Weed and Crop Detection Using YOLOv11s

Project Overview

This project involves training a YOLOv11s model to detect and classify crops and weeds in agricultural images. The goal is to provide accurate real-time detection to assist in automated weeding systems.

We used the WeedCrop Image Dataset for training and evaluation. The dataset contains labeled images with bounding boxes for 'crop', 'weed', and 'background'.

Model and Methodology

Model Used: YOLOv11s (a lightweight, real-time object detection model)

Classes: crop, weed

Loss Functions:

- Box Loss: Measures bounding box regression error

- DFL (Distribution Focal Loss): Improves bounding box quality by predicting a distribution over possible box offsets

- CFL (Classification Focal Loss): Handles class imbalance by focusing more on hard-to-classify examples

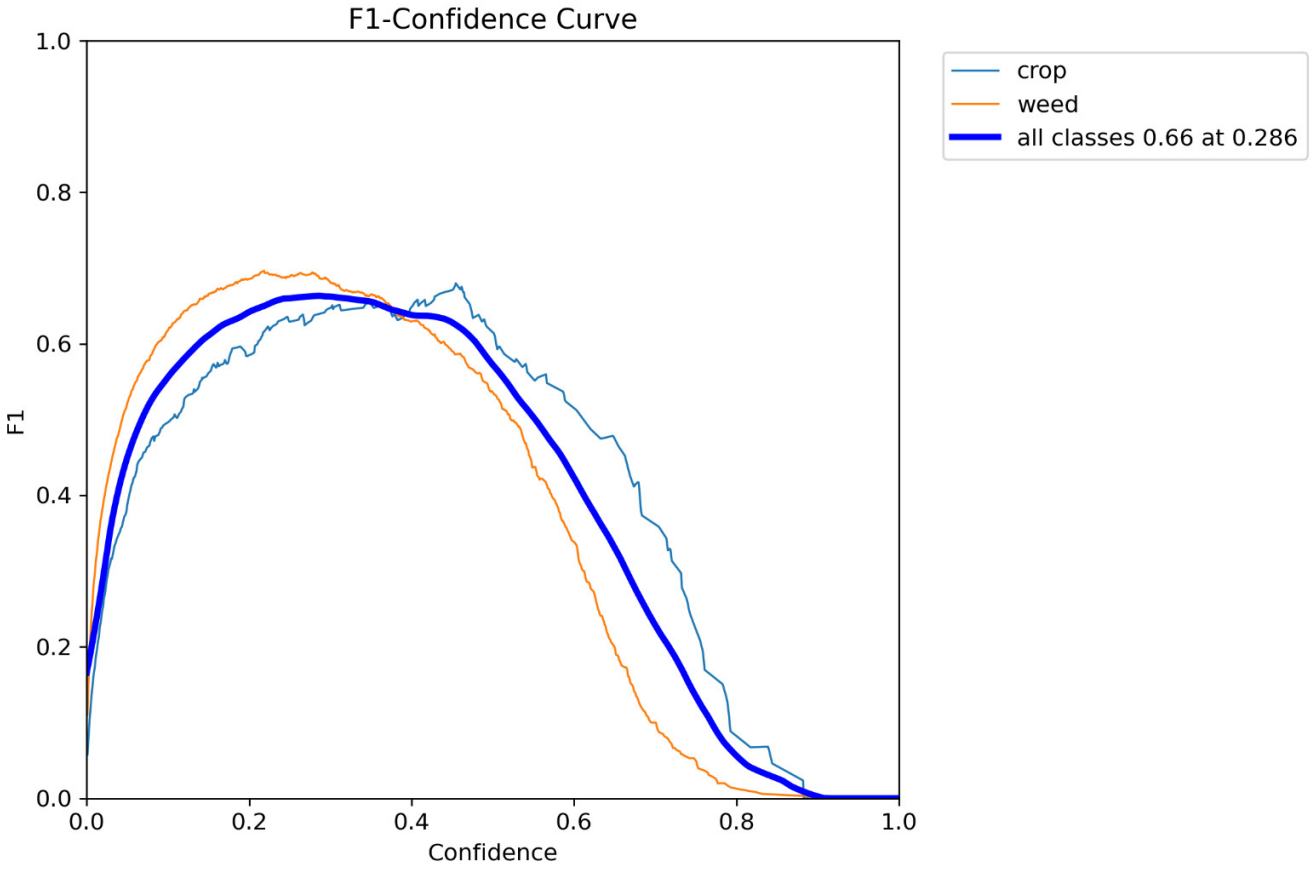
Performance Metrics

Class-wise Detection Metrics:

