

Model Development Phase

Date	21 June 2025
Team ID	SWTID1750180744
Project Title	Smart Sorting: Transfer Learning For Identifying Rotten Fruits And Vegetables
Maximum Marks	10 Marks

Initial Model Training Code, Model Validation and Evaluation Report

The initial model training code will be showcased in the future through a screenshot. The model validation and evaluation report will include a summary and training and validation performance metrics for multiple models, presented through respective screenshots.

Initial Model Training Code (5 marks):

```
from tensorflow.keras.applications.vgg16 import VGG16
from tensorflow.keras.layers import Dense, Flatten
from tensorflow.keras.models import Model

vgg = VGG16(include_top=False, weights="imagenet", input_shape=(224, 224, 3))

for layer in vgg.layers:
    print(layer)

print(len(vgg.layers))

for layer in vgg.layers:
    layer.trainable = False

x = Flatten()(vgg.output)
output = Dense(28, activation='softmax')(x)

vgg16 = Model(inputs=vgg.input, outputs=output)

vgg16.summary()
```

```
from keras.callbacks import EarlyStopping
from keras.optimizers import Adam

opt = Adam(learning_rate=0.0001)

# Early stopping callback
early_stopping = EarlyStopping(monitor='val_accuracy', patience=3, restore_best_weights=True)

# Compile the model
vgg16.compile(optimizer= opt, loss="categorical_crossentropy", metrics=["accuracy"])

# Train the model
history = vgg16.fit(
    train,
    validation_data=test,
    epochs=15,
    callbacks=[early_stopping]
)
```

Model Validation and Evaluation Report (5 marks):

