An Old-Fashioned Way of Leaf Classification

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Overview

1 **Introduction**

- Background
- Dataset

2 **Method & Discussion**

- Baseline Model
- Preprocessing
- Feature Extraction
- Model & Comparison
- Limitation & Improvement

3 **Summary**

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Introduction

Background

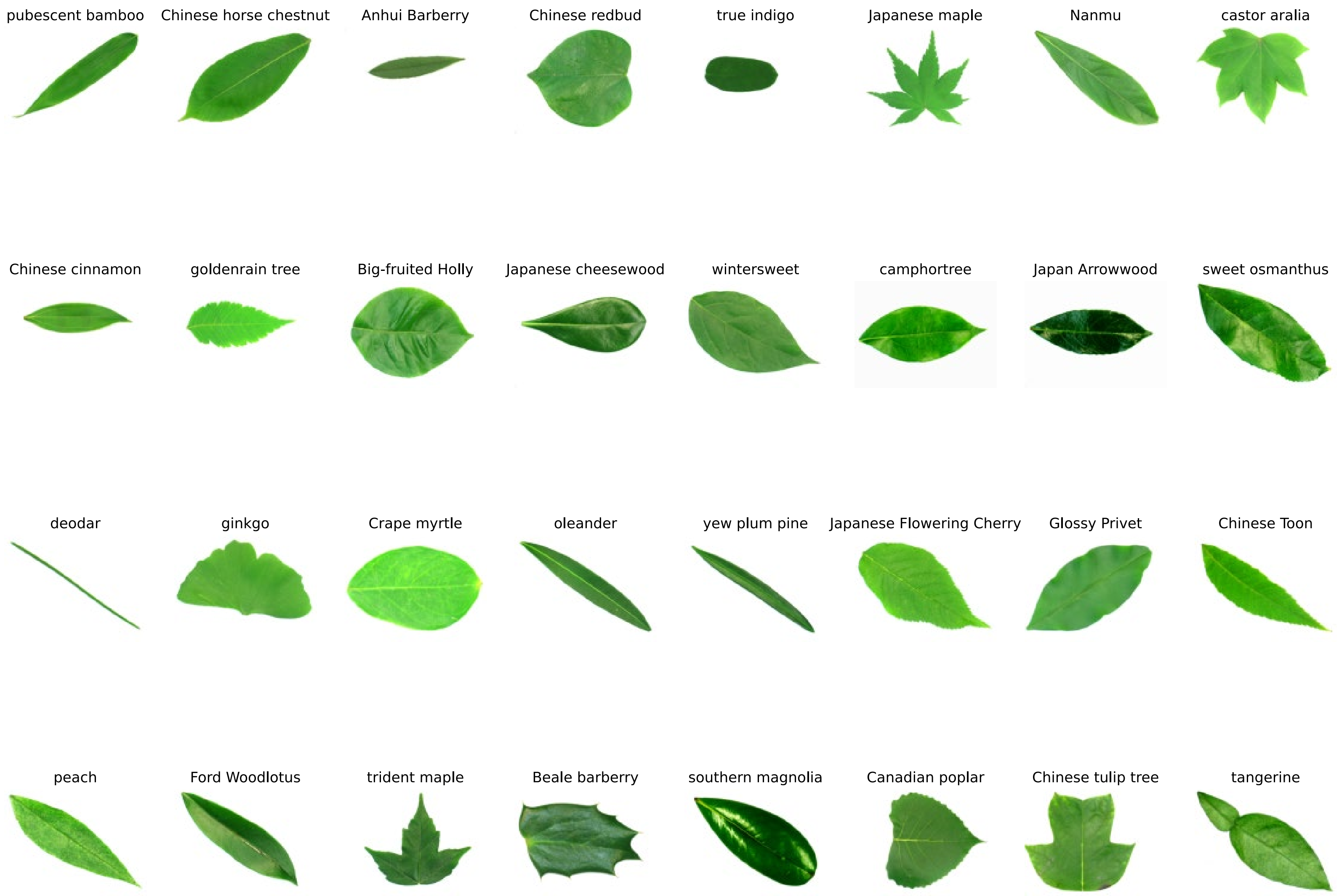
- Know the name of the plant or flower
- Intelligent Agriculture: identify weed and crops
- Leaves are good indicators of different plants, including the shape, and texture etc.
- Not highly accurate Apps/Software on the market based on Deep Learning

Goal: Apply the Knowledge of CS 302, **extract good features of leaf** image and perform classification in an old-fashioned way

stevepb ilyessuti

Dataset

- Stephen Wu et. al. 2007
- 32 classes and 1907 images
- RGB Image on White Background
- Size 1600 by 1200 (resize to 400 by 300)
- Split Train/Test by 70% and 30% for each class



