```python
import streamlit as st
import tensorflow as tf
import numpy as np
from tensorflow.keras.models import load_model
from PIL import Image


def add_bg_from_url():
    st.markdown(
         f"""
         <style>
         .stApp {{
             background-image: linear-gradient(rgba(0,0,0,0.2), rgba(0,0,0,2)), url("https://i.pinimg.com/736x/c9/6d/60/c96d601d5ba32d581f40a8a06d1e0971.jpg");
             background-attachment: fixed;
             background-size: cover;
         }}

         /* Tambahan style untuk membuat konten lebih readable */
         .main {{
             background-color: rgba(255, 255, 255, 0.85);
             padding: 20px;
             border-radius: 10px;
         }}

         .sidebar .sidebar-content {{
             background-color: rgba(255, 255, 255, 0.9);
         }}
         </style>
         """,
         unsafe_allow_html=True
    )

add_bg_from_url()

model = load_model(r"D:\Kuliah\.Semester 5\ML\UAS\BestModel_MobilNetCNN_Seaborn.h5")

class_names = ['PaprikaHijau', 'PaprikaKuning', 'PaprikaMerah']


def preprocess_image(image_array):
    return tf.cast(image_array, tf.float32) / 255.0


def classify_image(image_path):
    try:

        input_image = tf.keras.utils.load_img(image_path, target_size=(180, 180))
        input_image_array = tf.keras.utils.img_to_array(input_image)
        input_image_exp_dim = tf.expand_dims(input_image_array, 0)

        predictions = model.predict(input_image_exp_dim)
        result = tf.nn.softmax(predictions[0])

        class_idx = np.argmax(result)
        confidence_scores = result.numpy()

        return class_names[class_idx], confidence_scores
    except Exception as e:
        return "Error", str(e)

def custom_progress_bar(confidence, color_map):
    percentage1 = confidence[0] * 100  # Hijau
    percentage2 = confidence[1] * 100  # Kuning
    percentage3 = confidence[2] * 100  # Merah

    progress_html = f"""
    <div style="width: 100%; border: 1px solid #ddd; border-radius: 5px; overflow: hidden; width: 100%; font-size: 14px;">
        <div style="width: {percentage1:.2f}%; background: {color_map['PaprikaHijau']}; color: white; text-align: center; height: 24px; float: left;">
            {percentage1:.2f}%
        </div>
        <div style="width: {percentage2:.2f}%; background: {color_map['PaprikaKuning']}; color: white; text-align: center; height: 24px; float: left;">
            {percentage2:.2f}%
        </div>
        <div style="width: {percentage3:.2f}%; background: {color_map['PaprikaMerah']}; color: white; text-align: center; height: 24px; float: left;">
            {percentage3:.2f}%
        </div>
    </div>
    """
    st.sidebar.markdown(progress_html, unsafe_allow_html=True)

st.title("Prediksi Jenis Paprika - Seaborn")

uploaded_files = st.file_uploader("Unggah Gambar (Beberapa diperbolehkan)", type=["jpg", "png", "jpeg"], accept_multiple_files=True)

if st.sidebar.button("Prediksi"):
    if uploaded_files:
        st.sidebar.write("### Hasil Prediksi")
        for uploaded_file in uploaded_files:
            with open(uploaded_file.name, "wb") as f:
                f.write(uploaded_file.getbuffer())

            label, confidence = classify_image(uploaded_file.name)

            if label != "Error":
                color_map = {
                    "PaprikaHijau": "#008000",
                    "PaprikaKuning": "#FFD700",
                    "PaprikaMerah": "#FF0000"
                }

                label_color = color_map.get(label, "#000000")

                st.sidebar.write(f"*Nama File:* {uploaded_file.name}")
                st.sidebar.markdown(f"<h4 style='color: {label_color};'>Prediksi: {label}</h4>", unsafe_allow_html=True)

                st.sidebar.write("*Confidence:*")
```

```
                display_names = ["PaprikaHijau", "PaprikaKuning", "PaprikaMerah"]  # Sesuai urutan model tanpa 'Paprika'
                for i, name in enumerate(display_names):
                    st.sidebar.write(f"- {name}: {confidence[i] * 100:.2f}%")

                custom_progress_bar(confidence, color_map)

                st.sidebar.write("---")
            else:
                st.sidebar.error(f"Kesalahan saat memproses gambar {uploaded_file.name}: {confidence}")
    else:
        st.sidebar.error("Silakan unggah setidaknya satu gambar untuk diprediksi.")

if uploaded_files:
    st.write("### Preview Gambar")
    for uploaded_file in uploaded_files:
        image = Image.open(uploaded_file)
        st.image(image, caption=f"{uploaded_file.name}", use_column_width=True)
```

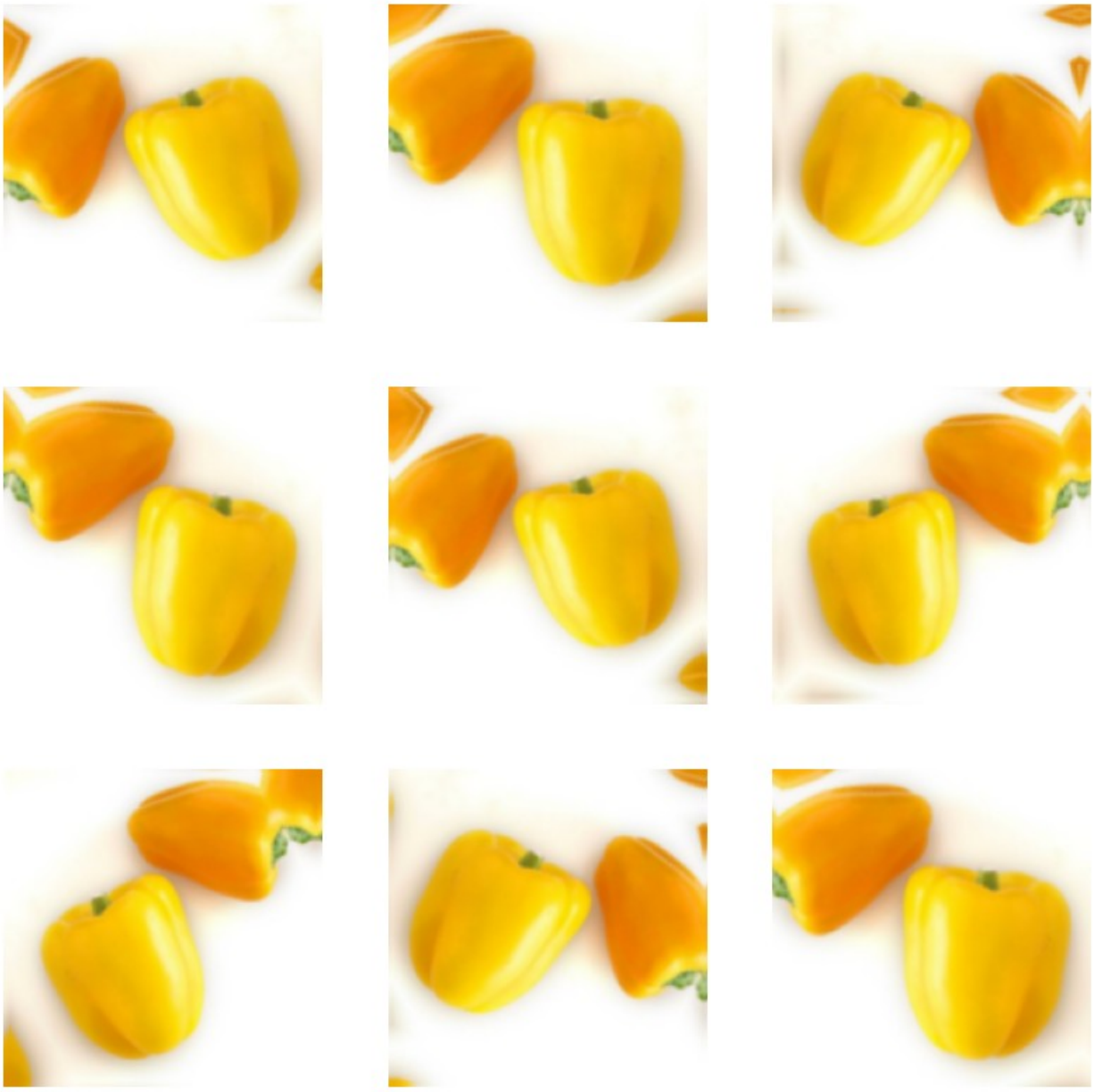
```
import tensorflow as tf
from keras.models import Sequential
from keras.layers import Dense, Flatten, Dropout
from keras.applications import VGG16
from keras.callbacks import ModelCheckpoint, EarlyStopping
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np

img_size = 180
batch_size = 32
random_state = 71
data_dir = "Dataset"

def load_data(directory, img_size, batch_size, random_state):
    dataset = tf.keras.utils.image_dataset_from_directory(
        directory,
        seed=random_state,
        image_size=(img_size, img_size),
        batch_size=batch_size
    )
    return dataset

dataset = load_data(data_dir, img_size, batch_size, random_state)
class_names = dataset.class_names
```

```
Found 330 files belonging to 3 classes.
```

```
def visualize_data(dataset, num_images):
    plt.figure(figsize=(10, 10))
    for images, labels in dataset.take(1):
        for i in range(num_images):
            ax = plt.subplot(3, 3, i + 1)
            plt.imshow(images[i].numpy().astype("uint8"))
            plt.title(class_names[labels[i]])
            plt.axis("off")

visualize_data(dataset, 9)
```


```
val_split = 0.1
test_split = 0.1
total_count = len(dataset)
val_size = int(total_count * val_split)
test_size = int(total_count * test_split)
train_size = total_count - val_size - test_size

train_ds = dataset.skip(val_size + test_size)
val_ds = dataset.skip(test_size).take(val_size)
test_ds = dataset.take(test_size)
```

```
def normalize(image, label):
    return image / 255.0, label

data_augmentation = Sequential([
    tf.keras.layers.RandomFlip("horizontal", input_shape=(img_size,
img_size, 3)),
    tf.keras.layers.RandomRotation(0.1),
    tf.keras.layers.RandomZoom(0.1)
])

def augment_and_normalize(image, label):
    image = data_augmentation(image)
    return normalize(image, label)

train_ds = train_ds.map(augment_and_normalize)
val_ds = val_ds.map(normalize)
test_ds = test_ds.map(normalize)

plt.figure(figsize=(10, 10))
for images, labels in train_ds.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
        augmented_image = tf.clip_by_value(augmented_images[0] * 255,
0, 255)  # Scale back to 0–255
        plt.subplot(3, 3, i + 1)
        plt.imshow(augmented_image.numpy().astype("uint8"))
        plt.axis("off")
plt.show()
```



```
vgg_base = VGG16(weights=None, include_top=False,
input_shape=(img_size, img_size, 3))

model = Sequential([
    vgg_base,
    Flatten(),
    Dense(256, activation='relu'),
    Dropout(0.5),
    Dense(128, activation='relu'),
    Dropout(0.5),
    Dense(len(class_names), activation='softmax')
])
```

```
model.compile(
    optimizer=tf.keras.optimizers.Adam(learning_rate=0.00001),
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

model.summary()
```

```
Model: "sequential_26"
```

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 5, 5, 512)	14,714,688
flatten_8 (Flatten)	(None, 12800)	0
dense_24 (Dense)	(None, 256)	3,277,056
dropout_16 (Dropout)	(None, 256)	0
dense_25 (Dense)	(None, 128)	32,896
dropout_17 (Dropout)	(None, 128)	0
dense_26 (Dense)	(None, 3)	387

