Stew Segmentation and Fish Size Estimation

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Content




Problem

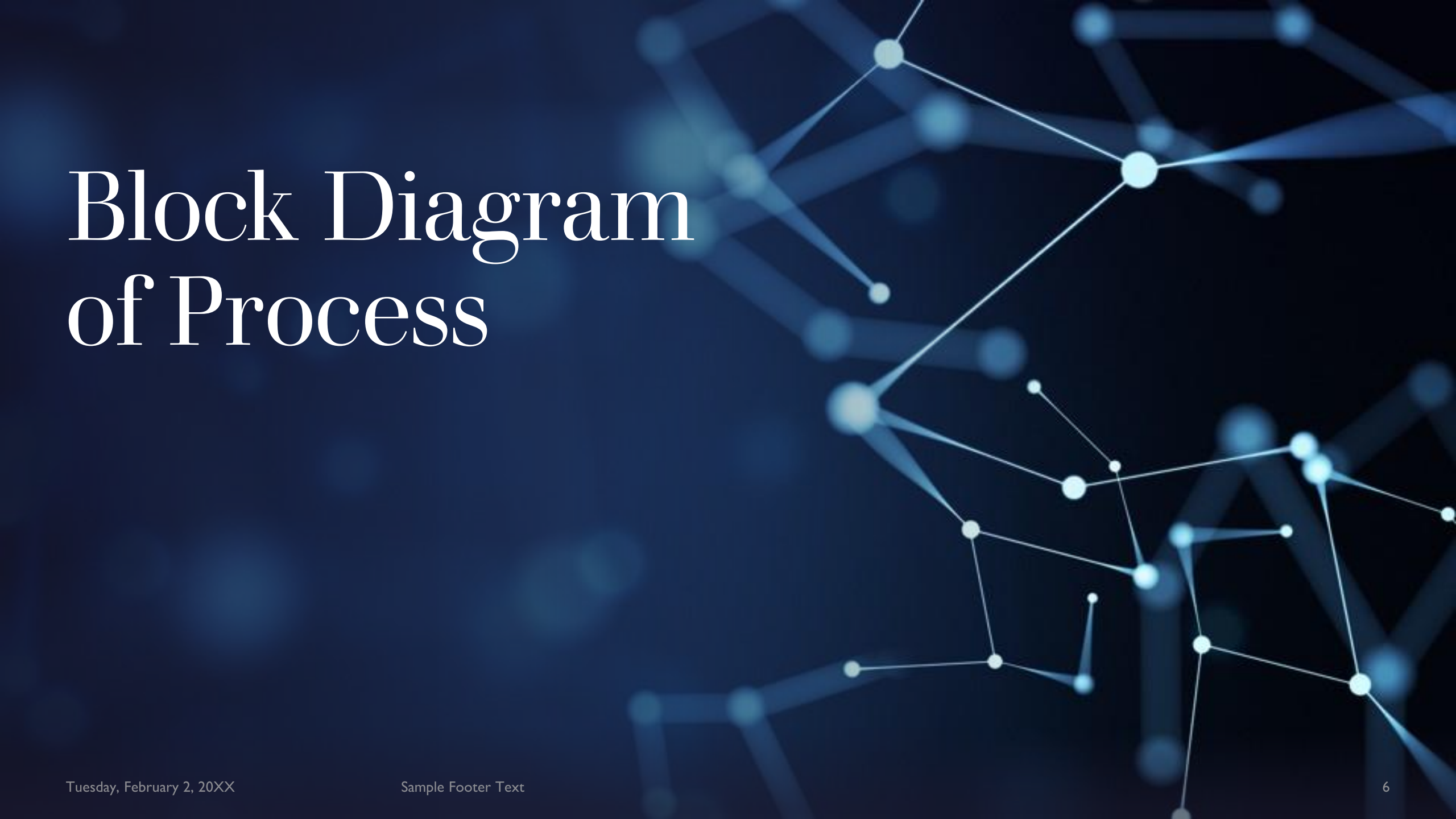
- Segment area inside stew from top-view images
- Segment fish and Estimate length compared to 200-liter tank

Objection

- Automatically Detect single fish without manually counting
- Estimate Average size of fish
- Detect and Extract each stew
- Track Growth of fish

