

Visual Plant Disease Detection

using Deep Learning, Machine Learning &
eXplainble AI techniques

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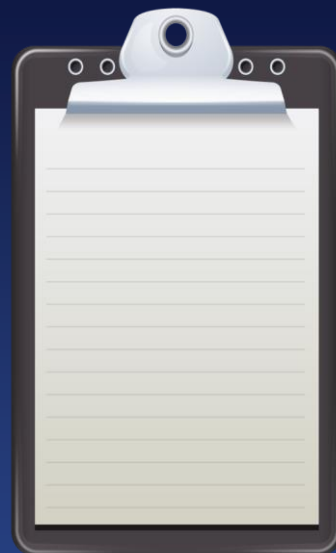
01 INTRODUCTION



Introduction

Plant diseases classification is an important task in agriculture since there is a big variety of plants and their diseases. Some diseases can not be cured, and the only solution is to cut the diseased plant otherwise the whole plantation can be destroyed. Early detection of these diseases is crucial to prevent their spread and minimize the damage.

02 DATASET



New Plant Diseases Dataset



- 54,305 samples
- 38 classes
- Imbalanced distribution



03

MACHINE LEARNING

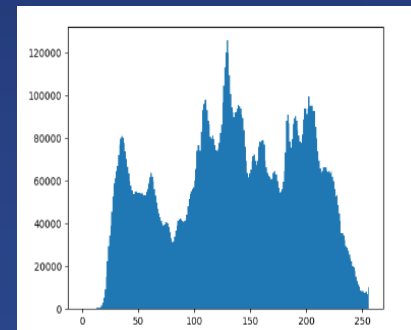
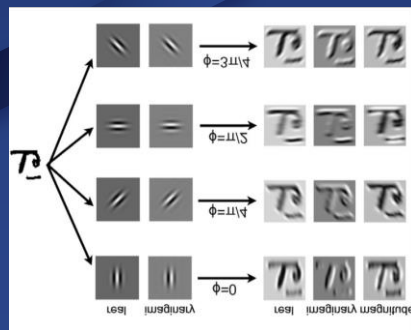
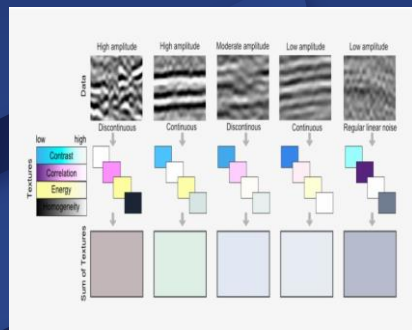
Features Extraction

Haralick Texture Features

Gabor Features

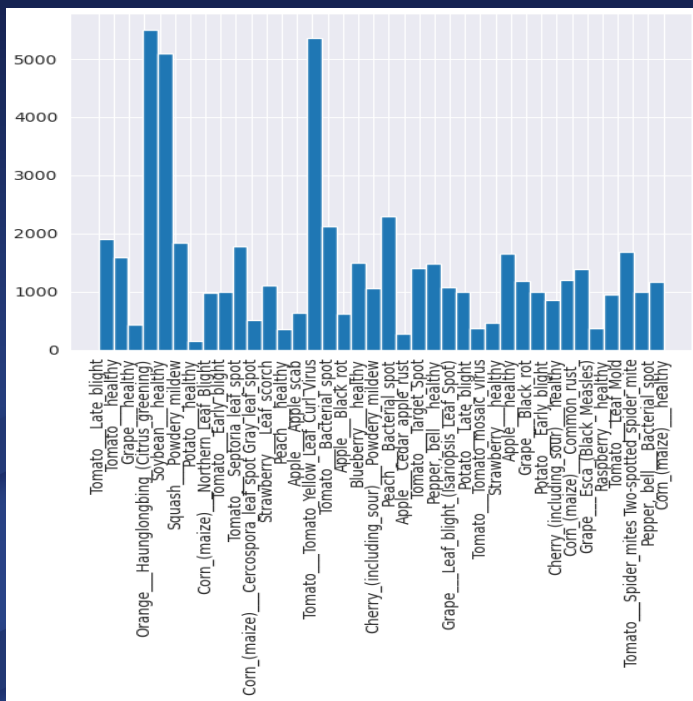
Shape Features

Color Features



Data Exploration

Dataset shape = (54304, 564)



Orange_Haunglongbing_(Citrus_greening)	5507
Tomato_Tomato_Yellow_Leaf_Curl_Virus	5357
Soybean_healthy	5090
Peach_Bacterial_spot	2297
Tomato_Bacterial_spot	2127
Tomato_Late_blight	1909
Squash_Powdery_mildew	1835
Tomato_Septoria_leaf_spot	1771
Tomato_Spider_mites_Two-spotted_spider_mite	1676
Apple_healthy	1645
Tomato_healthy	1591
Blueberry_healthy	1502
Pepper_bell_healthy	1478
Tomato_Target_Spot	1404
Grape_Esca_(Black_Measles)	1383
Corn_(maize)_Common_rust	1192
Grape_Black_rot	1180
Corn_(maize)_healthy	1162
Strawberry_Leaf_scorch	1109
Grape_Leaf_blight_(Isariopsis_Leaf_Spot)	1076
Cherry_(including_sour)_Powdery_mildew	1052
Tomato_Early_blight	1000
Potato_Late_blight	1000
Potato_Early_blight	1000
Pepper_bell_Bacterial_spot	997
Corn_(maize)_Northern_Leaf_Blight	985
Tomato_Leaf_Mold	952
Cherry_(including_sour)_healthy	854
Apple_Apple_scab	630
Apple_Black_rot	621
Corn_(maize)_Cercospora_leaf_spot_Gray_leaf_spot	513
Strawberry_healthy	456
Grape_healthy	423
Tomato_Tomato_mosaic_virus	373
Raspberry_healthy	371
Peach_healthy	360
Apple_Cedar_apple_rust	275
Potato_healthy	152

