

AI low-cost Camera for counting and classification of microbes in nature water

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Figure 1: Digital Field Microscope



Figure 2: Handheld Microscope

PROBLEM

Toxic algae blooms impact Florida's ecosystems. Researchers face high costs with digital field microscopes (Fig. 1: \$1,795, <https://aquaticsensors.com/product/digital-field-microscope/>). Low-cost light microscopes have limited capabilities (Fig. 2), leading to manual sample analysis. Our goal is to employ a low-cost digital camera and AI for live algae sample classification and quantification.

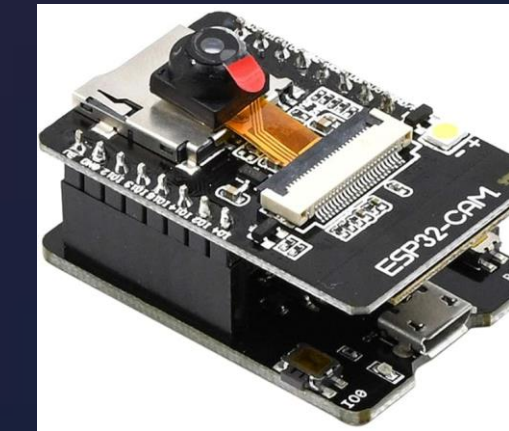


Figure 3: ESP32-CAM board