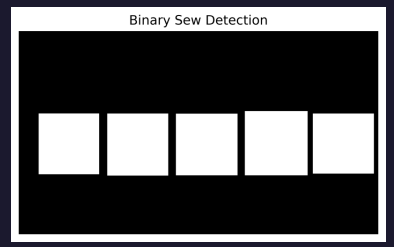
Content

Block Diagram of Process

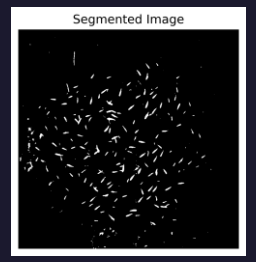


Big Picture

Input

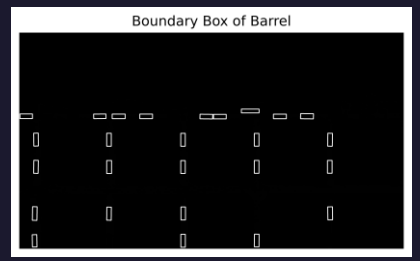


Stew Segmentation



stew1: Fish Segmentation

stew2: Fish Segmentation



Barrel Segmentation

Barrel Ratio

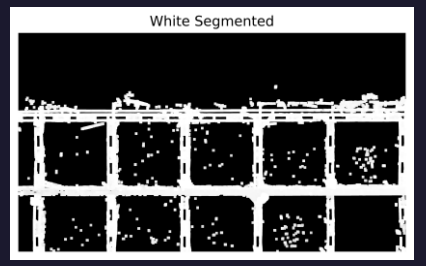
Pixel Fish Length

Real Fish Length

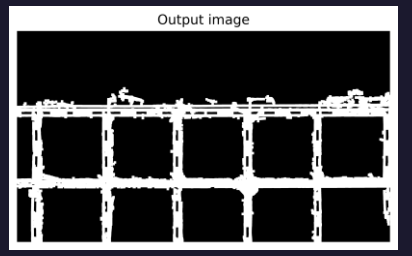
Stew Segmentation

Input

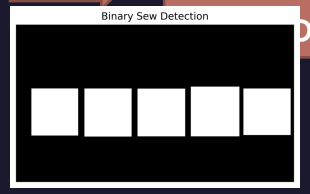
Bitwise Masking



Opening, Square 7x7, iteration = 6

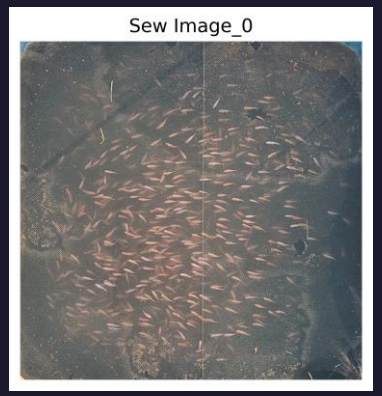


Connected ponent



Draw Contour

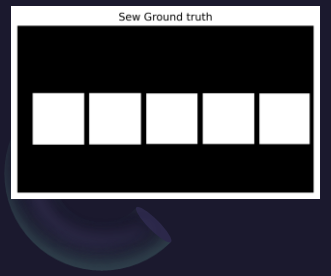
Create Sub-Image with ROI



Fill within ROI with white and black for others

Resize with ROI

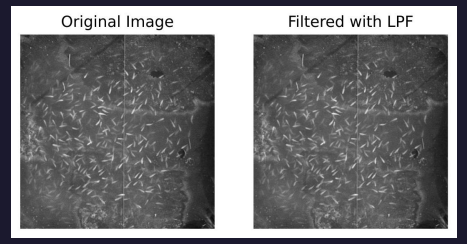
Stew Ground truth

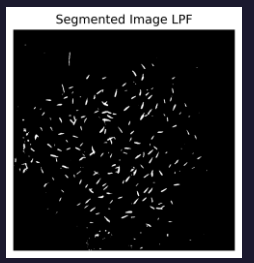


Evaluation measures

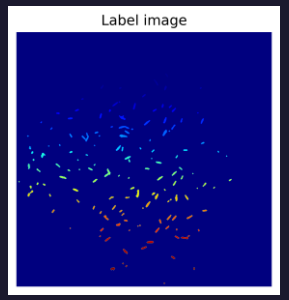
Sub-Image of Each Stew

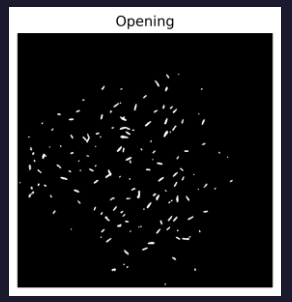
Fish Segmentation





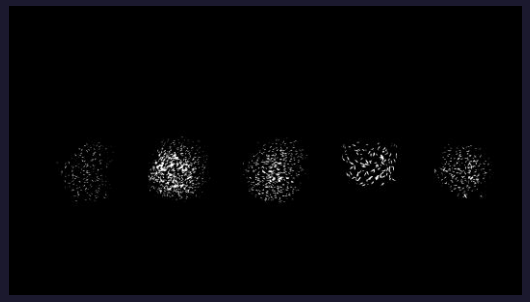
Sub-Image of Each Stew → Gauss Filtering 7x7 → LPF in Frequency with D0 = 150 → Euclidean Distance, center = 9, cutoff = 230

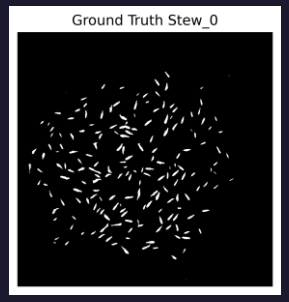




Fish Ground truth → Resize with ROI →

Connected Component ← Opening, disk 2

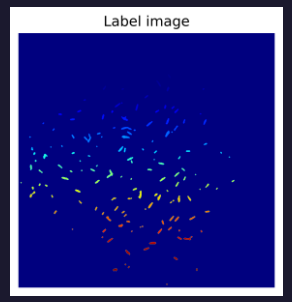




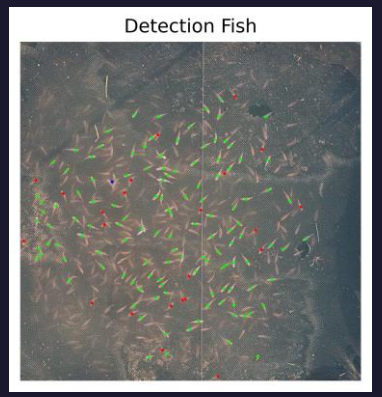
Label Image

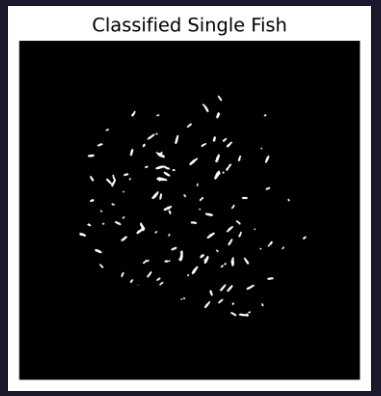
Fish Detection

Label Image → Classifier Features → Detection from features → Classified single fish → Average fish size in pixels

