Classification of Degree of Freshness and Healthiness of Fruits and Vegetables

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Introduction

Food waste is a major global issue, with fruits and vegetables being the most wasted. Our project uses deep learning to classify the freshness and healthiness of fruits and vegetables. We implemented VGG16 for freshness classification and EfficientNet-B0 for detecting diseases in tomatoes. Our system aims to reduce food waste by providing real-time freshness and healthiness information.

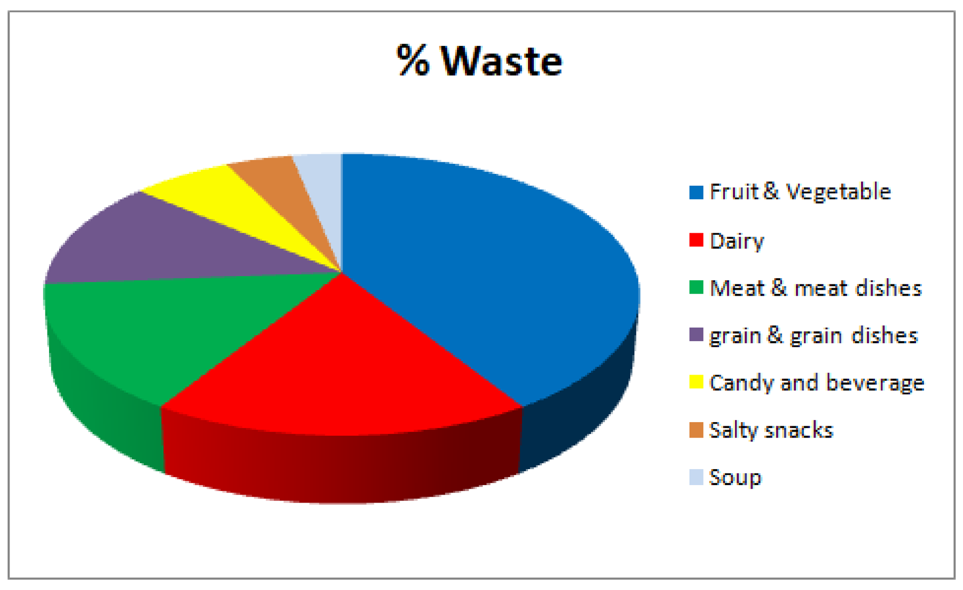

Figure 1: food waste by category

Datasets

Two primary datasets were used in this study: the FruitVeg dataset and the PlantVillage dataset. The FruitVeg dataset, used by the benchmark paper, has 60,059 RGB images of 11 fruits and vegetables, categorized as fresh, medium-fresh, or rotten. The images were split 70-30 for training and testing, with the training set further divided 70-20-10 for training, validation, and testing.

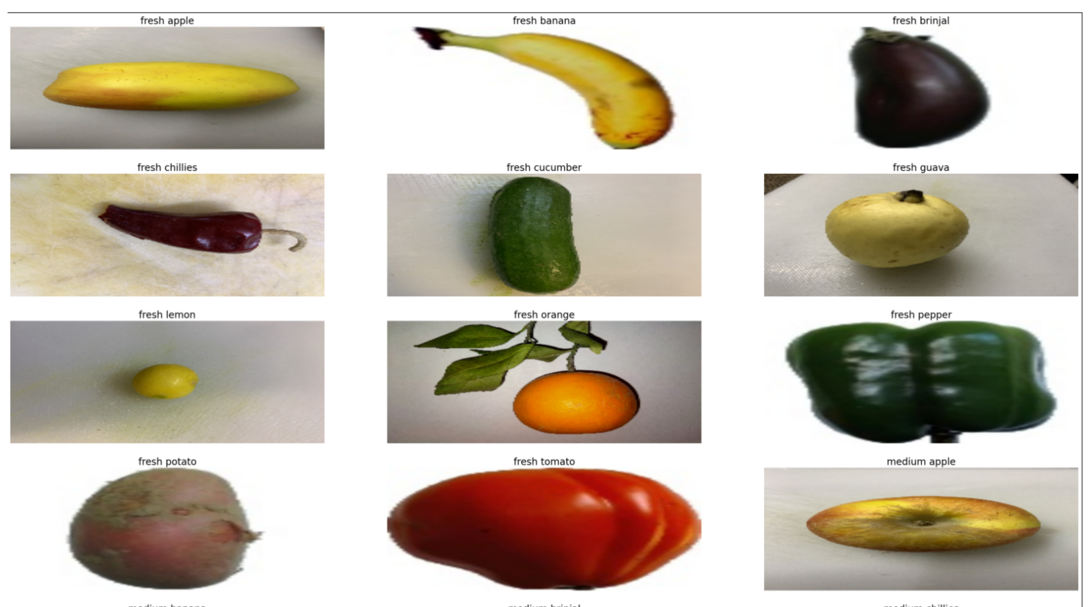

Figure 2: Instances of FruitVeg dataset

The PlantVillage dataset focuses on fruit and vegetable leaf diseases, containing 54,305 RGB images of various leaves. The tomato subset has 18,160 images in 10 classes (9 diseases, 1 healthy). It was split into 60% training, 10% validation, and 30% testing sets for model evaluation.