Metric	Crop	Weed	All (Average)
Precision	0.753	0.694	0.723
Recall	0.612	0.792	0.702
mAP@0.5	0.681	0.739	0.710
mAP@0.5:0.95	0.361	0.388	0.374

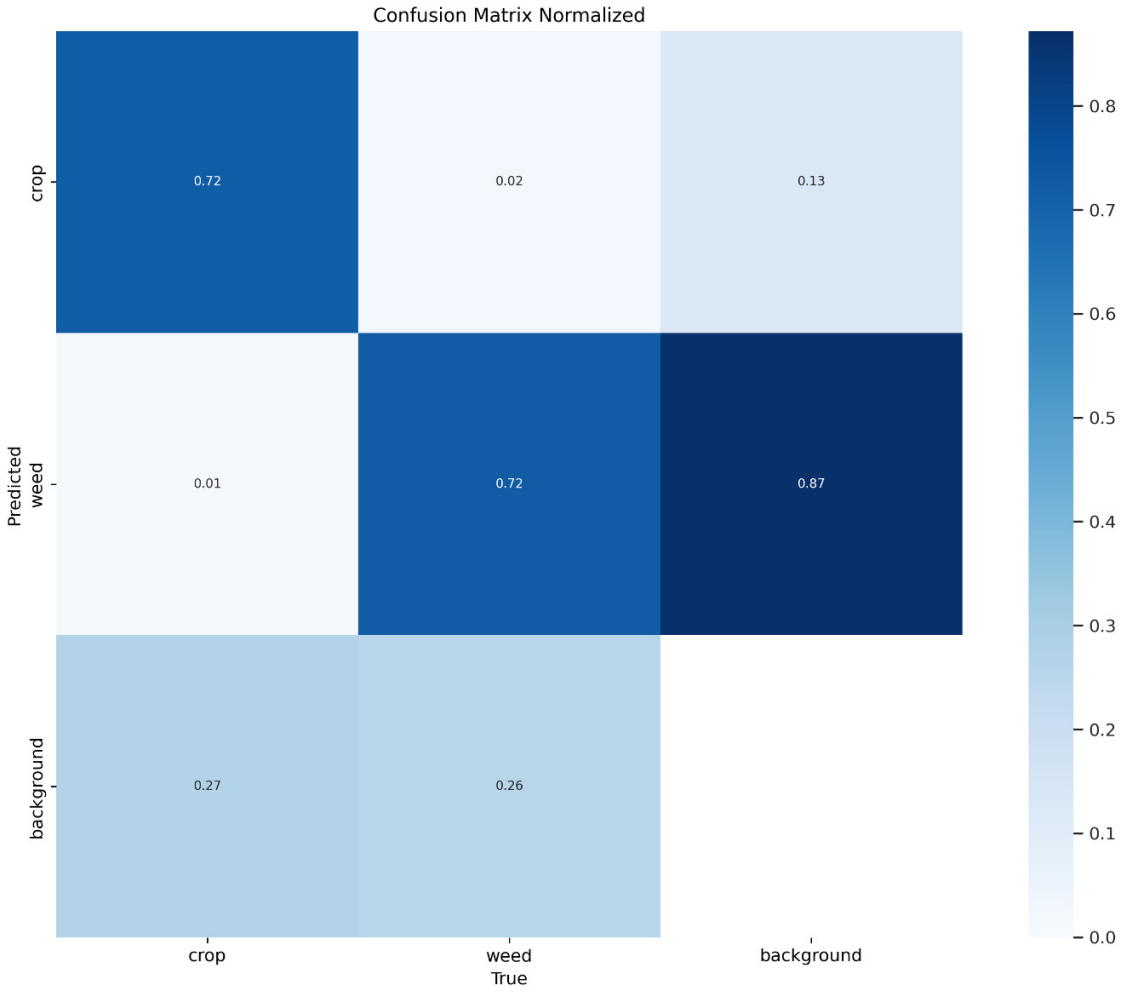
Threshold Selection

Based on the F1-Confidence Curve, we observed that the best trade-off between precision and recall occurred at a confidence threshold of 0.4. This threshold maximizes F1-score while reducing the risk of misclassifying crops as weeds.



