Binary Classification of Xenopus Frog Embryos Using Mask R-CNN

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Introduction

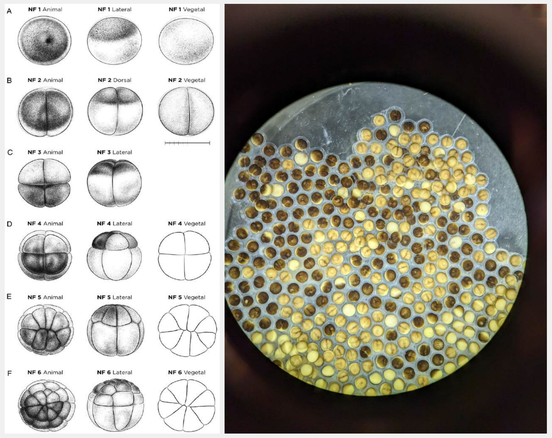

Figure 1. Xenopus embryos and their stages of development

- In previous semesters, participants in the capstone course developed a program for multi-class quantification using a machine learning algorithm based on the Stardist model.
- This semester, our project serves a similar purpose but is instead based on the Mask R-CNN model. This ongoing project is being conducted in collaboration with the Aquatic Germplasm Genetic Research Center (AGGRC) and the Marine Biological Laboratory (MBL).

Objectives

- Our goal is to develop a model using the Mask R-CNN architecture to classify fertilized and unfertilized *Xenopus frog embryos* and to compare its efficacy with that of the Stardist-based program.

VIA-Annotations

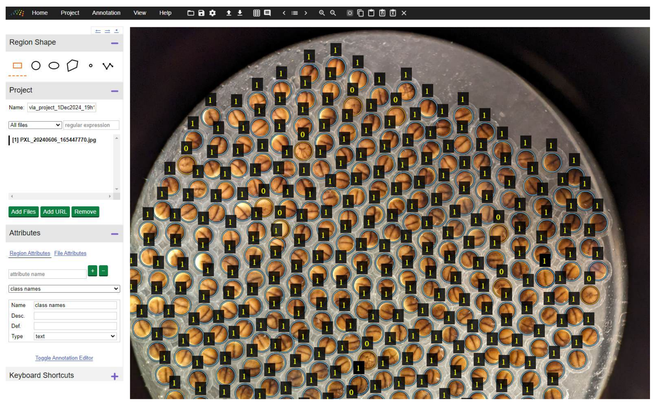

Figure 2. VGG-VIA Tool

- VGG Image Annotator (VIA) tool was been used to label each embryo in the images as fertilized (1), marked in blue, or unfertilized (0), marked in orange.

Density of Annotated Images

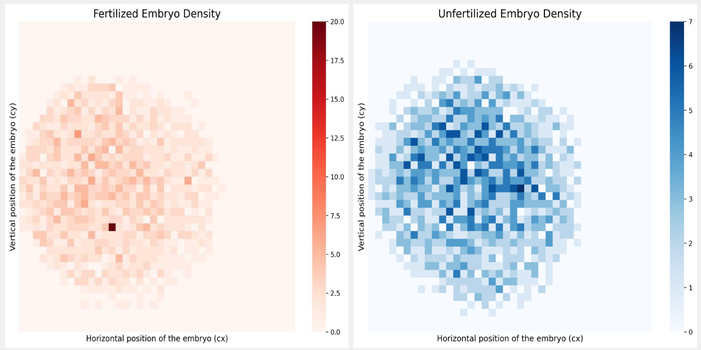

Figure 3. Heat maps of fertilized and unfertilized embryos

- The heatmap divides the image into regions based on the specified size, counting how many embryos fall within each region.
- A density of 20 indicates 20 embryos were found in that area.
- Higher densities are shown with darker colors (e.g., deep red for fertilized, deep blue for unfertilized), while lighter colors represent lower densities, visualizing the spatial distribution of embryos.

Mask R-CNN Architechture

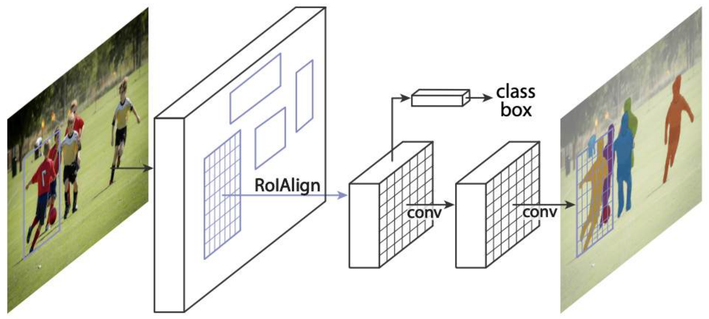

Figure 4. Mask R-CNN framework

- Mask R-CNN (regional convolutional neural network) is a two stage framework that begins with an image scan and generates proposals then end with classification and box generation.
- The backbone of Mask R-CNN is the Feature Pyramid Network + ResNet 101.
- ResNets facilitates the training of deep neural network without suffering from degradation in performance.
- Figure 4 illustrates instance segmentation using a function called “RoiAlign” in Mask R-CNN.
- The raw image dataset is been provided by AGGRC. We used VGG Image Annotater to count and classify frog eggs in each image to train the model.

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Future work

- We plan to have the model running soon to gather data and perform a proper analysis. Since the model was written using outdated Python libraries, we need to determine the required versions of those libraries.
- We aim to conduct a comprehensive comparison of the Mask R-CNN and Stardist neural networks, focusing on classification accuracies and other performance metrics when applied to the Xenopus frog embryo dataset.
- We intend to fully implement the model and integrate it with the GUI developed over the summer by the DeVision team.

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