Data Preprocessing

Data Scaling

Over - Sampling

Under - Sampling

	Before SMOTE	After SMOTE	UNDERSAMPLING
Orange__Haunglongbing_(Citrus_greening)	4390	4390	1000
Tomato__Tomato_Yellow_Leaf_Curl_Virus	4318	4390	1000
Soybean__healthy	4064	4390	1000
Peach__Bacterial_spot	1870	4390	1000
Tomato__Bacterial_spot	1705	4390	1000
Tomato__Late_blight	1534	4390	1000
Squash__Powdery_mildew	1479	4390	1000
Tomato__Septoria_leaf_spot	1387	4390	1000
Tomato__Spider_mites Two-spotted_spider_mite	1344	4390	1000
Tomato__healthy	1313	4390	1000
Apple__healthy	1271	4390	1000
Blueberry__healthy	1214	4390	1000
Pepper__bell__healthy	1199	4390	1000
Tomato__Target_Spot	1115	4390	1000
Grape__Esca_(Black_Measles)	1096	4390	1000
Grape__Black_rot	956	4390	1000
Corn_(maize)__Common_rust__	944	4390	1000
Corn_(maize)__healthy	931	4390	1000
Strawberry__Leaf_scorch	875	4390	1000
Grape__Leaf_blight_(Isariopsis_Leaf_Spot)	867	4390	1000
Cherry_(including_sour)__Powdery_mildew	842	4390	1000
Potato__Late_blight	816	4390	1000
Pepper__bell__Bacterial_spot	800	4390	1000
Tomato__Early_blight	793	4390	1000
Corn_(maize)__Northern_Leaf_Blight	791	4390	1000
Potato__Early_blight	791	4390	1000
Tomato__Leaf_Mold	744	4390	1000
Cherry_(including_sour)__healthy	676	4390	1000
Apple__Black_rot	594	4390	1000
Apple__Apple_scab	582	4390	1000
Corn_(maize)__Cercospora_leaf_spot Gray_leaf_spot	399	4390	1000
Strawberry__healthy	366	4390	1000
Grape__healthy	342	4390	1000
Raspberry__healthy	293	4390	1000
Tomato__Tomato_mosaic_virus	290	4390	1000
Peach__healthy	280	4390	1000
Apple__Cedar_apple_rust	223	4390	1000
Potato__healthy	119	4390	1000

