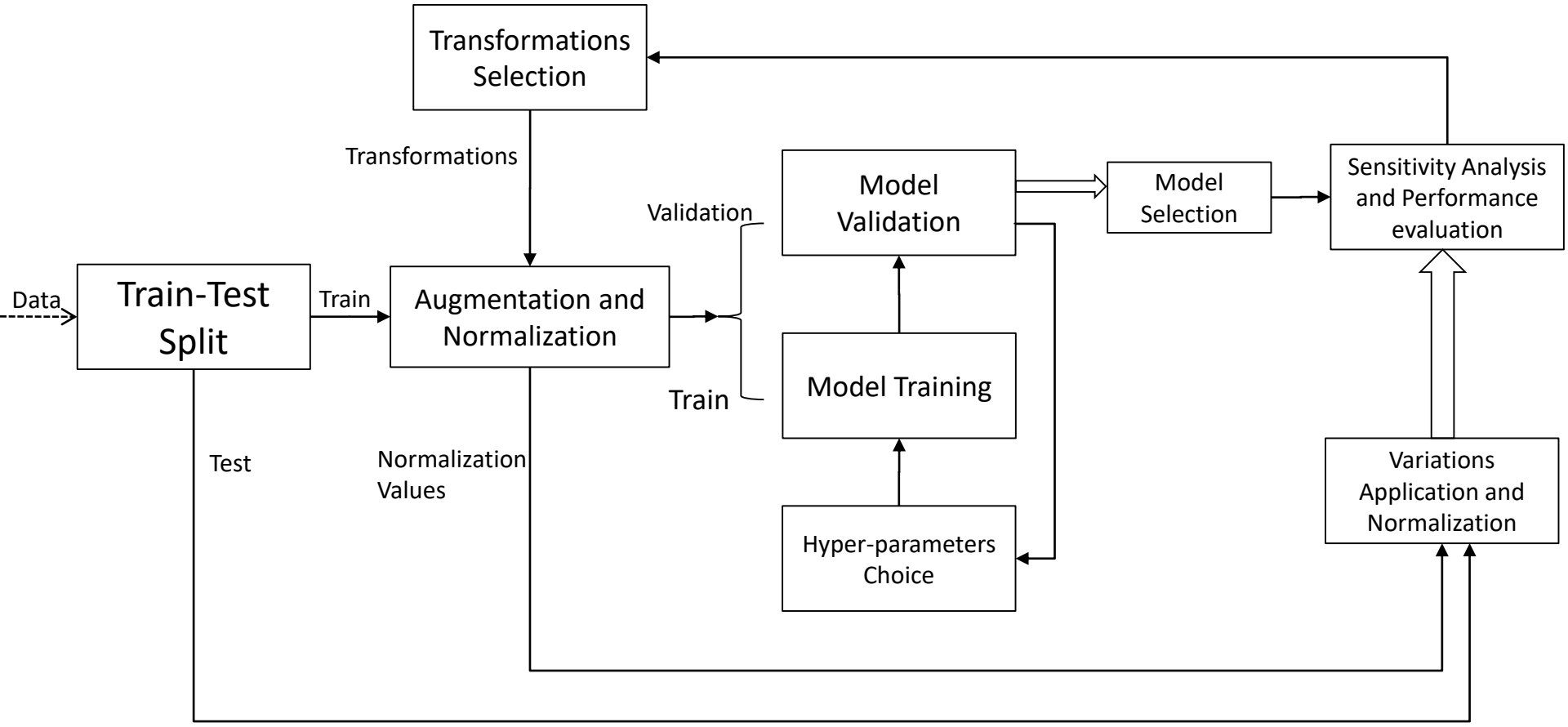

# Deep Learning approach to Tomato Plant Diseases Recognition and related Sensitivity Analysis

Deep Learning: Theory, Techniques and Applications

A.Y. 2017/2018

Alessandro Erba, Mirco Manzoni, Giuseppe Mascellaro

# Proposed Workflow Approach



# Dataset

Bacterial Spot
2.127 samples

Early Blight
1.000 samples

Healthy
1.590 samples

Late Blight
1.909 samples

Leaf Mold
952 samples

Septoria leaf spot
1.771 samples

Two Spotted Spider mite
1.676 samples

Target Spot
1.404 samples

Tomato Mosaic Virus
373 samples

Tomato Yellow Leaf Curl virus
5.356 samples

# Data Augmentation and Normalization

Before the Training and Validation pahses data are augmented and Normalized.

