

WCR Beetle Detection

By: Pavan, Jeremy, Ayush, Sam

Background of project

- Western corn rootworm beetles (*Diabrotica virgifera virgifera*)
- Native to North America, and one of the most destructive pests of corn in the United States.
- Larvae feed on the roots of corn plants - leads to reduced crop yields and plant death.
- Problematic because it developed resistance to many insecticides.
- Farmers continue using these insecticides and BT crops rather than other measures continuing the issue.



Beetle Traps

- Currently, traps spread across the fields are used to count and predict the estimated number of beetles in an area.
- A drone is used to take pictures and manually count the number of beetles in each trap.
- Farmers tend to use this less due to the convenience of using insecticides and BT corn.
- Predicting and avoiding large beetle populations can save lots of money for farmers and prevent beetles from developing resistance.



Details about measurement

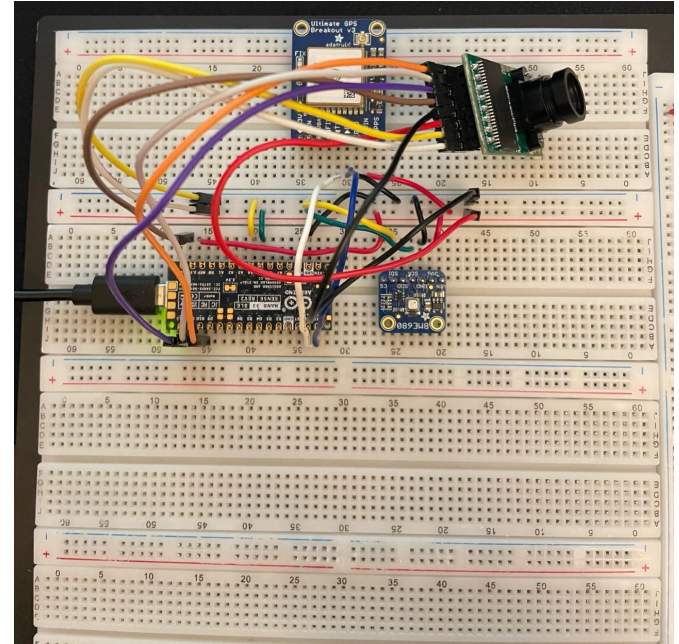
- Camera
 - Save photo
 - Name in .CSV for ease of use
- BME
 - Environmental data
 - Compare amounts to other measurements like temp
- RTC
 - Timestamp (in .CSV)
- GPS
 - Location for trap validation



Details about board

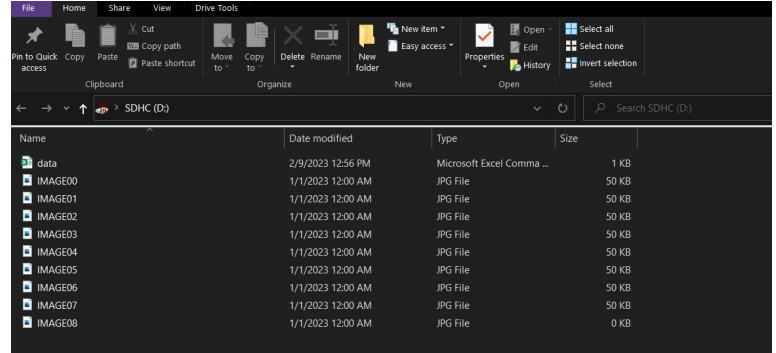
Components:

- Arduino Nano
 - Lighter and more powerful than the mega.
Ideal for ML task mounted on drone.
- Arducam 2MP camera (i2c & SPI)
- Ultimate GPS (combined RTC) (UART)
- BME680 (i2c)



Details about data acquisition

- Format of the Data
 - Save Image
 - Measurements
 - Image name
 - Time to save image
 - Write CSV



```
> void writeCSV(String picname, String speed_knots, String direction) { ...  
}  
String picturename = "IMAGE00.JPG";  
> void getphoto() { ...  
}
```

```
myFile.print(__TIME__);myFile.print(",");myFile.print(__DATE__);myFile.print(",");  
myFile.print(picname);myFile.print(",");myFile.print(speed_knots);myFile.print(",");myFile.println(direction);  
Serial.println("Finished writing to file.");  
lcd.setCursor(0,1);  
lcd.print("Closing");  
myFile.close();
```