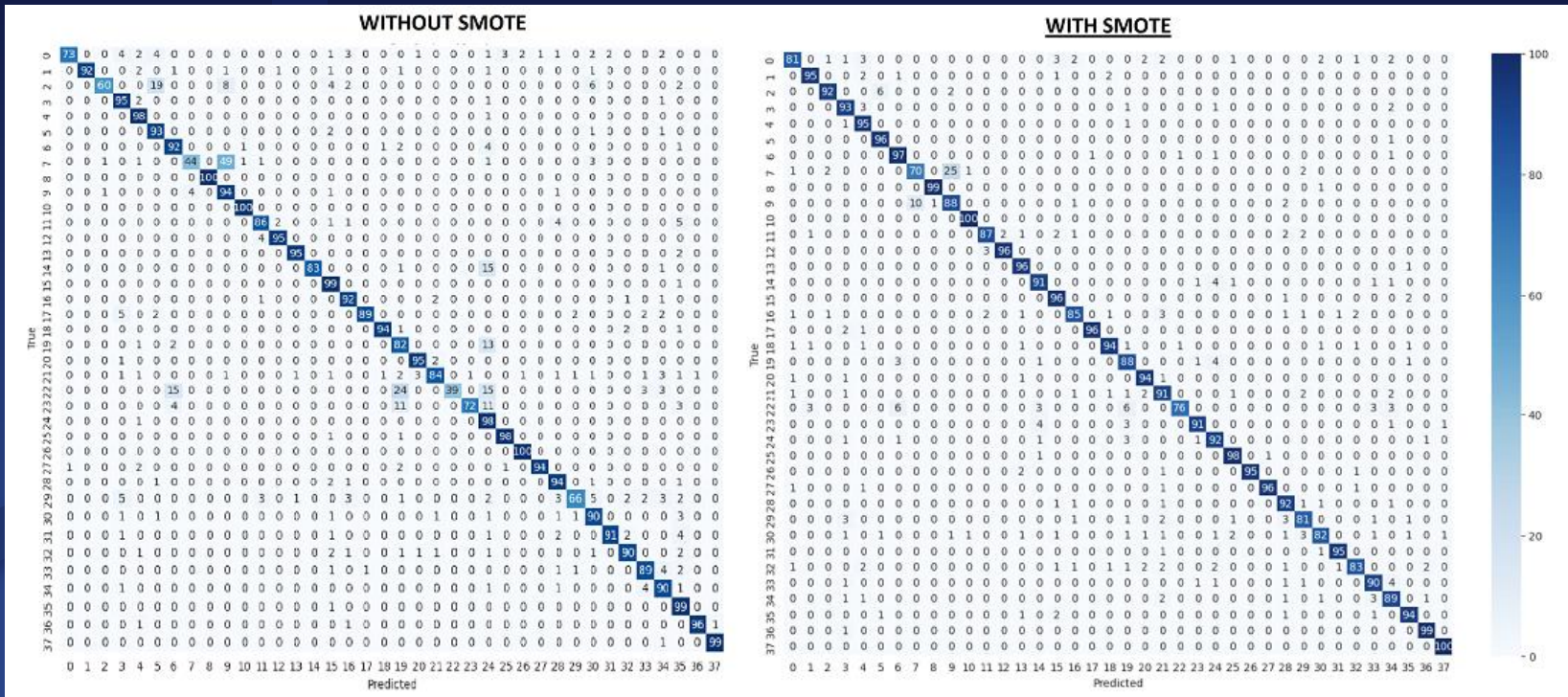
Classification Reports without SMOTE

	Random Forest			KNN			SVM		
Apple__Apple_scab	0.98	0.74	0.84	0.84	0.55	0.67	0.76	0.86	0.81
Apple__Apple_Black_rot	0.98	0.92	0.95	0.74	0.84	0.79	0.92	0.93	0.92
Apple__Cedar_apple_rust	0.96	0.5	0.66	0.56	0.35	0.43	0.8	0.79	0.8
Apple__healthy	0.87	0.93	0.9	0.86	0.88	0.87	0.87	0.91	0.89
Blueberry__healthy	0.92	0.99	0.95	0.93	0.98	0.95	0.96	0.98	0.97
Cherry_(including_sour)__Powdery_mildew	0.88	0.93	0.91	0.8	0.88	0.84	0.91	0.91	0.91
Cherry_(including_sour)__healthy	0.91	0.9	0.9	0.87	0.87	0.87	0.95	0.95	0.95
Corn_(maize)__Cercospora_leaf_spot_Gray_leaf_spot	0.84	0.43	0.56	0.79	0.7	0.75	0.78	0.78	0.78
Corn_(maize)__Common_rust	1	1	1	0.99	1	0.99	0.99	1	0.99
Corn_(maize)__Northern_Leaf_Blight	0.76	0.95	0.84	0.86	0.83	0.84	0.86	0.9	0.88
Corn_(maize)__healthy	0.99	1	0.99	0.97	0.93	0.95	0.98	1	0.99
Grape__Black_rot	0.88	0.88	0.88	0.84	0.88	0.86	0.87	0.92	0.89
Grape__Esca_(Black_Measles)	0.98	0.93	0.96	0.98	0.93	0.95	0.99	0.95	0.97
Grape__Leaf_blight_(Isariopsis_Leaf_Spot)	0.94	0.95	0.94	0.95	0.96	0.95	0.97	1	0.98
Grape__healthy	0.97	0.83	0.9	0.79	0.88	0.83	0.93	0.95	0.94
Orange__Haunglongbing_(Citrus_greening)	0.96	0.98	0.97	0.98	0.95	0.97	0.98	0.97	0.97
Peach__Bacterial_spot	0.97	0.94	0.96	0.94	0.91	0.92	0.93	0.93	0.93
Peach__healthy	0.91	0.92	0.91	0.82	0.97	0.89	0.88	0.95	0.92
Pepper_bell__Bacterial_spot	0.97	0.94	0.95	0.86	0.86	0.86	0.95	0.94	0.95
Pepper_bell__healthy	0.84	0.84	0.84	0.83	0.81	0.82	0.9	0.93	0.91
Potato__Early_blight	0.95	0.95	0.95	0.92	0.96	0.94	0.98	0.98	0.98
Potato__Late_blight	0.9	0.85	0.88	0.92	0.84	0.84	0.84	0.85	0.85
Potato__healthy	0.92	0.36	0.52	0.89	0.52	0.65	0.83	0.88	0.85
Raspberry__healthy	1	0.69	0.82	0.86	0.85	0.86	0.97	0.93	0.95
Soybean__healthy	0.91	0.98	0.95	0.95	0.95	0.95	0.98	0.98	0.98
Squash__Powdery_mildew	0.97	0.99	0.98	0.94	0.95	0.94	0.99	0.98	0.98
Strawberry__Leaf_scorch	0.98	1	0.99	0.96	0.94	0.95	1	0.96	0.98
Strawberry__healthy	0.97	0.94	0.95	0.95	0.96	0.95	0.95	0.91	0.92
Tomato__Bacterial_spot	0.9	0.96	0.93	0.95	0.96	0.95	0.92	0.95	0.94
Tomato__Early_blight	0.9	0.64	0.75	0.89	0.94	0.92	0.83	0.76	0.79
Tomato__Late_blight	0.9	0.87	0.89	0.83	0.75	0.79	0.89	0.83	0.86
Tomato__Leaf_Mold	0.99	0.92	0.95	0.9	0.83	0.86	0.95	0.92	0.93
Tomato__Septoria_leaf_spot	0.93	0.91	0.92	0.85	0.9	0.87	0.94	0.92	0.93
Tomato__Spider_mites_Two-spotted_spider_mite	0.93	0.9	0.91	0.93	0.89	0.91	0.93	0.92	0.93
Tomato__Target_Spot	0.85	0.89	0.87	0.91	0.91	0.91	0.91	0.9	0.9
Tomato__Tomato_Yellow_Leaf_Curl_Virus	0.93	0.98	0.95	0.91	0.97	0.94	0.96	0.96	0.96
Tomato__Tomato_mosaic_virus	0.93	0.95	0.94	0.87	0.96	0.91	0.94	0.92	0.93
Tomato__healthy			0.99			0.98			0.99
accuracy	0.93	0.93	0.93	0.91	0.91	0.91	0.94	0.94	0.94
macro avg	0.93	0.88	0.89	0.88	0.87	0.87	0.92	0.92	0.92
weighted avg	0.93	0.93	0.93	0.91	0.91	0.91	0.94	0.94	0.94
	precision	recall	f1-score	precision	recall	f1-score	precision	recall	f1-score

