A COMPUTER VISION FRAMEWORK FOR EARLY-STAGE SUNFLOWER STAND COUNT ESTIMATION

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INTRODUCTION

Estimation of stand count at early growth stages of sunflower is critical, impacting key traits such as survival and biomass accumulation. Current data collection processes are lengthy and labor-intensive. High-throughput methods using tools like UAVs and robots combined with computer vision have been applied in other crops to estimate stand count, and this study introduces a similar approach for sunflower. The research involved three phases: (1) collecting thousands of images of plants at two early growth stages, vegetative emergence (VE) and four true leaves (V4); (2) annotating images and training an object detection model; and (3) deploying the model on field videos of research plots. Model performance was evaluated using mean average precision (mAP), precision, recall, F1score, and accuracy, and results were compared to manually collected ground truth data using a Wilcoxon signed rank test and Pearson correlation. Preliminary findings indicate the model effectively detects plants across all field conditions, though additional training is still needed to improve accuracy. This study shows potential for automating the traditionally manual task of collecting sunflower stand count, allowing for more efficient phenotyping tools.

Manual Counting

- Lengthy
- Labor-intensive
- Limits large-scale phenotyping

Object Detection Models

- Annotation (bounding boxes)
- Augmentation (alteration of images)
- Model training (learned patterns)
- Model analysis (FN/FP rate, precision, recall, mAP)
- Model deployment (object tracking, visualizations)

