DeepFE: Deep Learning for Frog Eggs Quantification

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Introduction to AGGRC

The AGGRC's mission is to globally advance germplasm repositories and genetic resource commercialization for aquatic species through interdisciplinary collaboration. Their approach empowers diverse communities to establish their own repositories by providing technologies and services. Their primary focus is standardizing and enhancing cryopreservation methods for aquatic species. Dr. Terrence Tiersch leads the center which is organized into four core program areas catering to research and industrial applications.

Problem Statement and Samples

The project commences by undertaking the enumeration and analysis of frog eggs, which are captured through digital imaging techniques.

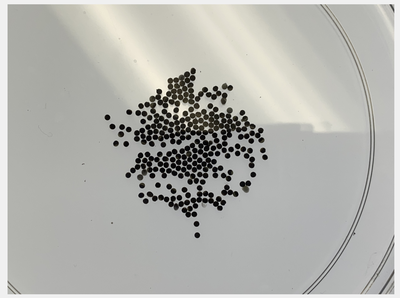

Figure 1. Less number of frog eggs in petri dish

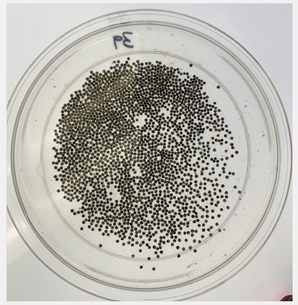

Figure 2. Large number of frog eggs in petri dish

The current egg counter Softwares exhibit constrained accuracy when applied to large datasets, necessitating the development of improved computational tools to address this limitation. In this study, we propose a solution by devising a UNet-based Convolutional Neural Network (CNN) that achieves significantly higher accuracy compared to existing tools.

Softwares

Fiji serves as a comprehensive image processing package, incorporating a fully equipped distribution of ImageJ. It encompasses a rich assortment of plugins specifically designed to streamline and enhance the scientific analysis of images. By bundling these plugins together, Fiji offers a convenient and all-inclusive solution for researchers and scientists engaged in the rigorous analysis of scientific imagery. This integrated package empowers users to efficiently conduct intricate image analysis tasks, contributing to advancements and breakthroughs in diverse scientific domains. Below are the three Plugins used in this project:

- StarDist
- LabKit

Process

The Flowchart presented below illustrates distinct phases within the annotation procedure employed for each image.

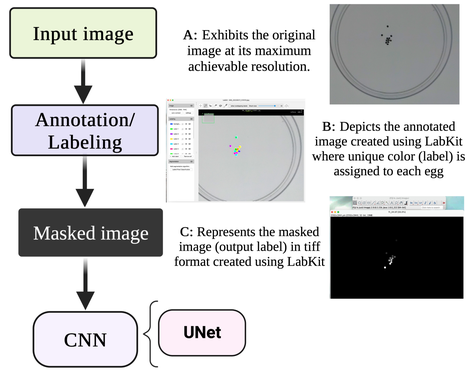

Figure 3. Flowchart representing steps involved in image data generation and deep learning methods used for training

Convolutional Neural Network (UNet)

CNN is a deep learning architecture specialized for computer vision tasks, using convolutional layers to extract meaningful features from images and achieve high accuracy in tasks like image recognition and object detection.

- UNet is a cutting-edge deep learning architecture designed for image data, featuring a U-shaped design that efficiently extracts features and precisely localizes objects.
- UNet excels in image segmentation and image-to-image translation tasks, finding broad applications in medical imaging, computer vision, and diverse fields due to its exceptional performance and accuracy.

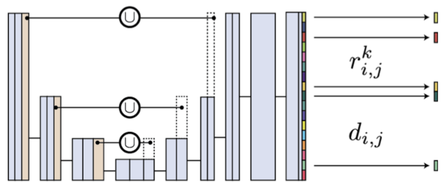

Figure 4. UNet architecture

where $r^k_{i,j}$ is distance to the boundary of the object to which the pixel belongs, along a set of n predefined radial directions with equidistant angles and $d_{i,j}$ is the object probability defined as (normalized) Euclidean distance to the nearest background pixel.

StarDist

StarDist is a cell detection method that employs a shape representation capable of accurately localizing cell nuclei in microscopy images.

- This representation utilizes star-convex polygons, which are well-suited for approximating the roundish shapes commonly observed in cell nuclei.
- By employing this flexible shape representation, StarDist achieves localization accuracy comparable to instance segmentation methods without requiring additional refinement.
- StarDist employs a lightweight neural network based on the U-Net architecture which ensures ease of training and usability.

Example of StarDist Working

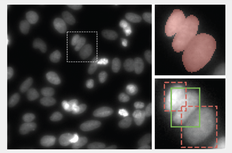

Figure 5. Figure 5 shows images with crowded nuclei may encounter segmentation errors like merging of touching cells (upper right) and suppression of valid instances due to bounding box overlap (lower right), leading to inaccurate cell representations and hindered identification in densely populated areas.

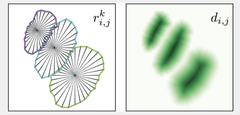

Figure 6. Figure 6 shows the StarDist approach predicts object probabilities $d_{i,j}$ and star-convex polygons characterized by radial distances r_k, facilitating accurate object detection and localization.

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References

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