Classification Reports with SMOTE

	Random Forest			KNN			SVM			
Apple__Apple_scab	0.82	0.81	0.82	0.67	0.6	0.63	0.66	0.84	0.74	1.0 0.8 0.6 0.4 0.2 0.0
Apple__Black_rot	0.93	0.93	0.93	0.71	0.84	0.77	0.89	0.96	0.92	
Apple__Cedar_apple_rust	0.84	0.94	0.89	0.4	0.67	0.5	0.66	0.94	0.78	
Apple__healthy	0.9	0.91	0.91	0.91	0.83	0.87	0.91	0.88	0.89	
Blueberry__healthy	0.87	0.96	0.91	0.92	0.95	0.93	0.92	0.96	0.94	
Cherry_(including_sour)__Powdery_mildew	0.89	0.96	0.92	0.77	0.84	0.8	0.82	0.91	0.86	
Cherry_(including_sour)__healthy	0.88	0.95	0.92	0.8	0.89	0.84	0.95	0.99	0.97	
Corn_(maize)__Cercospora_leaf_spot_Gray_leaf_spot	0.76	0.71	0.73	0.62	0.76	0.68	0.63	0.87	0.73	
Corn_(maize)__Common_rust	1	0.99	0.99	0.99	0.98	0.98	1	0.99	0.99	
Corn_(maize)__Northern_Leaf_Blight	0.84	0.87	0.85	0.86	0.67	0.75	0.92	0.79	0.85	
Corn_(maize)__healthy	0.96	1	0.98	0.99	0.94	0.96	0.97	0.97	0.97	
Grape__Black_rot	0.89	0.89	0.89	0.73	0.82	0.77	0.83	0.89	0.86	
Grape__Esca_(Black_Measles)	0.99	0.95	0.97	0.95	0.93	0.94	0.95	0.94	0.95	
Grape__Leaf_blight_(Isariopsis_Leaf_Spot)	0.91	0.95	0.93	0.85	0.98	0.91	0.94	0.96	0.95	
Grape__healthy	0.77	0.93	0.84	0.52	0.91	0.67	0.75	0.99	0.85	
Orange__Haunglongbing_(Citrus_greening)	0.96	0.96	0.96	0.98	0.85	0.91	0.97	0.92	0.95	
Peach__Bacterial_spot	0.94	0.86	0.9	0.9	0.88	0.89	0.9	0.9	0.9	
Peach__healthy	0.95	0.97	0.96	0.85	0.95	0.9	0.99	0.95	0.97	
Pepper__bell__Bacterial_spot	0.93	0.94	0.93	0.74	0.83	0.78	0.86	0.91	0.88	
Pepper__bell__healthy	0.82	0.89	0.85	0.73	0.75	0.74	0.86	0.88	0.87	
Potato__Early_blight	0.93	0.93	0.93	0.9	0.92	0.91	0.95	0.97	0.96	
Potato__Late_blight	0.77	0.93	0.84	0.76	0.89	0.82	0.81	0.83	0.82	
Potato__healthy	0.81	0.79	0.8	0.51	0.82	0.63	0.76	0.85	0.8	
Raspberry__healthy	0.79	0.94	0.86	0.73	0.9	0.8	0.97	0.94	0.95	
Soybean__healthy	0.96	0.92	0.94	0.98	0.86	0.92	0.98	0.93	0.96	
Squash__Powdery_mildew	0.97	0.98	0.97	0.96	0.92	0.94	0.97	0.98	0.97	
Strawberry__Leaf_scorch	1	0.97	0.99	0.95	0.91	0.93	0.97	0.97	0.97	
Strawberry__healthy	0.94	0.93	0.94	0.77	0.94	0.85	0.97	0.94	0.96	
Tomato__Bacterial_spot	0.88	0.91	0.9	0.82	0.9	0.86	0.9	0.93	0.91	
Tomato__Early_blight	0.84	0.82	0.83	0.72	0.82	0.76	0.78	0.84	0.81	
Tomato__Late_blight	0.92	0.82	0.87	0.88	0.8	0.84	0.87	0.81	0.84	
Tomato__Leaf_Mold	0.96	0.95	0.95	0.83	0.93	0.88	0.93	0.89	0.91	
Tomato__Septoria_leaf_spot	0.95	0.82	0.88	0.91	0.79	0.84	0.91	0.85	0.88	
Tomato__Spider_mites_Two-spotted_spider_mite	0.92	0.9	0.91	0.87	0.92	0.89	0.9	0.89	0.9	
Tomato__Target_Spot	0.87	0.91	0.89	0.89	0.91	0.9	0.91	0.87	0.89	
Tomato__Tomato_Yellow_Leaf_Curl_Virus	0.96	0.93	0.95	0.93	0.9	0.91	0.96	0.91	0.93	
Tomato__Tomato_mosaic_virus	0.82	0.99	0.9	0.75	1	0.86	0.85	0.99	0.91	
Tomato__healthy	0.98	1	0.99	0.98	1	0.99	0.99	1	0.99	
accuracy			0.92			0.87			0.91	
macro avg	0.9	0.92	0.91	0.82	0.87	0.84	0.89	0.92	0.9	
weighted avg	0.92	0.92	0.92	0.88	0.87	0.87	0.92	0.91	0.92	
	precision	recall	f1-score	precision	recall	f1-score	precision	recall	f1-score	

