Problem Introduction

- Background:
  - Pests, Water, and Weed abatement are grower's biggest problems
  - Between 2007 and 2013, weeds resulted in $27 Billion crop loss for corn farms and $16 Billion for soy farmers (around 50% loss for each crop) [1]
  - Labor is becoming scarce and expensive, encouraging automation
- Project Goal:
  - Train a classifier to distinguish between sugar beet crop and 9 weeds using the Sugar Beets Dataset [2][3]
  - Quantify classifier performance (Precision, Recall, F1-Score)

Related Work

FarmWise,
California, USA

Nived Chebrolu[1], Philipp Lottes[1], Alexander Schaefer[2], Wera Winterhalter[2],
Wolfram Burgard[2] and Cyrill Stachniss[1]

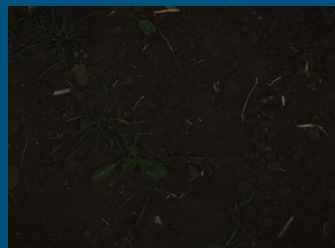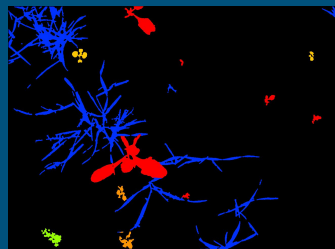Stachniss Lab,
University of Bonn,
Germany

Technical Approach: Overview

Annotated Masks

RGB Images

Batch Size of 32

Trained Model

Calculate Metrics

Refine Masks

Calculate Loss

New Data Set

Back Prop

Training Data Set

Testing Data Set

Optimizer/ Scheduler

For 100 Epochs

Training Complete

$$Pr = \frac{N_{TP}}{N_{TP} + N_{FP}}$$

$$Re = \frac{N_{TP}}{N_{TP} + N_{FN}}$$

$$F_{\beta} = \frac{(\beta^2 + 1) \times Pr \times Re}{\beta^2 \times Pr + Re}$$

$$F_1 = \frac{2 \times Pr \times Re}{Pr + Re}$$

Data Set Processing

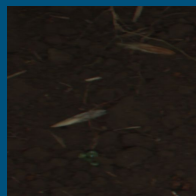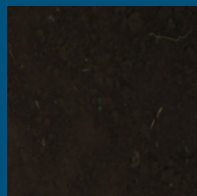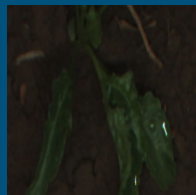Network Training