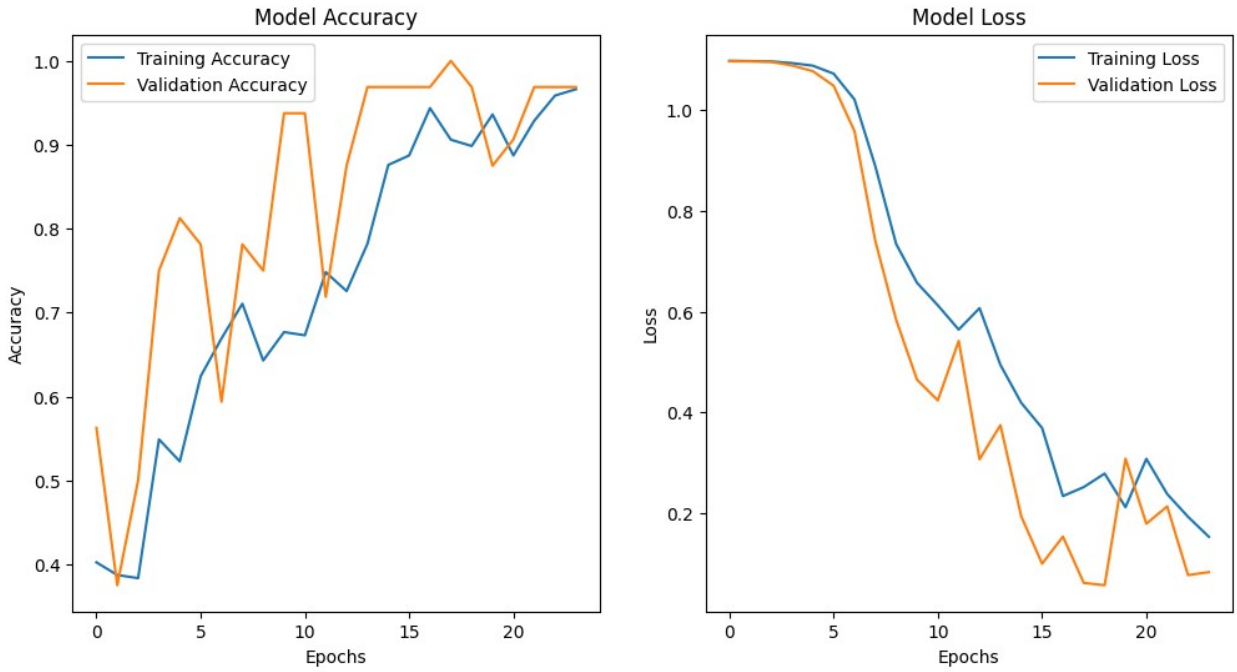
```
 Total params: 18,025,027 (68.76 MB)

 Trainable params: 18,025,027 (68.76 MB)

 Non-trainable params: 0 (0.00 B)
```

```
callbacks = [
    ModelCheckpoint("vgg16_best_model.keras", save_best_only=True,
monitor="val_accuracy", mode="max"),
    EarlyStopping(monitor="val_loss", patience=5,
restore_best_weights=True)
]

history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=25,
    callbacks=callbacks
)

Epoch 1/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 14s 1s/step - accuracy: 0.3714 - loss: 1.0983
- val_accuracy: 0.5625 - val_loss: 1.0972
Epoch 2/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 893ms/step - accuracy: 0.4101 - loss:
1.0973 - val_accuracy: 0.3750 - val_loss: 1.0968
Epoch 3/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 887ms/step - accuracy: 0.3665 - loss:
1.0968 - val_accuracy: 0.5000 - val_loss: 1.0960
Epoch 4/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 1000ms/step - accuracy: 0.5327 - loss:
1.0944 - val_accuracy: 0.7500 - val_loss: 1.0889
Epoch 5/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 1s/step - accuracy: 0.5045 - loss: 1.0900
- val_accuracy: 0.8125 - val_loss: 1.0776
Epoch 6/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 889ms/step - accuracy: 0.6178 - loss:
1.0778 - val_accuracy: 0.7812 - val_loss: 1.0486
Epoch 7/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 885ms/step - accuracy: 0.6529 - loss:
1.0338 - val_accuracy: 0.5938 - val_loss: 0.9586
Epoch 8/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 902ms/step - accuracy: 0.6943 - loss:
0.9233 - val_accuracy: 0.7812 - val_loss: 0.7404
Epoch 9/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 887ms/step - accuracy: 0.6423 - loss:
0.7556 - val_accuracy: 0.7500 - val_loss: 0.5837
Epoch 10/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 10s 1s/step - accuracy: 0.6857 - loss: 0.6532
- val_accuracy: 0.9375 - val_loss: 0.4650
Epoch 11/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 895ms/step - accuracy: 0.6794 - loss:
0.6216 - val_accuracy: 0.9375 - val_loss: 0.4237
Epoch 12/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 896ms/step - accuracy: 0.7250 - loss:
0.6217 - val_accuracy: 0.7188 - val_loss: 0.5419
```

```
Epoch 13/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 898ms/step - accuracy: 0.6878 - loss:
0.6322 - val_accuracy: 0.8750 - val_loss: 0.3068
Epoch 14/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 1s/step - accuracy: 0.7711 - loss: 0.5165
- val_accuracy: 0.9688 - val_loss: 0.3747
Epoch 15/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 920ms/step - accuracy: 0.8577 - loss:
0.4382 - val_accuracy: 0.9688 - val_loss: 0.1936
Epoch 16/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 895ms/step - accuracy: 0.8924 - loss:
0.3769 - val_accuracy: 0.9688 - val_loss: 0.0995
Epoch 17/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 890ms/step - accuracy: 0.9382 - loss:
0.2553 - val_accuracy: 0.9688 - val_loss: 0.1533
Epoch 18/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 1s/step - accuracy: 0.9177 - loss: 0.2366
- val_accuracy: 1.0000 - val_loss: 0.0614
Epoch 19/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 887ms/step - accuracy: 0.8992 - loss:
0.2775 - val_accuracy: 0.9688 - val_loss: 0.0568
Epoch 20/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 894ms/step - accuracy: 0.9378 - loss:
0.1884 - val_accuracy: 0.8750 - val_loss: 0.3081
Epoch 21/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 894ms/step - accuracy: 0.9002 - loss:
0.3023 - val_accuracy: 0.9062 - val_loss: 0.1789
Epoch 22/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 885ms/step - accuracy: 0.9352 - loss:
0.2239 - val_accuracy: 0.9688 - val_loss: 0.2132
Epoch 23/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 9s 906ms/step - accuracy: 0.9557 - loss:
0.1882 - val_accuracy: 0.9688 - val_loss: 0.0769
Epoch 24/25
9/9 ━━━━━━━━━━━━━━━━━━━━ 8s 886ms/step - accuracy: 0.9787 - loss:
0.1385 - val_accuracy: 0.9688 - val_loss: 0.0828
```

```
history_df = pd.DataFrame(history.history)
plt.figure(figsize=(12, 6))

plt.subplot(1, 2, 1)
plt.plot(history_df['accuracy'], label='Training Accuracy')
plt.plot(history_df['val_accuracy'], label='Validation Accuracy')
plt.title('Model Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.plot(history_df['loss'], label='Training Loss')
```

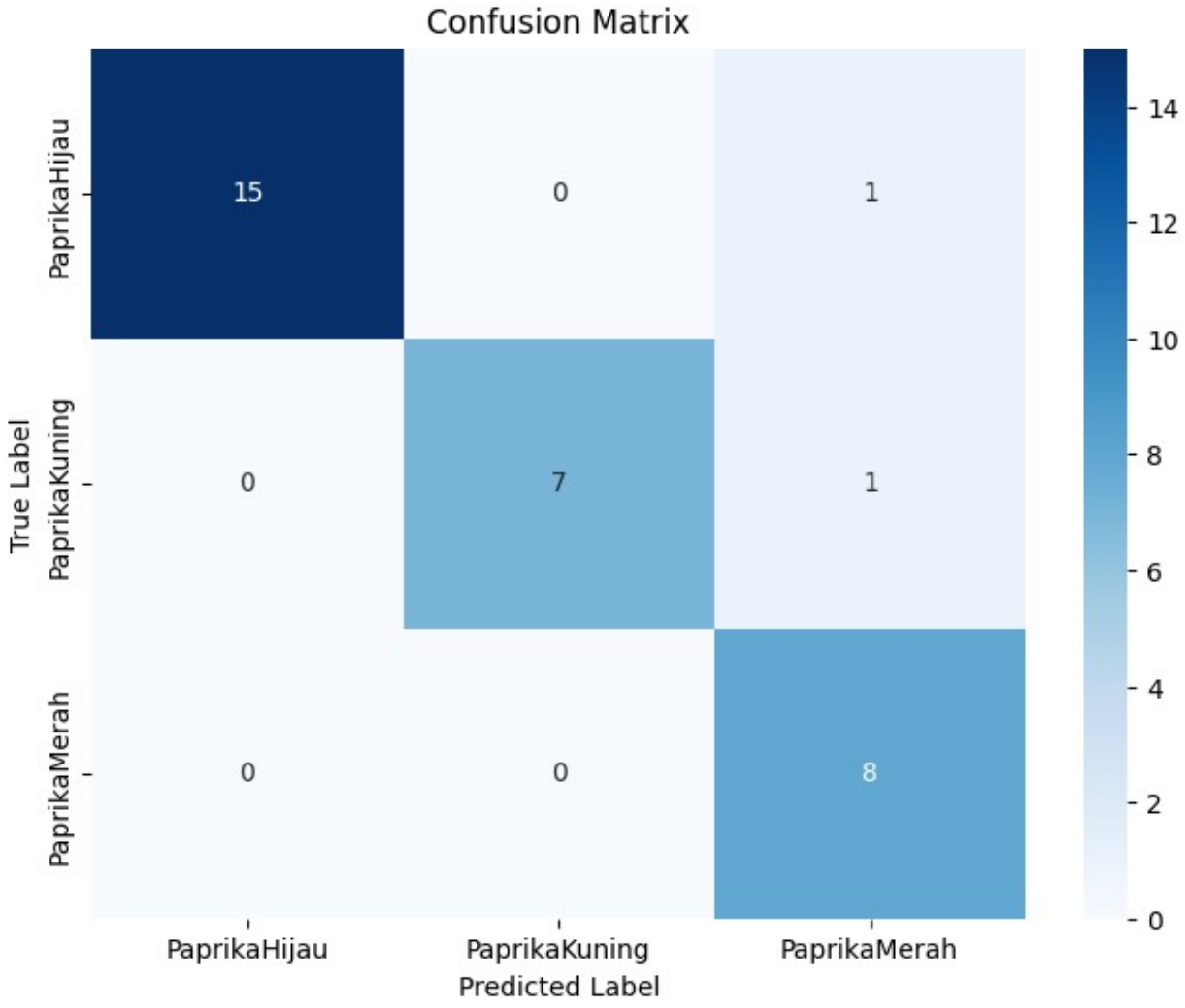
```
plt.plot(history_df['val_loss'], label='Validation Loss')
plt.title('Model Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```




```
def evaluate_model(model, test_ds):
    test_images, test_labels = [], []
    for images, labels in test_ds:
        test_images.append(images.numpy())
        test_labels.append(labels.numpy())

    test_images = np.concatenate(test_images)
    test_labels = np.concatenate(test_labels)

    predictions = np.argmax(model.predict(test_images), axis=1)

    cm = confusion_matrix(test_labels, predictions)

    accuracy = np.trace(cm) / np.sum(cm)
    precision = np.diag(cm) / np.sum(cm, axis=0)
    recall = np.diag(cm) / np.sum(cm, axis=1)
    f1_score = 2 * (precision * recall) / (precision + recall)

    plt.figure(figsize=(8, 6))
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
xticklabels=class_names, yticklabels=class_names)
```

```
    plt.title('Confusion Matrix')
    plt.xlabel('Predicted Label')
    plt.ylabel('True Label')
    plt.show()

    print("Confusion Matrix:")
    print(cm)
    print(f"Accuracy: {accuracy:.4f}")
    print(f"Precision: {precision}")
    print(f"Recall: {recall}")
    print(f"F1 Score: {f1_score}")

evaluate_model(model, test_ds)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 497ms/step
```



```
Confusion Matrix:
[[15  0  1]
 [ 0  7  1]
 [ 0  0  8]]
Accuracy: 0.9375
Precision: [1.  1.  0.8]
Recall: [0.9375 0.875  1.    ]
F1 Score: [0.96774194 0.93333333 0.88888889]

model.save("BestModel_VGG-16_Seaborn.h5")

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

def classify_images(image_path, save_path='predicted_image.jpg'):
    try:
        input_image = tf.keras.utils.load_img(image_path,
target_size=(img_size, img_size))
        input_image_array = tf.keras.utils.img_to_array(input_image)
        input_image_exp_dim = tf.expand_dims(input_image_array, 0)

        predictions = model.predict(input_image_exp_dim)
        result = tf.nn.softmax(predictions[0])
        class_idx = np.argmax(result)
        confidence = np.max(result) * 100

        print(f"Prediksi: {class_names[class_idx]}")
        print(f"Confidence: {confidence:.2f}%")

        input_image = Image.open(image_path)
        input_image.save(save_path)

        return f"Prediksi: {class_names[class_idx]} dengan confidence
{confidence:.2f}%. Gambar asli disimpan di {save_path}."
    except Exception as e:
        return f"Terjadi kesalahan: {e}"

result = classify_images(r'.jpg', save_path='paprika.jpg')
print(result)

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 64ms/step
Prediksi: PaprikaHijau
Confidence: 57.61%
Prediksi: PaprikaHijau dengan confidence 57.61%. Gambar asli disimpan
di paprika.jpg.

print("Eliandani Andreskia Setiawan / 220711965 / Seaborn / Perbedaan
Paprika Merah, Kuning, Hijau Menggunaakn VGG-16")
```

Eliandani Andreskia Setiawan / 220711965 / Seaborn / Perbedaan Paprika Merah, Kuning, Hijau Menggunaakn VGG-16

30l2mi5z0

December 19, 2024

[171]:
```
import os
import numpy as np

import tensorflow as tf
from tensorflow.keras import layers
from tensorflow.keras.preprocessing.image import load_img, ImageDataGenerator
from tensorflow.keras.models import Sequential, load_model
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Dense, Dropout,␣
↪Flatten
```

[172]:
```
count = 0  # digunakan untuk menghitung jumlah gambar
base_path = r'D:\UAJY\UAJY_sem_5\ML\UAS\data_paprika'
dirs = os.listdir(base_path)

for dir in dirs:
    # Gunakan os.path.join untuk menggabungkan path dengan benar
    full_path = os.path.join(base_path, dir)
    files = list(os.listdir(full_path))
    print(dir + ' Folder has ' + str(len(files)) + ' Images')
    count = count + len(files)
print('Images Folder has ' + str(count) + ' Images')
```

```
PaprikaHijau Folder has 110 Images
PaprikaKuning Folder has 110 Images
PaprikaMerah Folder has 110 Images
Images Folder has 330 Images
```

[173]:
```
base_dir = r'data_paprika'
img_size = 180
batch = 32
```

[174]:
```
train_ds = tf.keras.utils.image_dataset_from_directory(
    base_dir,
    validation_split=0.2,    # Pisahkan 20% data
    subset="training",       # Ambil 80% untuk training
    seed=123,
    image_size=(img_size, img_size),
    batch_size=batch,
```

