Counting Mosquito Eggs using Computer Vision

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Place: CRI and Institut Pasteur collaborative project (Remote)
Duration of the internship: 4 Months

Introduction

Female mosquitoes lay their eggs near or in water, and after hatching mosquito larvae spend a week in this aquatic enviroanment before they fly away as adults. The microbial and chemical composition of the water in which they spend their childhood affects the health of the larvae and the adult mosquitoes they will turn into. Previous research has shown that specific microbes or nutrients in the larval environment make for very healthy adult mosquitoes, whereas larval exposure to other compounds and bacterial strains decreases e.g the life-span of adult mosquitoes. It is unknown how female mosquitoes evaluate a body of water before she lays her precious eggs.

To characterize the environmental cues that influence the oviposition choices of mosquitoes, laboratory experiments in which mosquitoes can choose between several potential egg laying sites are often performed.

Figure 1: Aedes aegypti mosquitoes [1]

Scientific Problem

In these experiments' mosquitoes deposit eggs on an 'egg paper' that is partly submerged in the water of the egg laying site. It is common practice that the number of eggs deposited on the paper is counted by hand. This method is very labor intensive and prevents large-scale egg laying experiments. In our project, we aim to develop a computer vision pipeline that takes a photograph of an egg paper as input, and accurately determines the number of eggs deposited on the paper. One challenge is that eggs are often deposited in clusters and individual eggs may overlap, providing an interesting computer vision challenge.

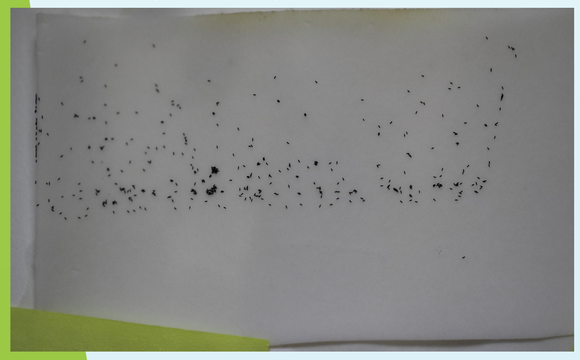

Figure 2: A picture of eggs deposited by *Aedes aegypti* mosquitoes on egg paper. Eggs may be deposited in clusters of scattered over the paper

Tools

Project Tools:
-Pycharm
-Google Colab Pro
-GitHub
-WandB (For visualization of results)
Project Management Tools:
-Notion

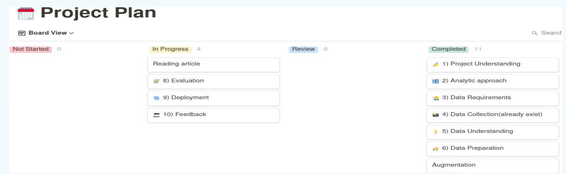

Figure 3: Personal Project Dashboard from NOTION Application

Methodology

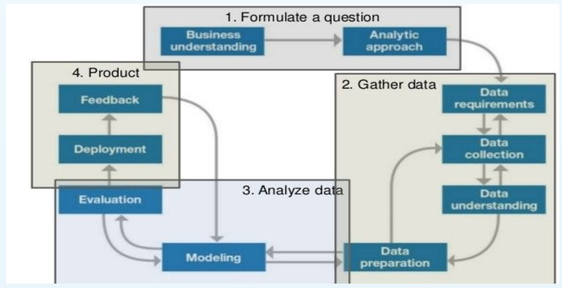

Figure 4: Table of Data Science Methodology [2]

1)Formulate a question or goal
We expect that applying a variety of deep learning models to this problem will result in an accurate algorithm to determine the number of eggs present on the image.
2)Gather data
As a result of the experiments carried out in the laboratory condition, the photographs of the mosquito eggs in the egg papers are taken. The size of the photos taken in our data-set is 5184X3456 and we have many ambient conditions (light reflection or uneven illumination) when photographing the eggs.
For the data preparation part:
***Image preprocessing**
We tried 4 different model, but we focused on 2 model, especially.
When we used the segmentation model, we only have 13 images.
For our object detection model, we created a dataset of 300 images ourselves. While creating this dataset, we made an annotation using 'VGG16 annotator ' application.
For the first model, we inverted the images and converted them to gray scale, and using the cropping image method, we enabled our model to learn better.

Figure 5: Showing the masks from Mask-RCNN model

Methodology(cont.)

For our second model, we divided each of our pictures into 6 parts, resized to 1024X1024, annotated, and then inverted. We also resized our test images to 1024X1024.

Figure 6: Inverted image

***Image Augmentations**
We used flip, rotate, affine, crop for segmentation model and brightness, vertically flip, horizontally flip, change color to gray for object detection model.
3)Analyze data
***Modeling Part**
We tried the Mask-RCNN and ResUnet models for segmentation, and the Faster-RCNN and Retinanet models for object detection within a period of 4 months. Our 2 focused models are Mask-RCNN and Faster-RCNN.
1)Mask-RCNN Model
We made a lot of changes in our dataset, backbone and configuration values, but we could not get good results.

Figure 7: Segmentation of eggs with Mask-RCNN model

After getting the results of the model, we decided to give up the sample segmentation and focus on object detection by changing the flow of our project, because this model was both too heavy and we got very low results when we evaluated it.
2)Faster-RCNN Model
It is a fully convolutional network that simultaneously predicts object bounds and objectness scores at each position. [3]
***Model Configurations**
-Changed batch size from 2 to 8
-Tried 10 different weights with Resnet50 or Resnet101 backbones
-Run the code with different learning rate
-Changed overlap threshold from 0,5 to 0,7
- Tried to split data set with 2 version

Evaluation and Results

Figure 8: The real image has 102 eggs, our model detect 86 eggs with 0,8 threshold level

Evaluation and Results(cont.)


```
Average Precision  (AP) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.359
Average Precision  (AP) @[ IoU=0.50      | area=   all | maxDets=100 ] = 0.720
Average Precision  (AP) @[ IoU=0.75      | area=   all | maxDets=100 ] = 0.318
Average Precision  (AP) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.359
Average Precision  (AP) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = -1.000
Average Precision  (AP) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = -1.000
Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=  1 ] = 0.023
Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets= 10 ] = 0.166
Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.410
Average Recall     (AR) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.410
Average Recall     (AR) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = -1.000
Average Recall     (AR) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = -1.000
[06/22 07:40:07 d2.evaluation.coco_evaluation]: Evaluation results for bbox:
|   AP   |  AP50  |  AP75  |  APs   |  APm   |  APl   |
|:------:|:------:|:------:|:------:|:------:|:------:|
| 35.910 | 71.991 | 31.766 | 35.910 |  nan   |  nan   |
```

Figure 8: Total loss graph and IoU metrics

Deployment and Recommendations

Deployment part; our goal in the project is to enable easy calculation of eggs by making a clear and understandable interface suitable for the end user that biologists can use.

Figure 9: Dashboard of the project website

We can recommend, for the later stages of the project, it is worked with fewer layers by freezing the resnet50 layers. In addition, a separate data set consisting of clustered eggs can be established to better detect overlapped eggs.

Conclusion and Skills

During my internship, I learned what the problems that can be encountered in real life are, and I learned how to adapt to the changes in the plan of the project. I tried to understand being able to work interdisciplinary. I did face one big challenge that is lack of dataset and tried to deal with it.
My hard/soft skills are Deep Learning, OpenCV, Streamlit, Segmentation and object detection models, Python skills, Project management, (remote) communication
In the future, I want to focus on the engineering part of computer vision and machine learning.

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References

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