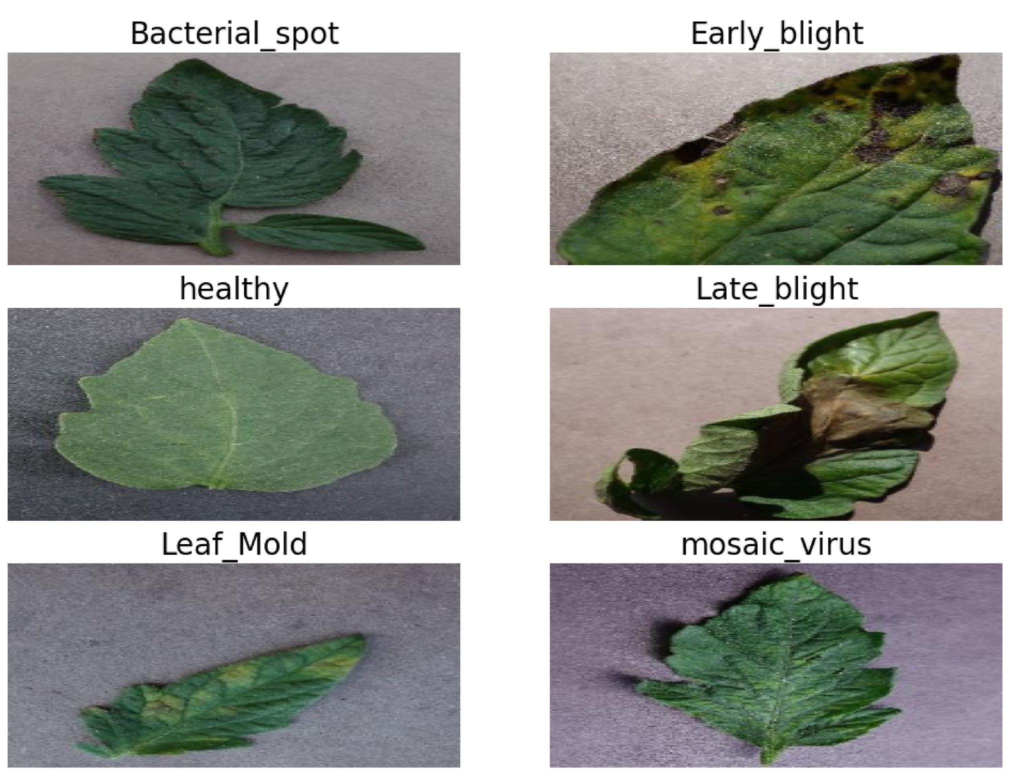

Figure 3: Instances of PlantVillage tomatoes subset

Methodology

We used the FruitVeg dataset for the freshness assessment, which includes images of fruits and vegetables categorized into three classes: fresh, medium-fresh, and rotten. We utilized the VGG16 architecture from the Keras library, freezing its layers and adding two dense layers with ReLU as the activation function and Softmax as the output layer. Regularization was applied using a dropout rate of 20%, and categorical cross-entropy was used as the loss function. The model was optimized using the Adam optimizer with a learning rate of 0.0001 and trained for 15 epochs.

