Identification of Palmer Amaranth in Cotton Utilizing Deep Learning

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Introduction

With a total estimated economic impact of $18.5 billion across the entire U.S. economy, U.S cotton production still remains a lucrative production crop (Vulchi, 2022). Cotton yield losses due to *Amaranthus palmeri* (Palmer amaranth) can be as high as 65% (Berger et al 2015). Subsequently successful management of this weed is predicated on early detection and expeditious herbicide application.

Modern technology advancements have allowed researchers and growers alike to utilize unmanned aerial vehicles (UAVs) to replace traditional agricultural equipment to perform farming operations. UAVs, along side other available technologies, can be used in scouting, identification and treatment of Palmer amaranth in cotton.

Objective

The objective is to build upon and improve the current state of technology- assisted weed management in cotton, with two specific approaches of:

(1)Automate the detection of Palmer amaranth

(2)Increase the efficiency of treatment with spray capable UAVs

Materials and Methods

Utilizing ArcGIS Pro's export training data tool, a single UAV image of an early season cotton field with an abundance of Palmer amaranth present was split into 256x 256 pixel tiles.

- To use this tool in ArcGIS Pro the Deep learning libraries must be installed prior

Understanding this was an object classification task, the Palmer amaranth in the training images were manually labeled using an open sourced python based software called LabelImg.

Once Image labels were complete the YoloV5x model was selected, trained, and tested on the labeled dataset.

- 680 images training, 125 images testing
- Epochs: 20
- Batch size: 16

Results: Algorithm input and output

Figure 1

Figure 2

Figure 1: User labeled image used to train the Yolov5x deep learning model.
Figure 2: Model results output of the Yolov5x prediction of Palmer amaranth.

Results: Confusion Matrix

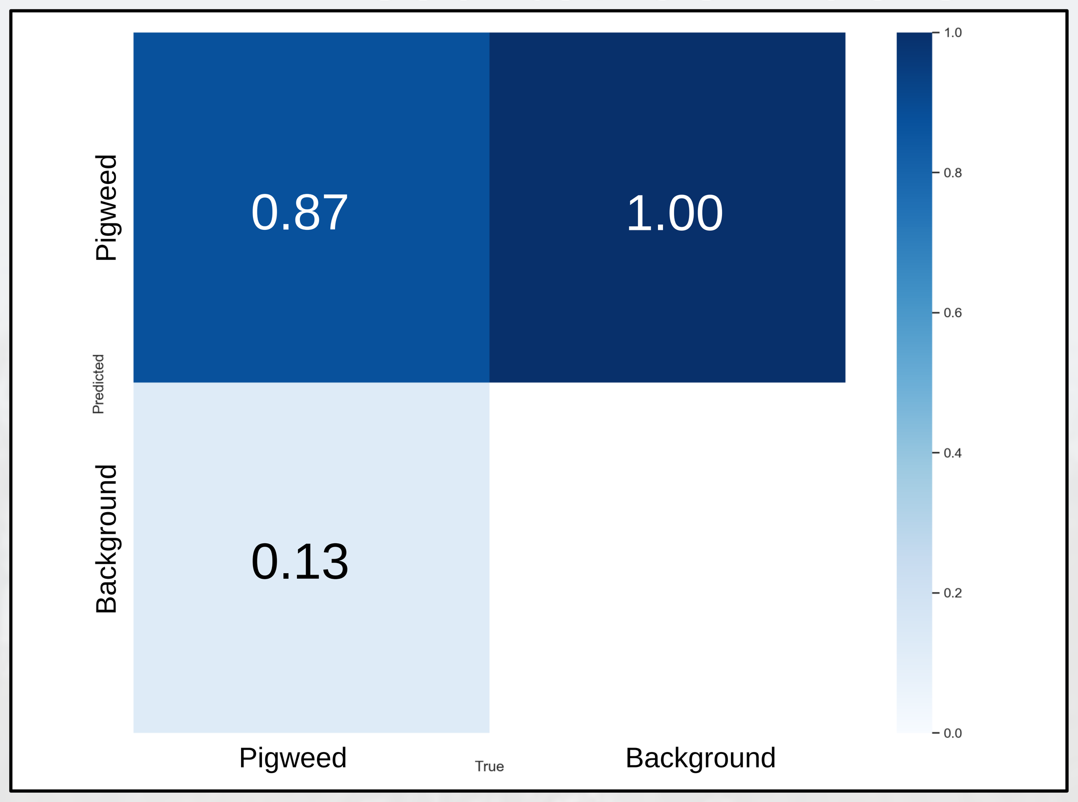

Figure 3: The confusion matrix illustrates an 87% model accuracy of Palmer amaranth identification.