```
)
```

```
Found 330 files belonging to 3 classes.
Using 264 files for training.
```

[175]:
```
val_test_ds = tf.keras.utils.image_dataset_from_directory(
    base_dir,
    validation_split=0.2,
    subset="validation",
    seed=123,
    image_size=(img_size, img_size),
    batch_size=batch,
)
```

```
Found 330 files belonging to 3 classes.
Using 66 files for validation.
```

[176]:
```
class_names = dataset.class_names
print("Class Names:", class_names)
```

```
Class Names: ['PaprikaHijau', 'PaprikaKuning', 'PaprikaMerah']
```

[177]:
```
val_size = len(val_test_ds) // 2
val_ds = val_test_ds.take(val_size)
test_ds = val_test_ds.skip(val_size)

print("Total Images:", len(dataset))
print("Train Images:", len(train_ds))
print("Validation Images:", len(val_ds))
print("Test Images:", len(test_ds))
```

```
Total Images: 11
Train Images: 9
Validation Images: 1
Test Images: 2
```

[178]:
```
train_ds = dataset.take(train_count)
val_ds = dataset.skip(train_count)
```

[179]:
```
import matplotlib.pyplot as plt

i = 0
plt.figure(figsize=(10,10))

for images, labels in train_ds.take(1):
    for i in range(9):
        plt.subplot(3,3, i+1)
        plt.imshow(images[i].numpy().astype('uint8'))
```

```
        plt.title(class_names[labels[i]])
        plt.axis('off')
```

[180]:
```
import numpy as np


for images, labels in train_ds.take(1):
    images_array = np.array(images)
    print(images_array.shape)
```

```
(32, 180, 180, 3)
```

[181]:
```
AUTOTUNE = tf.data.AUTOTUNE
```

[182]:
```
train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size = AUTOTUNE)
```

[183]:
```
val_ds = val_ds.cache().shuffle(1000).prefetch(buffer_size = AUTOTUNE)
```

[184]:
```
data_augmentation = Sequential([
    layers.RandomFlip("horizontal", input_shape = (img_size,img_size,3)),
    layers.RandomRotation(0.1),
    layers.RandomZoom(0.1)
])
```

```
C:\Users\ACER\AppData\Roaming\Python\Python312\site-
packages\keras\src\layers\preprocessing\tf_data_layer.py:19: UserWarning: Do not
pass an `input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in the model
instead.
  super().__init__(**kwargs)
```

[185]:
```
i = 0
plt.figure(figsize=(10,10))

for images, labels in train_ds.take(3):
    for i in range(9):
        images = data_augmentation(images)
        plt.subplot(3,3, i+1)
        plt.imshow(images[0].numpy().astype('uint8'))
        plt.axis('off')
```

[186]:
```
#import library yang dibutuhkan
from tensorflow.keras.applications import MobileNet #digunakan untuk␣
 ↪memanfaatkan model yang sudah dilatih sebelumnya untuk pengenalan gambar
from tensorflow.keras.models import Model #digunakan untuk membuat dan␣
 ↪mengonfigurasi arsitektur model

#membuat model dengan bobot yang telah dilatih sebelumnya
#include_top=False berarti tidak menggunakan lapisan klasifikasi dari mobilenet␣
 ↪hanya bagian ekstraksi fitur
base_model = MobileNet(include_top=False, input_shape=(img_size, img_size, 3))

#membuka (unfreeze beberapa lapisan untuk proses fine tuning)
base_model.trainable = True #seluruh model bisa dilatih
```

```
fine_tune_at = len(base_model.layers) // 2  #menentukan bahwa setengah lapisan terakhir akan di unfreeze
for layer in base_model.layers[:fine_tune_at]:
    layer.trainable = False #mengunci (freeze) lapisan pertama hingga setengah bagian pertama agar tidak dilatih kembali

model = Sequential([
    data_augmentation,
    layers.Rescaling(1./255),
    base_model,
    layers.GlobalAveragePooling2D(),
    Dense(128, activation='relu'),
    Dropout(0.3),
    Dense(len(class_names), activation='softmax')
])

#membuat model akhir dengan lapisan tambahan
###Terdapat code yang hilang disini! lihat modul untuk menemukanya
```

```
C:\Users\ACER\AppData\Local\Temp\ipykernel_13632\2025012950.py:7: UserWarning:
`input_shape` is undefined or non-square, or `rows` is not in [128, 160, 192,
224]. Weights for input shape (224, 224) will be loaded as the default.
  base_model = MobileNet(include_top=False, input_shape=(img_size, img_size, 3))
```

[187]:
```
from tensorflow.keras.optimizers import Adam #untuk mengoptimalkan proses pelatihan model

#mengkompilasi model dengan optimizer, loss function, dan metrics
model.compile(
    optimizer=Adam(learning_rate=1e-4), #menggunakan optimizer Adam dengan learning rate 0.0001
    loss='sparse_categorical_crossentropy', #untuk klasifikasi multi-kelas
    metrics=['accuracy'] #akurasi digunakan sebagai metrik evaluasi
)
```

[188]:
```
#menampilkan ringkasan dari model
model.summary()
```

```
Model: "sequential_15"
```

Layer (type)	Output Shape	Param #
sequential_14 (Sequential)	(None, 180, 180, 3)	0
rescaling_6 (Rescaling)	(None, 180, 180, 3)	0

```
mobilenet_1.00_224 (Functional)   (None, 5, 5, 1024)          3,228,864

global_average_pooling2d_7        (None, 1024)                      0
(GlobalAveragePooling2D)

dense_15 (Dense)                  (None, 128)                 131,200

dropout_8 (Dropout)               (None, 128)                       0

dense_16 (Dense)                  (None, 3)                       387
```

Total params: 3,360,451 (12.82 MB)

Trainable params: 3,069,443 (11.71 MB)

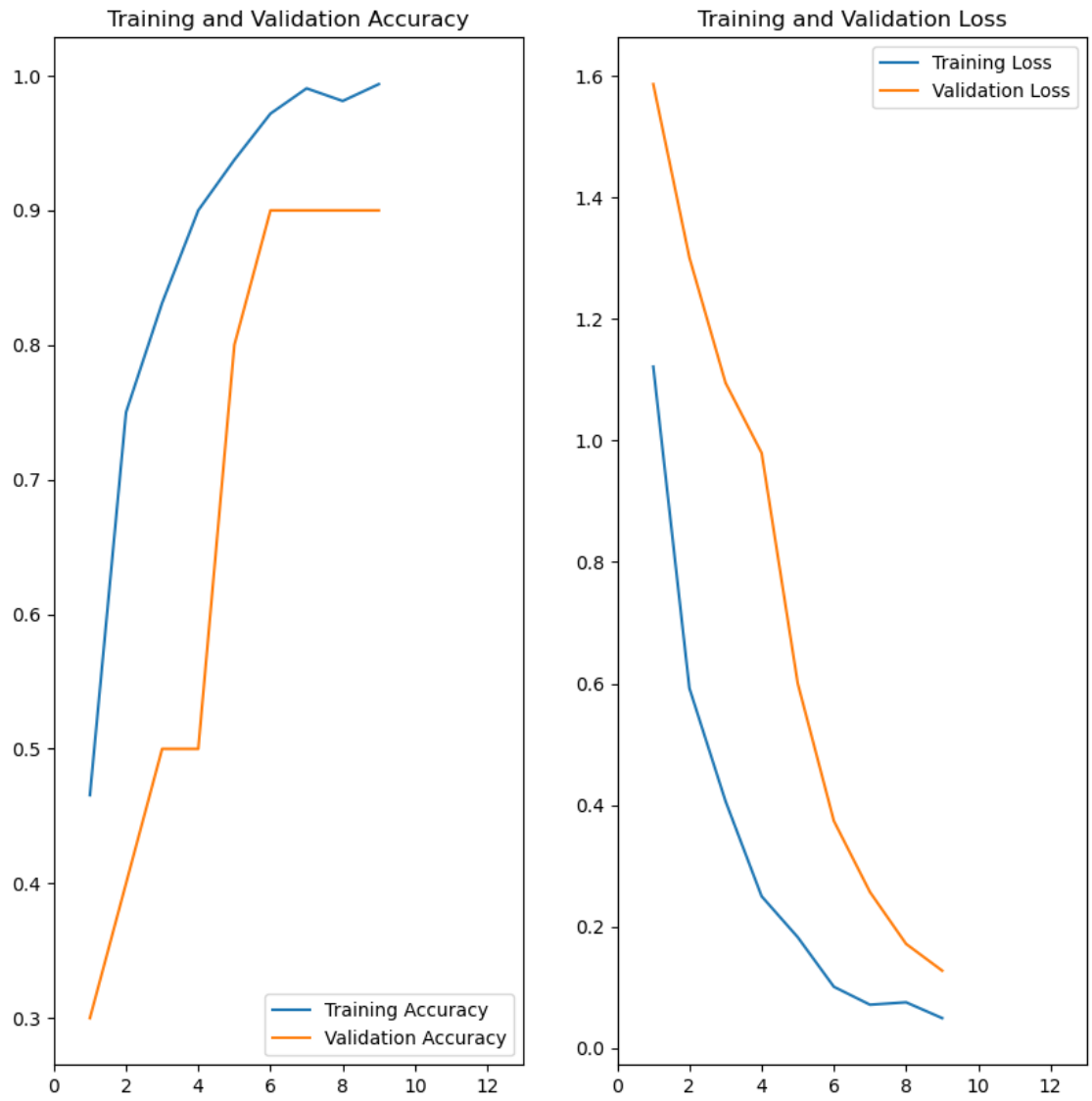
Non-trainable params: 291,008 (1.11 MB)

[189]:
```
#early stopping digunakan untuk menghentikan pelatihan lebih awal jika model␣
 ↪tidak ada peningkatan
from tensorflow.keras.callbacks import EarlyStopping

#Ada fungsi early stopping disini, jangan keskip tuan :D
early_stopping = EarlyStopping(monitor='val_accuracy',
                               patience=3,
                               mode='max')

#melatih model menggunakan data latih dan validasi dengan early stopping
history= model.fit(train_ds, #data pelatihan yang telah disiapkan
                   epochs=30, # jumlah maksimal epoch
                   validation_data=val_ds,  #data validasi untuk mengevaluasi␣
 ↪model pada setiap epoch
                   callbacks=[early_stopping]) #menambahkan early stopping ke␣
 ↪dalam callback untuk pelatihan
```

```
Epoch 1/30
10/10             14s 511ms/step -
accuracy: 0.4416 - loss: 1.2186 - val_accuracy: 0.3000 - val_loss: 1.5862
Epoch 2/30
10/10             4s 420ms/step -
accuracy: 0.7443 - loss: 0.6298 - val_accuracy: 0.4000 - val_loss: 1.3009
Epoch 3/30
10/10             5s 501ms/step -
accuracy: 0.8306 - loss: 0.4017 - val_accuracy: 0.5000 - val_loss: 1.0949
Epoch 4/30
```

```
10/10             4s 411ms/step -
accuracy: 0.8866 - loss: 0.2812 - val_accuracy: 0.5000 - val_loss: 0.9794
Epoch 5/30
10/10             4s 401ms/step -
accuracy: 0.9465 - loss: 0.1775 - val_accuracy: 0.8000 - val_loss: 0.6003
Epoch 6/30
10/10             4s 402ms/step -
accuracy: 0.9804 - loss: 0.0908 - val_accuracy: 0.9000 - val_loss: 0.3741
Epoch 7/30
10/10             4s 414ms/step -
accuracy: 0.9874 - loss: 0.0764 - val_accuracy: 0.9000 - val_loss: 0.2571
Epoch 8/30
10/10             4s 402ms/step -
accuracy: 0.9739 - loss: 0.0869 - val_accuracy: 0.9000 - val_loss: 0.1717
Epoch 9/30
10/10             4s 406ms/step -
accuracy: 0.9893 - loss: 0.0614 - val_accuracy: 0.9000 - val_loss: 0.1277
```

[190]:
```
ephocs_range = range(1, len(history.history['loss']) + 1)

plt.figure(figsize=(10, 10)) #membuat figure dengan ukuran 10x10 untuk␣
 ↪menampilkan 2 grafik (Training and Validation Accuracy dan Loss)

plt.subplot(1, 2, 1)
plt.plot(ephocs_range, history.history['accuracy'], label='Training Accuracy')
plt.plot(ephocs_range, history.history['val_accuracy'], label='Validation␣
 ↪Accuracy')
plt.legend(loc='lower right')
plt.xlim(0, 13)
plt.title('Training and Validation Accuracy')