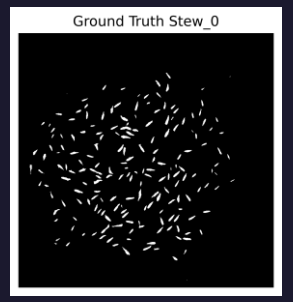


[area, eccentricity, compactness, major, image_bbox]

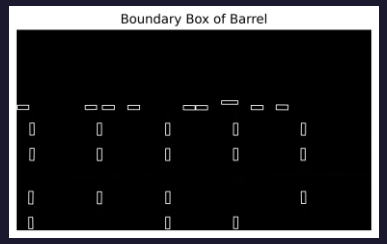




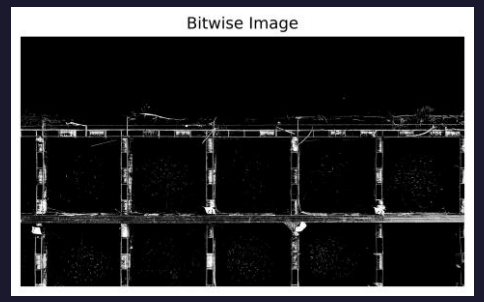
Fish Ground truth → Resize with ROI →

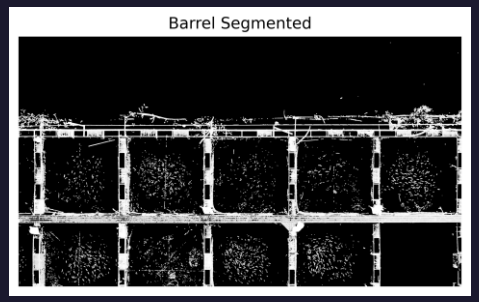


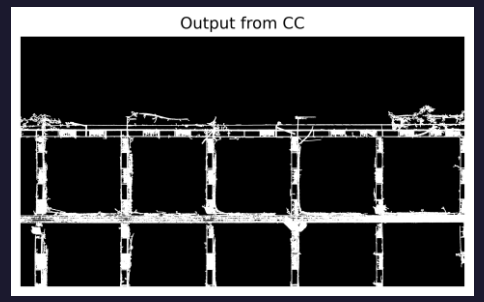
Barrel Segmentation



Input → Bitwise Masking → Opening, Square 3x3, iteration = 3 → Connected Component → Draw Contour







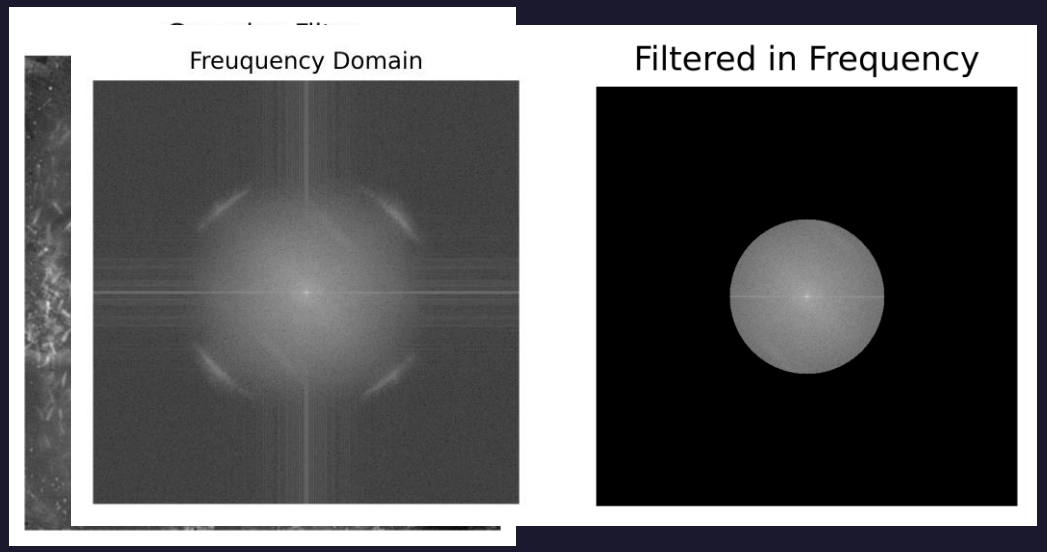
Draw Contour → Find average perimeter and Find ratio between cm and pixels → Real fish Length