Figure 4: ESP32-CAM mounted on microscope

SOLUTION

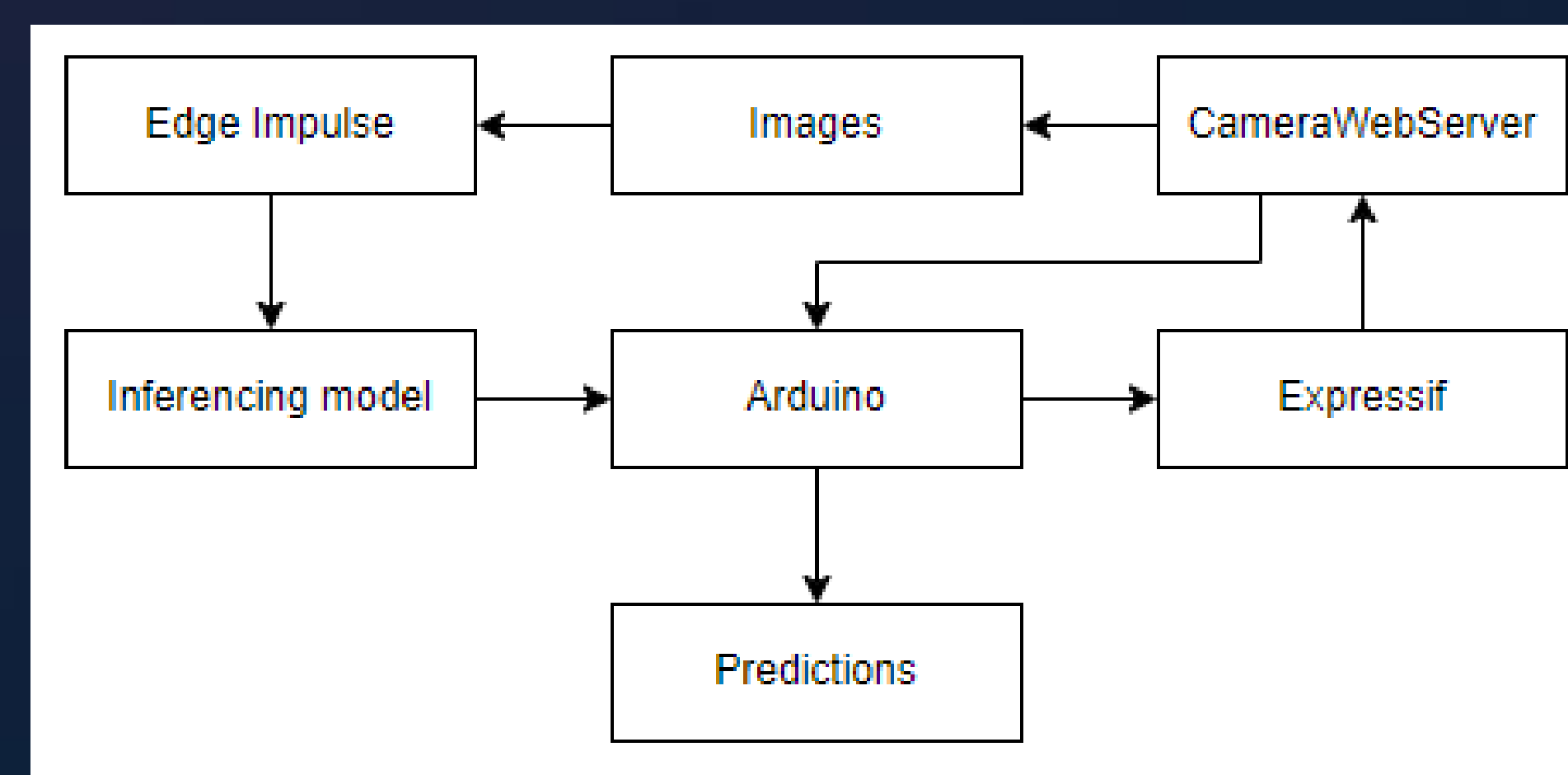
The ESP32-CAM development board (Fig. 3) with an OV2640 camera supports WiFi. Dr. Chen provided a Nikon 100-400x resolution microscope and a 3D printed mount for the ESP32-CAM (Fig. 4). We gathered 2,197 images and retrained a pretrained multi-layer convolutional neural network (CNN) MobileNetV1 for 4 algae classes and 1 non-algae class. Using Edge Impulse and Espressif libraries, we flashed the model onto the chip for inferencing. Due to the board's limited internal 1.3 MB storage and 327KB RAM, our program had to be lightweight. The achieved 59.8% accuracy serves as a promising proof of concept.