Random Forest Confusion Matrix



04

DEEP LEARNING



Data Preprocessing

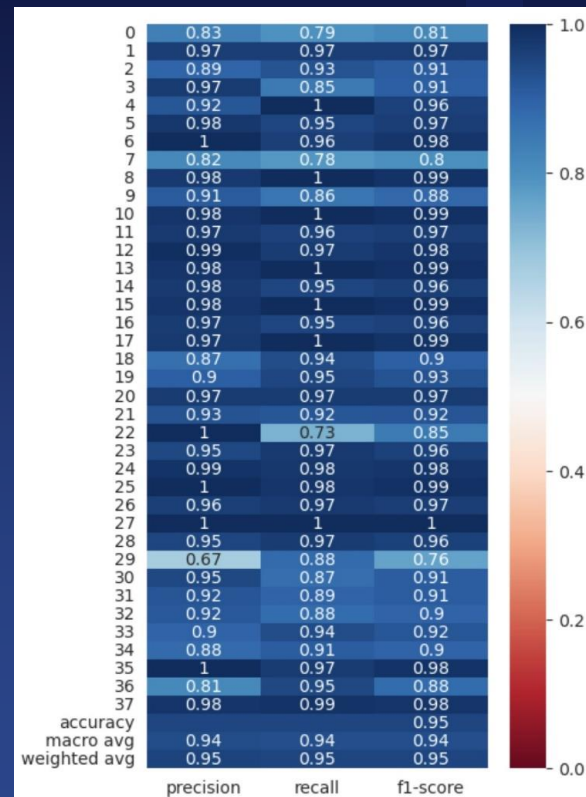
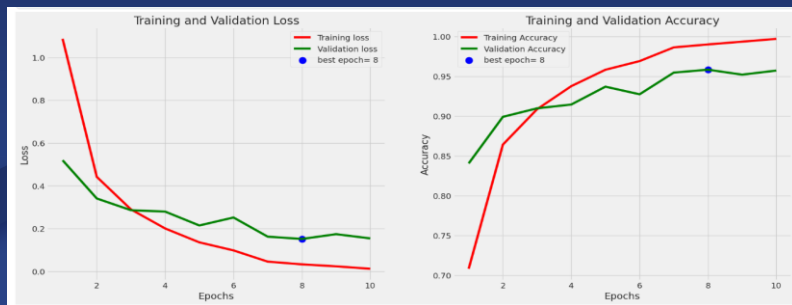
□ Data Augmentation

- ✓ Flipping
- ✓ Rotating
- ✓ RGB Shift
- ✓ Channel Shuffle
- ✓ Gray-Scale
- ✓ Segmentation

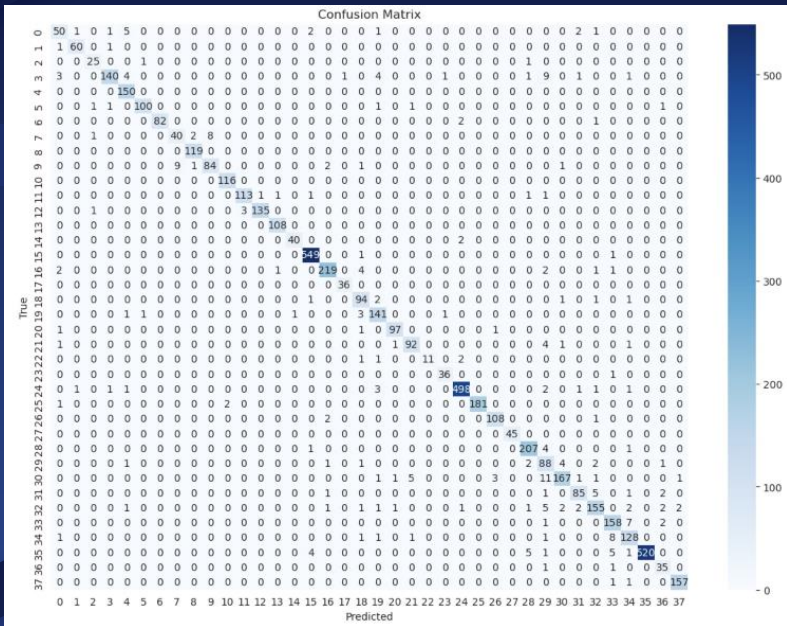


CNN's Results

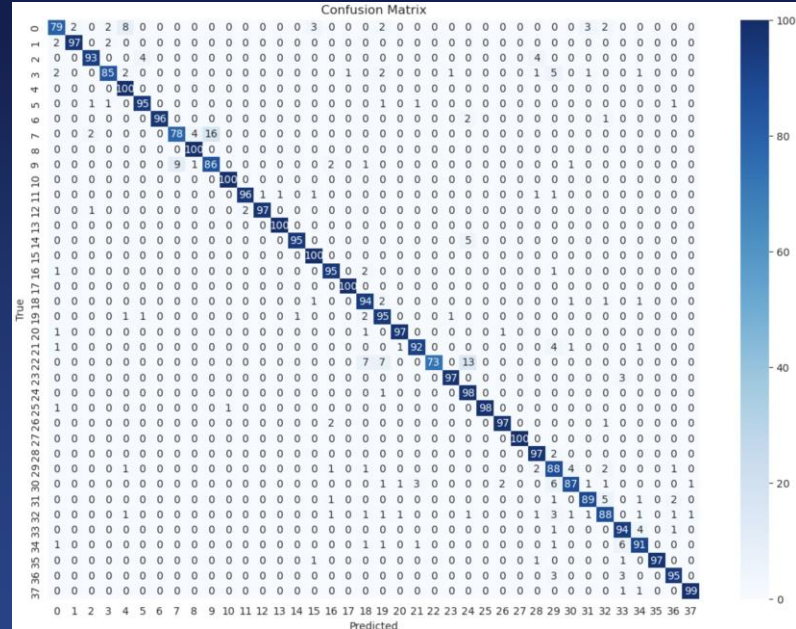
Model	Validation Accuracy	Validation Loss	Test Accuracy	Test Loss
CNN	95.83%	0.151	96.28%	0.146