Content

Preprocessing

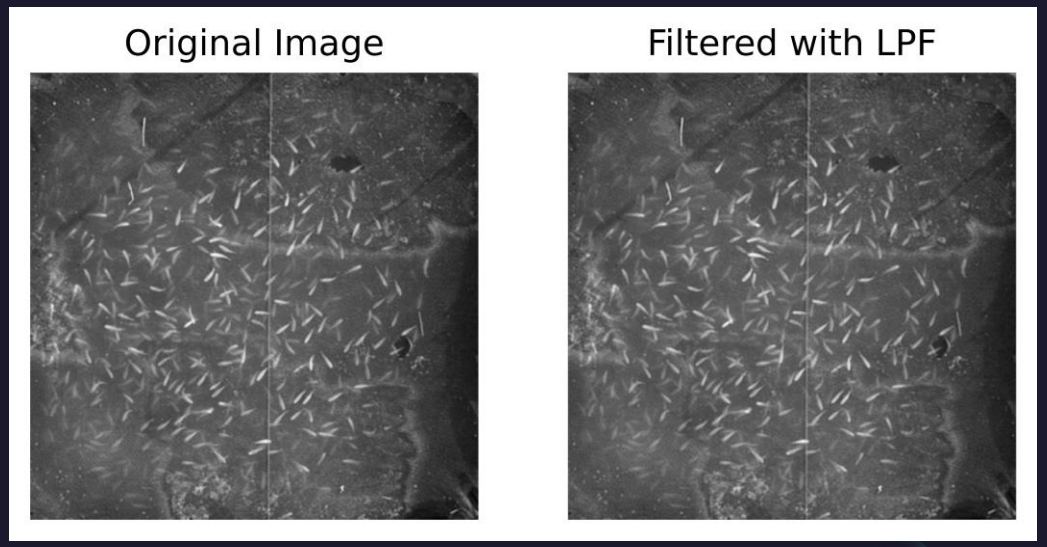
GAUSSIAN FILTERING

To reduce noise from small fish or dust, especially stew noise
Gaussian is good for being low pass filter when stew is high frequency.



LOW PASS IN FREQUENCY DOMAIN

Low Pass Filter in frequency is used to ban high frequency components such as stew. In such process, corner of fish will be blurred.



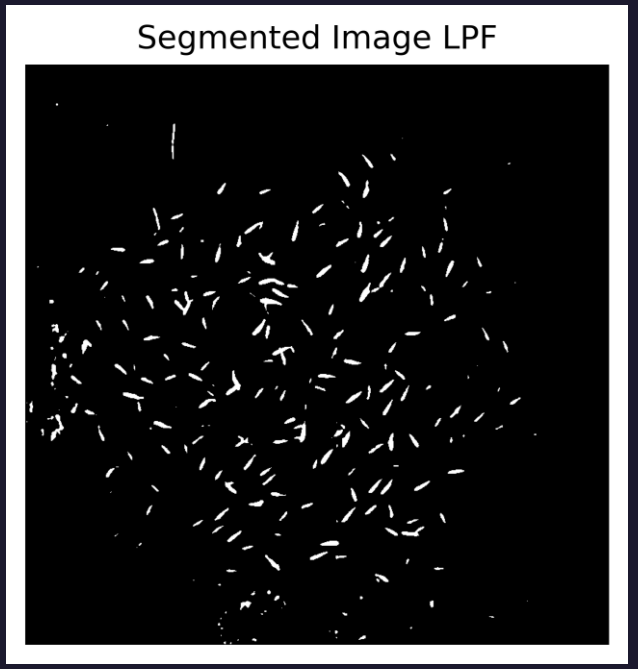
Content

Segmentation

EUCLIDEAN DISTANCE

Euclidean Distance LPF

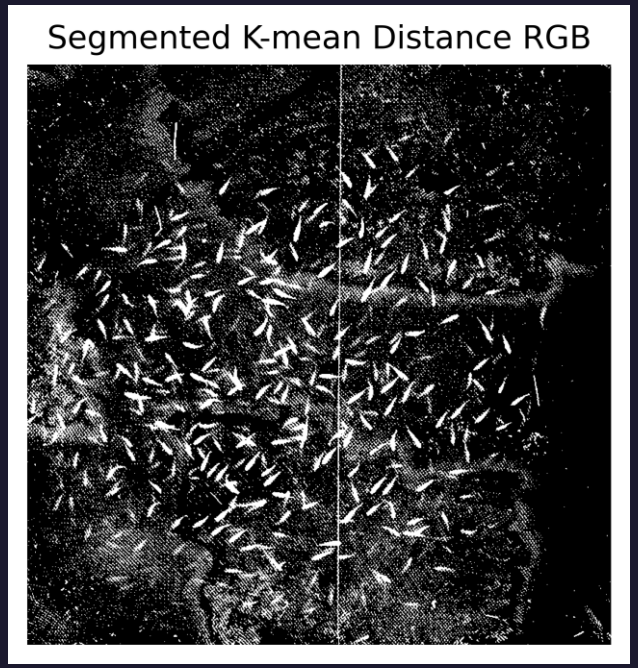
- IoU = 0.568, Precision = 0.996, Recall = 0.99
- Accuracy = 0.986, Error Rate = 1-Acc = 0.014
- Confusion Matrix =
- [[0.96790578 0.01015241 0.98961983]
- [0.00371103 0.01823078 0.83086927]
- [0.99618056 0.64230912 0.98613656]]



Segmentation

K-MEAN CLUSTERING (3) RGB

- K-mean clustering RGB
- IoU = 0.178 , Precision = 0.871, Recall = 0.999
- Accuracy = 0.874, Error Rate = 1-Acc = 0.126
- Confusion Matrix =
- [[8.46446357e-01 9.74691072e-04 9.98849815e-01]
- [1.25170458e-01 2.74084932e-02 1.79634825e-01]
- [8.71173022e-01 9.65659559e-01 8.73854851e-01]]