Data Analysis

Labeled Dataset



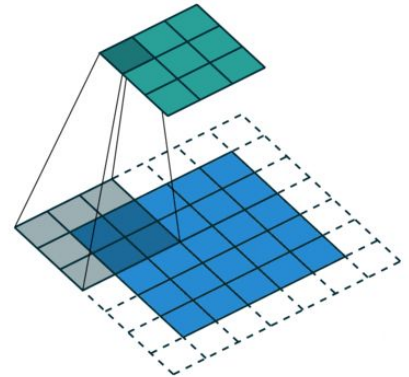
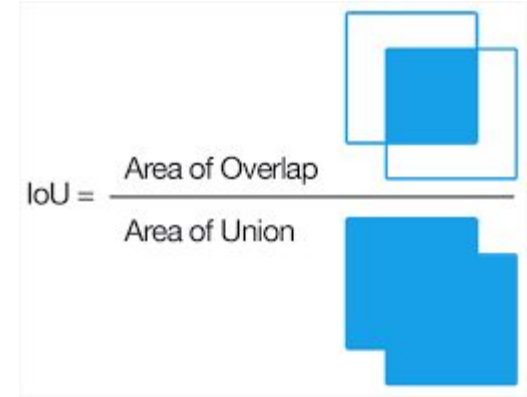
Cropping

- Idea: cropping the background out makes the job easier on the ML model
- Problem: finding the boundaries of the trap and transforming the shape into a rectangle
- Use “magic wand” algorithm to find boundary of yellow trap
 - Closely related to color filtering
- Warp quadrilateral boundary into rectangle (“perspective mapping”)



Machine Learning Terminology

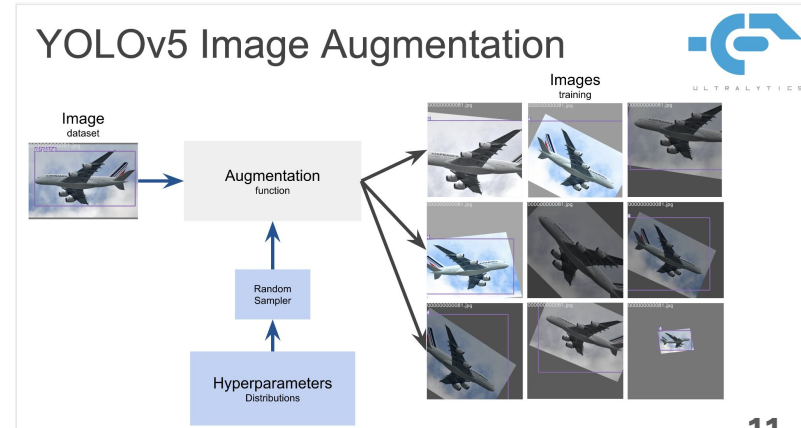
- Intersection over Union (IoU)
 - Quantifies degree of overlap between two regions
- Precision
 - Proportion of predicted positives that were correct
- Recall
 - Proportion of actual positives that were predicted correctly
- Average Precision
 - Area under precision-recall curve, calculated class-wise
- mean Average Precision (mAP)
- Convolutional Neural Network (CNN)
 - Great for Computer Vision
 - Extracts high-level features like edges