Classifier Evaluation
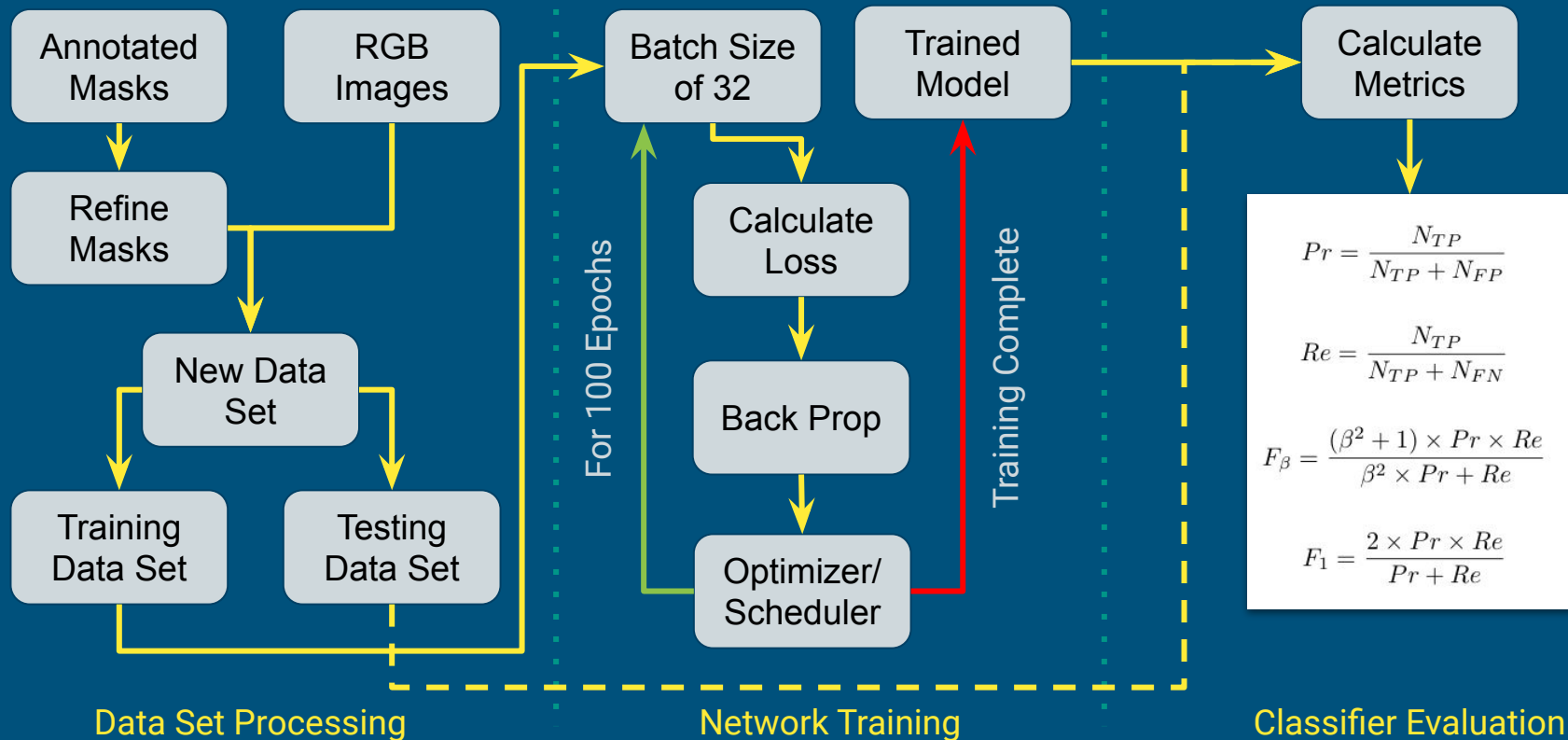
Technical Approach: Dataset Manipulation
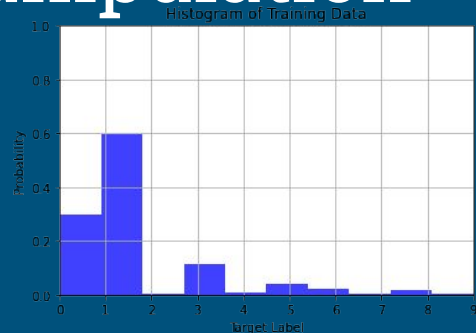

Original Dataset
(251 Masked Images)

R.O.I.
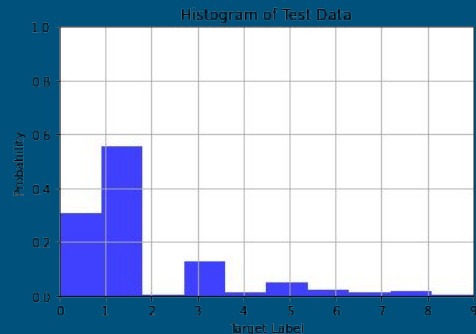
Crop / Weed Regions of Interest
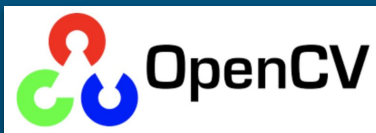(3998 Subsampled Images)