Segmentation

EUCLIDEAN DISTANCE OPENING

Opening Euclidean

IoU = 0.414, Precision = 0.998, Recall = 0.984

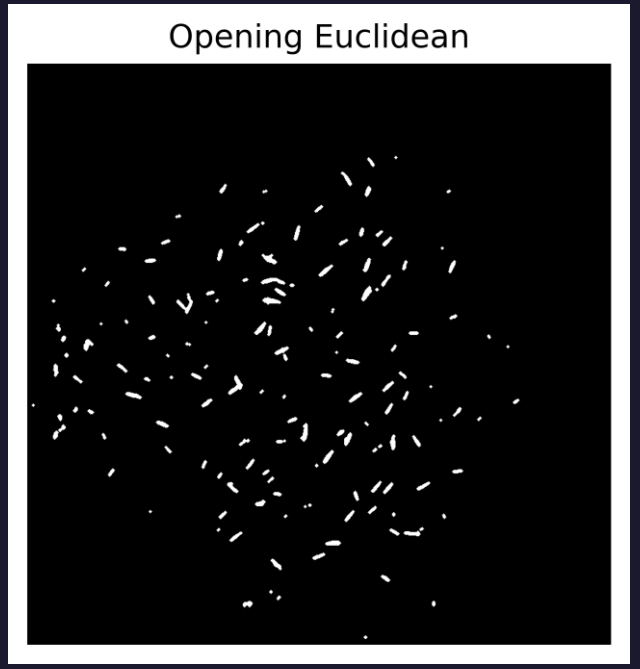
Accuracy = 0.982, Error Rate = 1-Acc = 0.018

Confusion Matrix =

[[0.97003088 0.01598103 0.98379226]

[0.00158594 0.01240216 0.88662229]

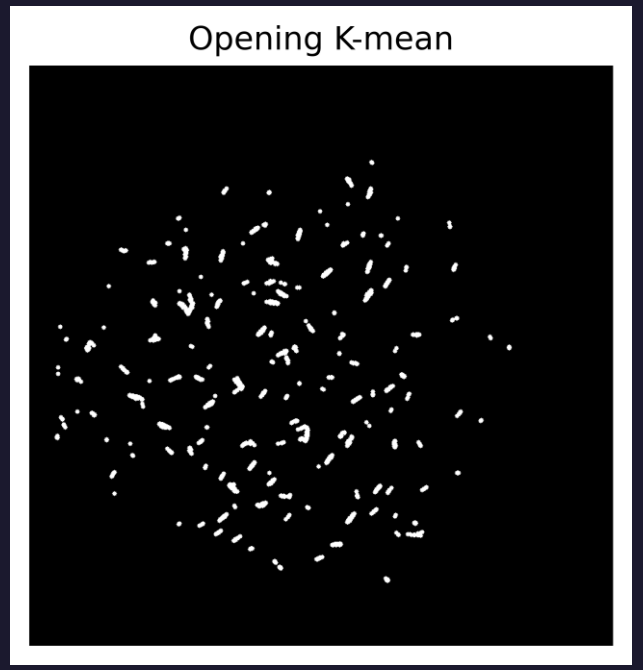
[0.99836773 0.43695434 0.98243303]]



Segmentation

K-MEAN CLUSTERING (3) RGB OPENING

- Opening K-mean
- IoU = 0.462, Precision = 0.996, Recall = 0.986
- Accuracy = 0.983, Error Rate = 1-Acc = 0.017
- Confusion Matrix =
- [[0.96781417 0.01351502 0.98622785]
- [0.00380265 0.01486817 0.79633205]
- [0.99608627 0.52383724 0.98268234]]



Segmentation Summary

	IoU	Precision	Recall	Accuracy	Error Rate
Euclidean Distance	0.568	0.996	0.99	0.986	0.014
Eu_Opening	0.414	0.998	0.984	0.982	0.018
K-mean	0.178	0.871	0.999	0.874	0.126
K-mean_Opening	0.462	0.996	0.986	0.983	0.017

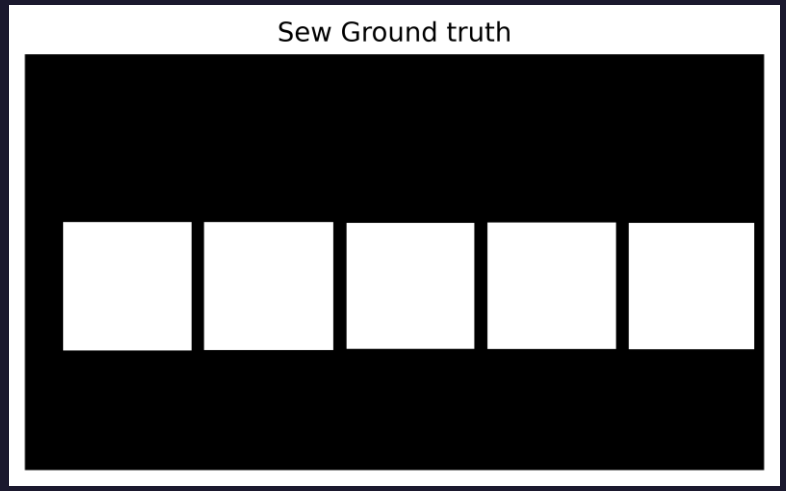
Without Opening, Euclidean Distance provide better result with higher IoU and Accuracy