plt.subplot(1, 2, 2)
plt.plot(ephocs_range, history.history['loss'], label='Training Loss')
plt.plot(ephocs_range, history.history['val_loss'], label='Validation Loss')
plt.legend(loc='upper right')
plt.xlim(0, 13)
plt.title('Training and Validation Loss')
plt.show()
```



[191]:
```
model.save('BestModel_MobilNetCNN_Seaborn.h5')
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered legacy. We
recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
```

[192]:
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.models import load_model
from PIL import Image
```

```
model = load_model(r'BestModel_MobilNetCNN_Seaborn.h5')
class_names = ['PaprikaHijau', 'PaprikaKuning', 'PaprikaMerah' ]


def classify_images(image_path, save_path='predicted_image.jpg'):
    try:
        #memuat dan mempersiapkan gambar untuk prediksi
        input_image = tf.keras.utils.load_img(image_path, target_size=(180,␣
↪180)) #membuat gambar dari path dan mnegubah ukurannya menjadi 180x180 pixel
        input_image_array = tf.keras.utils.img_to_array(input_image) #mengubah␣
↪gambar jadi array numpy agar bisa di proses model
        input_image_exp_dim = tf.expand_dims(input_image_array, 0) ␣
↪#menambahkan dimensi batch agar sesuai dengan input model
                                                                    #dimensi␣
↪menjadi (1, 180, 180, 3)

        #melakukan prediksi
        predictions = model.predict(input_image_exp_dim) #melakukan prediksi␣
↪pada gambar yang telah diproses
        result = tf.nn.softmax(predictions[0]) #menghitung hasil prediksi␣
↪menggunakan softmax untuk mendapatkan probabilitas tiap kelas
        class_idx = np.argmax(result) #menemukan indeks kelas dengan␣
↪probabilitas tertinggi
        confidence = np.max(result) * 100 #menghitung confidence dalam␣
↪persentase

        #menampilkan hasil prediksi dan confidence
        print(f"Prediksi: {class_names[class_idx]}") #menampilkan nama kelas␣
↪yang diprediksi
        print(f"Confidence: {confidence:.2f}%") #menampilkan nilai confidence

        #menyimpan gambar asli tanpa teks
        input_image = Image.open(image_path) #membuka gambar yang ada di path
        input_image.save(save_path) #menyimpan gambar asli ke dalam path yang␣
↪telah ditentukan

        return f"Prediksi: {class_names[class_idx]} dengan confidence␣
↪{confidence:.2f}%. Gambar asli disimpan di {save_path}."
    except Exception as e:
        return f"Terjadi kesalahan: {e}"

#contoh penggunaan fungsi
```

```
result = classify_images(r"D:
 ↪\UAJY\UAJY_sem_5\ML\UAS\data_paprika\PaprikaHijau\Green_42.jpg" ,␣
 ↪save_path='hijau.jpg')
print(result)
###Terdapat code yang hilang disini! lihat modul untuk menemukanya
```

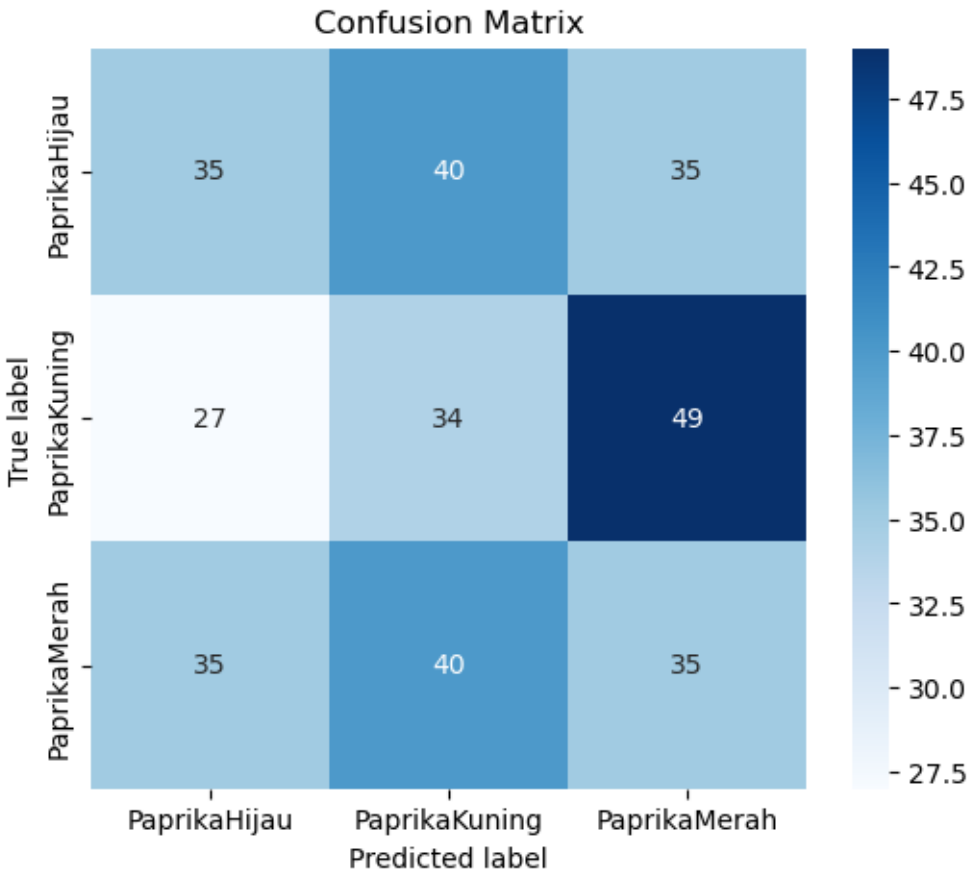
```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be
built. `model.compile_metrics` will be empty until you train or evaluate the
model.

1/1             1s 712ms/step
Prediksi: PaprikaHijau
Confidence: 56.10%
Prediksi: PaprikaHijau dengan confidence 56.10%. Gambar asli disimpan di
hijau.jpg.
```

[193]:
```
import tensorflow as tf
from tensorflow.keras.models import load_model
import seaborn as sns
import matplotlib.pyplot as plt

#memuat model yang telah dilatih sebelumnya
mobileNet_model = load_model(r'BestModel_MobilNetCNN_Seaborn.h5')#gunakan path␣
 ↪masing masing ya

#memuat data test yang sebenarnya
test_data = tf.keras.preprocessing.image_dataset_from_directory(
    r'data_paprika', #direktori data uji
    labels='inferred', #label otomatis dari subfolder yang ada
    label_mode='categorical',  #menghasilkan label dalam bentuk one-hot encoding
    batch_size=32, #ukuran batch untuk pemrosesan
    image_size=(180, 180) #ukuran gambar yang akan diproses
)

#prediksi model
y_pred = mobileNet_model.predict(test_data)
y_pred_class = tf.argmax(y_pred, axis=1)  #konversi ke kelas prediksi

#ekstrak label sebenarnya dari test_data dan konversi ke bentuk indeks kelas
true_labels = [] #menyimpan label asli dalam bentuk indeks
for _, labels in test_data:
    true_labels.extend(tf.argmax(labels, axis=1).numpy())  #konversi one-hot ke␣
 ↪indeks kelas
true_labels = tf.convert_to_tensor(true_labels) #mengkonversi list ke tensor␣
 ↪untuk perhitungan

#membuat confusion matrix untuk evaluasi
```

```
conf_mat = tf.math.confusion_matrix(true_labels, y_pred_class)

#menghitung akurasi berdasarkan confusion matrix
accuracy = tf.reduce_sum(tf.linalg.diag_part(conf_mat)) / tf.
 ↪reduce_sum(conf_mat)

#mnghitung presisi dan recall dari confusion matrix
precision = tf.linalg.diag_part(conf_mat) / tf.reduce_sum(conf_mat, axis=0)
recall = tf.linalg.diag_part(conf_mat) / tf.reduce_sum(conf_mat, axis=1)

#menghitung F1 Score
f1_score = 2 * (precision * recall) / (precision + recall)

#visualisasi Confusion Matrix
plt.figure(figsize=(6, 5)) #mengatur ukuran gambar
sns.heatmap(conf_mat.numpy(), annot=True, fmt='d', cmap='Blues', #annot=True␣
 ↪untuk menampilkan angka di dalam setiap sel matriks
                                                                #fmt='d' untuk␣
 ↪menampilkan bilangan bulat tanpa desimal
           xticklabels=["PaprikaHijau", "PaprikaKuning", "PaprikaMerah"],␣
 ↪yticklabels=["PaprikaHijau", "PaprikaKuning", "PaprikaMerah"])
plt.title('Confusion Matrix')
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()

# Menampilkan hasil
print("Confusion Matrix:\n", conf_mat.numpy())
print("Akurasi:", accuracy.numpy())
print("Presisi:", precision.numpy())
print("Recall:", recall.numpy())
print("F1 Score:", f1_score.numpy())
```

```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be
built. `model.compile_metrics` will be empty until you train or evaluate the
model.
```

```
Found 330 files belonging to 3 classes.
11/11            4s 269ms/step
```




```
Confusion Matrix:
 [[35 40 35]
 [27 34 49]
 [35 40 35]]
Akurasi: 0.3151515151515151
Presisi: [0.36082474 0.29824561 0.29411765]
Recall: [0.31818182 0.30909091 0.31818182]
F1 Score: [0.33816425 0.30357143 0.30567686]
```

print("Veronica Regina Mambu / 220711948/ Seaborn/ Perbedaan Paprika Merah, Kuning Hijau Menggunaakn MobileNet")

```
import tensorflow as tf
import numpy as np
import random
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten,
Dense, Dropout, BatchNormalization
from tensorflow.keras.regularizers import l2
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt


seed_value = 71
tf.random.set_seed(seed_value)
np.random.seed(seed_value)
random.seed(seed_value)
```

```
2024-12-19 20:19:41.453396: I tensorflow/core/util/port.cc:153] oneDNN
custom operations are on. You may see slightly different numerical
results due to floating-point round-off errors from different
computation orders. To turn them off, set the environment variable
`TF_ENABLE_ONEDNN_OPTS=0`.
2024-12-19 20:19:41.472418: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:477] Unable to
register cuFFT factory: Attempting to register factory for plugin
cuFFT when one has already been registered
WARNING: All log messages before absl::InitializeLog() is called are
written to STDERR
E0000 00:00:1734614381.497586 2685741 cuda_dnn.cc:8310] Unable to
register cuDNN factory: Attempting to register factory for plugin
cuDNN when one has already been registered
E0000 00:00:1734614381.503886 2685741 cuda_blas.cc:1418] Unable to
register cuBLAS factory: Attempting to register factory for plugin
cuBLAS when one has already been registered
2024-12-19 20:19:41.527624: I
tensorflow/core/platform/cpu_feature_guard.cc:210] This TensorFlow
binary is optimized to use available CPU instructions in performance-
critical operations.
To enable the following instructions: AVX2 AVX512F AVX512_VNNI
AVX512_BF16 AVX512_FP16 AVX_VNNI AMX_TILE AMX_INT8 AMX_BF16 FMA, in
other operations, rebuild TensorFlow with the appropriate compiler
flags.
```

```
def load_data(directory, img_size=(224, 224), batch_size=32):

    dataset = tf.keras.utils.image_dataset_from_directory(
        directory,
        image_size=img_size,
        batch_size=batch_size,
```

```
        shuffle=True
    )
    return dataset


data_directory = "Dataset UAS"
dataset = load_data(data_directory)


class_names = dataset.class_names
print(f"Class names: {class_names}")
```

```
Found 330 files belonging to 3 classes.
Class names: ['PaprikaHijauFix', 'PaprikaKuningFix',
'PaprikaMerahFix']
```

```
W0000 00:00:1734614384.114357 2685741 gpu_device.cc:2344] Cannot
dlopen some GPU libraries. Please make sure the missing libraries
mentioned above are installed properly if you would like to use GPU.
Follow the guide at https://www.tensorflow.org/install/gpu for how to
download and setup the required libraries for your platform.
Skipping registering GPU devices...
```

```
def visualize_data(dataset, num_images=9):
    label_map = {
        'PaprikaHijauFix': 'PaprikaHijau',
        'PaprikaKuningFix': 'PaprikaKuning',
        'PaprikaMerahFix': 'PaprikaMerah'
    }

    plt.figure(figsize=(10, 10))
    for images, labels in dataset.take(1):
        for i in range(num_images):
            plt.subplot(3, 3, i + 1)
            plt.imshow(images[i].numpy().astype("uint8"))
            # Map label index to class name and custom label
            label_name = class_names[labels[i]]
            custom_label = label_map.get(label_name, "Unknown")
            plt.title(custom_label)
            plt.axis("off")
    plt.show()


visualize_data(dataset)
```

```
2024-12-19 20:19:44.585828: I
tensorflow/core/framework/local_rendezvous.cc:405] Local rendezvous is
aborting with status: OUT_OF_RANGE: End of sequence
```