REQUIREMENTS

- Nikon SKT Optical Microscope with 200x resolution lens
- Custom 3D-printed mount for ESP32-CAM
- Adeeep ESP32-CAM board (<https://www.amazon.com/dp/B08P2578LV>)
- Arduino IDE 2.1.1 (www.Arduino.cc)
- Espressif Systems ESP32 library package (<https://github.com/espressif/arduino-esp32>)
- Edge Impulse Library (www.EdgeImpulse.com)



SYSTEM DESIGN

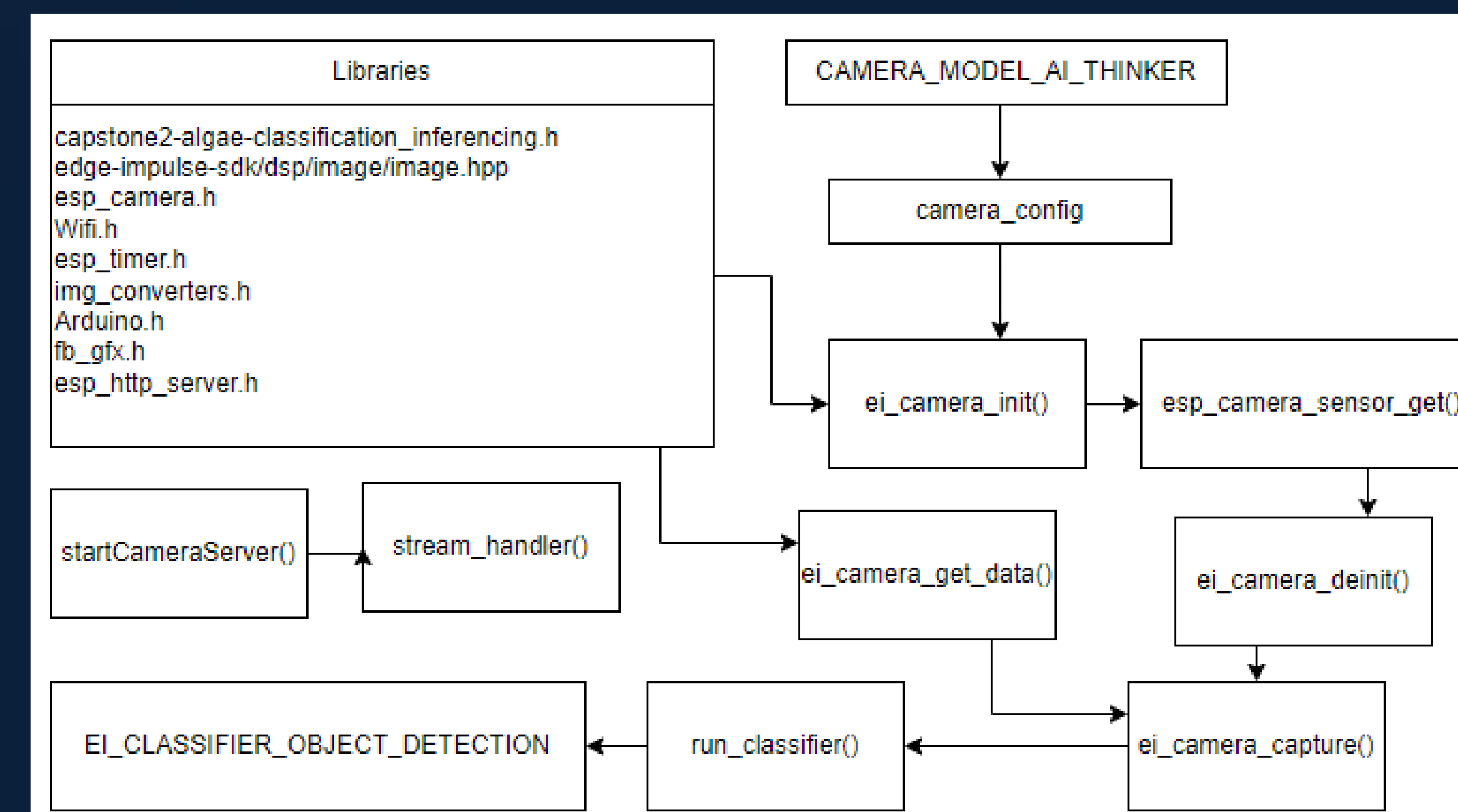


VERIFICATION

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WiFi connected
Camera Stream Ready! Go to: http://192.168.114.77
Edge Impulse Inferencing Demo
Camera initialized
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
  Closterium: 0.00781
  Microcystis: 0.01562
  Nitzschia: 0.36719
  Non-algae: 0.55078
  Oscillatoria: 0.06250
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
  Closterium: 0.00781
  Microcystis: 0.01953
  Nitzschia: 0.38672
  Non-algae: 0.51562
  Oscillatoria: 0.07031
  