Each sample is transformed taking two transformations from this pool:

- Flip Top Bottom,
- Flip Left Right,
- Rotate 90°,
- Rotate 180°,
- Rotate 270°,
- Flip Top Bottom and Rotate 90°,
- Flip Top Bottom and Rotate 270°.

Data are normalized in two different ways:

- Dataset Normalization
- Per-leaf Normalization

# Binary Classification - Setup

- Healthy vs Infected
- Architecture: LeNet
- Xavier initialization
- Rectified linear unit (ReLU) activation function
- Binary cross-entropy Loss
- Adam Optimizer
- 10-Fold cross Validation

# Binary Classification - Results

Accuracy 99.92%

Precision 99.34%

Recall 99.67%

F1 - measure 99.5%

Confusion Matrix

| | |
|---|---|
| TP = 300 | FN = 1 |
| FP = 2 | TN = 3375 |

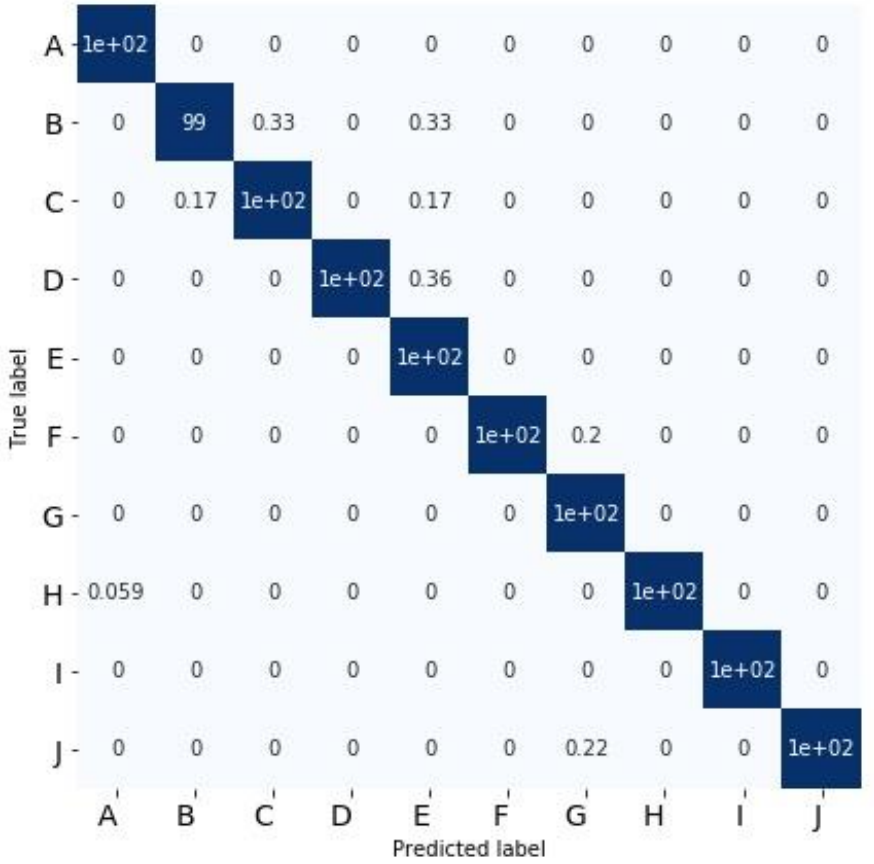
# Multi-class Classification

- AlexNet architecture
  - Train from scratch
  - Transfer Learning
- Xavier initialization
- Rectified linear unit (ReLU) function
- Cross-entropy Loss
- Adam Optimizer
- Cross-validation