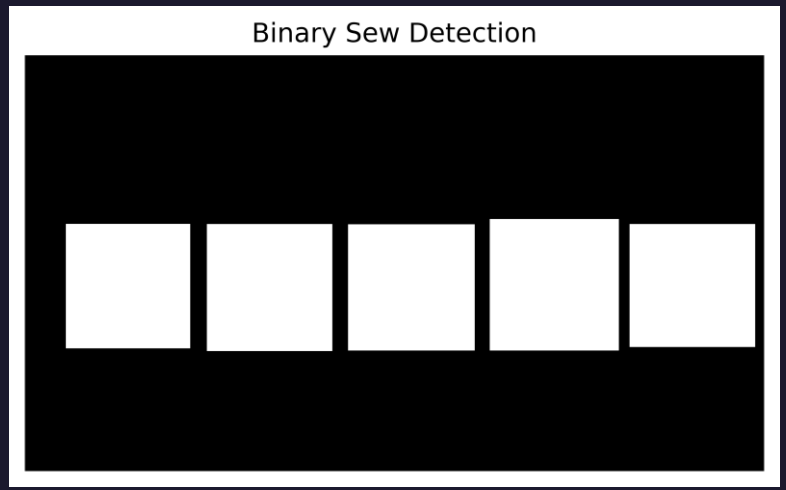
After Opening, Euclidean distance and K-mean clustering give close result but Euclidean distance has slightly better IoU

Segmentation (Stew)

stew Segmentation

- IoU = 0.952, Precision = 0.994, Recall = 0.988
- Accuracy = 0.987, Error Rate = 1-Acc = 0.013
- Confusion Matrix =
- [[0.73163852 0.00866138 0.98830018]
- [0.00408928 0.25561082 0.98425384]
- [0.99444186 0.96722554 0.98724934]]





Segmentation (stew)

	IoU	Precision	Recall	Accuracy	Error Rate
15(2)	0.907	0.988	0.979	0.975	0.025
15(3)	0.949	0.994	0.988	0.986	0.014
15(4)	0.948	0.997	0.984	0.986	0.014
15(5)	0.950	0.997	0.985	0.987	0.013
15(6)	0.952	0.994	0.988	0.987	0.013

	IoU	Precision	Recall	Accuracy	Error Rate
Mean	0.941	0.994	0.985	0.984	0.016

stew Segmentation

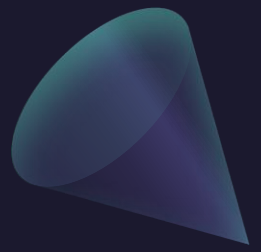
stew Segmentation work well with every data and has high performance

Content

Feature Extraction

```python
def classifierFeatures(X, seg_img):
    total_area = seg_img.shape[0] * seg_img.shape[1]
    y = []
    for i  in range(len(X)):
        if (X[i][0] >= 0.00003*total_area) and (X[i][1] > 0.1) and (X[i][2] < 40) :
            output_class = "Single"
        elif (X[i][0] >= 0.00005*total_area) and (X[i][1] > 0.1) and (X[i][2] >= 40) :
            output_class = "Overlapped"
        else:
            output_class = "Non-fish"
        y.append(output_class)
    return y
```

X = [area, eccentricity, compactness, major, image_bbox]



FEATURE

Single Fish: Classify with area to reduce inaccuracy from noise, eccentricity is not set properly, and compactness is set less than 40 from fish shape is oval
Overlapped Fish: Classify with area larger than single fish area, eccentricity is not set properly, and compactness is set more than 40 for weird shape
And other condition is non-fish

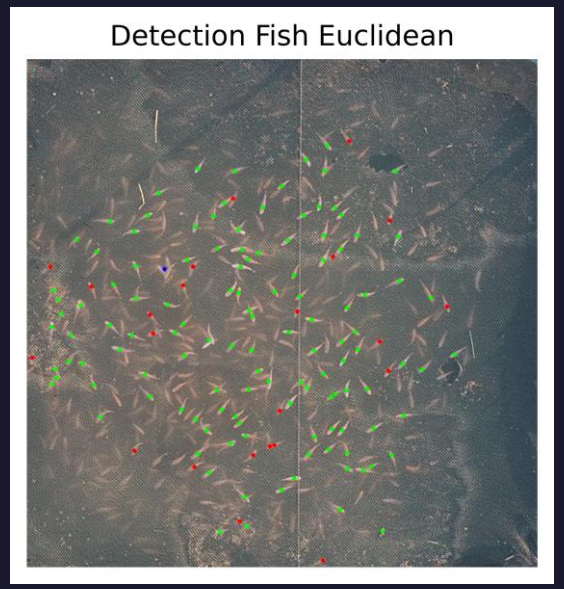
Feature Extraction

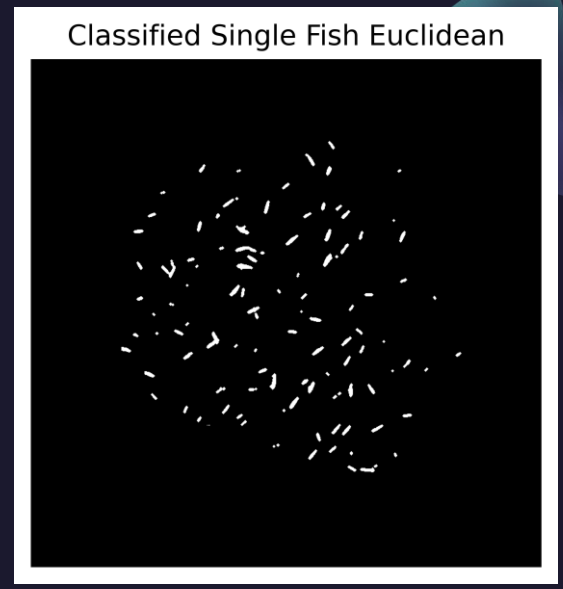
Classified Fish (Euclidean Distance)
IoU = 0.344, Precision = 0.999, Recall = 0.98