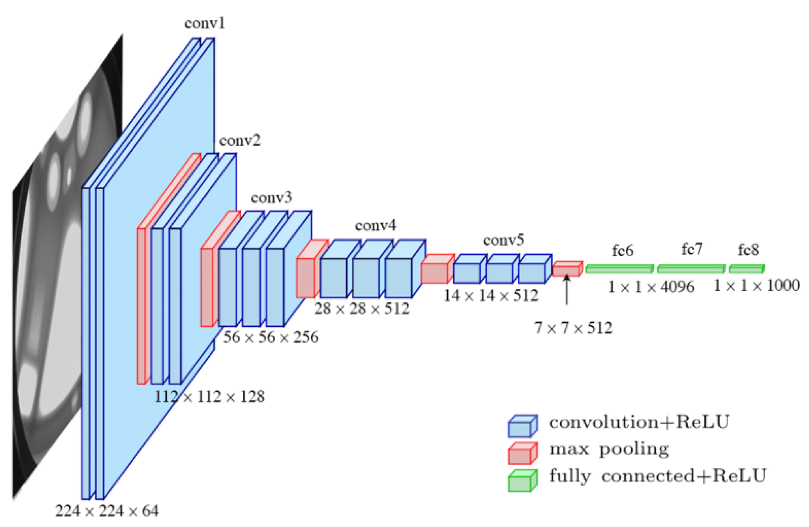

Figure 4: VGG16 Architecture

for the PlantVillage dataset, Six different CNN models were implemented, including VGG16, VGG19, InceptionV3, EfficientNet-B0, and DenseNet121 from the Keras library, and AlexNet, which was manually implemented. Each model's architecture was combined with two dense layers, batch normalization to prevent overfitting, and dropout for regularization. The models were trained for 20 epochs, except for InceptionV3, which was trained for 5 epochs to avoid overfitting. The models were optimized using the Adam optimizer with a learning rate of 0.0001 and evaluated using the categorical cross-entropy loss function. EfficientNet-B0 model showed the best results.

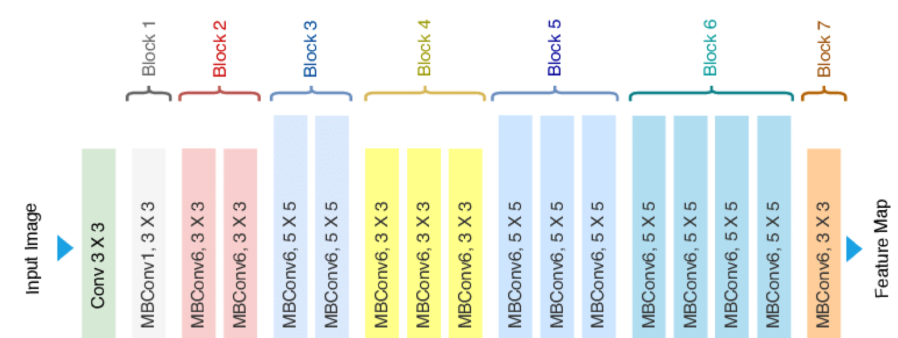

Figure 5: EfficientNet-B0 architecture

Experiments

For FruitVeg dataset, 4 VGG16 configurations were tested, with Experiment 3 (two dense layers of 128 and 64 neurons for 15 epochs) achieving the highest accuracy of 94.58% (Table 1). For the PlantVillage dataset, six CNN models were compared, with EfficientNet-B0 performing best at 96.04% accuracy.

Table 1: VGG16 Experiments

Experiment	Parameters			Metrics			
	epochs	No. of Dense Layers	No. of Neurons in the dense layers	Training Acc	F1 Macro	Test Acc	Loss
1	15	2	32,16	0.7584	0.8539	0.9128	0.3426
2	15	2	64,32	0.9169	0.9102	0.9296	0.3870
3	15	2	128,64	0.9832	0.9207	0.9458	0.2140
4	20	3	128,64,32	0.9675	0.9148	0.9390	0.2493

Results

Figure 1 illustrates the model's performance over 15 epochs, showing consistent improvement and convergence.

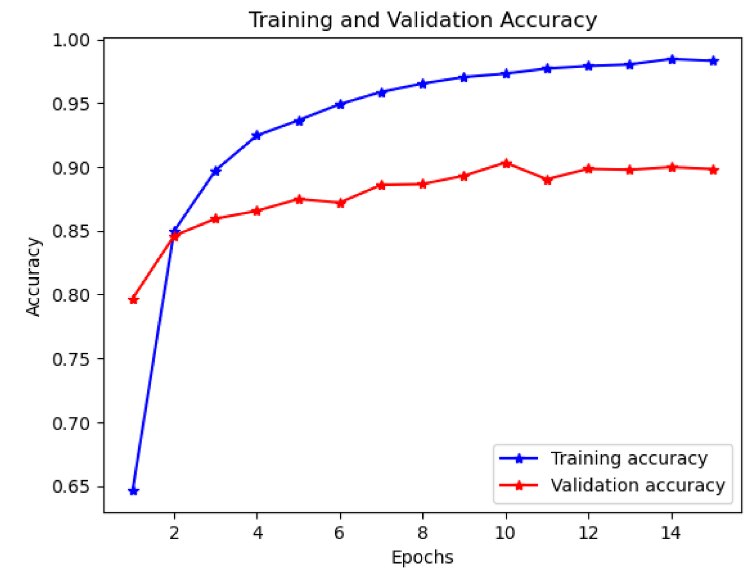

Figure 6: Training Accuracy for VGG16

The VGG16 model achieved a test accuracy of 94.58%, as shown in the confusion matrix (Figure 7), with high precision and recall across various classes.