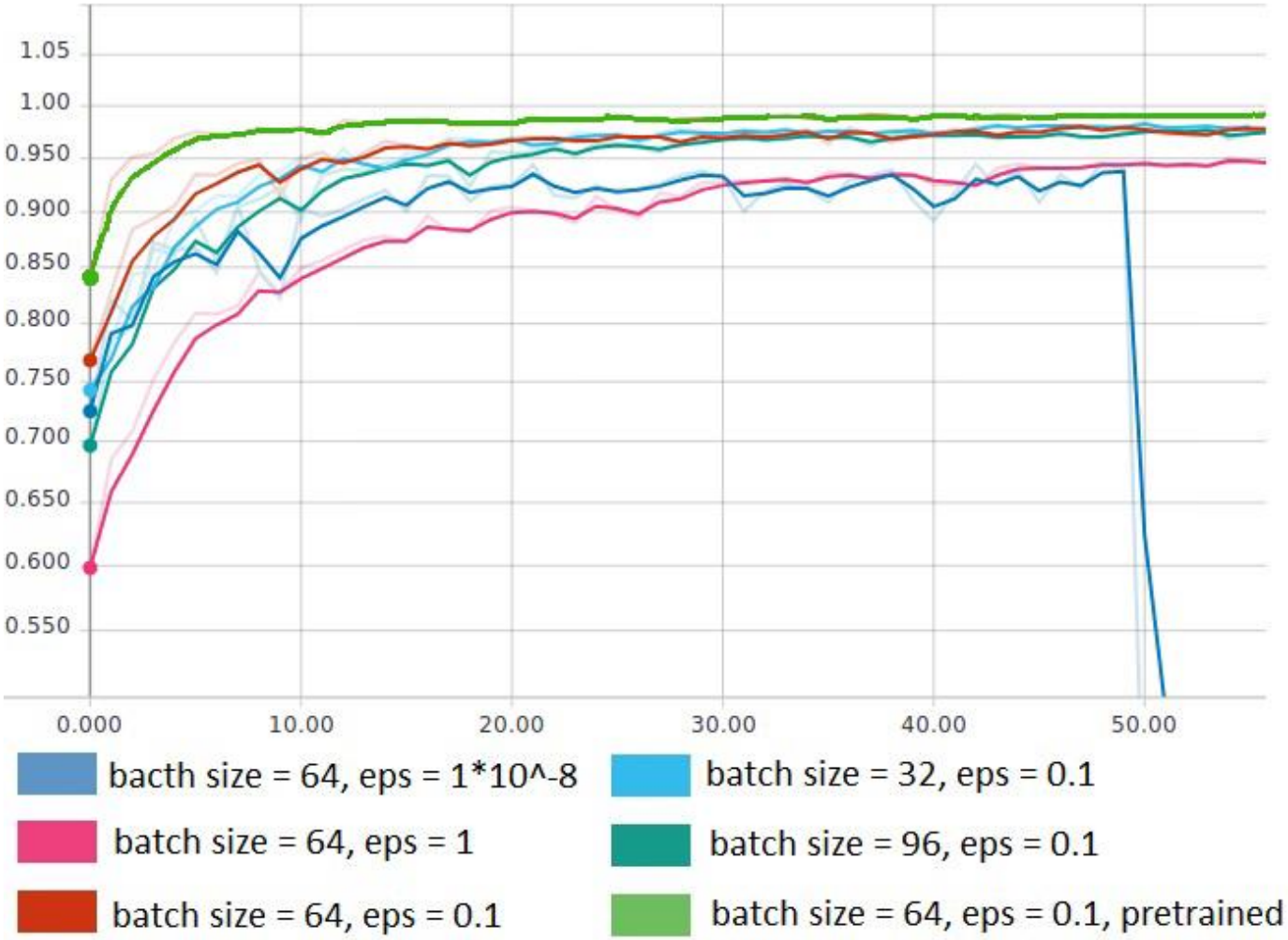
# Multi-class Classification - Results

Accuracy: 99.85%
Macro precision: 99.83%
Macro recall (Trues Rate): 99.82%
Falses Rate: 0.18%
Macro F1: 99.83%