Accuracy = 0.981, Error Rate = 1-Acc = 0.019

Confusion Matrix =
[[9.70819341e-01 1.83569322e-02 9.81442203e-01]
[7.974745l4e-04 1.00262521e-02 9.26321632e-01]
[9.99179229e-01 3.53246204e-01 9.80845593e-01]]

mean of major axis = 9.25 cm
average length of single fish = 18.50 cm
average length Error of single fish = -29.65 %
average length of overlapped fish = 32.12 cm





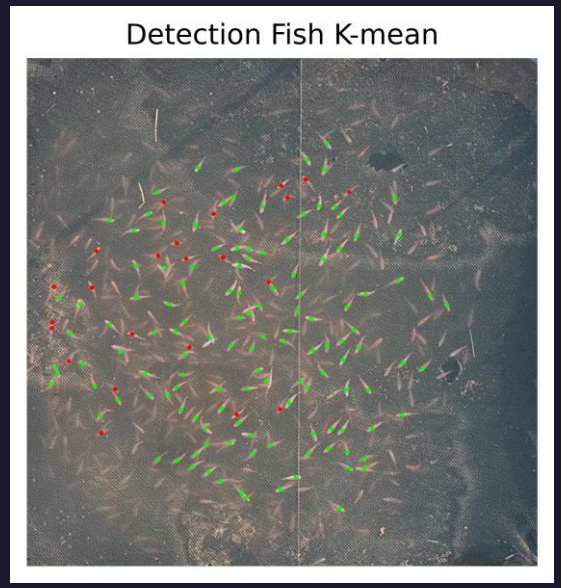
Feature Extraction

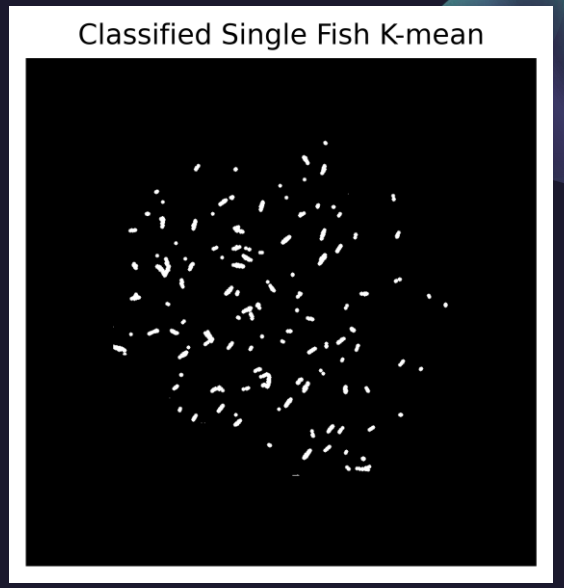
Classified Fish (K-mean Clustering)
IoU = 0.371, Precision = 0.997, Recall = 0.983

Accuracy = 0.98, Error Rate = 1-Acc = 0.02

Confusion Matrix =
[[0.96878435 0.01679953 0.98295474]
[0.00283246 0.01158366 0.8035212]
[0.9970848 0.40811683 0.98036801]]

mean of major axis = 8.70 cm
average length of single fish = 17.40 cm
average length Error of single fish = -33.83 %
average length of overlapped fish = 32.95 cm





Feature Extraction Summary

		IoU	Precision	Recall	Accuracy	Error Rate
15(6)	stew0	0.476	0.998	0.993	0.991	0.009
	stew1	0.609	0.995	0.983	0.979	0.021
	stew2	0.393	0.976	0.995	0.972	0.028
	stew3	0.452	0.962	0.997	0.961	0.039
	stew4	0.594	0.988	0.995	0.984	0.016

Euclidean Distance

	IoU	Precision	Recall	Accuracy	Error Rate
15(2)	0.5104	0.987	0.9724	0.9602	0.0398
15(3)	0.4692	0.9824	0.9854	0.9688	0.0312
15(4)	0.4496	0.9808	0.991	0.9726	0.0274
15(5)	0.5048	0.9838	0.9926	0.9774	0.0226
15(6)	0.5048	0.9838	0.9926	0.9774	0.0226

Feature Extraction Summary

		IoU	Precision	Recall	Accuracy	Error Rate
15(6)	stew0	0.379	0.995	0.992	0.987	0.01
	stew1	0.397	0.997	0.971	0.9969	0
	stew2	0.486	0.993	0.991	0.985	0.02
	stew3	0.420	0.992	0.982	0.975	0.03
	stew4	0.542	0.987	0.993	0.981	0.02

K-mean Clustering

	IoU	Precision	Recall	Accuracy	Error Rate
15(2)	0.3506	0.9954	0.9644	0.9606	0.0394
15(3)	0.5296	0.9924	0.9768	0.9698	0.0302
15(4)	0.4176	0.991	0.9848	0.9768	0.0232
15(5)	0.4448	0.9928	0.9858	0.9794	0.0206
15(6)	0.4448	0.9928	0.9858	0.98498	0.01502

Feature Extraction Summary

Euclidean Distance

	IoU	Precision	Recall	Accuracy	Error Rate
15(2)	0.5104	0.987	0.9724	0.9602	0.0398
15(3)	0.4692	0.9824	0.9854	0.9688	0.0312
15(4)	0.4496	0.9808	0.991	0.9726	0.0274
15(5)	0.5048	0.9838	0.9926	0.9774	0.0226
15(6)	0.5048	0.9838	0.9926	0.9774	0.0226
mean	0.48776	0.9836	0.9868	0.9713	0.02872