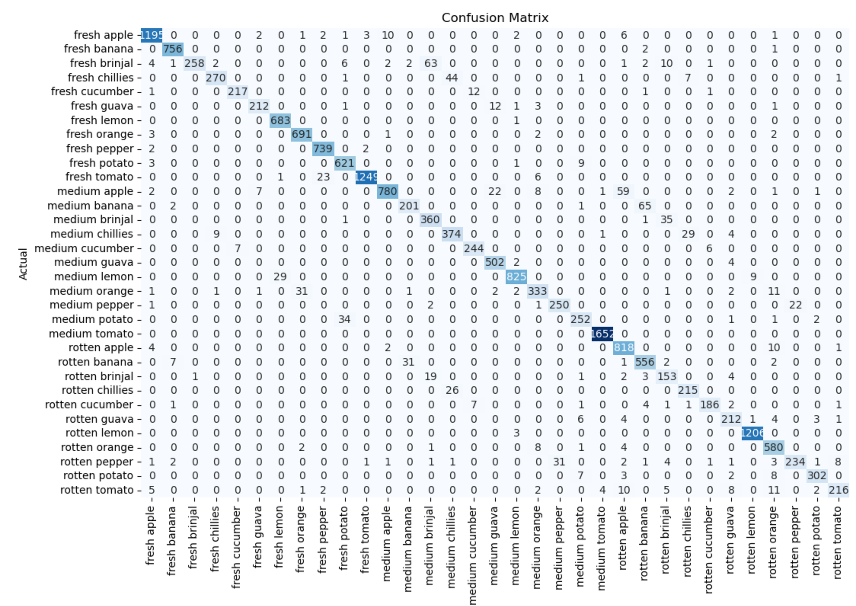

Figure 7: Confusion Matrix for VGG16

EfficientNet-B0 achieved an impressive test accuracy of 96.04%, as highlighted in Table 2

Table 2: Accuracies for the 6 different CNNs

Architecture	Accuracy
VGG16	90.79%
VGG19	87.66%
DenseNet121	94.87%
InceptionV3	92.87%
AlexNet	94.71%
EfficientNet-B0	**96.04%**

Figure 8 shows the robust learning of Efficient-B0, achieving high accuracy early on and maintaining it throughout the training process.

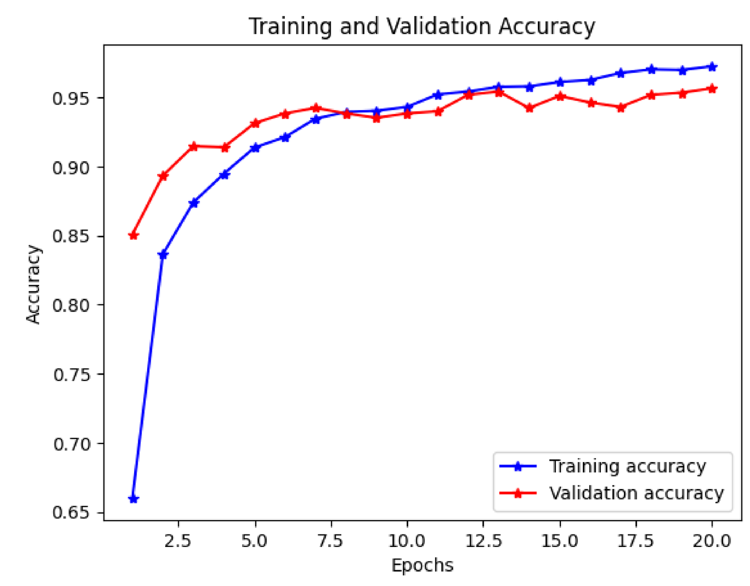

Figure 8: Training Accuracy for EfficientNet-B0

Conclusions

In this project, we improved deep learning models to tackle food waste by classifying fruit freshness and tomato diseases. We achieved 94.58% accuracy with VGG16 for fruit classification and 96.04% with EfficientNet-B0 for tomato diseases. These results highlight the potential of advanced machine learning in enhancing agricultural sustainability. Future work will refine models, expand datasets, and explore new architectures for better accuracy.