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy



# Multiclass Classification - Training accuracy with different setup

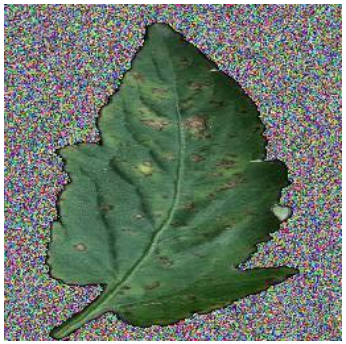


# Sensitivity Analysis Datasets

Original dataset

Segmented dataset

Random Background Crop dataset



Random Noise Background dataset

Random Noise Background dataset

# Sensitivity Analysis
## Normal Train vs Segmented Test

Train

Original dataset

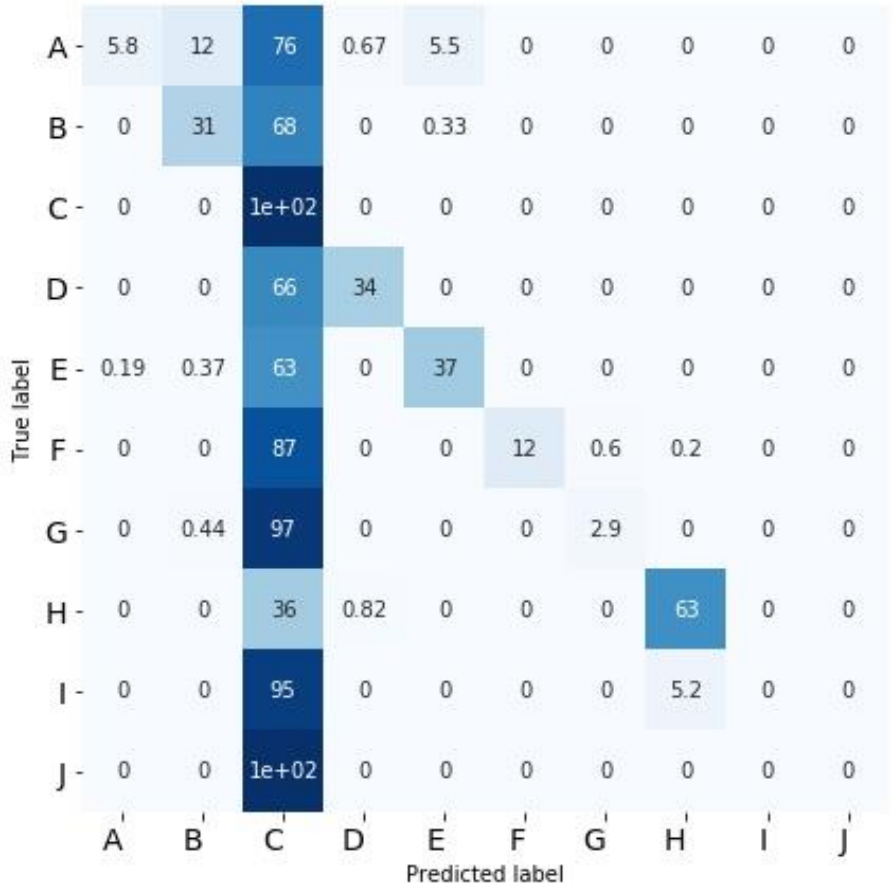
Test

Segmented dataset

Accuracy: 39.01%
Macro precision: NanN
Macro recall (Trues Rate): 28.58%
Falses Rate: 71.41%
Macro F1: NaN

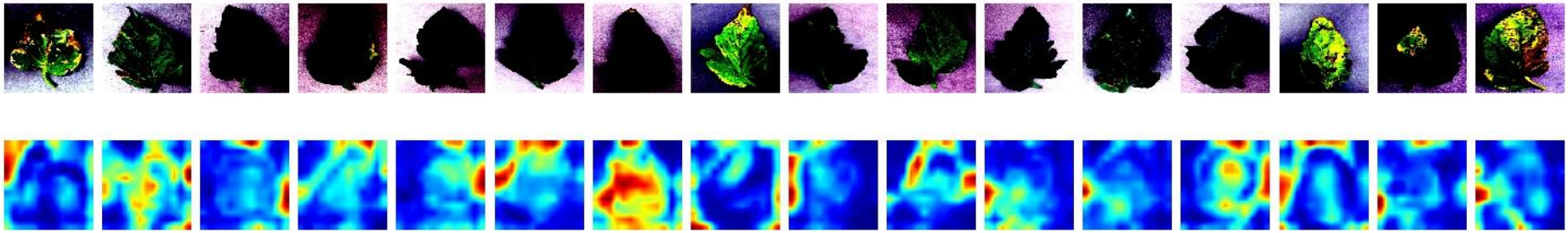
# Sensitivity Analysis
# Normal Train vs Segmented Test