Method & Discussion

Preprocessing- Image Augmentation

- Use Albumentations library
- Perform Vertical Flip and Horizontal Flip
- Training set size: 4002
- Test set size: 1719

Baseline Model

- Flatten the image into 400x300x3 vector
- Train a Random Forest Classifier

- Apply Transfer Learning
- Train ResNet50 over images

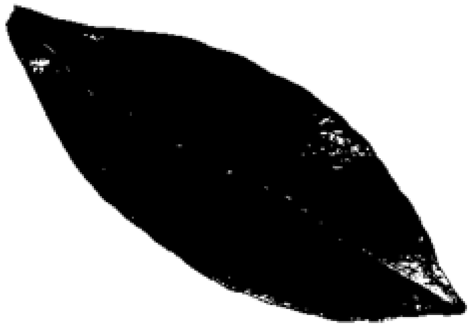
Model	Random Forest Classifier	ResNet50
Train Accuracy	1.0	0.99
Test Accuracy	0.88	0.91

Preprocessing – Background Removal

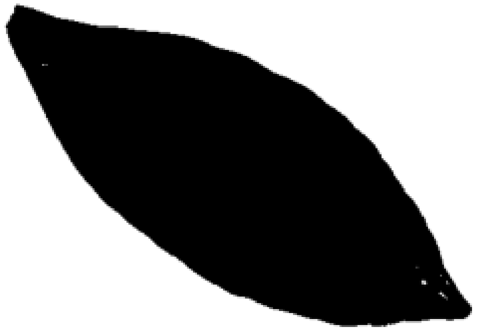
1. Convert to Gray image and apply Gaussian Filter
2. Otsu's Binarization
3. Apply Erosion Filter