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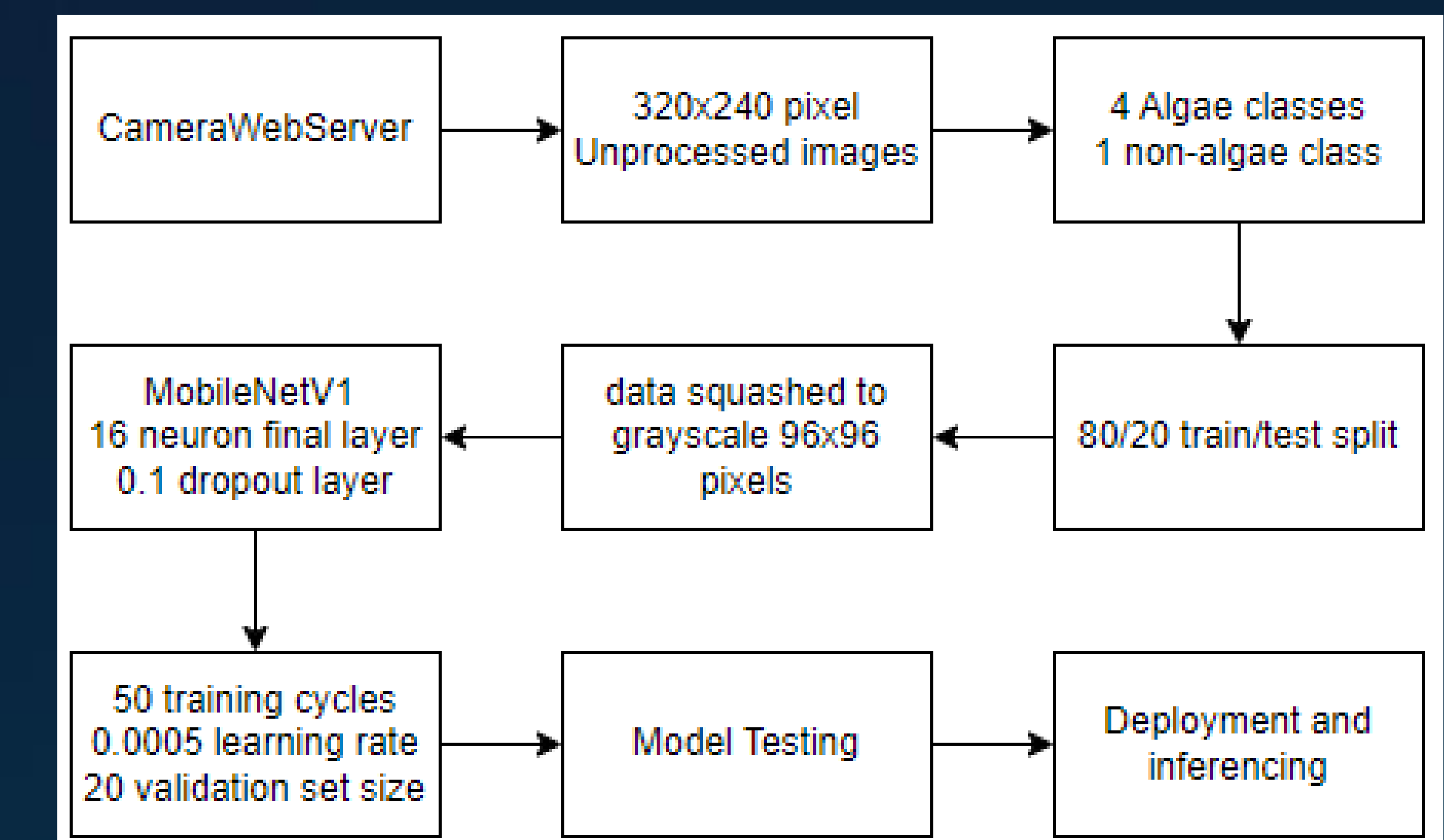
OBJECT DESIGN



SUMMARY

Using the ESP32-CAM development board with on-board WiFi and a built-in camera, we performed inferencing on 4 algae classes using photos from FIU MMC campus ponds. The camera cost us \$12. Our retrained CNN model achieved about 60% accuracy with Edge Impulse and Tensorflow Lite. We successfully deployed the model, utilizing only 84% of storage and 19% of RAM for global variables. However, due to time constraints, we couldn't deploy the Camera Web Server and inferencing simultaneously. Nonetheless, we managed to use the camera web server to capture photos and conduct live inferencing on the chip.

IMPLEMENTATION



REFERENCES

- <https://aquaticsensors.com/product/digital-field-microscope/>
- Aruiuo.cc
- Edgeimpulse.com
- Draw.io
- <https://github.com/espressif/arduino-esp32>

ACKNOWLEDGEMENT

The material presented in this poster is based upon the work supported by Dr. Antao Chen. We/I thank Dr. Chen for his assistance and mentorship that we received throughout the senior design project.