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy

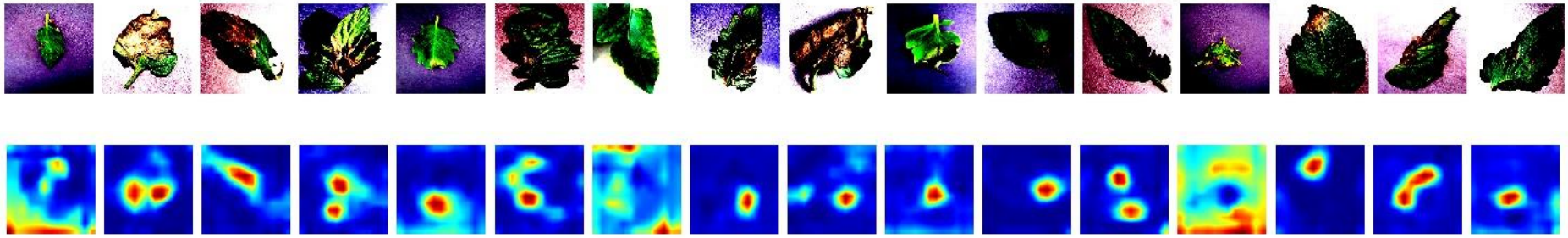


# Sensitivity Analysis
# Normal Train vs Normal Test Activation Visualization

Bacterial Spot Class



Late Blight Class



# Sensitivity Analysis - Segmented Test vs Normal Train

Train

Segmented dataset

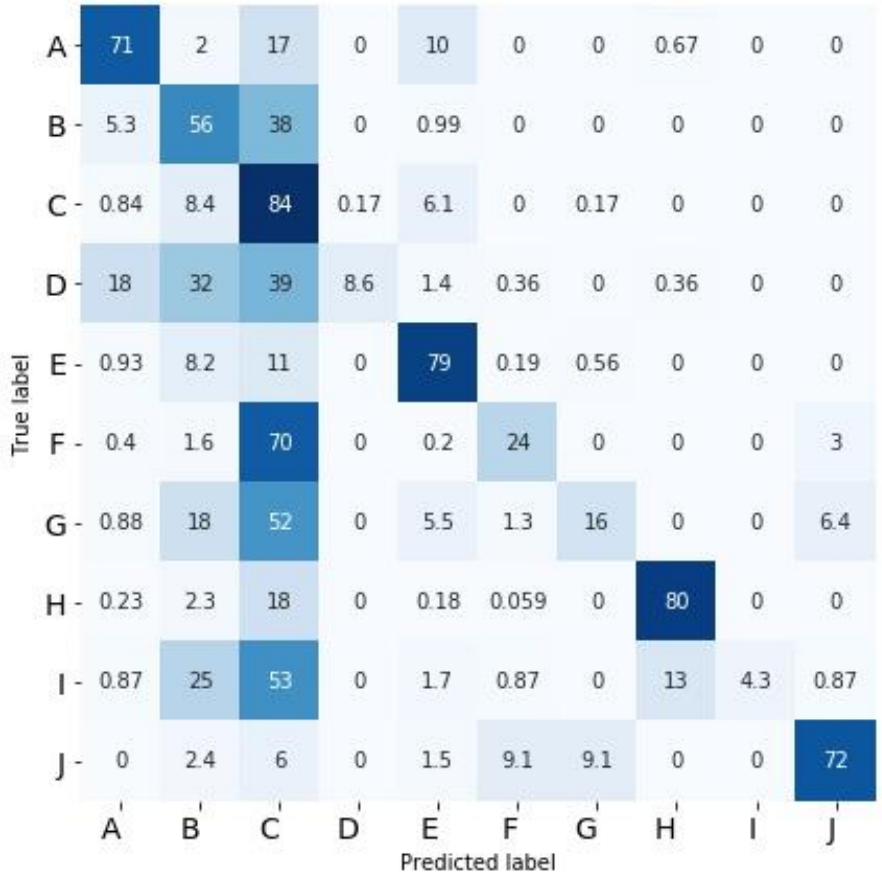
Test

Original dataset

Accuracy: 61.79%
Macro precision: 73.02%
Macro recall (Trues Rate): 49.41%
Falses Rate: 50.59%
Macro F1: 48.69%