Original

Binarized

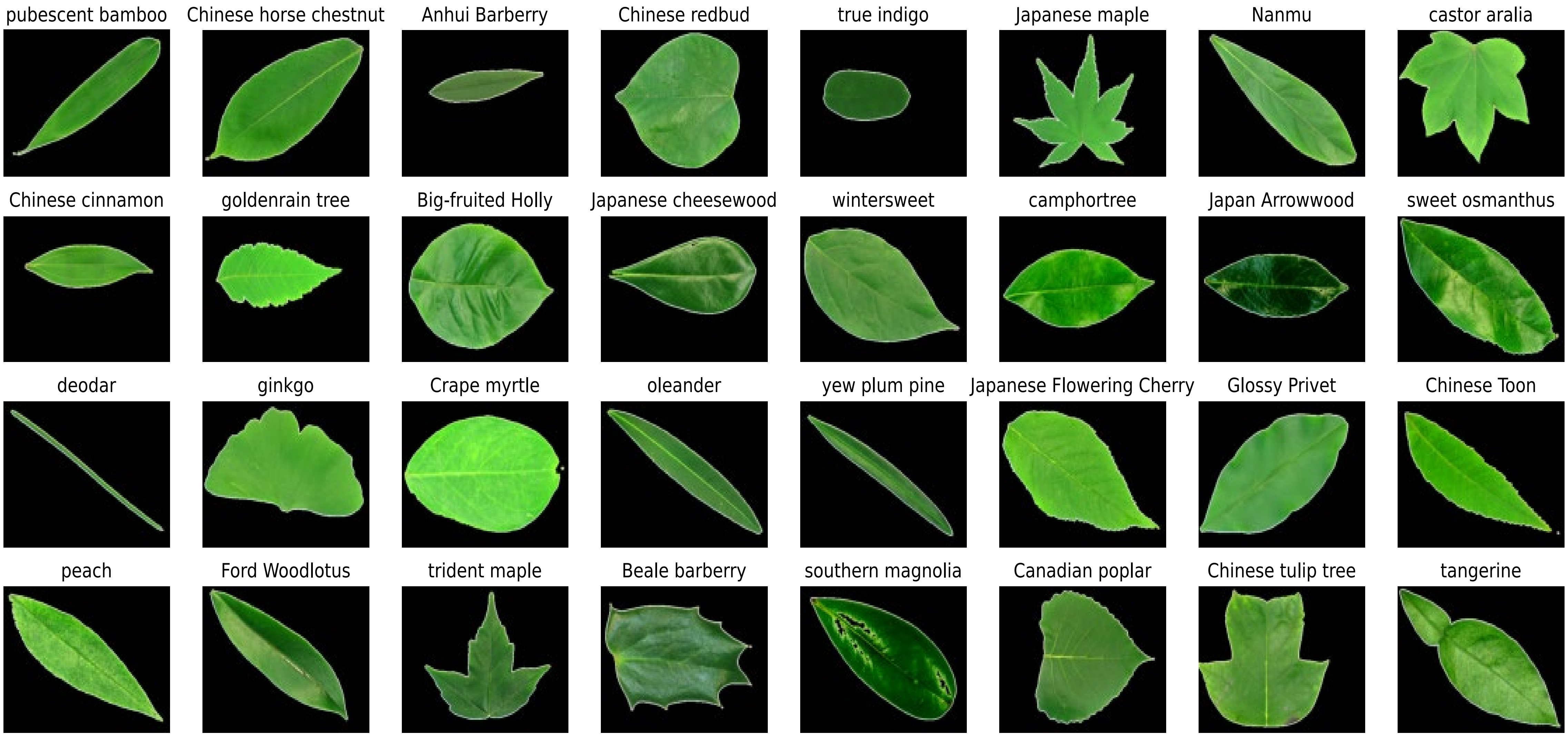


Erosion



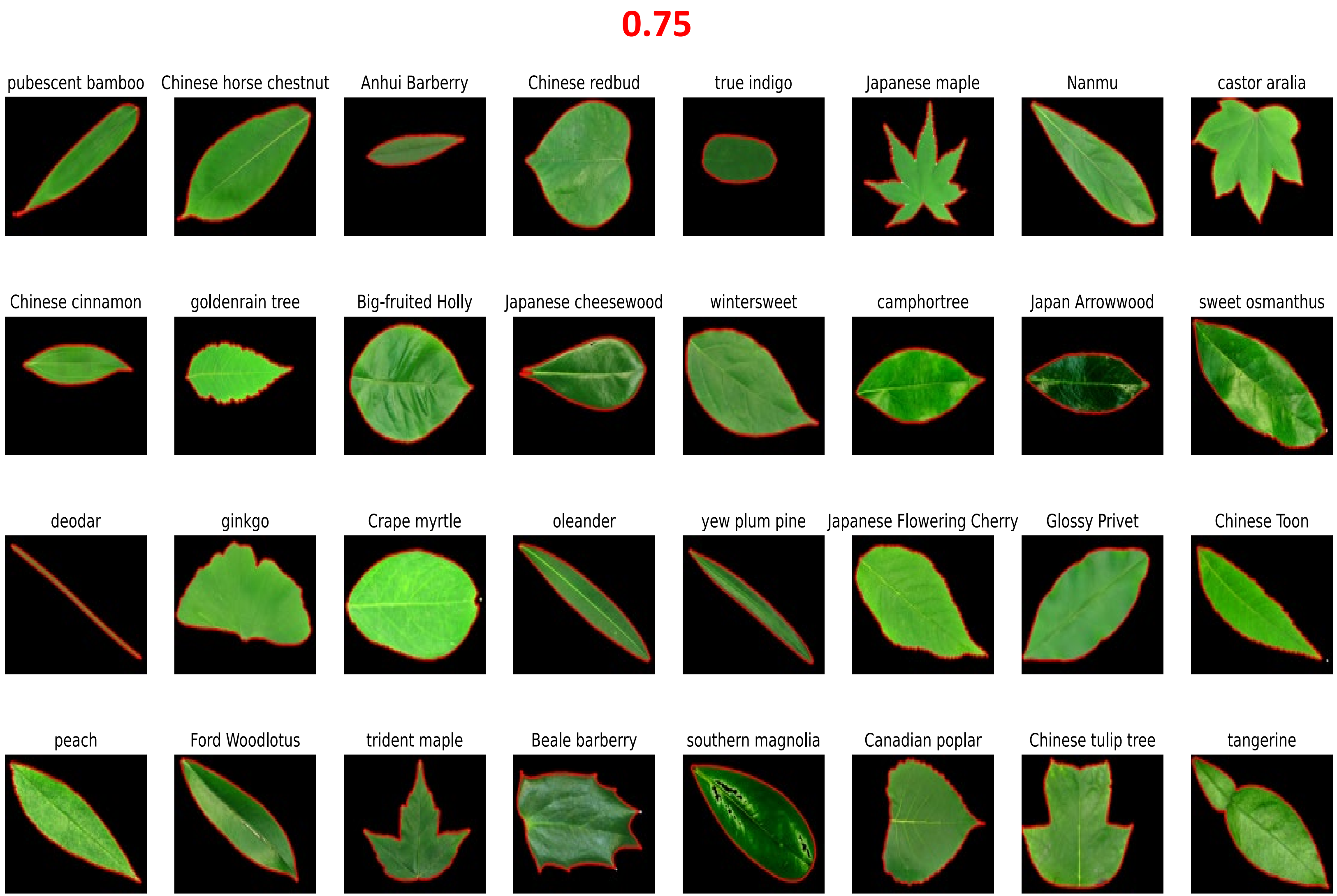
Without Background

Preprocessing



Feature Extraction – Fourier Descriptor

- Fourier Descriptors are translational and rotational invariant
- Use opencv to get contours
- Compute complex contour representation
- Drop phase information
- Use scaled absolute amplitude
- Take value from 1 to 100