Training

Test

Histogram of Training Data

2966 Images

Histogram of Test Data

1032 Images

OpenCV

NOTE: classifier selects data with weighted random sampling

Technical Approach: Classification
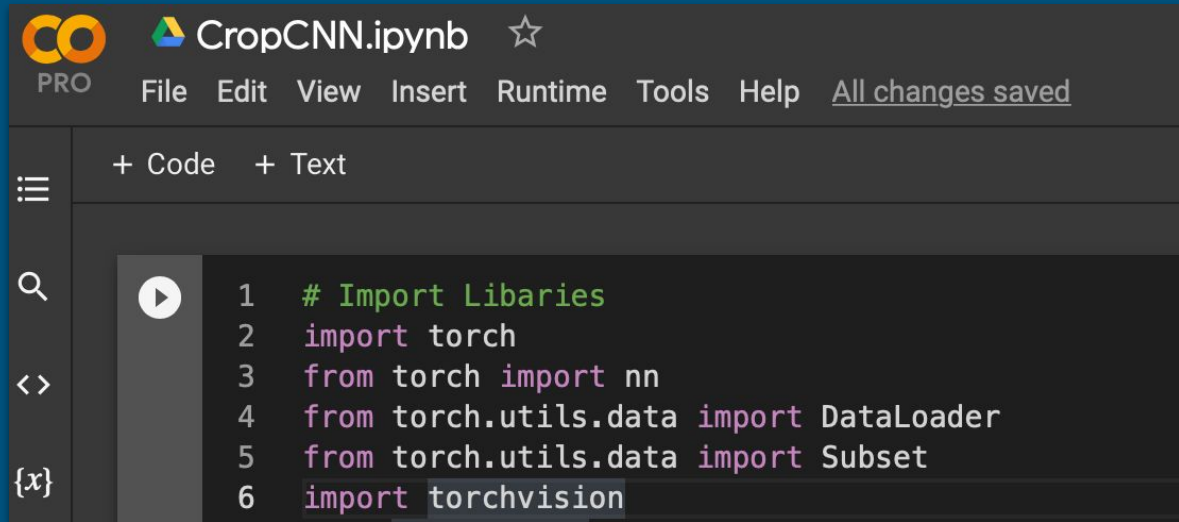
ResNet18

batch_size = 32

epochs = 100

eta = 0.01

imgDim = 224

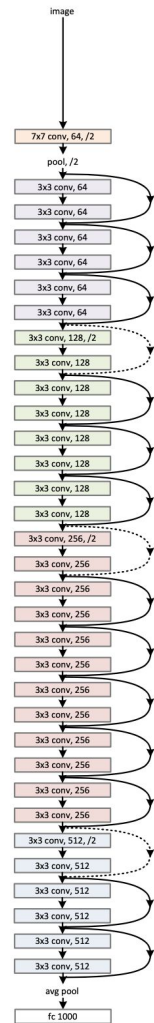step_size = 25

gamma = 0.01

cross entropy loss


```
1   # Import Libaries
2   import torch
3   from torch import nn
4   from torch.utils.data import DataLoader
5   from torch.utils.data import Subset
6   import torchvision
```

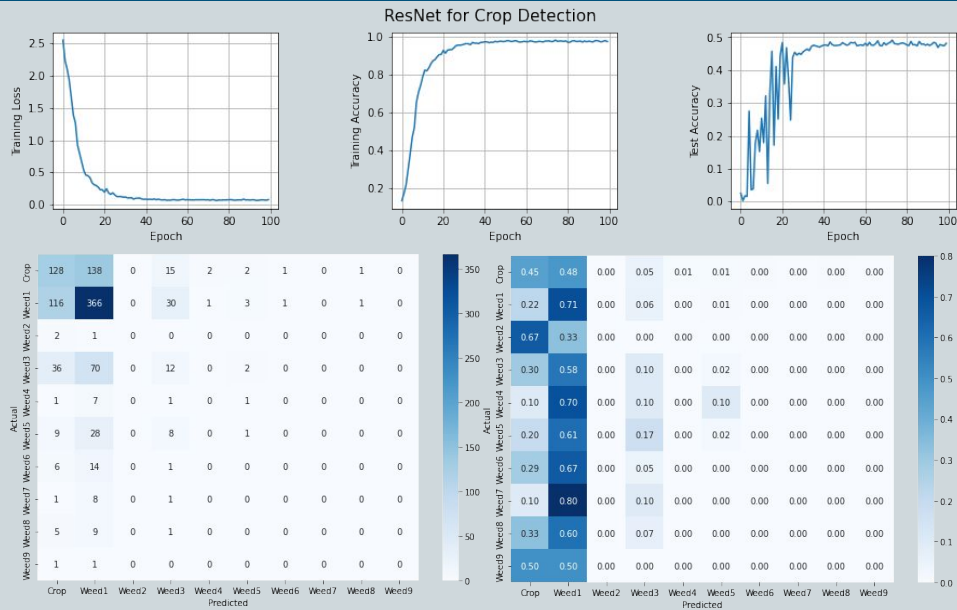$$l_n = -\sum_{c=1}^{C} \log \frac{\exp x_{n,c}}{\exp(\sum_{i=1}^{C} x_{n,i})} y_{n,c}$$