PaprikaKuning

PaprikaHijau

PaprikaHijau

PaprikaHijau

PaprikaHijau

PaprikaKuning

PaprikaKuning

PaprikaHijau

PaprikaHijau

```
augmentation = ImageDataGenerator(
    rotation_range=30,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)
```

```
def normalize_data(dataset):
    return dataset.map(lambda x, y: (tf.cast(x, tf.float32) / 255.0,
y))

def split_dataset(dataset, train_ratio=0.8, val_ratio=0.1):

    dataset_size = len(dataset)
    train_size = int(train_ratio * dataset_size)
    val_size = int(val_ratio * dataset_size)

    train_dataset = dataset.take(train_size)
    val_test_dataset = dataset.skip(train_size)
    val_dataset = val_test_dataset.take(val_size)
    test_dataset = val_test_dataset.skip(val_size)

    return train_dataset, val_dataset, test_dataset

train_ds, val_ds, test_ds = split_dataset(dataset)

train_ds = normalize_data(train_ds)
val_ds = normalize_data(val_ds)
test_ds = normalize_data(test_ds)

print(f"Train size: {len(train_ds)}, Validation size: {len(val_ds)},
Test size: {len(test_ds)}")
```

```
Train size: 8, Validation size: 1, Test size: 2
```

```
def build_alexnet(input_shape=(224, 224, 3), num_classes=3):

    model = Sequential([
        Conv2D(96, (11, 11), strides=4, activation='relu',
input_shape=input_shape,
               kernel_regularizer=l2(0.01)),
        MaxPooling2D((3, 3), strides=2),
        BatchNormalization(),
        Dropout(0.3),

        Conv2D(256, (5, 5), activation='relu', padding='same',
kernel_regularizer=l2(0.01)),
        MaxPooling2D((3, 3), strides=2),
        BatchNormalization(),
        Dropout(0.3),

        Conv2D(384, (3, 3), activation='relu', padding='same'),
        Conv2D(384, (3, 3), activation='relu', padding='same'),
        Conv2D(256, (3, 3), activation='relu', padding='same'),
        MaxPooling2D((3, 3), strides=2),
        BatchNormalization(),
        Dropout(0.3),
```

```
        Flatten(),
        Dense(4096, activation='relu', kernel_regularizer=l2(0.01)),
        Dropout(0.5),
        Dense(4096, activation='relu', kernel_regularizer=l2(0.01)),
        Dropout(0.5),
        Dense(num_classes, activation='softmax')
    ])
    model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy', metrics=['accuracy'])
    return model

model = build_alexnet()
model.summary()
```

```
/opt/tljh/user/envs/dltf/lib/python3.10/site-packages/keras/src/
layers/convolutional/base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

Model: "sequential"
```

```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
┃ conv2d (Conv2D)                      ┃ (None, 54, 54, 96)          ┃
34,944 ┃
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
┃ max_pooling2d (MaxPooling2D)         ┃ (None, 26, 26, 96)          ┃
0 ┃
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
┃ batch_normalization                  ┃ (None, 26, 26, 96)          ┃
384 ┃
┃ (BatchNormalization)                 ┃                             ┃
┃                                      ┃                             ┃
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
┃ dropout (Dropout)                    ┃ (None, 26, 26, 96)          ┃
0 ┃
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
┃ conv2d_1 (Conv2D)                    ┃ (None, 26, 26, 256)         ┃
```

```
614,656 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ max_pooling2d_1 (MaxPooling2D)  │ (None, 12, 12, 256)        │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ batch_normalization_1           │ (None, 12, 12, 256)        │
1,024 │
│ (BatchNormalization)            │                            │
│
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ dropout_1 (Dropout)             │ (None, 12, 12, 256)        │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d_2 (Conv2D)               │ (None, 12, 12, 384)        │
885,120 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d_3 (Conv2D)               │ (None, 12, 12, 384)        │
1,327,488 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ conv2d_4 (Conv2D)               │ (None, 12, 12, 256)        │
884,992 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ max_pooling2d_2 (MaxPooling2D)  │ (None, 5, 5, 256)          │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ batch_normalization_2           │ (None, 5, 5, 256)          │
1,024 │
│ (BatchNormalization)            │                            │
│
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ dropout_2 (Dropout)             │ (None, 5, 5, 256)          │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ flatten (Flatten)               │ (None, 6400)               │
0 │
├─────────────────────────────────┼────────────────────────────┼──────────
──────┤
│ dense (Dense)                   │ (None, 4096)               │
26,218,496 │
```

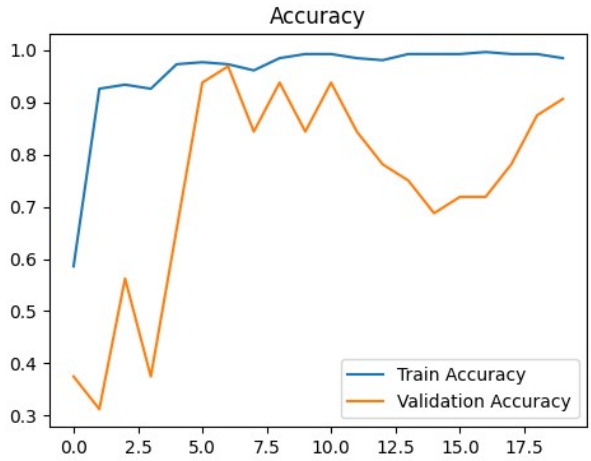
```
├─────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dropout_3 (Dropout)                 │ (None, 4096)                │
0 │
├─────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dense_1 (Dense)                     │ (None, 4096)                │
16,781,312 │
├─────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dropout_4 (Dropout)                 │ (None, 4096)                │
0 │
├─────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dense_2 (Dense)                     │ (None, 3)                   │
12,291 │
└─────────────────────────────────────┴─────────────────────────────┴──────────
──────┘

 Total params: 46,761,731 (178.38 MB)

 Trainable params: 46,760,515 (178.38 MB)

 Non-trainable params: 1,216 (4.75 KB)
```

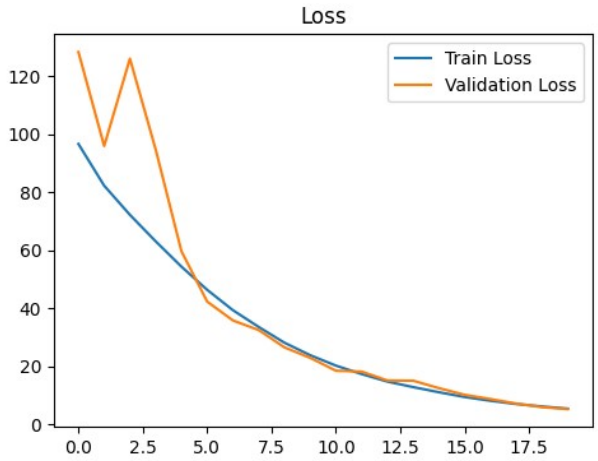
```
from tensorflow.keras.callbacks import ReduceLROnPlateau,
EarlyStopping

lr_scheduler = ReduceLROnPlateau(
    monitor='val_loss', factor=0.5, patience=5, verbose=1, min_lr=1e-6
)

early_stopping = EarlyStopping(
    monitor='val_loss', patience=10, restore_best_weights=True
)

def train_model(model, train_ds, val_ds, epochs=20):
    history = model.fit(
        train_ds,
        validation_data=val_ds,
        epochs=epochs,
        callbacks=[lr_scheduler, early_stopping]
    )

    plt.figure(figsize=(12, 4))

    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'], label='Train Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation
Accuracy')
    plt.legend()
```

```
    plt.title('Accuracy')

    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'], label='Train Loss')
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.legend()
    plt.title('Loss')

    plt.show()
    return history

history = train_model(model, train_ds, val_ds)
```

```
Epoch 1/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 284ms/step - accuracy: 0.4834 - loss:
98.8750 - val_accuracy: 0.3750 - val_loss: 128.4318 - learning_rate:
0.0010
Epoch 2/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 237ms/step - accuracy: 0.9114 - loss:
83.8901 - val_accuracy: 0.3125 - val_loss: 96.0019 - learning_rate:
0.0010
Epoch 3/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 238ms/step - accuracy: 0.9370 - loss:
73.8499 - val_accuracy: 0.5625 - val_loss: 126.1317 - learning_rate:
0.0010
Epoch 4/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 234ms/step - accuracy: 0.9097 - loss:
65.1119 - val_accuracy: 0.3750 - val_loss: 94.7901 - learning_rate:
0.0010
Epoch 5/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 235ms/step - accuracy: 0.9724 - loss:
55.8687 - val_accuracy: 0.6562 - val_loss: 59.6748 - learning_rate:
0.0010
Epoch 6/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 241ms/step - accuracy: 0.9741 - loss:
48.1750 - val_accuracy: 0.9375 - val_loss: 42.2939 - learning_rate:
0.0010
Epoch 7/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 241ms/step - accuracy: 0.9765 - loss:
40.5259 - val_accuracy: 0.9688 - val_loss: 35.7874 - learning_rate:
0.0010
Epoch 8/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 246ms/step - accuracy: 0.9602 - loss:
34.5616 - val_accuracy: 0.8438 - val_loss: 32.4782 - learning_rate:
0.0010
Epoch 9/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 223ms/step - accuracy: 0.9940 - loss:
28.9503 - val_accuracy: 0.9375 - val_loss: 26.4997 - learning_rate:
0.0010
Epoch 10/20
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 210ms/step - accuracy: 0.9901 - loss:
24.5835 - val_accuracy: 0.8438 - val_loss: 22.8815 - learning_rate:
0.0010
Epoch 11/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 222ms/step - accuracy: 0.9907 - loss:
20.8647 - val_accuracy: 0.9375 - val_loss: 18.4345 - learning_rate:
0.0010
Epoch 12/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 210ms/step - accuracy: 0.9889 - loss:
17.6992 - val_accuracy: 0.8438 - val_loss: 18.1380 - learning_rate:
0.0010
Epoch 13/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 210ms/step - accuracy: 0.9904 - loss:
15.0889 - val_accuracy: 0.7812 - val_loss: 15.0597 - learning_rate:
0.0010
Epoch 14/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 212ms/step - accuracy: 0.9872 - loss:
13.3028 - val_accuracy: 0.7500 - val_loss: 14.9901 - learning_rate:
0.0010
Epoch 15/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 207ms/step - accuracy: 0.9889 - loss:
11.4017 - val_accuracy: 0.6875 - val_loss: 12.4215 - learning_rate:
0.0010
Epoch 16/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 204ms/step - accuracy: 0.9910 - loss:
9.6262 - val_accuracy: 0.7188 - val_loss: 10.1211 - learning_rate:
0.0010
Epoch 17/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 203ms/step - accuracy: 0.9974 - loss:
8.2893 - val_accuracy: 0.7188 - val_loss: 8.6541 - learning_rate:
0.0010
Epoch 18/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 205ms/step - accuracy: 0.9967 - loss:
7.1420 - val_accuracy: 0.7812 - val_loss: 7.1087 - learning_rate:
0.0010
Epoch 19/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 203ms/step - accuracy: 0.9945 - loss:
6.2593 - val_accuracy: 0.8750 - val_loss: 5.8633 - learning_rate:
0.0010
Epoch 20/20
8/8 ━━━━━━━━━━━━━━━━━━━━ 2s 209ms/step - accuracy: 0.9829 - loss:
5.4749 - val_accuracy: 0.9062 - val_loss: 5.1831 - learning_rate:
0.0010
```



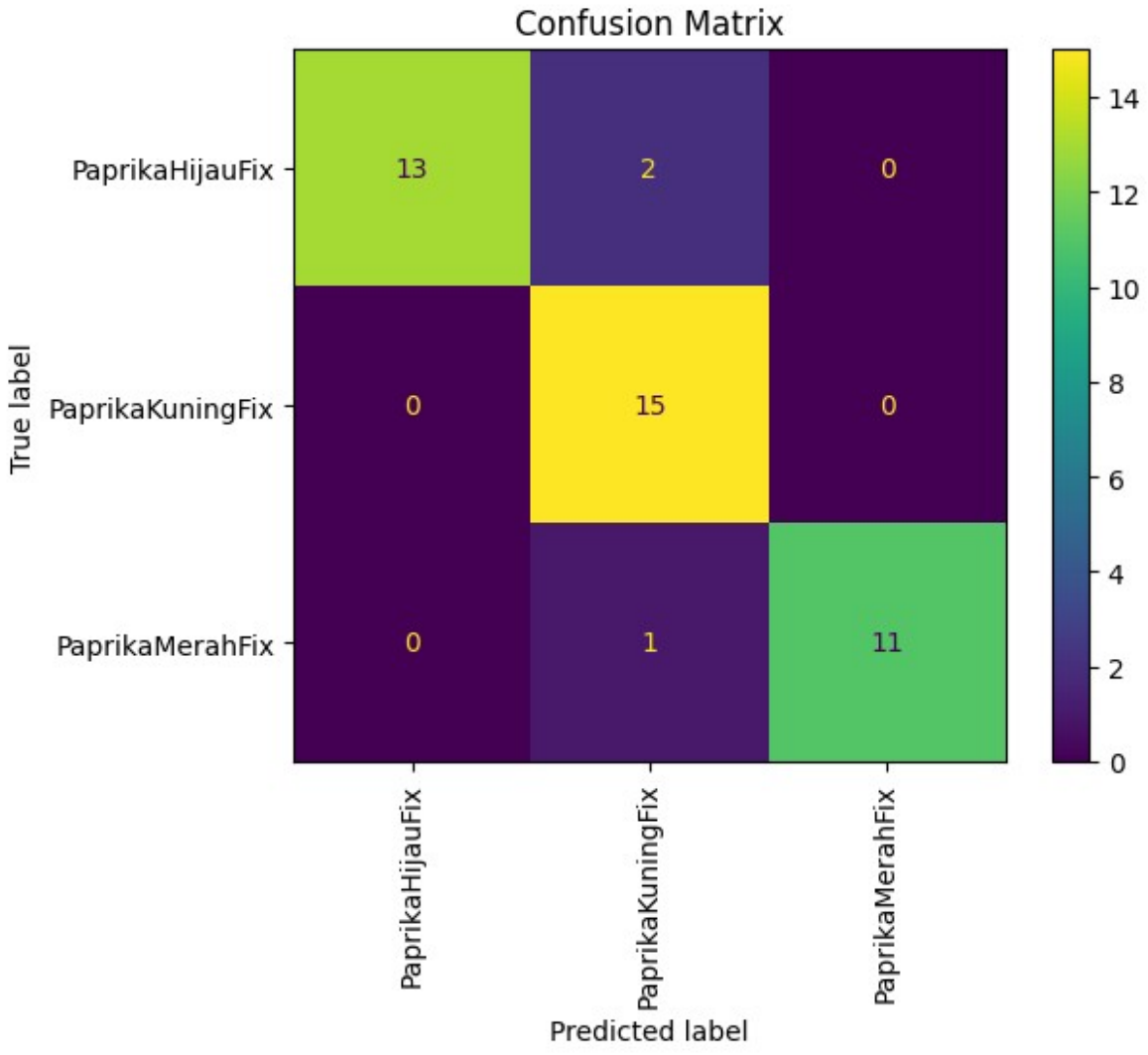



```
def evaluate_model(model, test_ds):

    test_loss, test_acc = model.evaluate(test_ds)
    print(f"Test Accuracy: {test_acc:.2f}")

evaluate_model(model, test_ds)
```

```
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 32ms/step - accuracy: 0.9737 - loss:
5.0376
Test Accuracy: 0.98
```

```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import numpy as np

def plot_confusion_matrix(model, test_ds):
    y_true = []
    y_pred = []

    for images, labels in test_ds:
        predictions = model.predict(images)
        y_true.extend(labels.numpy())
        y_pred.extend(np.argmax(predictions, axis=1))


    cm = confusion_matrix(y_true, y_pred)

    disp = ConfusionMatrixDisplay(
        confusion_matrix=cm, display_labels=class_names
    )
    disp.plot(cmap='viridis', xticks_rotation='vertical')
    plt.title("Confusion Matrix")
    plt.show()

evaluate_model(model, test_ds)

plot_confusion_matrix(model, test_ds)
```

```
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 25ms/step - accuracy: 0.9420 - loss:
5.3302
Test Accuracy: 0.93
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 189ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 153ms/step

2024-12-19 20:20:26.239342: I
tensorflow/core/framework/local_rendezvous.cc:405] Local rendezvous is
aborting with status: OUT_OF_RANGE: End of sequence
```




```
model.save("BestModel_AlexNet_Seaborn.h5")
print("Model saved as alexnet_paprika.h5")

WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
```