Feature Extraction – Hu Moments

0.55

1.0e+00

2.3e-02

3.6e-04

3.2e-04

2.2e-08

2.4e-05

1.7e-08

- Hu Moments have been proved to be invariant to translation, scale, and rotation, and reflection
- The 7th moment's sign changes for image reflection
- Use Opencv function

$$\varphi_1 = \mu_{02} + \mu_{20}$$

$$\varphi_2 = (\mu_{02} - \mu_{20})^2 + 4\mu_{20}^2$$

$$\varphi_3 = (\mu_{30} - 3\mu_{12})^2 + (3\mu_{21} - \mu_{03})^2$$

$$\varphi_4 = (\mu_{30} - \mu_{12})^2 + (\mu_{21} - \mu_{03})^2$$

$$\varphi_5 = (\mu_{30} - 3\mu_{12})(\mu_{30} + \mu_{12})\left[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} - \mu_{03})^2\right] + (3\mu_{21} - \mu_{03})(\mu_{21} + \mu_{03})\left[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2\right]$$

$$\varphi_6 = (\mu_{20} - \mu_{02})\left[(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2\right] + 4\mu_{11}(\mu_{30} + \mu_{12})(\mu_{21} + \mu_{03})$$

$$\varphi_7 = (3\mu_{21} - \mu_{03})(\mu_{30} + \mu_{12})\left[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})^2\right] + (\mu_{30} - 3\mu_{12})(\mu_{21} + \mu_{03})\left[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2\right]$$

(Alex and Eric)