CNN's Confusion Matrix

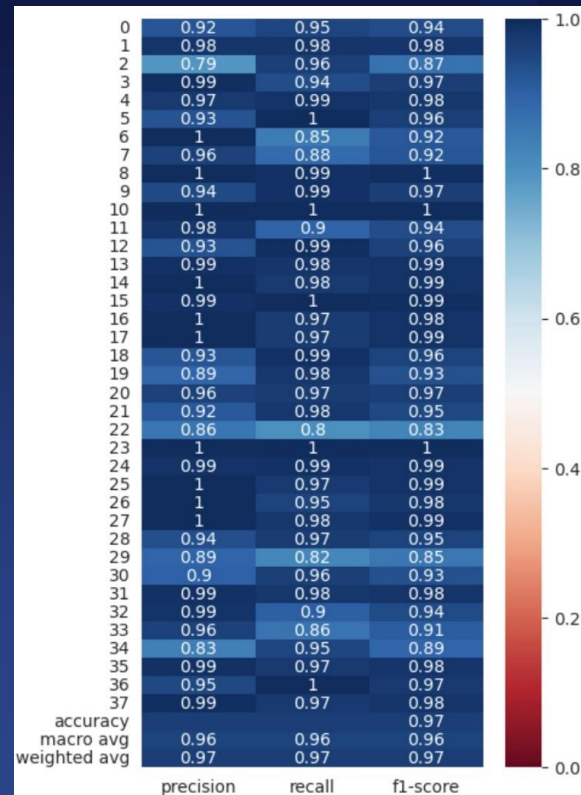
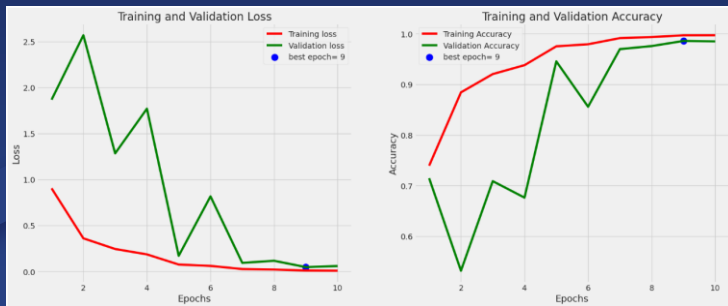


After Normalization

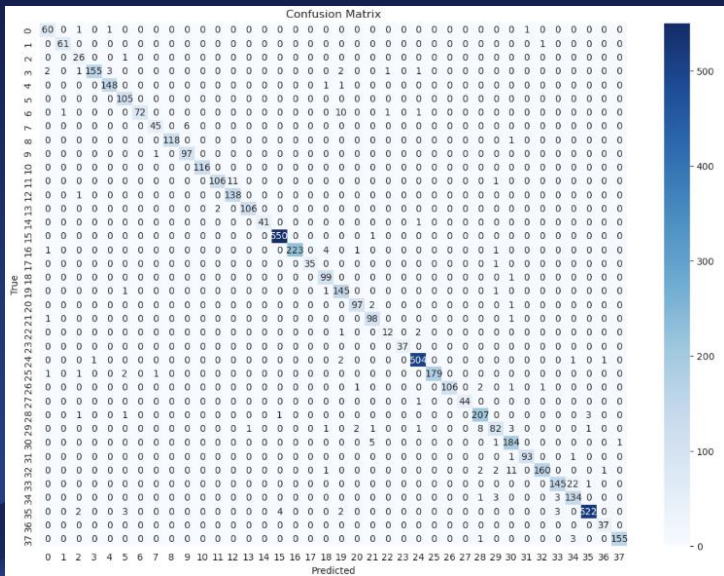


ResNet50's Performance

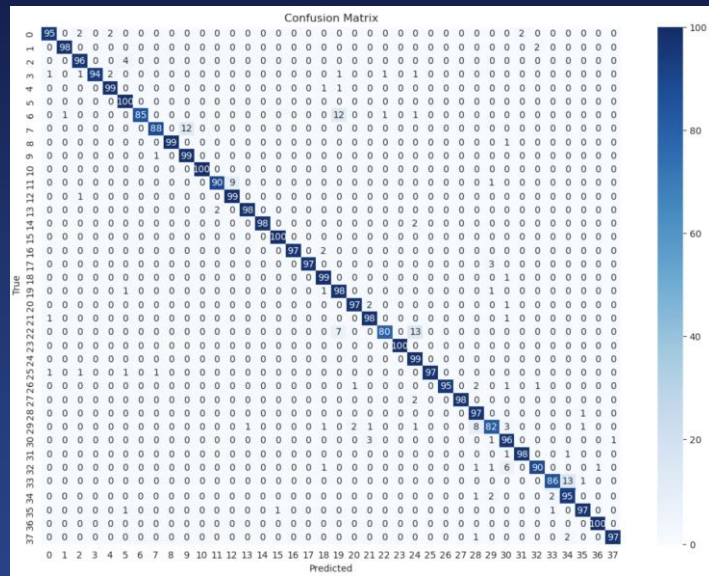
Model	Validation Accuracy	Validation Loss	Test Accuracy	Test Loss
ResNet50	98.60%	0.048	99.06%	0.050