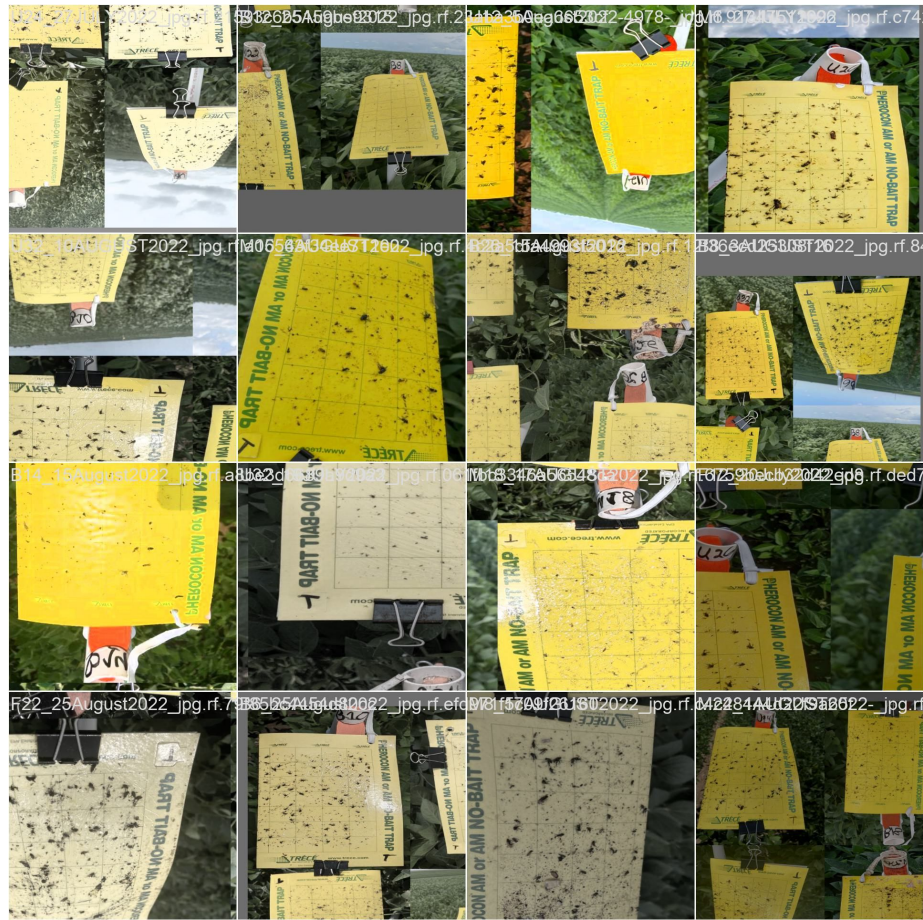


YOLOv5

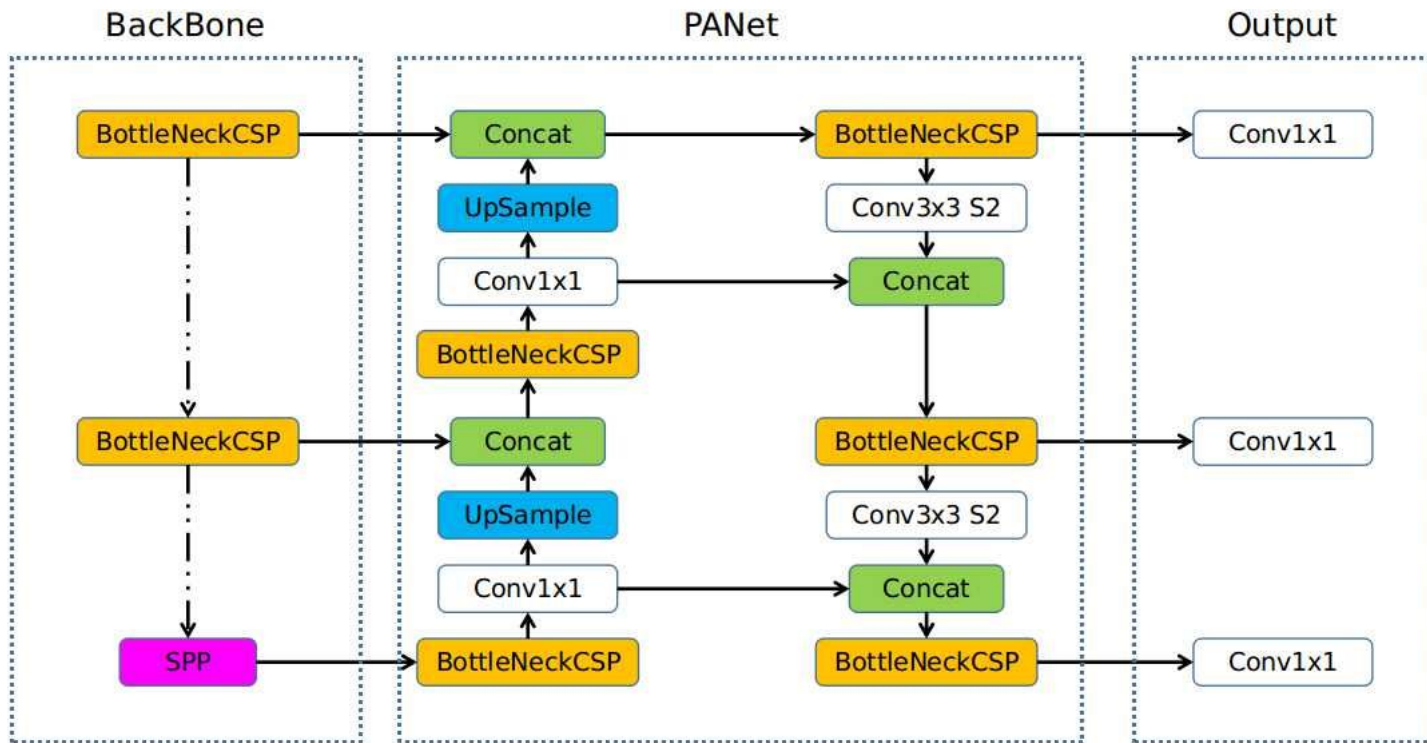
- ~250 images, 41 beetles
- 80-20 train-test split
- Excellent computer vision AI for object detection and image classification
- Preprocessing methods:
 - Cropping
 - Normalization
- Data augmentation methods:
 - RandomPerspective
 - Mosaic
 - Vertical/Horizontal Flip
- Outputs bounding box location

Model	size (pixels)	mAP ^{val} ₅₀₋₉₅	mAP ^{val} ₅₀	Speed CPU b1 (ms)	Speed V100 b1 (ms)	Speed V100 b32 (ms)	params (M)	FLOPs @640 (B)
YOLOv5n	640	28.0	45.7	45	6.3	0.6	1.9	4.5
YOLOv5s	640	37.4	56.8	98	6.4	0.9	7.2	16.5
YOLOv5m	640	45.4	64.1	224	8.2	1.7	21.2	49.0
YOLOv5l	640	49.0	67.3	430	10.1	2.7	46.5	109.1
YOLOv5x	640	50.7	68.9	766	12.1	4.8	86.7	205.7