Feature Extraction – Local Binary Pattern

100	90	80
10	120	130
20	50	140

Run 3x3 window

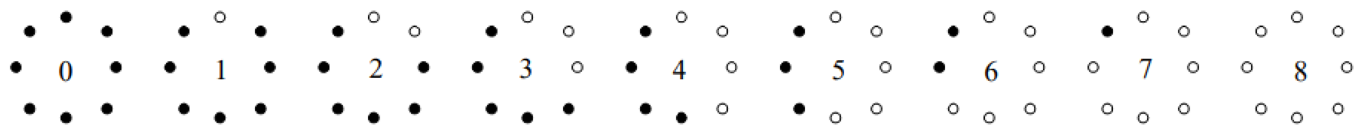
↓

0 0	1 0	0
0	24	1
0	0	1

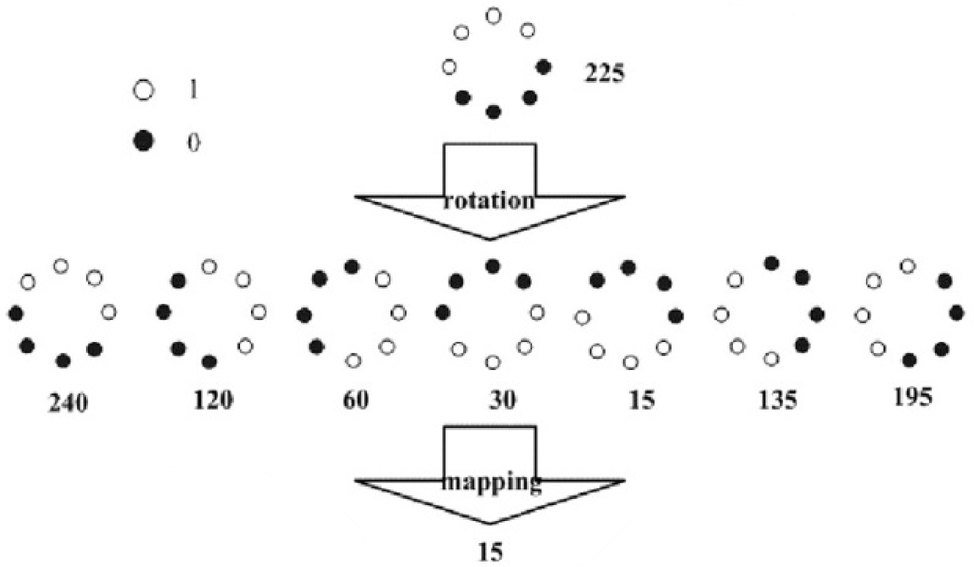
1 if larger than center

$2^3 + 2^4$

Uniform Pattern

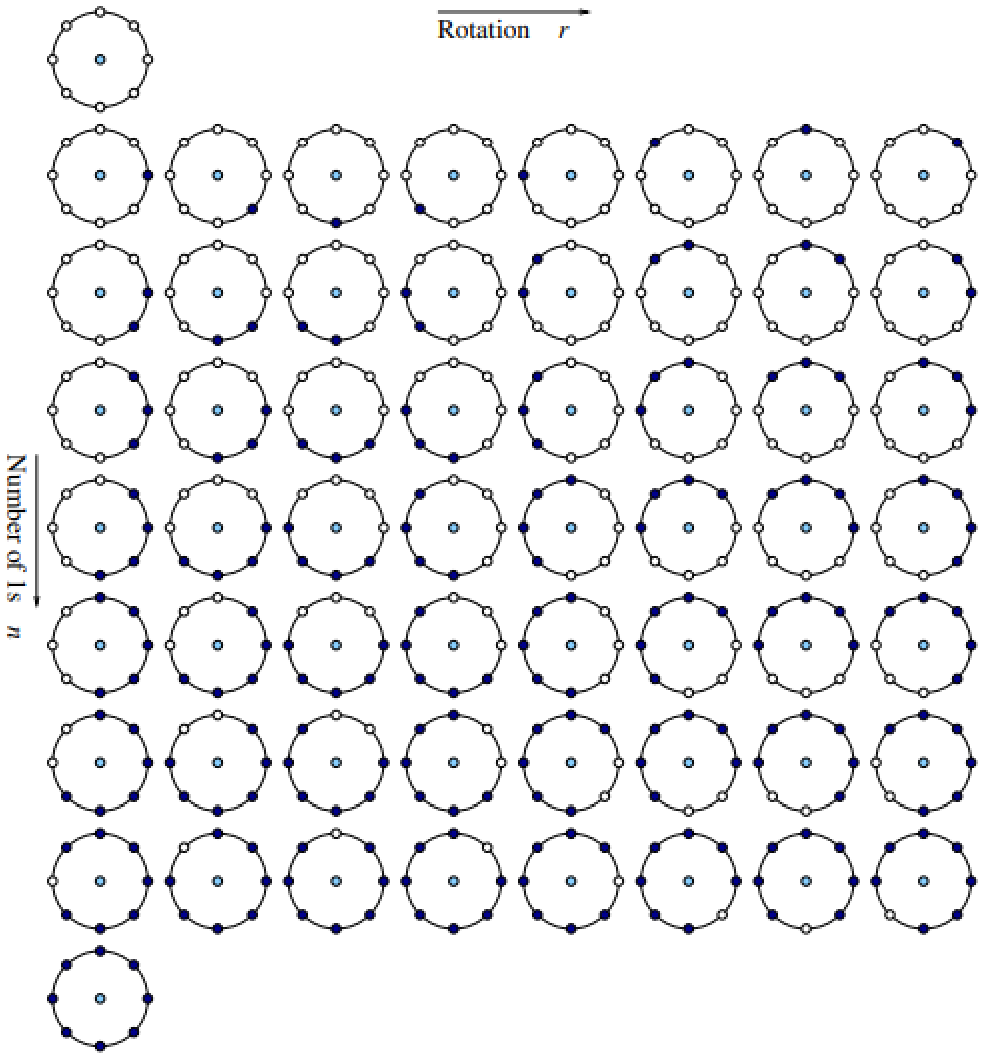


Rotate circles and get lowest value



Ojala et. al.