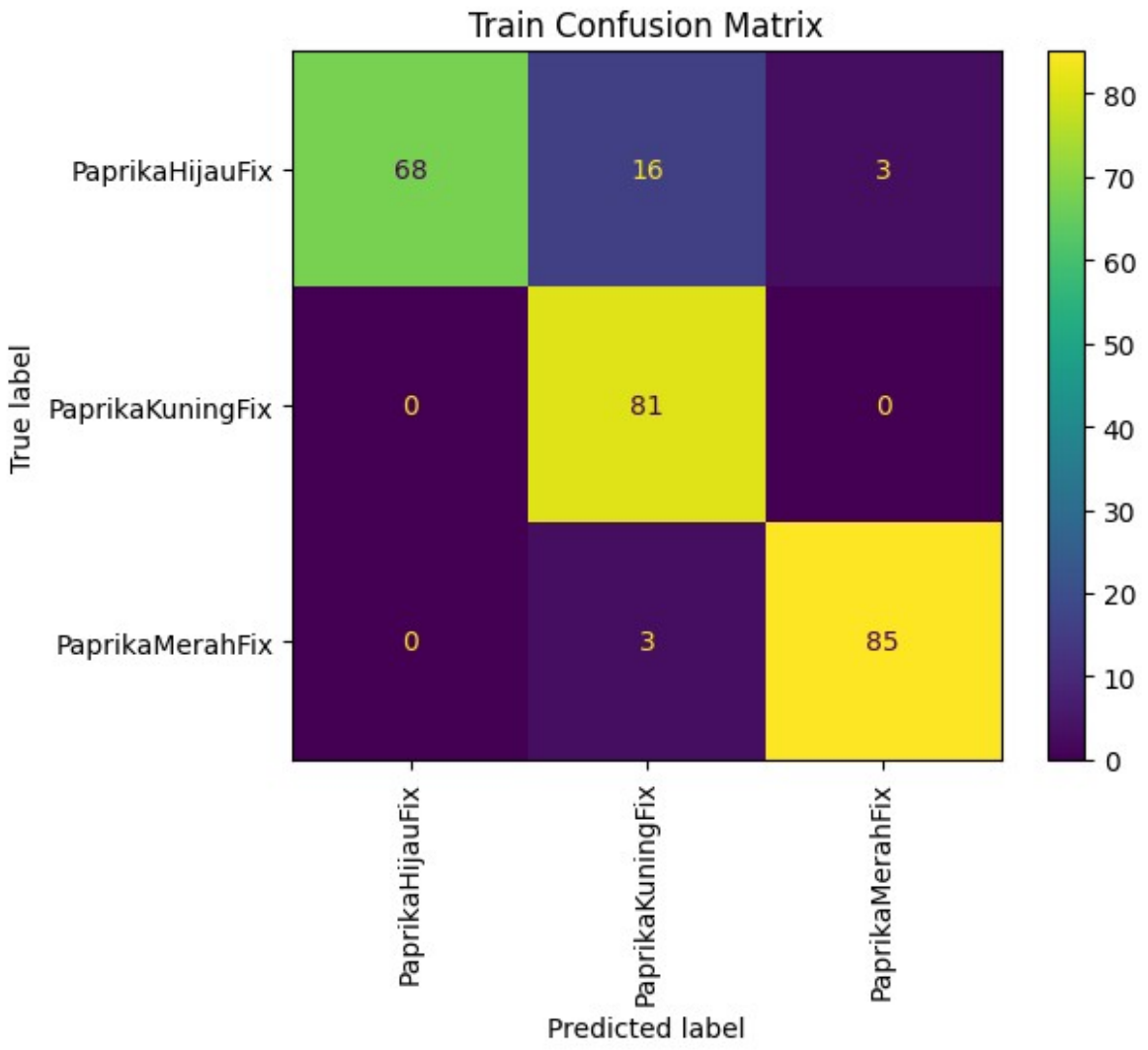
```
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as alexnet_paprika.h5
```

```
from tensorflow.keras.models import load_model

model_path = "BestModel_AlexNet_Seaborn.h5"
loaded_model = load_model(model_path)
print("Model loaded successfully.")
```

```
WARNING:absl:Compiled the loaded model, but the compiled metrics have
yet to be built. `model.compile_metrics` will be empty until you train
or evaluate the model.

Model loaded successfully.
```

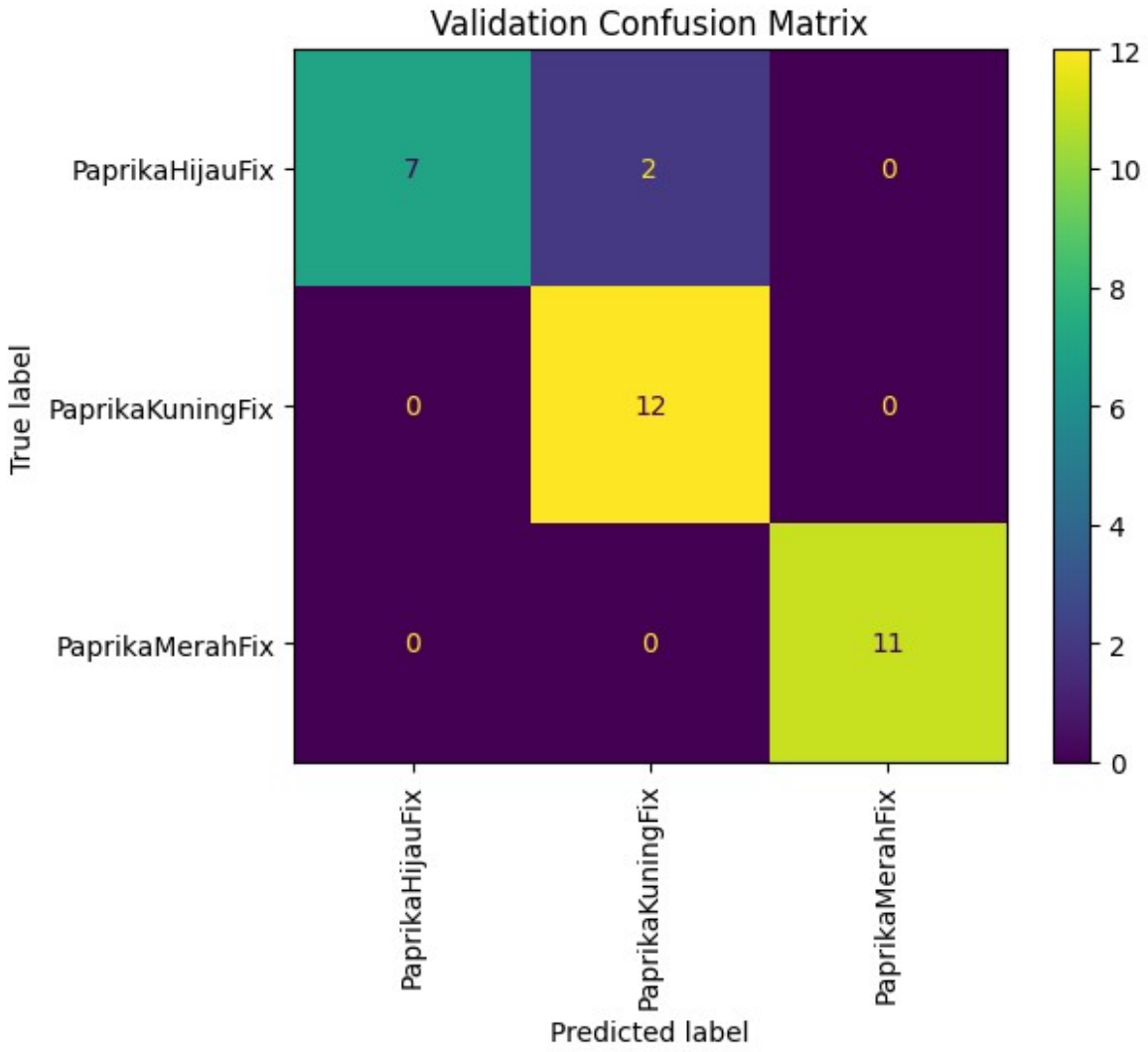
```
from sklearn.metrics import classification_report, confusion_matrix,
ConfusionMatrixDisplay
import matplotlib.pyplot as plt

def evaluate_entire_dataset(model, datasets, dataset_names):

    for ds, name in zip(datasets, dataset_names):
        print(f"\nEvaluating on {name} Dataset:")

        loss, accuracy = model.evaluate(ds)
        print(f"{name} Accuracy: {accuracy:.2f}")
        print(f"{name} Loss: {loss:.2f}")

        y_true = []
        y_pred = []

        for images, labels in ds:
            predictions = model.predict(images)
            y_true.extend(labels.numpy())
            y_pred.extend(np.argmax(predictions, axis=1))

        print(f"\n{name} Classification Report:")
        print(classification_report(y_true, y_pred,
target_names=class_names))

        cm = confusion_matrix(y_true, y_pred)
        disp = ConfusionMatrixDisplay(
            confusion_matrix=cm, display_labels=class_names
        )
        disp.plot(cmap='viridis', xticks_rotation='vertical')
        plt.title(f"{name} Confusion Matrix")
        plt.show()
```

```
evaluate_entire_dataset(
    model=loaded_model,
    datasets=[train_ds, val_ds, test_ds],
    dataset_names=["Train", "Validation", "Test"]
)


Evaluating on Train Dataset:
8/8 ━━━━━━━━━━━━━━━━━━━━ 1s 49ms/step - accuracy: 0.9363 - loss:
5.2468
Train Accuracy: 0.93
Train Loss: 5.26
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 247ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 93ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 94ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 98ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 101ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 97ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 100ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 100ms/step

Train Classification Report:
                   precision    recall  f1-score   support

 PaprikaHijauFix       1.00      0.78      0.88        87
PaprikaKuningFix       0.81      1.00      0.90        81
 PaprikaMerahFix       0.97      0.97      0.97        88

        accuracy                           0.91       256
       macro avg       0.93      0.92      0.91       256
    weighted avg       0.93      0.91      0.91       256
```



