Semi-Supervised Weed Detection Challenge

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1 Introduction

1.1 Problem Statement

Develop a model pipeline to accurately identify and localize weeds in images. The performance is evaluated using the following metric:

$$\text{Metric} = 0.5 \times (\text{F1-Score}) + 0.5 \times (\text{mAP@[0.5:0.95]}) \tag{1}$$

1.2 Dataset Overview

Labeled Images: 200 **Unlabeled Images:** 1000

2 Approaches Tried & Proposed Solution

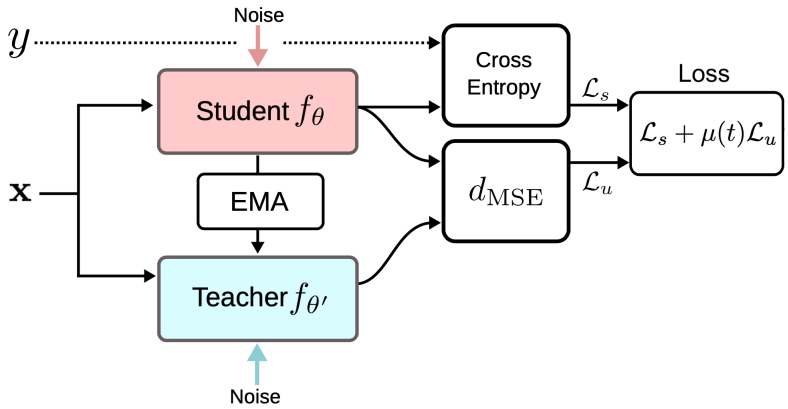
2.1 Initial Approaches

- **SimCLR (Semi-Supervised Learning)**:
  - Task: Image classification
  - Accuracy: 74%
- **Mean Teacher with YOLO-v8**:
  - Joint classification & detection approach.
  - Outcome: Increased training/inference time with less accurate results.
  - **mAP@[0.5:0.95]:** 0.531 on test set

2.2 Implemented Pipeline

1. Classification:

- **Model:** ResNet-50 fine-tuned with Mean Teacher Method.
- **Method:** Mean Teacher



  - **Student Model:** Learns from labeled/unlabeled data using cross-entropy loss for labeled examples.

- **Teacher Model:** An exponential moving average (EMA) of the student, providing stable targets for unlabeled data.
- **Benefit:** Enhances feature learning from unlabeled data, leading to robust classification.

2. Detection:

- **Model:** YOLO-v8s fine-tuned on augmented data. Apart from that we are using Resnet50 based on MTM architechture .
- **Data Augmentation:** Expanded the original 200 images with 160 augmented images (three variations), resulting in a 640-image dataset.

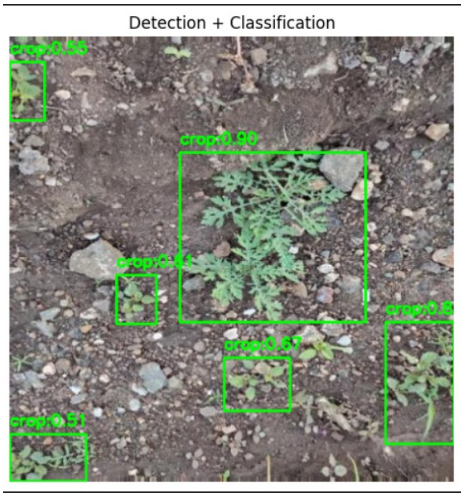
3. **Integrated Pipeline:** YOLO-v8 detects weed artifacts, and the fine-tuned ResNet-50 classifies detected regions by cropping it and then doing classification on it which increases the robustness of model.

3 Challenges

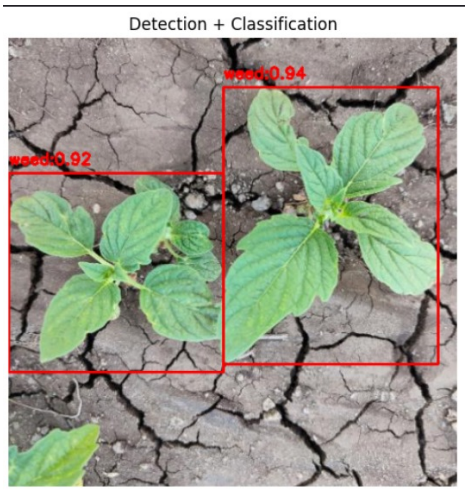
- **Limited Labeled Data:** Necessitates robust semi-supervised methods for effective utilization of unlabeled dataset and extensive augmentation.
- **Computational Complexity:** Mean Teacher & YOLO-v8 integration increased training/inference time.
- **Accuracy Challenge:** Without Mean Teacher, baseline model ResNet-50 achieved 74% accuracy. Using Mean Teacher method, augmentation, and 100 epochs, an F1-Score of 1 was obtained.
- **Pipeline Integration:** Ensuring seamless data flow between Detection and classification stages.

4 Results

- **Classification Model: F1 Score:** 0.76
- **Detection Model: mAP@[0.5:0.95]:** 0.881
- **Final Score :** 0.8205



Green - crop



Red - weed

5 Conclusion

The two-stage pipeline is designed to maximize the utility of both labeled and unlabeled data. In the first stage, the pipeline intelligently integrates unlabeled data to complement the labeled dataset, thereby enhancing the overall learning process. The second stage leverages advanced techniques to refine the model further. For example, the Mean Teacher Method was applied to a ResNet-50 architecture, resulting in a notable improvement in its performance. This method works by maintaining a teacher model whose predictions guide the student model during training, effectively reducing loss and improving accuracy.