

AI on Low-cost Camera for Counting and Classification of Microbes in Nature Water

Team Members: Artem Andrianov, Mojeed Oladele Ashaleye, Amanda
Beatriz Chacin-Livinalli, Noah C Cuevas, Max Samuel Karey
Product Owner: Dr. Antao Chen, *Beckman Coulter*

Instructor: Dr. S. Masoud Sadjadi

School of Computing and Information Sciences
Florida International University

July 28th, 2023



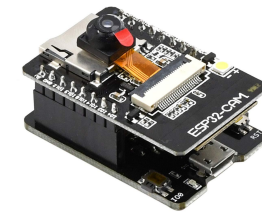
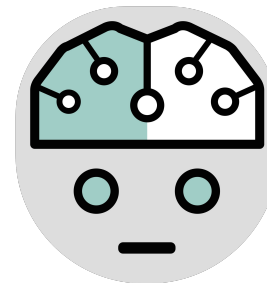
Motivation

- Traditional methods of water monitoring and classification of water borne microbes require expensive, time-consuming, and labor intensive processes.
- This hinders the extent of discovery able to be made by scientists and water quality and health officials.
- Utilizing artificial intelligence as a tool in these efforts could pose a new approach that is convenient, efficient and reliable.



Solution

- This project developed an artificial intelligence-based model to work in conjunction with a low-cost camera and microscope to detect and classify microbes in water samples.
- This system aims to:
 - Automatically detect and classify microbes in natural water and,
 - Produce real-time inference from data provided by the camera's live video stream.





Approach

- We tackled the issue of algae classification under a microscope using a low-cost camera by utilising a neural network developed on the Edge Impulse and trained to identify different types of algae from water sample.
- To capture live images and video OS microbe sample, we connected an ESP-32 camera to a Nikon light microscope.
 - The camera chip sent the data to a web server that collected and formed out dataset.

Approach, continued.

- We utilised a Convolutional Neural Network(CNN) to train the model. The dataset was used to teach the model how to distinguish between various algae species.
 - Edge Impulse was used to train the CNN with the provided dataset and parameters for optimal performance.
- The trained model was integrated it into a library that was later uploaded to the ESP32-CAM chip.





Project Development: Sprint 1 & 2

- The project was developed across 5 sprint development sessions throughout the Summer 2023 term.
 - Sprint 1:
 - Finding image dataset, investigated camera options, identified suitable libraries and performed background research on skills needed.
 - Sprint 2:
 - Continued finding image dataset, reached out to biologists for potential guidance, built dataset of >2,000 photos of algae from samples of FIU ponds along with Kaggle-supplied photos, continue researching on skills needed.



Project Development: Sprint 3 & 4

- Sprint 3:
 - Built algae dataset utilising 5 individual categories, began building Keras CNN model, generated additional images for dataset, and preprocessed our images using Keras.
- Sprint 4:
 - Attempted to export Keras model onto chip, troubleshooted exporting of model onto chip with no success, began building Edge Impulse model and generated more images for dataset.



Project Development: Sprint 5

- Sprint 5:
 - Created Github repository, developed a model using Edge Impulse, troubleshooted loading of model library onto Arduino IDE, attempted to integrate camera web server and Edge Impulse model in Arduino, troubleshooted loading of model onto ESP32-CAM, successfully inferencing model on ESP32-CAM.



Data

Oscillatoria



Closterium



Microcystis



Nitzschia





Implementation

- The system was implemented using:
 - a windows computer with a 64-bit operating system, 256GB storage, 12GB of memory, and an Intel® Core™ i5- 10210U CPU at 1.60GHz.
 - The Arduino IDE as the development environment used to run the systems program
 - An ESP-32 Camera development board mounted onto a Nikon light microscope

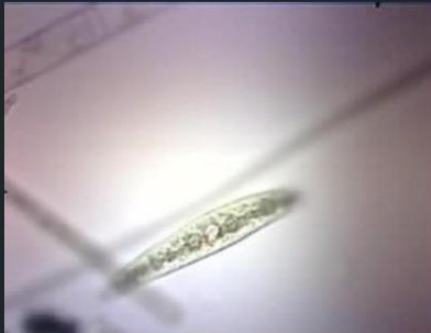




Results

```
Output Serial Monitor x
Message (Enter to send message to 'ESP32 Dev Module' on 'COM6')
New Line

Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.36328
Non-algae: 0.54297
Oscillatoria: 0.07031
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.33984
Non-algae: 0.57031
Oscillatoria: 0.06641
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.35156
Non-algae: 0.55469
Oscillatoria: 0.07031
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.35156
Non-algae: 0.55859
Oscillatoria: 0.06641
```



```
Output Serial Monitor x
Message (Enter to send message to 'ESP32 Dev Module' on 'COM6')
New Line 115200 baud

4688
Oscillatoria: 0.06250
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: 0.01562
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
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01953
Nitzschia: 0.37500
```

```
Output Serial Monitor x
Message (Enter to send message to 'ESP32 Dev Module' on 'COM6')
New Line 115200 baud

Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.37109
Non-algae: 0.55469
Oscillatoria: 0.05078
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.37891
Non-algae: 0.53125
Oscillatoria: 0.06641
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.33203
Non-algae: 0.58984
Oscillatoria: 0.05469
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01953
Nitzschia: 0.35156
Non-algae: 0.55469
Oscillatoria: 0.06641
```

```
Output Serial Monitor x
Message (Enter to send message to 'ESP32 Dev Module' on 'COM6')
New Line 115200 baud

Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.37109
Non-algae: 0.55469
Oscillatoria: 0.05078
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.37891
Non-algae: 0.53125
Oscillatoria: 0.06641
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01562
Nitzschia: 0.33203
Non-algae: 0.58984
Oscillatoria: 0.05469
Predictions (DSP: 7 ms., Classification: 453 ms., Anomaly: 0 ms.):
Closterium: 0.00781
Microcystis: 0.01953
Nitzschia: 0.35156
Non-algae: 0.55469
Oscillatoria: 0.06641
```





Conclusion

- This project utilizes AI-driven water monitoring with a low-cost camera and microscope and poses an innovative approach for new water monitoring methods.
- The Edge Impulse-trained Convolutional Neural network allows for automatic microbe detection and real-time inferences.
- This new approach could allow scientists and officials an alternative method of water monitoring that reduces cost while being efficient and reliable.