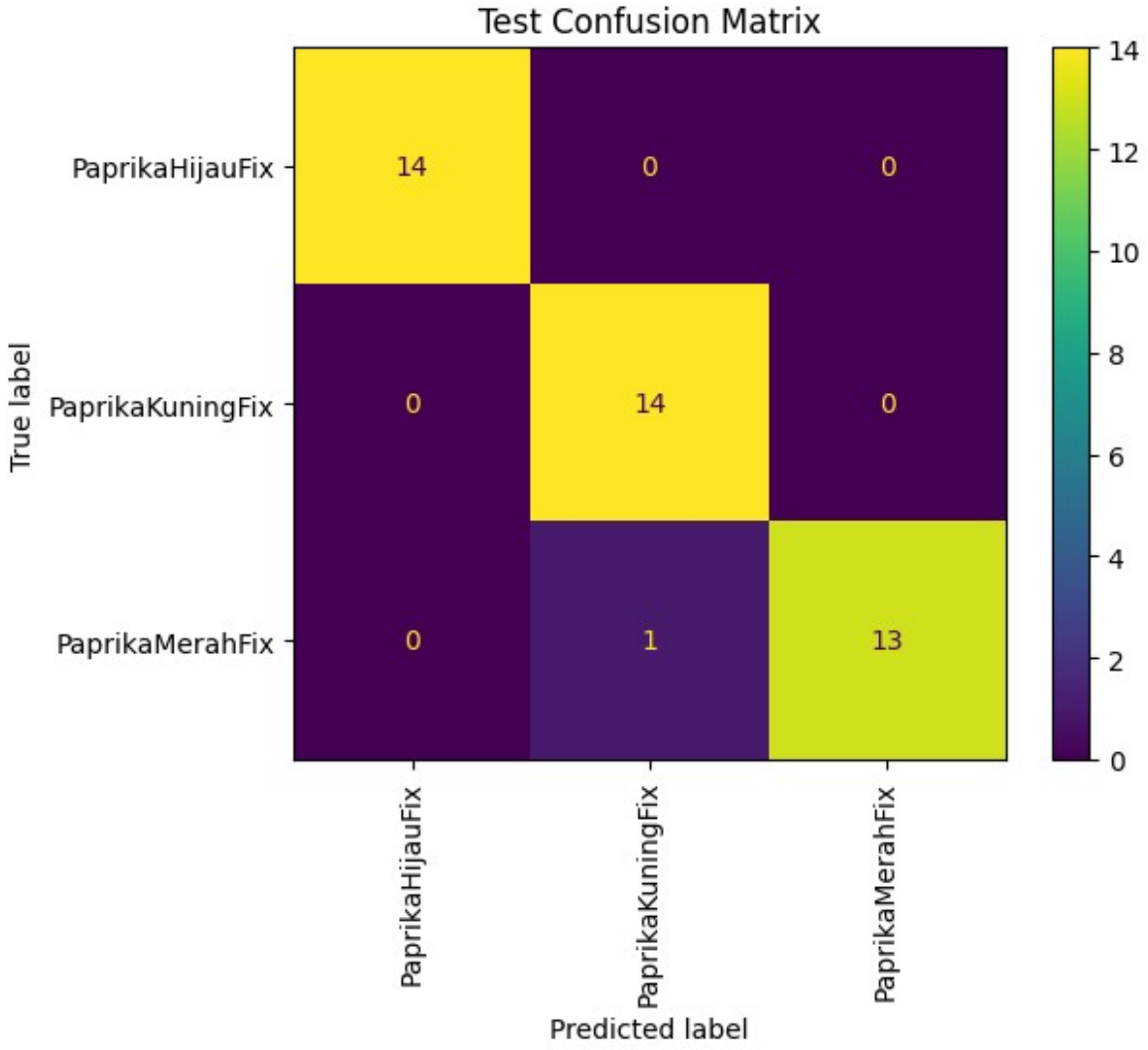

```
Evaluating on Validation Dataset:
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 108ms/step - accuracy: 0.9062 - loss:
5.3316
Validation Accuracy: 0.91
Validation Loss: 5.33
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 97ms/step

Validation Classification Report:
                  precision    recall  f1-score   support

 PaprikaHijauFix       1.00      0.78      0.88         9
PaprikaKuningFix       0.86      1.00      0.92        12
 PaprikaMerahFix       1.00      1.00      1.00        11

        accuracy                           0.94        32
       macro avg       0.95      0.93      0.93        32
```

```
    weighted avg       0.95      0.94      0.94        32

2024-12-19 20:20:31.291983: I
tensorflow/core/framework/local_rendezvous.cc:405] Local rendezvous is
aborting with status: OUT_OF_RANGE: End of sequence
```




```
Evaluating on Test Dataset:
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 38ms/step - accuracy: 0.8948 - loss:
5.4322
Test Accuracy: 0.90
Test Loss: 5.39
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 97ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 166ms/step

Test Classification Report:
```

	precision	recall	f1-score	support
PaprikaHijauFix	1.00	1.00	1.00	14
PaprikaKuningFix	0.93	1.00	0.97	14
PaprikaMerahFix	1.00	0.93	0.96	14
accuracy			0.98	42
macro avg	0.98	0.98	0.98	42
weighted avg	0.98	0.98	0.98	42




```
print("Made Ivan Jayasavitra Girinata / 220712063/ Seaborn/ Perbedaan Paprika Merah, Kuning Hijau Menggunaakn AlexNet")
```

```
Made Ivan Jayasavitra Girinata / 220712063/ Seaborn/ Perbedaan Paprika Merah, Kuning Hijau Menggunaakn AlexNet
```

```python
import tensorflow as tf
import numpy as np
from matplotlib import pyplot as plt

# Load data
data_dir = r"C:\Users\Lenovo\Documents\Kuliah - UAJY\Semester V - 2024-2025\Pembelajaran mesin dan Pembelajaran Mendalam - A\Projek UAS\data_paprika"
data = tf.keras.utils.image_dataset_from_directory(
    data_dir,
    seed=123,
    image_size=(180, 180),
    batch_size=16
)
class_names = data.class_names
print("Classes:", class_names)
```

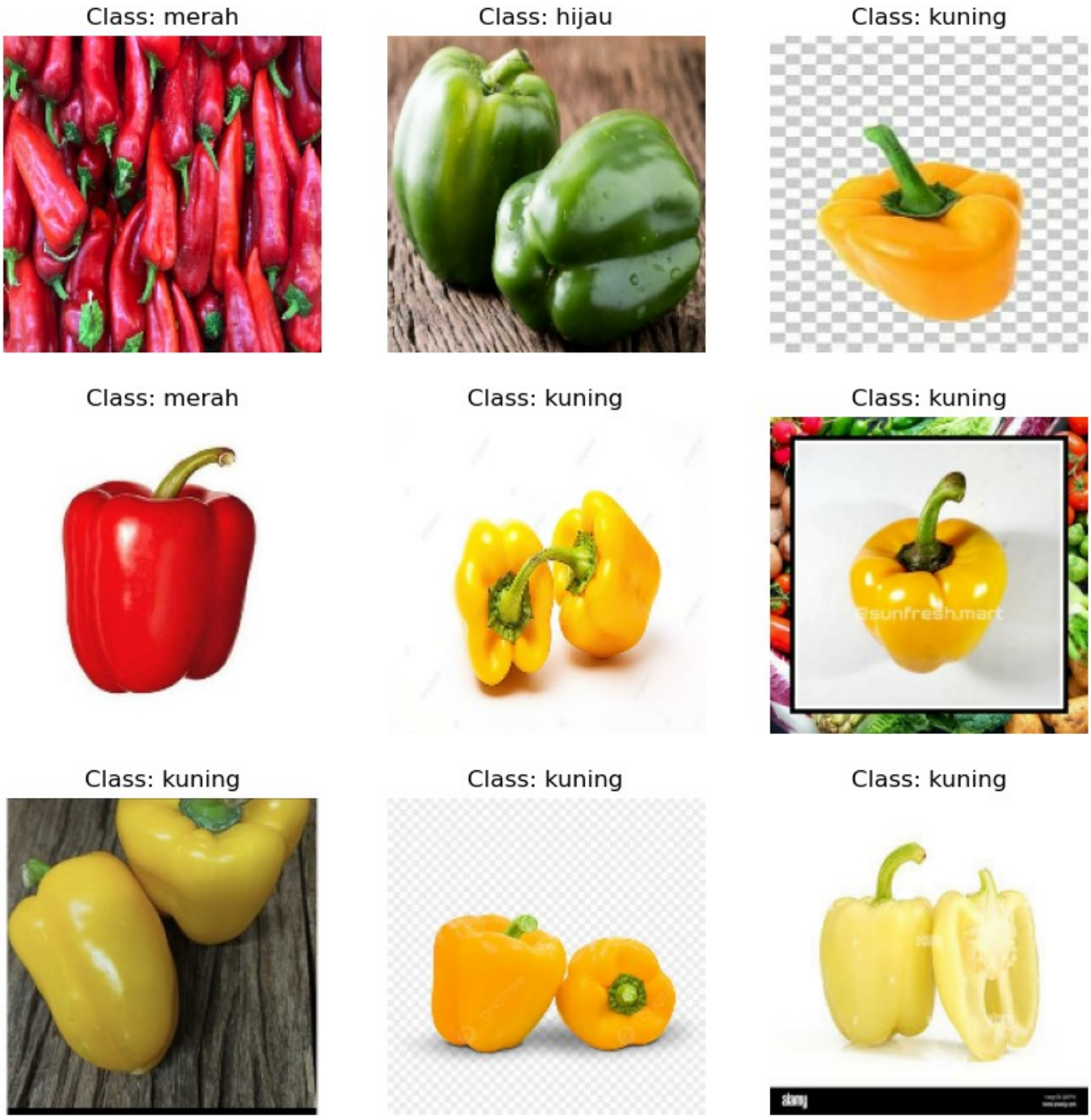
```
Found 330 files belonging to 3 classes.
Classes: ['hijau', 'kuning', 'merah']
```

```python
img_size = 180
batch_size = 32

dataset = tf.keras.utils.image_dataset_from_directory(
    data_dir,
    seed=123,
    image_size=(img_size, img_size),
    batch_size=batch_size,
    shuffle=True  # Added shuffle for better training
)
```

```
Found 330 files belonging to 3 classes.
```

```python
total_count = len(dataset)
train_ratio = 0.8
val_ratio = 0.1
test_ratio = 0.1

train_count = int(total_count * train_ratio)
val_count = int(total_count * val_ratio)
test_count = total_count - train_count - val_count

print("Total Images:", total_count)
print("Train Images:", train_count)
print("Validation Images:", val_count)
print("Test Images:", test_count)

train_ds = dataset.take(train_count)
temp_ds = dataset.skip(train_count)
val_ds = temp_ds.take(val_count)
test_ds = temp_ds.skip(val_count)
```

```
Total Images: 11
Train Images: 8
Validation Images: 1
Test Images: 2

AUTOTUNE = tf.data.AUTOTUNE

# Configure dataset for performance first
train_ds =
train_ds.cache().shuffle(1000).prefetch(buffer_size=AUTOTUNE)
val_ds = val_ds.cache().prefetch(buffer_size=AUTOTUNE)
test_ds = test_ds.prefetch(buffer_size=AUTOTUNE)

plt.figure(figsize=(10, 10))

for images, labels in train_ds.take(1):
    # Print debug information
    print("Image shape:", images.shape)
    print("Image dtype:", images.dtype)
    print("Value range:", tf.reduce_min(images).numpy(), "to",
tf.reduce_max(images).numpy())

    # Display first 9 images
    for i in range(min(9, len(images))):
        plt.subplot(3, 3, i + 1)
        image = images[i].numpy()
        plt.imshow(image.astype('uint8'))
        plt.title(f'Class: {class_names[labels[i]]}')
        plt.axis('off')
plt.show()

Image shape: (32, 180, 180, 3)
Image dtype: <dtype: 'float32'>
Value range: 0.0 to 255.0
```




```python
def create_googlenet(input_shape=(180, 180, 3), n_classes=3):
    # Define data augmentation inside the model function
    data_augmentation = tf.keras.Sequential([
        tf.keras.layers.RandomFlip("horizontal_and_vertical"),
        tf.keras.layers.RandomRotation(0.2),
        tf.keras.layers.RandomZoom(0.2),
        tf.keras.layers.RandomBrightness(0.2),
        tf.keras.layers.RandomContrast(0.2),
    ])

    def inception_block(x, f):
```

```
        t1 = tf.keras.layers.Conv2D(f[0], 1, activation='relu')(x)

        t2 = tf.keras.layers.Conv2D(f[1], 1, activation='relu')(x)
        t2 = tf.keras.layers.Conv2D(f[2], 3, padding='same',
activation='relu')(t2)

        t3 = tf.keras.layers.Conv2D(f[3], 1, activation='relu')(x)
        t3 = tf.keras.layers.Conv2D(f[4], 5, padding='same',
activation='relu')(t3)

        t4 = tf.keras.layers.MaxPool2D(3, 1, padding='same')(x)
        t4 = tf.keras.layers.Conv2D(f[5], 1, activation='relu')(t4)

        return tf.keras.layers.Concatenate()([t1, t2, t3, t4])

    inputs = tf.keras.Input(shape=input_shape)
    x = data_augmentation(inputs)

    # Initial layers
    x = tf.keras.layers.Conv2D(64, 7, strides=2, padding='same',
activation='relu')(x)
    x = tf.keras.layers.MaxPool2D(3, strides=2, padding='same')(x)
    x = tf.keras.layers.BatchNormalization()(x)

    # Reduce dimensionality
    x = tf.keras.layers.Conv2D(64, 1, activation='relu')(x)
    x = tf.keras.layers.Conv2D(192, 3, padding='same',
activation='relu')(x)
    x = tf.keras.layers.MaxPool2D(3, strides=2)(x)
    x = tf.keras.layers.BatchNormalization()(x)

    # Inception blocks
    x = inception_block(x, [64, 96, 128, 16, 32, 32])
    x = inception_block(x, [128, 128, 192, 32, 96, 64])
    x = tf.keras.layers.MaxPool2D(3, strides=2, padding='same')(x)

    x = inception_block(x, [192, 96, 208, 16, 48, 64])
    x = inception_block(x, [160, 112, 224, 24, 64, 64])
    x = tf.keras.layers.BatchNormalization()(x)

    # Global Average Pooling
    x = tf.keras.layers.GlobalAveragePooling2D()(x)
    x = tf.keras.layers.Dropout(0.5)(x)

    # Final dense layer
    outputs = tf.keras.layers.Dense(n_classes, activation='softmax')
(x)

    model = tf.keras.Model(inputs, outputs)
    return model
```

```python
# Create and compile model
model = create_googlenet()
model.compile(
    optimizer=tf.keras.optimizers.Adam(learning_rate=0.0001),
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)
model.summary()
```

```
Model: "functional_2"
```