ResNet50's Confusion Matrix

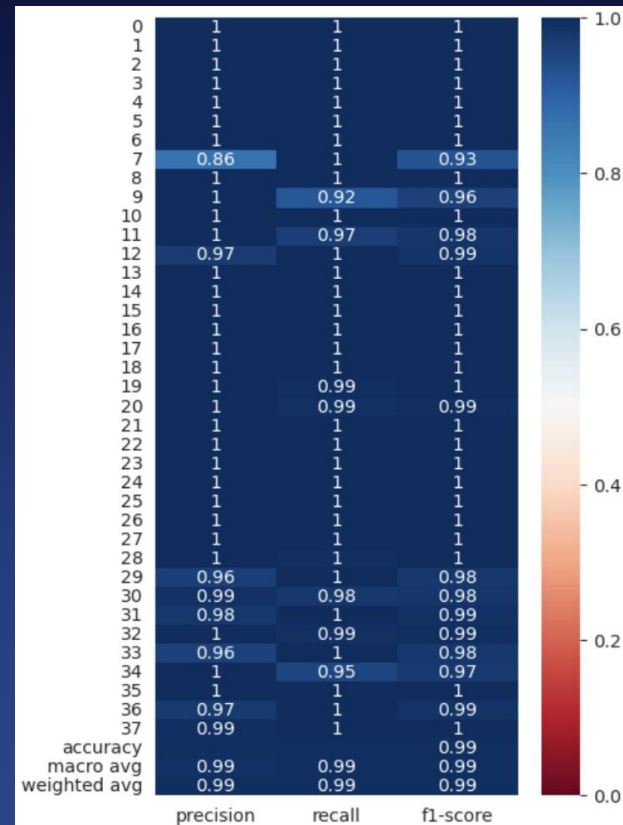
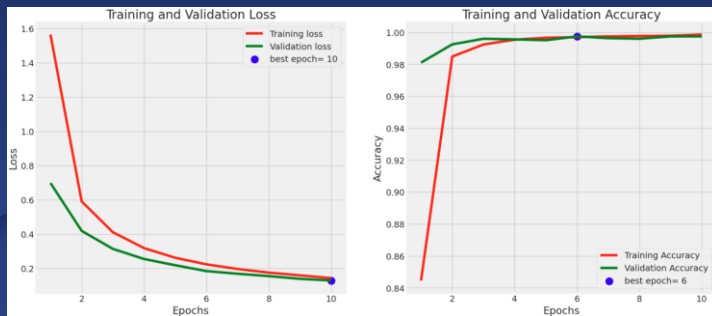


After Normalization

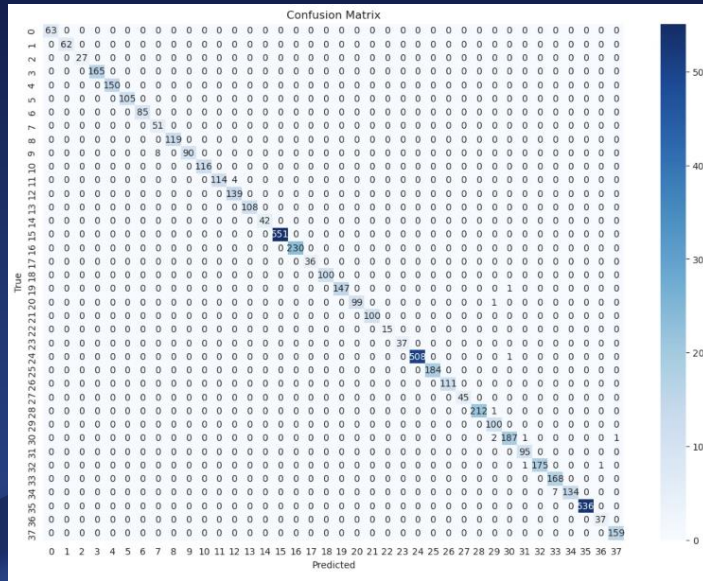


EfficientNet's Performance

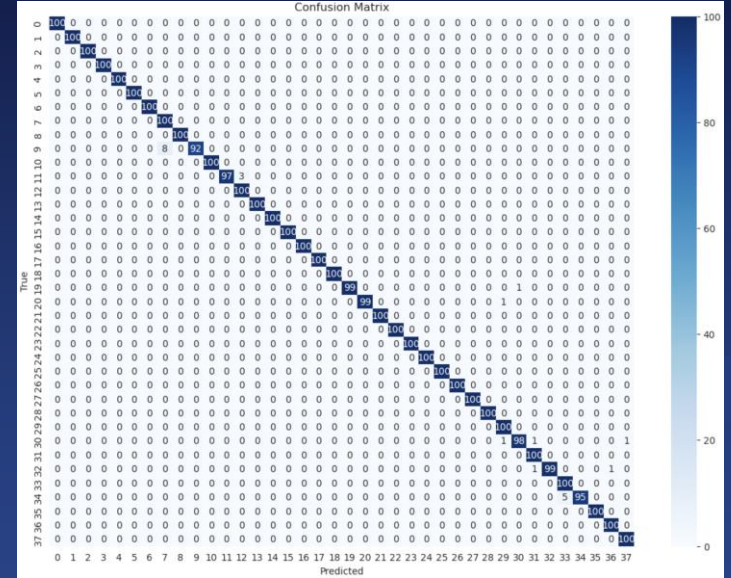
Model	Validation Accuracy	Validation Loss	Test Accuracy	Test Loss
EfficientNet	99.74%	0.129	99.79%	0.125



