Deep Learning Meets Aquaculture: Advanced Oyster Seeds (0-2 mm) Quantification with Stardist Neural network

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Introduction

Figure 1. Oyster sizes in order of range 0-2mm

- To efficiently count oyster seeds of the size of 0-2mm within a Petri dish, we use a Machine Learning model based on Stardist2D, which excels at nuclei/cell detection. This is a project made in collaboration with Louisiana Sea Grant Research Lab.
- Sample weights of Oyster seeds are filtered into size groups 0-2mm, 2-4mm, and >4mm. For Fall 2024 we are working with oyster seeds of size less than 2mm.

Objectives

- **Automated Oyster Seed Counting:** Our primary objective is to create a tool that allows Louisiana Sea Grant researchers to swiftly and accurately count oyster seeds in images, enhancing research efficiency and data precision.
- **Dataset Augmentation:** We explore and implement a number of dataset augmentation approaches to increase data diversity and quality, which are crucial for increasing the model's performance and generalizability.
- **Model Architecture - Stardist:** We utilize Stardist with a U-Net backbone, which calculates object probabilities and radial distances to effectively segment and quantify oyster seeds.
- Below Figure (2) shows the object probabilities and radial distance of an input image.

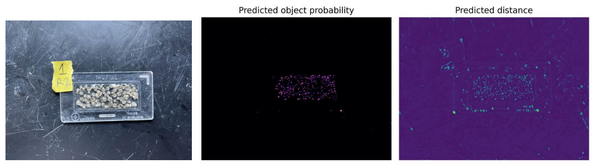

Figure 2. Training model based on Stardist- Object probabilities and radial distances of Oyster Image(0-2mm)

Distance and Probability Loss over 500 Epochs of size 0-2mm Oysters

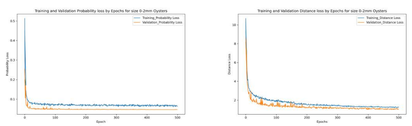

Figure 3. Distance and Probability Loss over 500 Epochs

- The model's ability to adjust its internal parameters for better data fitting is demonstrated by the training and validation metrics for distance loss and probability loss.
- The metrics provided reflect the performance of the model over 500 epochs. Analysis of these metrics reveals that metrics do have some fluctuations, which is expected in the learning process.

Metrics of F1 score, Precision, Accuracy and Recall over Epochs

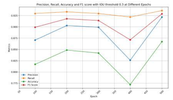

Figure 4. Illustration of the metrics-F1 score, Precision, Accuracy, and Recall on Epochs 500

- The graph depicts the variations in f1 score, accuracy, recall, and precision for varying epochs during the training of U-Net CNN architecture and StarDist.
- The dataset was split into 75 percent training and 25 percent testing and model was evaluated using an Intersection over Union (IoU) threshold equal to 0.3.
- Testing the epochs of this model, a noticeable jump in accuracy occurs at 500, indicating the importance of prolonged training iterations in order to enhance the model's accuracy further.

GUI Prediction

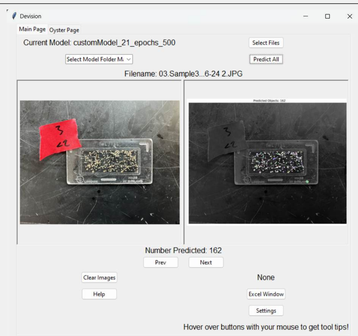

Figure 5. GUI Prediction of Oysters 0-2 mm

- The GUI provides an efficient platform for individuals and businesses seeking to use this models predictions.
- This interface enables users to upload multiple images they wish to count, select from multiple available models, if applicable, and features a detailed annotated visualization that highlights the model's oyster seed predictions while displaying the total number predicted.
- The original count of Oyster is 215, predicted as 163. Accuracy is 75
- In Figure(5) shows the predicted image by GUI based on the selected best model.

Prediction

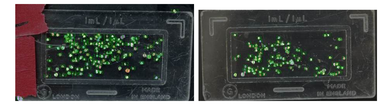

Figure 6. Predictions Oysters: Count-134(left), Count-96(right)

- After the model has been trained, it is tested on data that was not included in the training set.
- The best model gave 75 percent accuracy when predicting images with darker backgrounds.
- Figure 6 shows the counting of oyster seeds using the prediction model of Stardist.

Future work

- For future work, we would like to study oysters of sizes 4mm-6mm and continue our research in developing a robust machine-learning model.
- Additionally, we aim to develop a GUI based on the best model to count oysters of different sizes.
- We aim to enhance the robustness of our oyster prediction model by training it on images of oysters captured against lighter backgrounds, as the model's accuracy has been affected on such images.

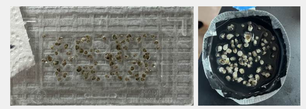

Figure 7. Oyster images: Lighter backgroud(left), 4mm-6mm(right)

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References

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