DEMO

Data Preprocessing Scripts, Training Notebook, Performance Test

Results: 10 Class Dataset

Labels	Precision	Recall	F1 Score
Crop	0.42	0.45	0.43
Weed1	0.57	0.71	0.63
Weed2	0.00	0.00	0.00
Weed3	0.17	0.10	0.13
Weed4	0.00	0.00	0.00
Weed5	0.11	0.02	0.04
Weed6	0.00	0.00	0.00
Weed7	0.00	0.00	0.00
Weed8	0.00	0.00	0.00
Weed9	0.00	0.00	0.00

Results: 3 Class Dataset

Labels	Precision	Recall	F1 Score
Crop	0.52	0.52	0.52
Weed (Big)	0.56	0.59	0.57
Weed (Small)	0.50	0.48	0.49
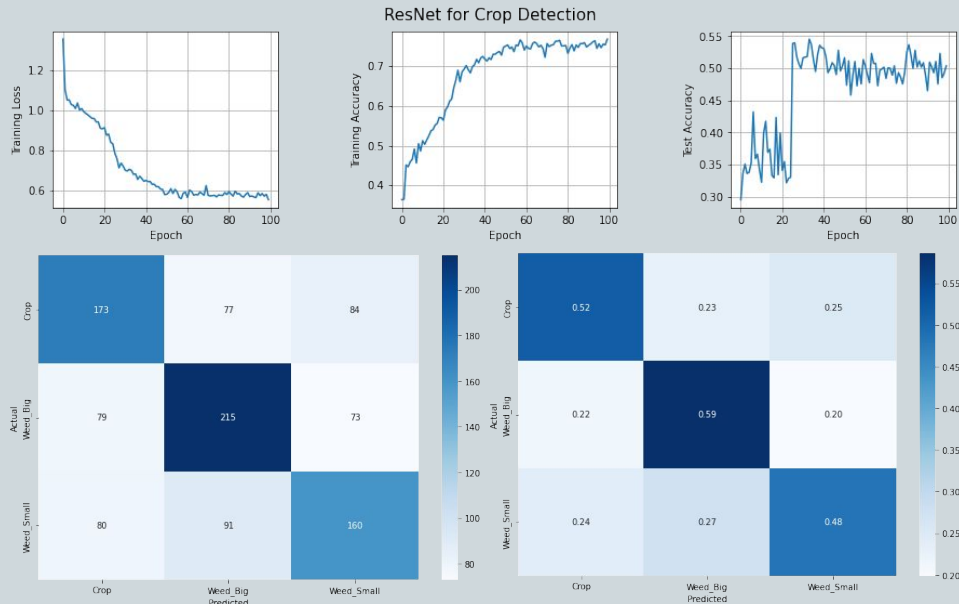
Conclusions

- Summary:
  - Classifiers performed poorly on the Sugar Beets data set
  - Weighted random sampling improved the performance of the 10-class classifier, the results still showed a heavy bias
  - The 3-class classifier showed the best results
- Future Work:
  - **Masking Improvements:** several regions have crops and weeds are growing next to each other, creating a two-class image
  - **Data Augmentation:** either creating new synthetic data based upon the original samples or by duplicating existing samples with added noise and transforms (rotations, flips, skews, etc.)
  - **Additional Tuning:** only a small selection of network architectures and parameters were tested

References

[1] "Crop Loss." Weed Science Society of America.
https://wssa.net/wssa/weed/croploss-2/

[2] Lu, Yuzhen, and Sierra Young. "A survey of public datasets for computer vision tasks in precision agriculture." Computers and Electronics in Agriculture 178 (2020): 105760.

[3] "2016 Sugar Beets Dataset" http://www.ipb.uni-bonn.de/data/sugarbeets2016/

Questions?