EfficientNet Confusion Matrix



After Normalization



Side-By-Side Comparison

Model	Validation Accuracy	Validation Loss	Test Accuracy	Test Loss
CNN	95.83%	0.151	96.28%	0.146
ResNet50	98.60%	0.048	99.06%	0.050
EfficientNet	99.74%	0.129	99.79%	0.125

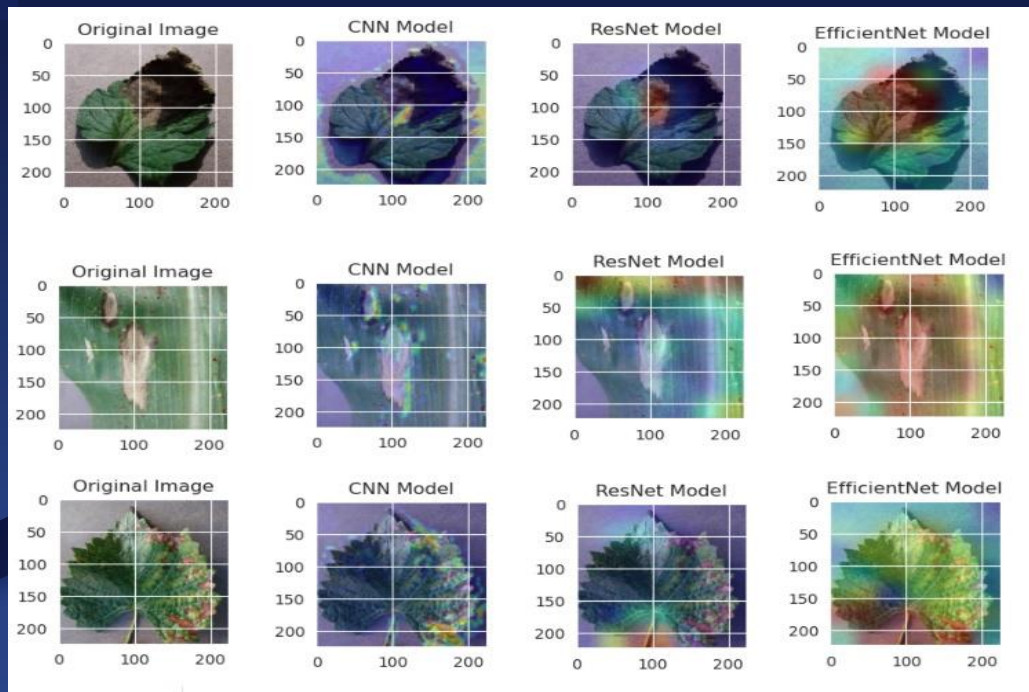


05 EXPLAINABLE AI

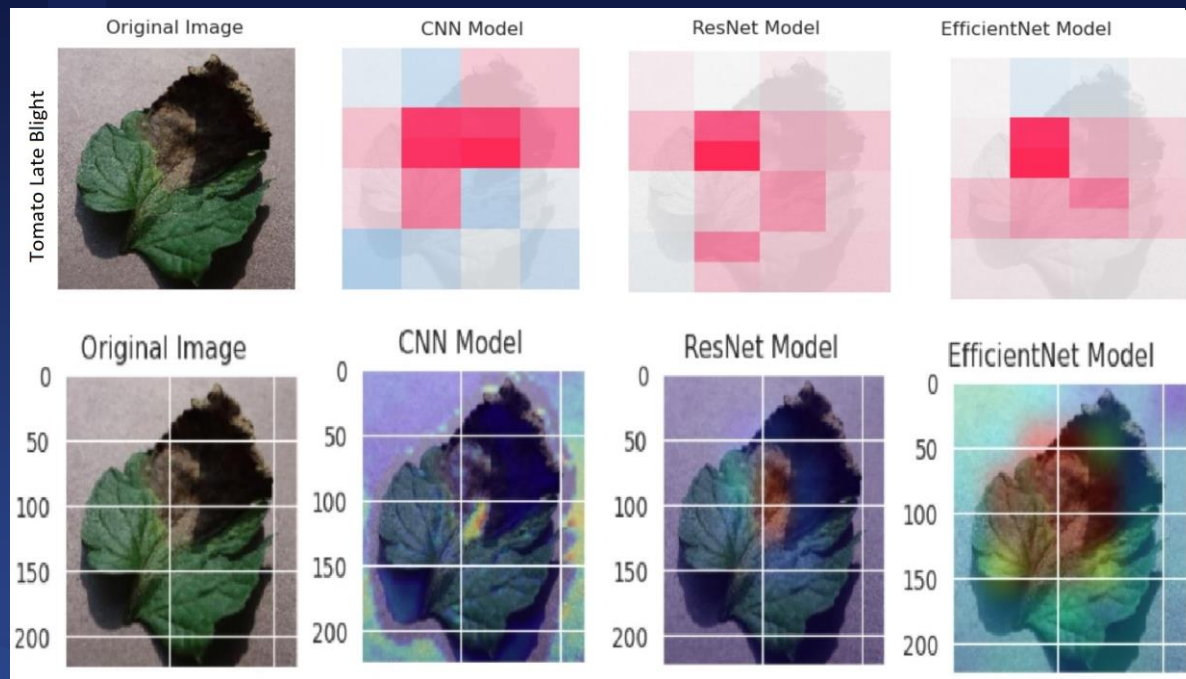
SHAP



Grad-CAM



COMPARISON OF XAI TECHNIQUES



***THANK YOU FOR
YOUR TIME!!!***