# Sensitivity Analysis
# Segmented Train vs Normal Test

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy



# Sensitivity Analysis
# Random Background Crop Train vs Normal Test

Train

Random Background Crop dataset

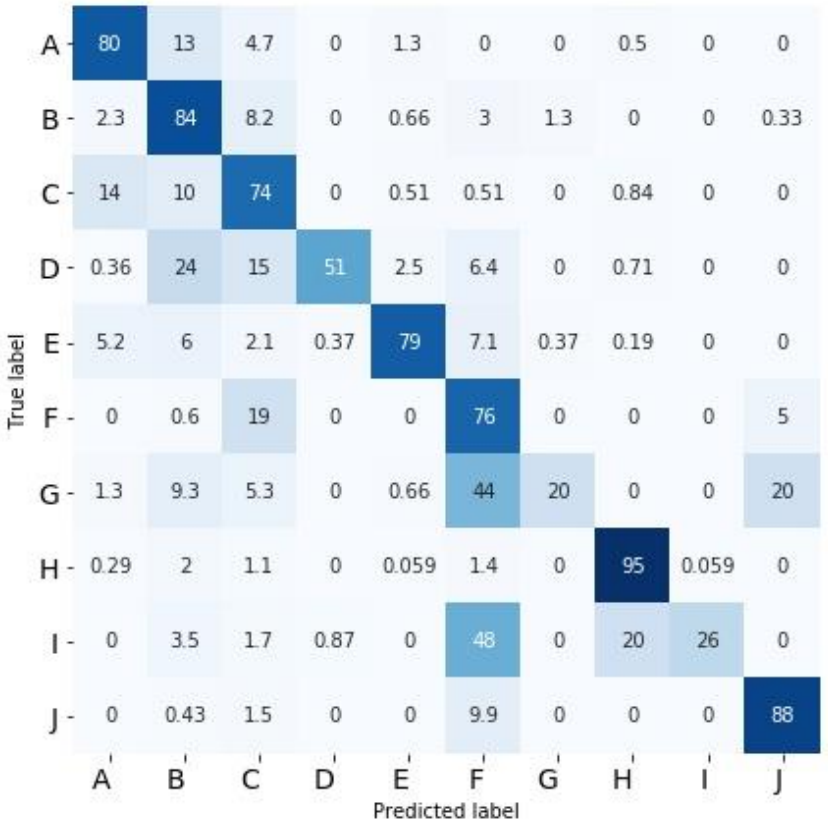
Test

Original dataset

Accuracy: 76.92%
Macro precision: 76.92%
Macro recall (Trues Rate): 79.43%
Falses Rate: 32.70%
Macro F1: 67.15%