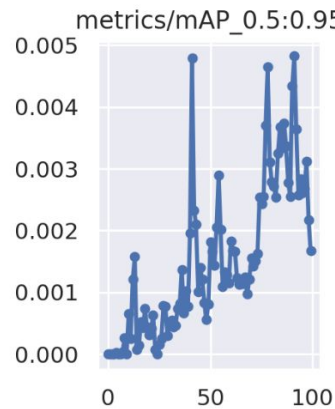
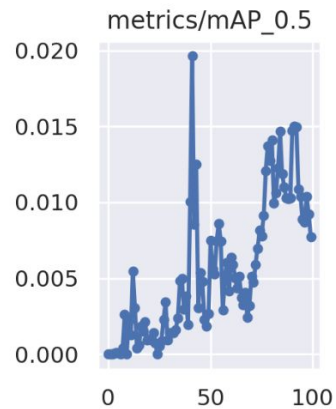
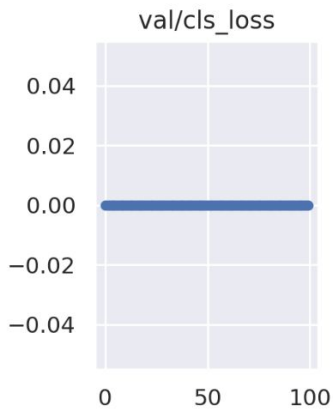
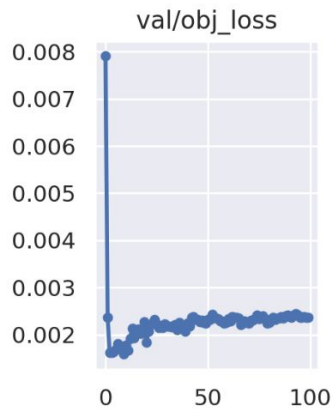
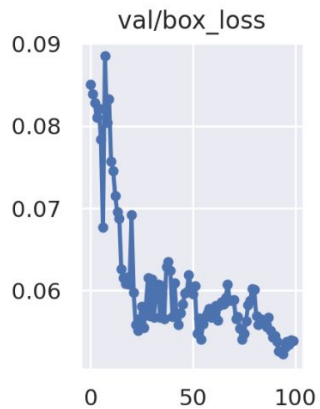
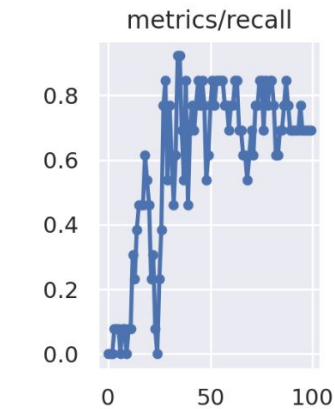
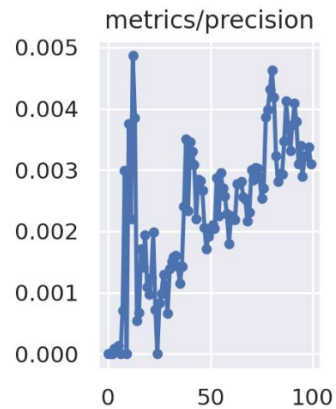
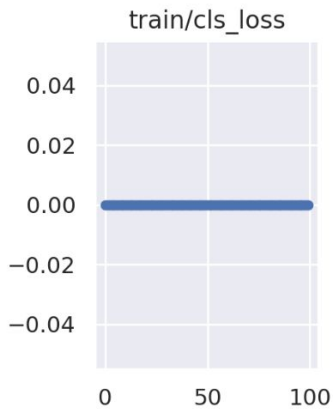
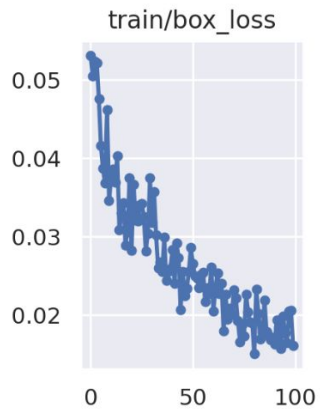




Overview of YOLOv5







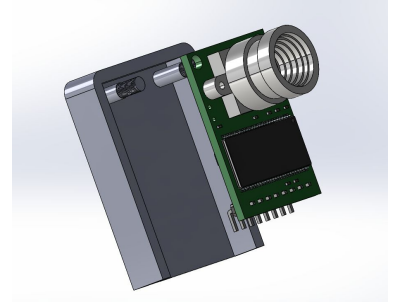
Trouble along the way...

- GPS Data reading
 - Satellite communication problem
- Code Complications
 - Looking into writing library
- Arduino Nano interface complications
- Making model more accurate (mAP)
- CAD Model (Air flow)



Plans

- PCB and case development
- Continue cropping
- Color filtering (detecting beetles by looking at the color)
- **Vertical trap images** - currently we only have angled trap images
- Testing using spare traps
- Implementing ML model into part of data acquisition



Future Prospects

- Integrating a drone to help take pictures of traps in the field.
- Adding an ultrasonic module (to help find the right height to capture picture (HC-SR04)



Thank you for listening!

Sources

<https://github.com/ultralytics/yolov5>

<https://stackoverflow.com/questions/2992264/extracting-a-quadrilateral-image-to-a-rectangle>

<https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53>

<https://pyimagesearch.com/2016/11/07/intersection-over-union-iou-for-object-detection/>