RESEARCH

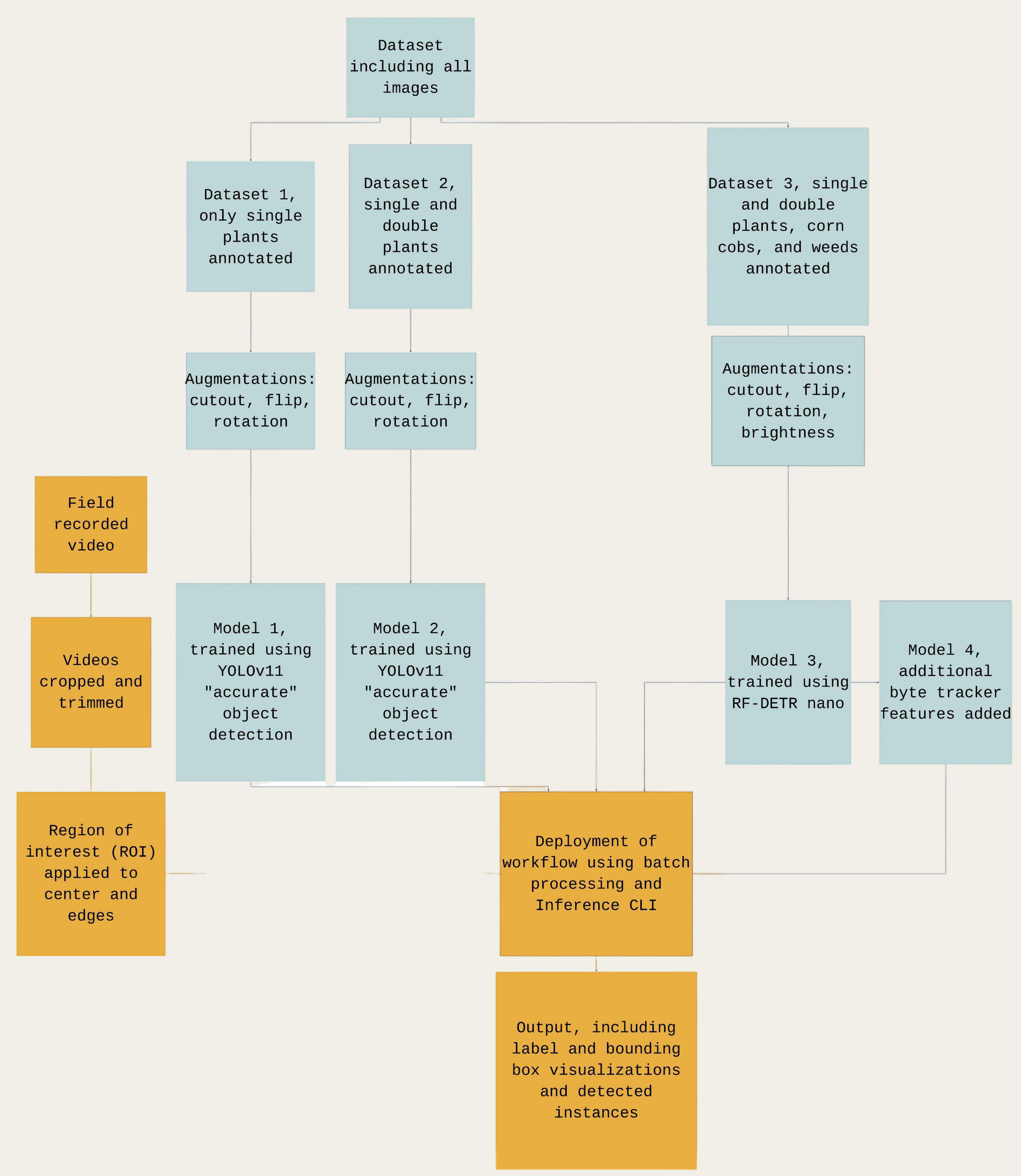
Objectives

- Train an object detection model to count sunflower plants at VE and V4 growth stages
- Evaluate under variable field and lighting conditions
- Deploy on real field data and compare to ground truth

Data Collection

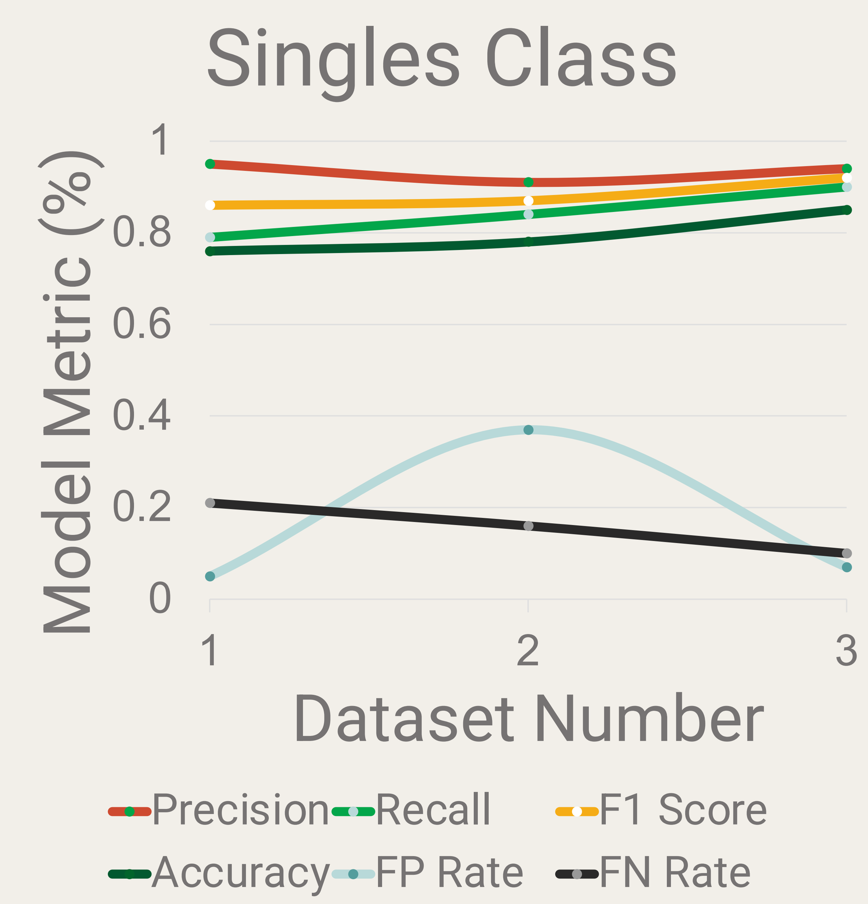
- **Model training:** 30,750 images over two years, two growth stages, and three field sites with a split of 70% training, 20% validation, and 10% test
- **Model deployment:** video of each plot at each field and growth stage via tractor-mounted drone camera, with a subset counted manually for validation