Feature Extraction – Local Binary Pattern



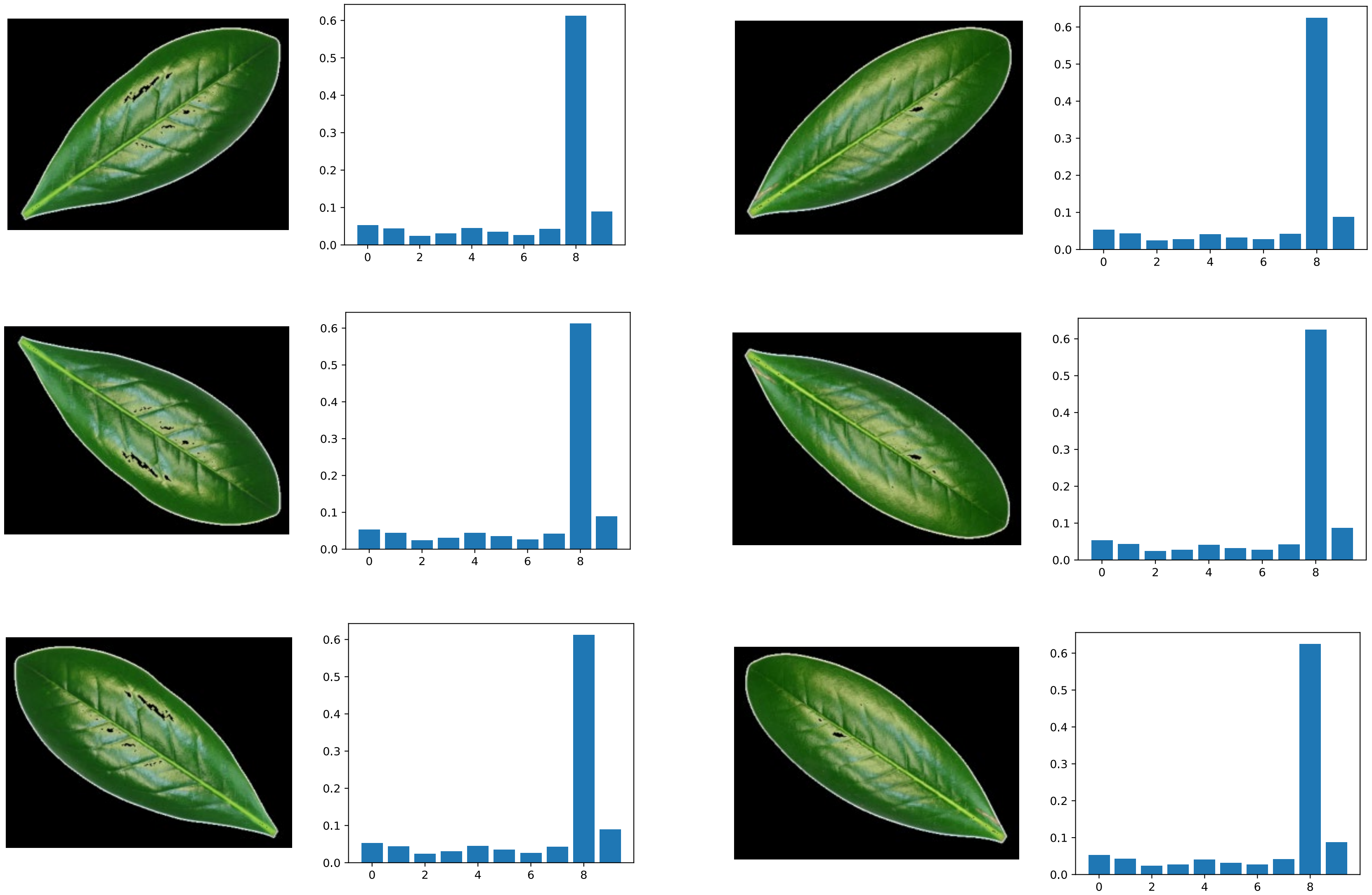
- Texture Identification
- Scale Invariant and Rotation Invariant
- Select radius 1 and sampling 8 neighbors
- Compute Histogram of LBP values including uniform and nonuniform
- 10 features in total

Ahonen et. al.

