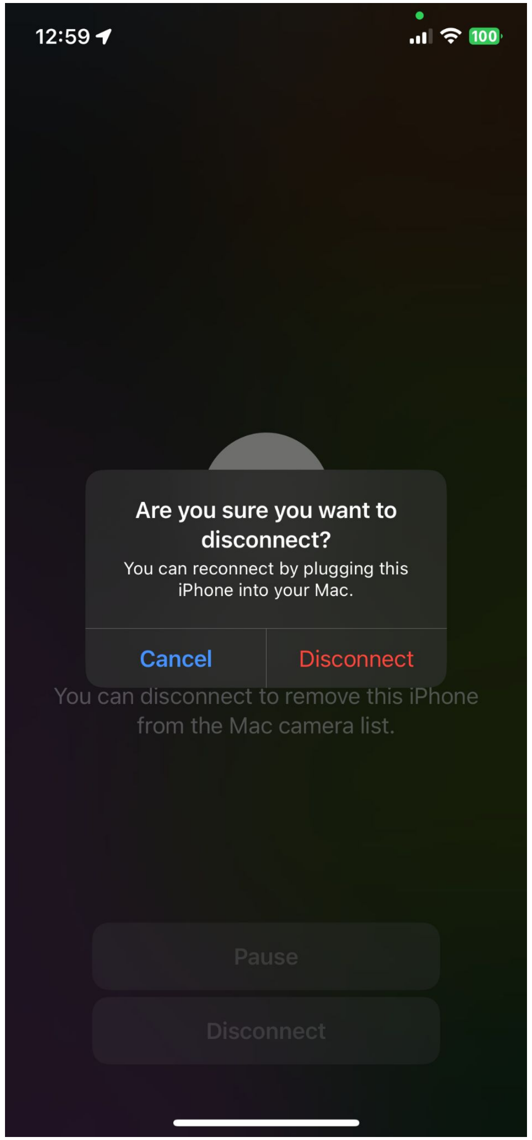


User Interface: ESP32-CAM

- ESP32-CAM's configuration options
  - Brightness
  - Contrast
  - Saturation
  - Stream quality
  - Exposure
  - Frame rate
  - Frame size
  - White balance mode
  - And more

User Interface: iPhone





Conclusion

- A convolutional neural network was trained on a large dataset of closterium, nitzschia, microcystis, oscillatoria, and non-algae
- This algae detection model allows users to quickly and easily classify algae with the ESP32-CAM, or even their smartphone
- Flexibility has greatly increased due to the model switching from a classification model to an object detection model
- The best focus for future work would be to increase the dataset drastically and to engineer a heatsink for the ESP32-CAM to mitigate overheating, thus improving performance