Results: Precision Recall Curve

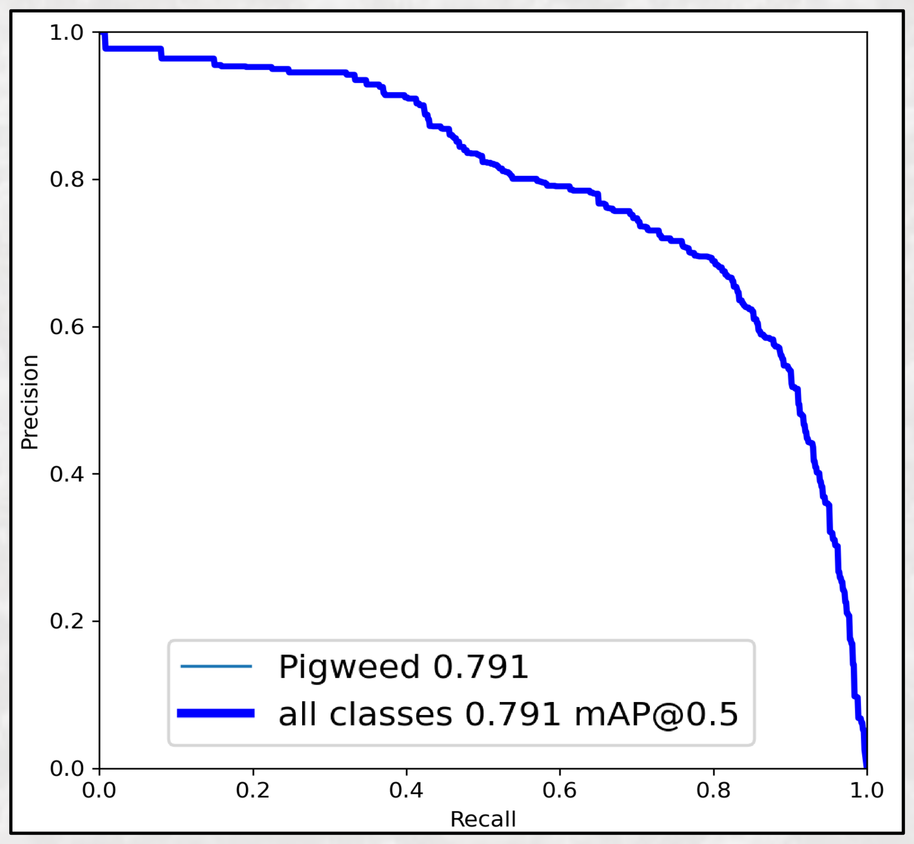

Figure 4: The model's PR curve that communicates the model's performance, with an AP score of 0.791, through precision (positive predictive value) and recall (sensitivity).

Future Work

With only 800 images parsed from a single field image, the algorithm dataset was suboptimal as Yolov5 recommends at least 1500 training images for the identification of a class.

As this trial will continue in the 2023 season, regular drone flights will be performed to collect field images at varying growth stages of both the cotton crop and Palmer amaranth.

The objective during this growing season is the collection of field images for robust and optimal training of the algorithm.

Conclusions

The YoloV5x model was effective in detection of Palmer Amaranth, but not necessarily time efficient. Deep learning does show great potential with creation of weed maps that can be used for UAV based site specific application of herbicide. Further work however is needed for deployment of a trained model because of the extensive time component and personnel familiar with weed identification required for image labeling and refinement of the route optimization code.

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