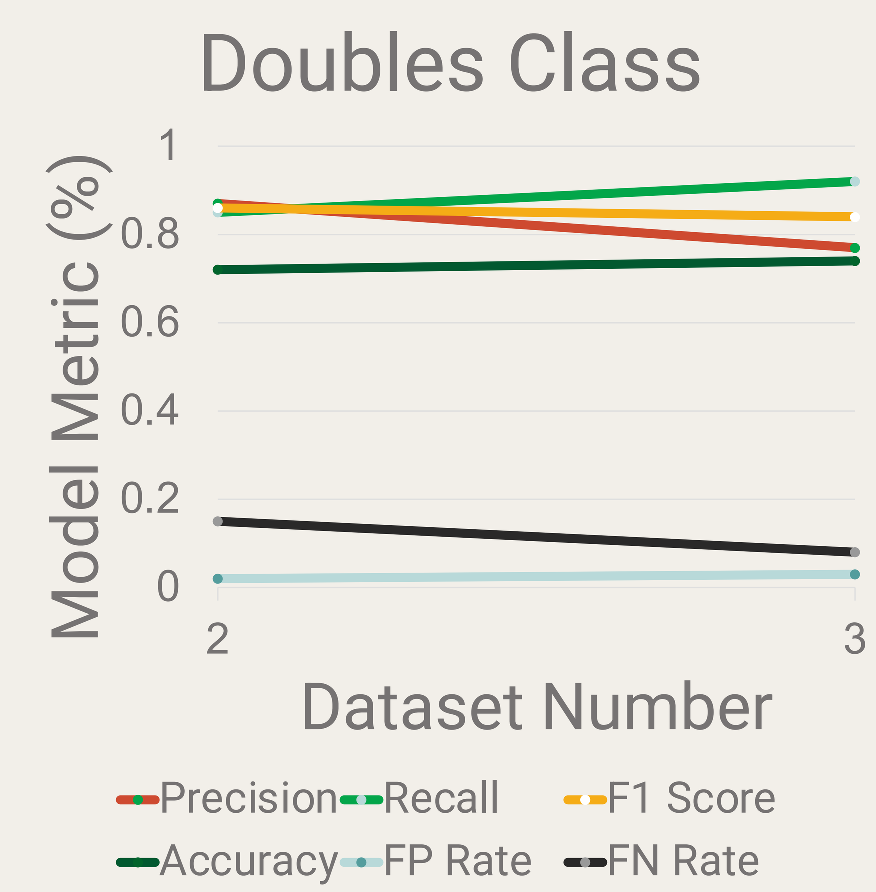
Model Training and Deployment



Blue boxes represent steps associated with model training and yellow boxes represent steps associated with model deployment

RESULTS





Discussion

Model training of dataset 3 showed promising results

- Lowest false negative rate (single and double)
- Lowest false positive rate (single)
- Highest recall (single and double), precision, F1 score, and accuracy (single)

Model deployment produced significantly different counts than true counts when validated using video data, over or under counting (Wilcoxon signed rank test), though some counts were correlated with true counts (Pearson correlation)

Conclusions

- **Model training** metrics confirm that automated counting is not only feasible, but highly promising
- **Model deployment** and validation must be improved by better object tracking and higher quality video data
- Once refined, this model will revolutionize sunflower phenotyping, enabling fast, accurate, and scalable stand count data collection

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