K-mean Clustering

	IoU	Precision	Recall	Accuracy	Error Rate
15(2)	0.3506	0.9954	0.9644	0.9606	0.0394
15(3)	0.5296	0.9924	0.9768	0.9698	0.0302
15(4)	0.4176	0.991	0.9848	0.9768	0.0232
15(5)	0.4448	0.9928	0.9858	0.9794	0.0206
15(6)	0.4448	0.9928	0.9858	0.98498	0.01502
mean	0.43748	0.9929	0.97952	0.9743	0.02568

Average Fish Length

		Eu Length (cm)	Error (%)	K Length (cm)	Error (%)
15(6)	stew0	18.50	29.65	17.40	33.83
	stew1	27.24	4.91	23.00	19.73
	stew2	21.65	17.51	17.72	32.50
	stew3	25.21	6.84	21.93	18.96
	stew4	32.83	16.86	32.55	17.56
	mean	25.086	15.154	22.52	24.516

	Eu Length (cm)	Error (%)	K Length (cm)	Error (%)
mean	25.1076	12.7468	22.6532	21

Euclidean Distance has better result which is 12.5% error from ground truth and K-mean Clustering has 21% error from ground truth

Content

Ablation Study

By Removing Preprocessing; LPF in Frequency and Gaussian filtering

		IoU	Precision	Recall	Accuracy	Error Rate
15(6)	stew0	0.476	0.998	0.993	0.991	0.009
	stew1	0.609	0.995	0.983	0.979	0.021
	stew2	0.393	0.976	0.995	0.972	0.028
	stew3	0.452	0.962	0.997	0.961	0.039
	stew4	0.594	0.988	0.995	0.984	0.016
	mean	0.5048	0.9838	0.9926	0.9774	0.0226

Euclidean Distance
With Preprocessing

		IoU	Precision	Recall	Accuracy	Error Rate
15(6)	stew0	0.356	0.999	0.982	0.981	0.019
	stew1	0.440	0.978	0.991	0.971	0.029
	stew2	0.477	0.995	0.972	0.969	0.031
	stew3	0.563	0.992	0.991	0.984	0.016
	stew4	0.461	0.993	0.993	0.986	0.014
	mean	0.4594	0.9914	0.9858	0.9782	0.0218

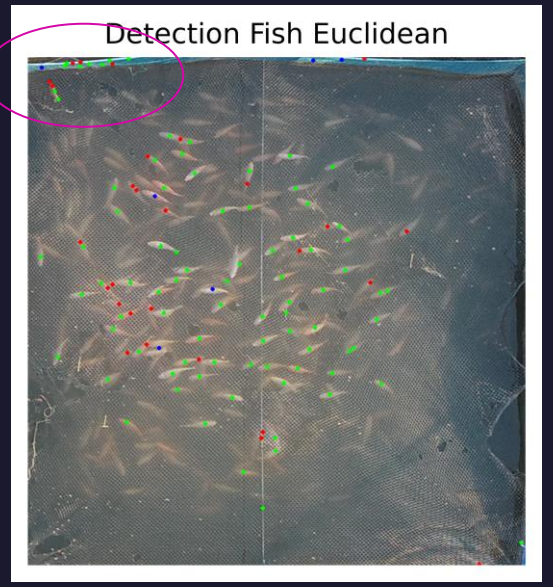
Euclidean Distance
Without Preprocessing

Ablation Study

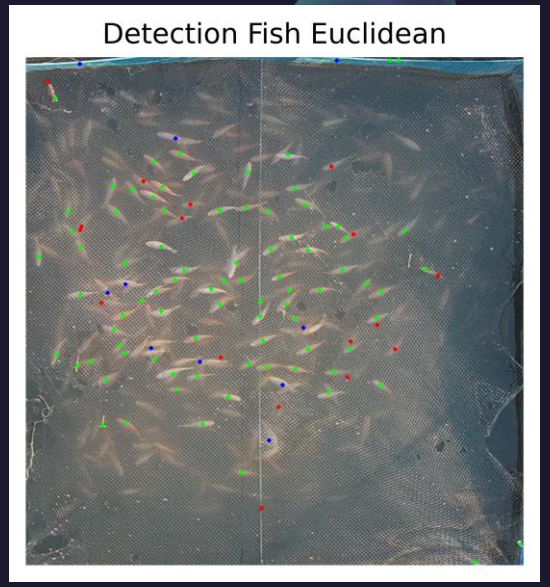
Classified Fish

		Length (cm)	Error (%)	Ablation Length (cm)	Error (%)
15(6)	stew0	18.50	29.65	17.72	32.60
	stew1	27.24	4.91	25.18	12.11
	stew2	21.65	17.51	19.72	24.89
	stew3	25.21	6.84	23.93	11.56
	stew4	32.83	16.86	30.83	21.92
	mean	25.086	15.154	23.476	20.616

With Preprocessing, IoU increase by 5% and Length Error reduce by 5%



Without preprocessing



With preprocessing

Content

Summary

Fish segmentation with Euclidean can provide

IoU with 49% ,Accuracy 97% and 15.15% error in fish length

Overall performance is quite poor due to noise and labeling problem; labeler is not sure whether to segment as single fish or overlapped fish result in low IoU performance, but fish length is understandable from segmentation error

Performance can be improved by more features or use machine learning model to classify fish

Future Work

Estimate Average size of fish to tracking growth of fish

Check fish's health with color of overall fish

Estimate time for feeding and harvesting

With more implementation, can be use as a part of "smart farm".

a farm that can automatically feed fish and estimate time to feed and harvest. It can also detect anomaly such as disease by color of fish such as Aeromonas or disease from Flexibacter columnaris

Thank You

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