# Sensitivity Analysis
# Random Background Crop Train vs Normal Test

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy



# Sensitivity Analysis
# Random Noise Background Train vs Normal Test

Train

Random Noise
Background dataset

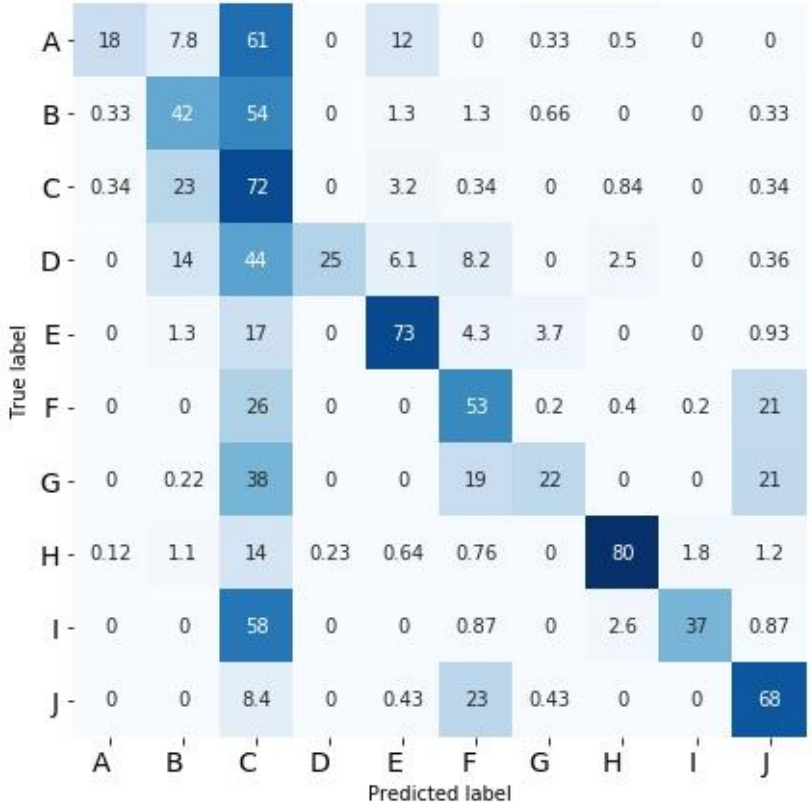
Test

Original dataset

Accuracy: 57.89 %
Macro precision: 66.68%
Macro recall (Trues Rate): 49.01%
Falses Rate: 50.99%
Macro F1: 49.93%

# Sensitivity Analysis
# Random Noise Background Train vs Normal Test

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy



# Sensitivity Analysis – Per Leaf Normalization
# Random Background Image Train vs Normal Test

Train

Random Noise
Background dataset

**Per Leaf Normalization**

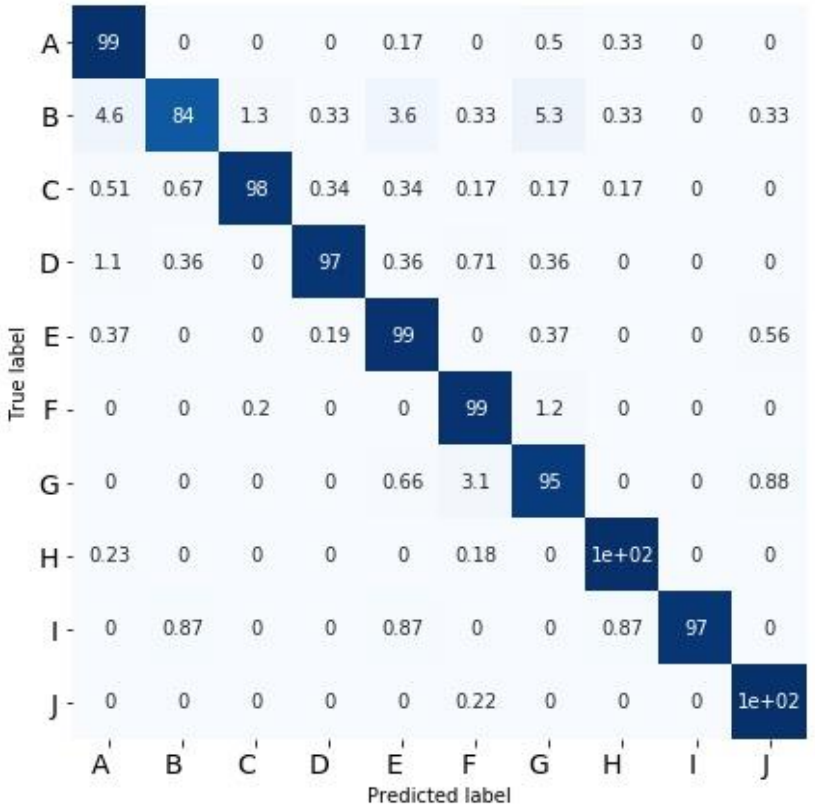
Test

Original dataset

Accuracy: 97.77%
Macro precision: 97.52%
Macro recall (Trues Rate): 96.69%
Falses Rate: 3.31%
Macro F1: 97.04%