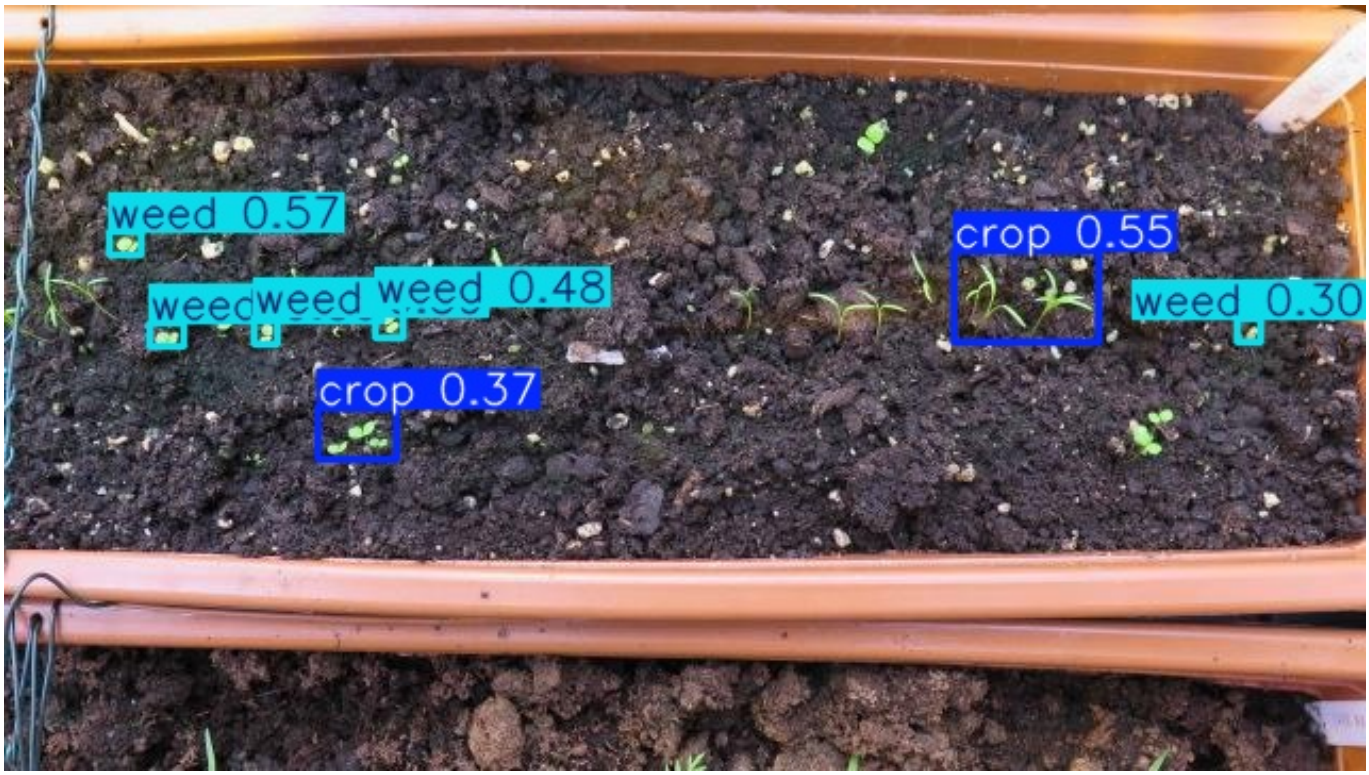
Confusion Matrix

The normalized confusion matrix highlights model performance across all classes.



Example Output

The model successfully detects multiple instances of crops and weeds with confidence scores displayed:



Conclusion

The YOLOv11s-based model demonstrates good detection accuracy, particularly for weed detection. The selected confidence threshold of 0.4 provides a reliable balance between minimizing false positives on crops and maintaining overall detection performance.

Future improvements may involve:

- Collecting more labeled crop samples
- Applying advanced augmentation
- Experimenting with larger or more accurate YOLO variants (e.g., YOLOv11m or v8)