Model	Summary	Training and Validation Performance Metrics																																																																		
VGG16 (Transfer Learning with Custom Dense Layer)	<div> <pre><inputLayer name=input_layer_3, built=True> <Conv2D name=block1_conv1, built=True> <Conv2D name=block1_conv2, built=True> <MaxPooling2D name=block1_pool, built=True> <Conv2D name=block2_conv1, built=True> <Conv2D name=block2_conv2, built=True> <MaxPooling2D name=block2_pool, built=True> <Conv2D name=block3_conv1, built=True> <Conv2D name=block3_conv2, built=True> <Conv2D name=block3_conv3, built=True> <MaxPooling2D name=block3_pool, built=True> <Conv2D name=block4_conv1, built=True> <Conv2D name=block4_conv2, built=True> <Conv2D name=block4_conv3, built=True> <MaxPooling2D name=block4_pool, built=True> <Conv2D name=block5_conv1, built=True> <Conv2D name=block5_conv2, built=True> <Conv2D name=block5_conv3, built=True> <MaxPooling2D name=block5_pool, built=True> 19 Model: "Functional_3"</pre> </div> <table> <thead> <tr> <th>Layer (type)</th><th>Output Shape</th><th>Param #</th></tr> </thead> <tbody> <tr> <td>input_layer_3 (InputLayer)</td><td>(None, 224, 224, 3)</td><td>0</td></tr> <tr> <td>block1_conv1 (Conv2D)</td><td>(None, 224, 224, 32)</td><td>3,136</td></tr> <tr> <td>block1_conv2 (Conv2D)</td><td>(None, 224, 224, 64)</td><td>36,864</td></tr> <tr> <td>block1_pool (MaxPooling2D)</td><td>(None, 112, 112, 64)</td><td>0</td></tr> <tr> <td>block2_conv1 (Conv2D)</td><td>(None, 112, 112, 128)</td><td>13,824</td></tr> <tr> <td>block2_conv2 (Conv2D)</td><td>(None, 112, 112, 128)</td><td>167,104</td></tr> <tr> <td>block2_pool (MaxPooling2D)</td><td>(None, 56, 56, 128)</td><td>0</td></tr> <tr> <td>block3_conv1 (Conv2D)</td><td>(None, 56, 56, 256)</td><td>33,792</td></tr> <tr> <td>block3_conv2 (Conv2D)</td><td>(None, 56, 56, 256)</td><td>338,688</td></tr> <tr> <td>block3_conv3 (Conv2D)</td><td>(None, 56, 56, 256)</td><td>338,688</td></tr> <tr> <td>block3_pool (MaxPooling2D)</td><td>(None, 28, 28, 256)</td><td>0</td></tr> <tr> <td>block4_conv1 (Conv2D)</td><td>(None, 28, 28, 512)</td><td>1,100,800</td></tr> <tr> <td>block4_conv2 (Conv2D)</td><td>(None, 28, 28, 512)</td><td>2,258,880</td></tr> <tr> <td>block4_conv3 (Conv2D)</td><td>(None, 28, 28, 512)</td><td>2,258,880</td></tr> <tr> <td>block4_pool (MaxPooling2D)</td><td>(None, 14, 14, 512)</td><td>0</td></tr> <tr> <td>block5_conv1 (Conv2D)</td><td>(None, 14, 14, 512)</td><td>2,258,880</td></tr> <tr> <td>block5_conv2 (Conv2D)</td><td>(None, 14, 14, 512)</td><td>2,258,880</td></tr> <tr> <td>block5_conv3 (Conv2D)</td><td>(None, 14, 14, 512)</td><td>2,258,880</td></tr> <tr> <td>block5_pool (MaxPooling2D)</td><td>(None, 7, 7, 512)</td><td>0</td></tr> <tr> <td>flatten_3 (Flatten)</td><td>(None, 25088)</td><td>0</td></tr> <tr> <td>dense_3 (Dense)</td><td>(None, 10)</td><td>250,890</td></tr> </tbody> </table> <p>Total params: 12,411,140 (58.81 MB) Trainable params: 12,411,140 (58.81 MB) Non-trainable params: 0 (0.00 MB)</p>	Layer (type)	Output Shape	Param #	input_layer_3 (InputLayer)	(None, 224, 224, 3)	0	block1_conv1 (Conv2D)	(None, 224, 224, 32)	3,136	block1_conv2 (Conv2D)	(None, 224, 224, 64)	36,864	block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0	block2_conv1 (Conv2D)	(None, 112, 112, 128)	13,824	block2_conv2 (Conv2D)	(None, 112, 112, 128)	167,104	block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0	block3_conv1 (Conv2D)	(None, 56, 56, 256)	33,792	block3_conv2 (Conv2D)	(None, 56, 56, 256)	338,688	block3_conv3 (Conv2D)	(None, 56, 56, 256)	338,688	block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0	block4_conv1 (Conv2D)	(None, 28, 28, 512)	1,100,800	block4_conv2 (Conv2D)	(None, 28, 28, 512)	2,258,880	block4_conv3 (Conv2D)	(None, 28, 28, 512)	2,258,880	block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0	block5_conv1 (Conv2D)	(None, 14, 14, 512)	2,258,880	block5_conv2 (Conv2D)	(None, 14, 14, 512)	2,258,880	block5_conv3 (Conv2D)	(None, 14, 14, 512)	2,258,880	block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0	flatten_3 (Flatten)	(None, 25088)	0	dense_3 (Dense)	(None, 10)	250,890	<pre>Epoch 1/15: 140/140 -> 140s 418ms/step - accuracy: 0.7913 - loss: 0.6479 - val_accuracy: 0.7936 - val_loss: 0.7363 Epoch 2/15: 140/140 -> 140s 575ms/step - accuracy: 0.7938 - loss: 0.6428 - val_accuracy: 0.7936 - val_loss: 0.7363 Epoch 3/15: 140/140 -> 140s 577ms/step - accuracy: 0.8225 - loss: 0.5455 - val_accuracy: 0.8852 - val_loss: 0.4814 Epoch 4/15: 140/140 -> 140s 581ms/step - accuracy: 0.8329 - loss: 0.5181 - val_accuracy: 0.8888 - val_loss: 0.4806 Epoch 5/15: 140/140 -> 140s 583ms/step - accuracy: 0.8436 - loss: 0.5124 - val_accuracy: 0.8186 - val_loss: 0.6658 Epoch 6/15: 140/140 -> 140s 586ms/step - accuracy: 0.8683 - loss: 0.4488 - val_accuracy: 0.8123 - val_loss: 0.6657 Epoch 7/15: 140/140 -> 140s 589ms/step - accuracy: 0.8596 - loss: 0.4478 - val_accuracy: 0.8239 - val_loss: 0.6333 Epoch 8/15: 140/140 -> 140s 591ms/step - accuracy: 0.8737 - loss: 0.4838 - val_accuracy: 0.8257 - val_loss: 0.6259 Epoch 9/15: 140/140 -> 140s 574ms/step - accuracy: 0.8814 - loss: 0.4118 - val_accuracy: 0.8293 - val_loss: 0.6822 Epoch 10/15: 140/140 -> 140s 568ms/step - accuracy: 0.8787 - loss: 0.4168 - val_accuracy: 0.8195 - val_loss: 0.6854 Epoch 11/15: 140/140 -> 140s 568ms/step - accuracy: 0.8889 - loss: 0.3828 - val_accuracy: 0.8374 - val_loss: 0.5824 Epoch 12/15: 140/140 -> 140s 568ms/step - accuracy: 0.8767 - loss: 0.4196 - val_accuracy: 0.8239 - val_loss: 0.6189 Epoch 13/15: 140/140 -> 140s 562ms/step - accuracy: 0.8845 - loss: 0.3712 - val_accuracy: 0.8311 - val_loss: 0.5972 Epoch 14/15: 140/140 -> 140s 563ms/step - accuracy: 0.8862 - loss: 0.3733 - val_accuracy: 0.8347 - val_loss: 0.5854</pre>
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