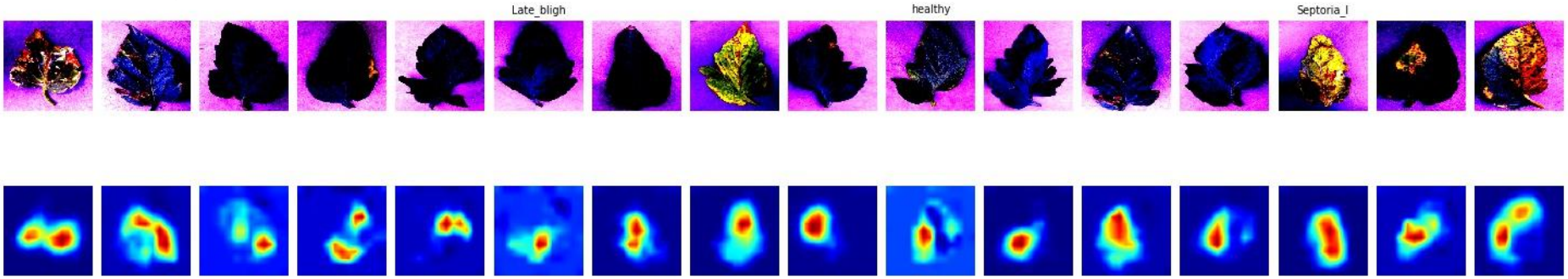
# Sensitivity Analysis
# Random Background Image Train vs Normal Test

(A) Bacterial Spot
(B) Early Blight
(C) Late Blight
(D) Leaf Mold
(E) Septoria Leaf Spot
(F) Two-spotted Spider Mites
(G) Target Spot
(H) Tomato Yellow Leaf Curl Virus
(I) Tomato Mosaic Virus
(J) Healthy

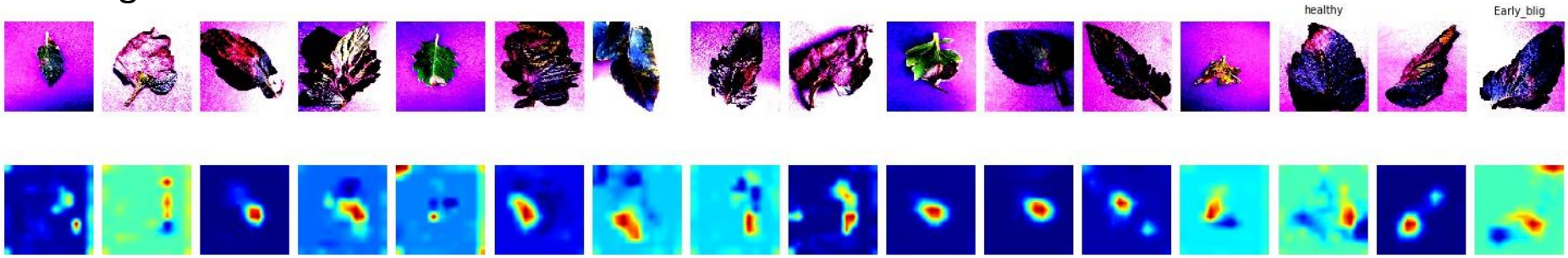


# Random Background Image Train vs Normal Test Activation Visualization

Bacterial Spot Class




Late Blight Class



# Extension: Test against Real Plantation Images

We built a set of 256 found on internet.

Bacterial Spot
26 samples

Early Blight
41 samples

Healthy
27 samples

Late Blight
31 samples

Leaf Mold
33 samples

Septoria leaf spot
36 samples

Two Spotted Spider mite
12 samples

Target Spot
12 samples

Tomato Mosaic Virus
18 samples

Tomato Yellow Leaf Curl virus
29samples

# Test against Real Plantation Images
# Results

- AlexNet

  Accuracy: 29.81%

  Macro precision: 30.36%

  Macro recall (Trues Rate): 25.86%

  Falses Rate: 74.13%

- VGG11

  Accuracy: 35.85%

Main Limitation: the set is not validated by a domain expert.