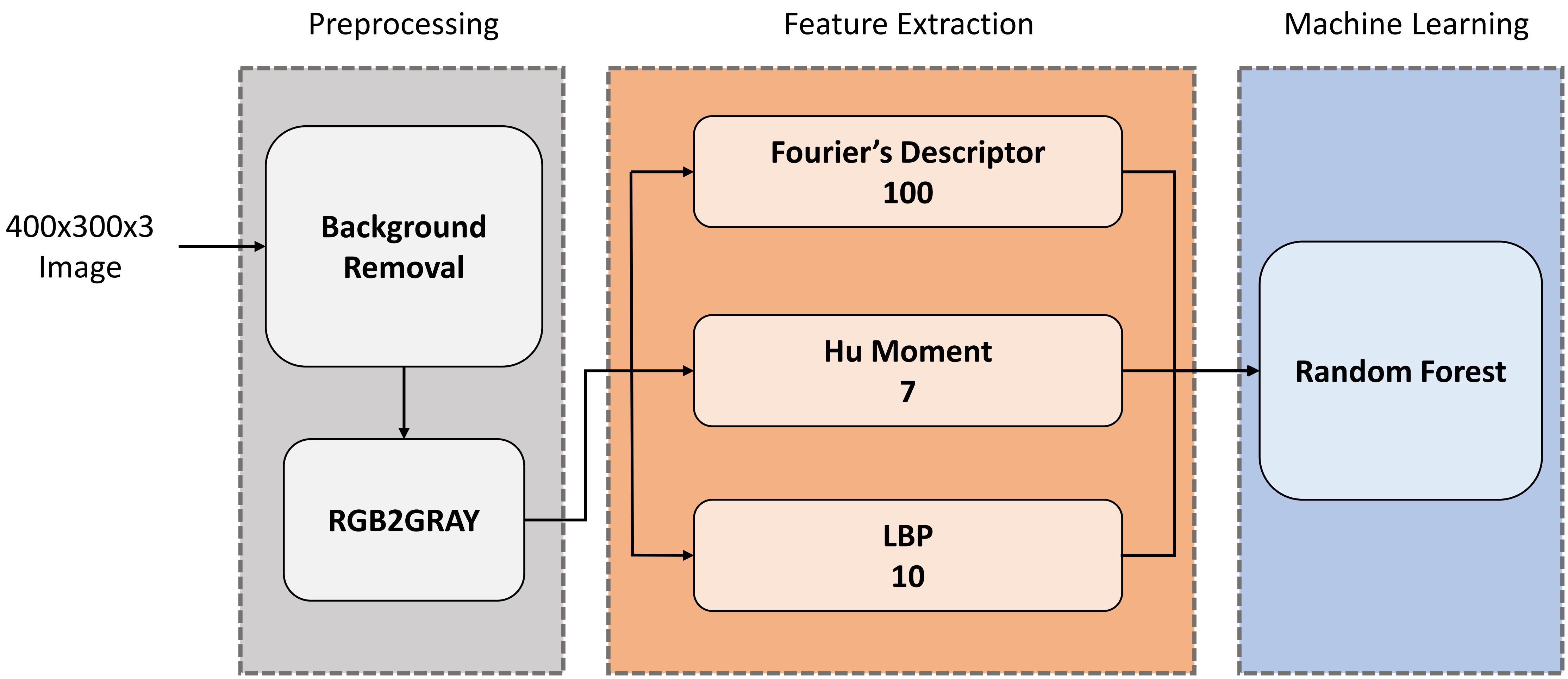
Feature Extraction – Local Binary Pattern

0.65

- Two cols are not identical
- Within the col, the value are same

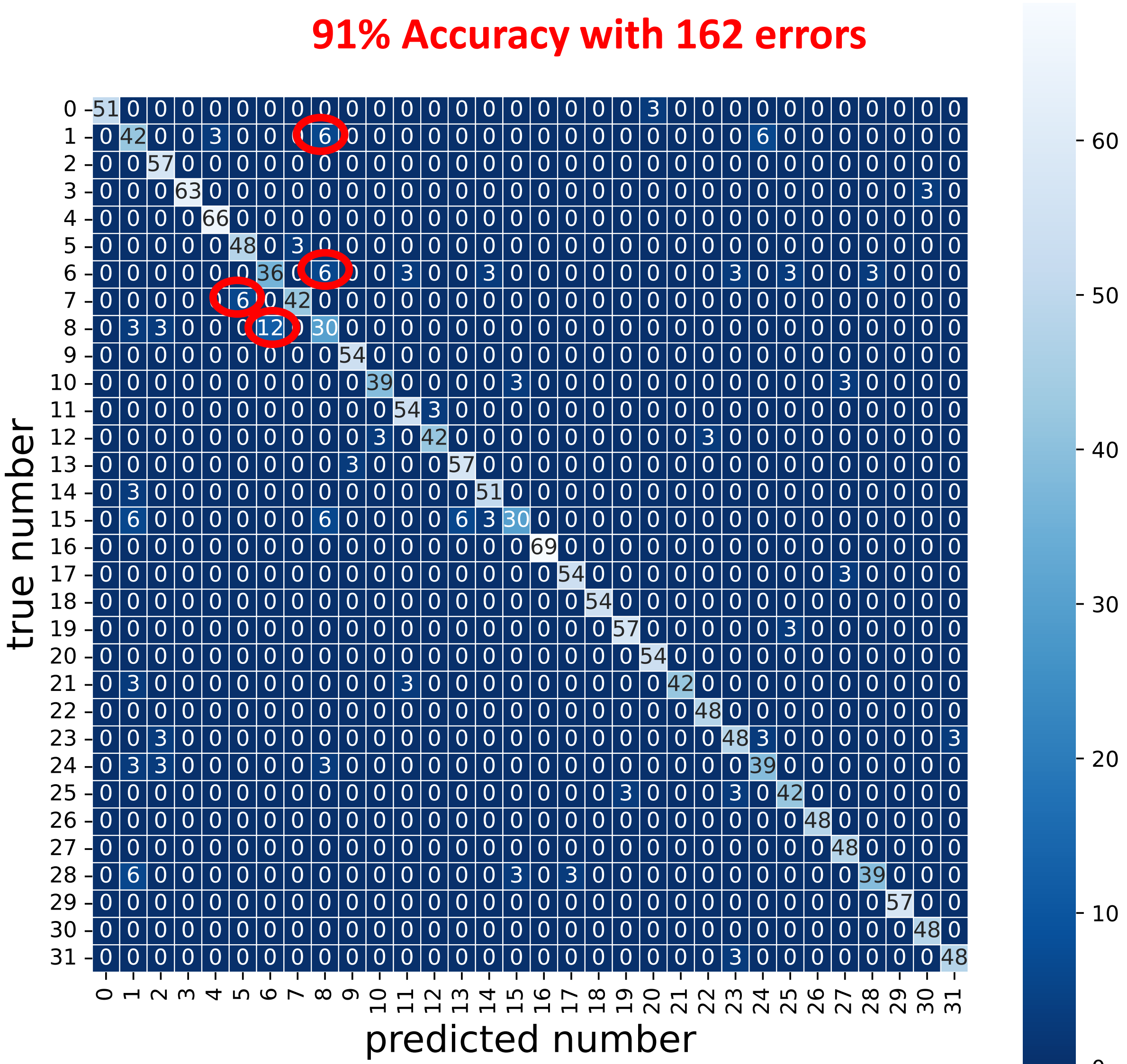


Model & Comparison

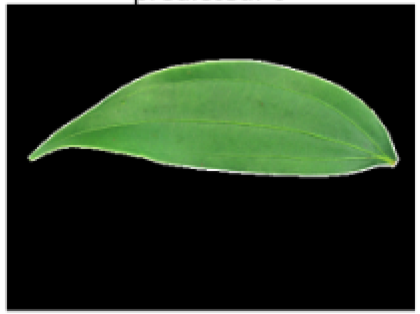


Model & Comparison

91% Accuracy with 162 errors

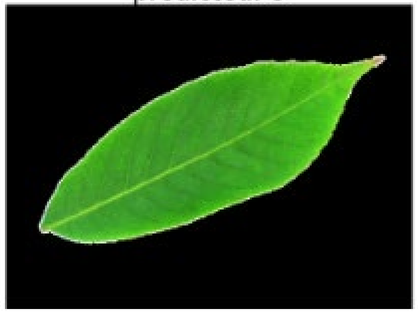


target: 8
predicted: 6



target: 6
predicted: 8

target: 1
predicted: 8



target: 7
predicted: 5

target: 5
predicted: 7

Model & Comparison

Model	Random Forest Classifier	ResNet50	Model X
Train Accuracy	1.0	0.99	1.0
Test Accuracy	0.88	0.91	0.91
Time (s)	2.85	6.22	119.46 (0.23)

- The final accuracy is 0.91
- Feature Extraction is time consuming

Limitation & Improvement

- Optimize feature extraction section and reduce time
- Tune hyperparameters or try more advanced models
- Explore more classical features

- The model is based on ideal situation
- Influenced by lighting and shooting angles
- Require Object (leaves) segmentation

https://www.saferbrand.com/articles/plants-turning-yellow

Summary

Summary

- Leaves Classification over 32 classes
- Apply Background Removal, Fourier Descriptors, Hu's moments, and Local Binary Pattern
- Train Random Forest over 117 features
- Accuracy over 90%
- The model is ideal and needs further improvement

Reference

1. Stevepb, https://pixabay.com/zh/photos/leaf-green-foliage-green-leaves-1001679/
2. https://pixabay.com/zh/photos/flowers-plum-blossom-spring-petals-7144467/
3. Ojala, Timo, Matti Pietikainen, and Topi Maenpaa. "Multiresolution gray-scale and rotation invariant texture classification with local binary patterns." *IEEE Transactions on pattern analysis and machine intelligence* 24.7 (2002): 971-987.
4. Ahonen, Timo, et al. "Rotation invariant image description with local binary pattern histogram fourier features." *Scandinavian conference on image analysis*. Springer, Berlin, Heidelberg, 2009.
5. https://www.saferbrand.com/articles/plants-turning-yellow

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Thank You

Q&A