Layer (type)	Output Shape	Param #	Connected to
input_layer_1 (InputLayer)	(None, 180, 180, 3)	0	-
sequential (Sequential)	(None, 180, 180, 3)	0	input_layer_1[0][0]
conv2d (Conv2D)	(None, 90, 90, 64)	9,472	sequential[0][0]
max_pooling2d (MaxPooling2D)	(None, 45, 45, 64)	0	conv2d[0][0]
batch_normalization (BatchNormalizatio…	(None, 45, 45, 64)	256	max_pooling2d[0][0]
conv2d_1 (Conv2D)	(None, 45, 45,	4,160	batch_normalization…

```
|                      | 64)                 |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| conv2d_2 (Conv2D)    | (None, 45, 45,      | 110,784 | conv2d_1[0][0]
|                      | 192)                |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| max_pooling2d_1      | (None, 22, 22,      |       0 | conv2d_2[0][0]
|
| (MaxPooling2D)       | 192)                |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| batch_normalizatio… | (None, 22, 22,      |     768 |
max_pooling2d_1[0][… |
| (BatchNormalizatio… | 192)                |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| conv2d_4 (Conv2D)    | (None, 22, 22,      |  18,528 |
batch_normalization… |
|                      | 96)                 |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| conv2d_6 (Conv2D)    | (None, 22, 22,      |   3,088 |
batch_normalization… |
|                      | 16)                 |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| max_pooling2d_2      | (None, 22, 22,      |       0 |
batch_normalization… |
| (MaxPooling2D)       | 192)                |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| conv2d_3 (Conv2D)    | (None, 22, 22,      |  12,352 |
batch_normalization… |
|                      | 64)                 |           |
|
├──────────────────────┼─────────────────────┼───────────┼──────────────────
──────┤
| conv2d_5 (Conv2D)    | (None, 22, 22,      | 110,720 | conv2d_4[0][0]
|
|                      | 128)                |           |
```

conv2d_7 (Conv2D)	(None, 22, 22, 32)	12,832	conv2d_6[0][0]
conv2d_8 (Conv2D)	(None, 22, 22, 32)	6,176	max_pooling2d_2[0][…
concatenate (Concatenate)	(None, 22, 22, 256)	0	conv2d_3[0][0], conv2d_5[0][0], conv2d_7[0][0], conv2d_8[0][0]
conv2d_10 (Conv2D)	(None, 22, 22, 128)	32,896	concatenate[0][0]
conv2d_12 (Conv2D)	(None, 22, 22, 32)	8,224	concatenate[0][0]
max_pooling2d_3 (MaxPooling2D)	(None, 22, 22, 256)	0	concatenate[0][0]
conv2d_9 (Conv2D)	(None, 22, 22, 128)	32,896	concatenate[0][0]

conv2d_11 (Conv2D)	(None, 22, 22, 192)	221,376	conv2d_10[0][0]
conv2d_13 (Conv2D)	(None, 22, 22, 96)	76,896	conv2d_12[0][0]
conv2d_14 (Conv2D)	(None, 22, 22, 64)	16,448	max_pooling2d_3[0][…
concatenate_1 (Concatenate)	(None, 22, 22, 480)	0	conv2d_9[0][0], conv2d_11[0][0], conv2d_13[0][0], conv2d_14[0][0]
max_pooling2d_4 (MaxPooling2D)	(None, 11, 11, 480)	0	concatenate_1[0][0]
conv2d_16 (Conv2D)	(None, 11, 11, 96)	46,176	max_pooling2d_4[0][…
conv2d_18 (Conv2D)	(None, 11, 11, 16)	7,696	max_pooling2d_4[0][…
max_pooling2d_5 (MaxPooling2D)	(None, 11, 11, 480)	0	max_pooling2d_4[0][…

conv2d_15 (Conv2D)	(None, 11, 11, 192)	92,352	max_pooling2d_4[0][…
conv2d_17 (Conv2D)	(None, 11, 11, 208)	179,920	conv2d_16[0][0]
conv2d_19 (Conv2D)	(None, 11, 11, 48)	19,248	conv2d_18[0][0]
conv2d_20 (Conv2D)	(None, 11, 11, 64)	30,784	max_pooling2d_5[0][…
concatenate_2 (Concatenate)	(None, 11, 11, 512)	0	conv2d_15[0][0], conv2d_17[0][0], conv2d_19[0][0], conv2d_20[0][0]
conv2d_22 (Conv2D)	(None, 11, 11, 112)	57,456	concatenate_2[0][0]
conv2d_24 (Conv2D)	(None, 11, 11, 24)	12,312	concatenate_2[0][0]

max_pooling2d_6 (MaxPooling2D)	(None, 11, 11, 512)	0	concatenate_2[0][0]
conv2d_21 (Conv2D)	(None, 11, 11, 160)	82,080	concatenate_2[0][0]
conv2d_23 (Conv2D)	(None, 11, 11, 224)	226,016	conv2d_22[0][0]
conv2d_25 (Conv2D)	(None, 11, 11, 64)	38,464	conv2d_24[0][0]
conv2d_26 (Conv2D)	(None, 11, 11, 64)	32,832	max_pooling2d_6[0][…
concatenate_3 (Concatenate)	(None, 11, 11, 512)	0	conv2d_21[0][0], conv2d_23[0][0], conv2d_25[0][0], conv2d_26[0][0]
batch_normalizatio… (BatchNormalizatio…	(None, 11, 11, 512)	2,048	concatenate_3[0][0]
global_average_poo… (GlobalAveragePool…	(None, 512)	0	batch_normalization…

```
│                                                                                                  │
├──────────────────────┼──────────────────────┼──────────┼──────────────────────┼──────────┤
│ dropout (Dropout)    │ (None, 512)          │        0 │ global_average_pool… │
├──────────────────────┼──────────────────────┼──────────┼──────────────────────┼──────────┤
│ dense (Dense)        │ (None, 3)            │    1,539 │ dropout[0][0]        │
└──────────────────────┴──────────────────────┴──────────┴──────────────────────┴──────────┘

 Total params: 1,506,795 (5.75 MB)

 Trainable params: 1,505,259 (5.74 MB)

 Non-trainable params: 1,536 (6.00 KB)
```

```python
# Callbacks
early_stopping = tf.keras.callbacks.EarlyStopping(
    monitor='val_accuracy',
    patience=10,
    restore_best_weights=True
)

reduce_lr = tf.keras.callbacks.ReduceLROnPlateau(
    monitor='val_loss',
    factor=0.2,
    patience=5,
    min_lr=1e-6
)

# Train the model
history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=50,
    callbacks=[early_stopping, reduce_lr]
)
```

```
WARNING:tensorflow:From c:\Users\Lenovo\anaconda3\Lib\site-packages\
keras\src\backend\common\global_state.py:73: The name
tf.reset_default_graph is deprecated. Please use
tf.compat.v1.reset_default_graph instead.


Model: "functional_1"

┏━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━┓
┃ Layer (type)         ┃ Output Shape         ┃ Param #  ┃ Connected to         ┃
```

```
┏━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━┓
┃ input_layer         ┃ (None, 180, 180,  ┃       0 ┃ -                 ┃
┃ (InputLayer)        ┃ 3)                ┃         ┃                   ┃
┡━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━┩
│ conv2d (Conv2D)     │ (None, 90, 90,    │   9,472 │ input_layer[0][0] │
│                     │ 64)               │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ max_pooling2d       │ (None, 45, 45,    │       0 │ conv2d[0][0]      │
│ (MaxPooling2D)      │ 64)               │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ conv2d_1 (Conv2D)   │ (None, 45, 45,    │   4,160 │ max_pooling2d[0]… │
│                     │ 64)               │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ conv2d_2 (Conv2D)   │ (None, 45, 45,    │ 110,784 │ conv2d_1[0][0]    │
│                     │ 192)              │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ max_pooling2d_1     │ (None, 22, 22,    │       0 │ conv2d_2[0][0]    │
│ (MaxPooling2D)      │ 192)              │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ conv2d_4 (Conv2D)   │ (None, 22, 22,    │  18,528 │ max_pooling2d_1[0][… │
│                     │ 96)               │         │                   │
├─────────────────────┼───────────────────┼─────────┼───────────────────┤
│ conv2d_6 (Conv2D)   │ (None, 22, 22,    │   3,088 │ max_pooling2d_1[0][… │
│                     │ 16)               │         │                   │
└─────────────────────┴───────────────────┴─────────┴───────────────────┘
```

```
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ max_pooling2d_2      │ (None, 22, 22,       │        0 │
max_pooling2d_1[0][… │
│ (MaxPooling2D)       │ 192)                 │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_3 (Conv2D)    │ (None, 22, 22,       │   12,352 │
max_pooling2d_1[0][… │
│                      │ 64)                  │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_5 (Conv2D)    │ (None, 22, 22,       │ 110,720 │ conv2d_4[0][0]
│
│                      │ 128)                 │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_7 (Conv2D)    │ (None, 22, 22,       │   12,832 │ conv2d_6[0][0]
│
│                      │ 32)                  │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_8 (Conv2D)    │ (None, 22, 22,       │    6,176 │
max_pooling2d_2[0][… │
│                      │ 32)                  │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ concatenate          │ (None, 22, 22,       │        0 │ conv2d_3[0][0],
│
│ (Concatenate)        │ 256)                 │          │ conv2d_5[0][0],
│
│                      │                      │          │ conv2d_7[0][0],
│
│                      │                      │          │ conv2d_8[0][0]
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_10 (Conv2D)   │ (None, 22, 22,       │   32,896 │ concatenate[0]
[0]    │
│                      │ 128)                 │          │
│
├──────────────────────┼──────────────────────┼──────────┼──────────────────────
──────┤
│ conv2d_12 (Conv2D)   │ (None, 22, 22,       │    8,224 │ concatenate[0]
```

```
[0]    |
|                       | 32)                 |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| max_pooling2d_3      | (None, 22, 22,      |        0 | concatenate[0]
[0]    |
| (MaxPooling2D)       | 256)                |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| conv2d_9 (Conv2D)    | (None, 22, 22,      |  32,896 | concatenate[0]
[0]    |
|                       | 128)                |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| conv2d_11 (Conv2D)   | (None, 22, 22,      | 221,376 | conv2d_10[0][0]
|
|                       | 192)                |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| conv2d_13 (Conv2D)   | (None, 22, 22,      |  76,896 | conv2d_12[0][0]
|
|                       | 96)                 |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| conv2d_14 (Conv2D)   | (None, 22, 22,      |  16,448 |
max_pooling2d_3[0][… |
|                       | 64)                 |           |
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| concatenate_1        | (None, 22, 22,      |        0 | conv2d_9[0][0],
|
| (Concatenate)        | 480)                |           | conv2d_11[0][0],
|
|                       |                     |           | conv2d_13[0][0],
|
|                       |                     |           | conv2d_14[0][0]
|
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
| max_pooling2d_4      | (None, 11, 11,      |        0 | concatenate_1[0]
[0]   |
| (MaxPooling2D)       | 480)                |           |
|
```

```
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_16 (Conv2D)  │ (None, 11, 11,      │  46,176 │
max_pooling2d_4[0][… │
│                     │ 96)                 │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_18 (Conv2D)  │ (None, 11, 11,      │   7,696 │
max_pooling2d_4[0][… │
│                     │ 16)                 │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ max_pooling2d_5     │ (None, 11, 11,      │       0 │
max_pooling2d_4[0][… │
│ (MaxPooling2D)      │ 480)                │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_15 (Conv2D)  │ (None, 11, 11,      │  92,352 │
max_pooling2d_4[0][… │
│                     │ 192)                │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_17 (Conv2D)  │ (None, 11, 11,      │ 179,920 │ conv2d_16[0][0]
│
│                     │ 208)                │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_19 (Conv2D)  │ (None, 11, 11,      │  19,248 │ conv2d_18[0][0]
│
│                     │ 48)                 │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ conv2d_20 (Conv2D)  │ (None, 11, 11,      │  30,784 │
max_pooling2d_5[0][… │
│                     │ 64)                 │         │
│
├─────────────────────┼─────────────────────┼─────────┼──────────────────
──────┤
│ concatenate_2       │ (None, 11, 11,      │       0 │ conv2d_15[0][0],
│
│ (Concatenate)       │ 512)                │         │ conv2d_17[0][0],
│
│                     │                     │         │ conv2d_19[0][0],
```

```
│
│                             │                         │            │ conv2d_20[0][0]
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_22 (Conv2D)          │ (None, 11, 11,          │     57,456 │ concatenate_2[0]
[0]   │
│                             │ 112)                    │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_24 (Conv2D)          │ (None, 11, 11,          │     12,312 │ concatenate_2[0]
[0]   │
│                             │ 24)                     │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ max_pooling2d_6             │ (None, 11, 11,          │          0 │ concatenate_2[0]
[0]   │
│ (MaxPooling2D)              │ 512)                    │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_21 (Conv2D)          │ (None, 11, 11,          │     82,080 │ concatenate_2[0]
[0]   │
│                             │ 160)                    │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_23 (Conv2D)          │ (None, 11, 11,          │    226,016 │ conv2d_22[0][0]
│
│                             │ 224)                    │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_25 (Conv2D)          │ (None, 11, 11,          │     38,464 │ conv2d_24[0][0]
│
│                             │ 64)                     │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ conv2d_26 (Conv2D)          │ (None, 11, 11,          │     32,832 │
max_pooling2d_6[0][… │
│                             │ 64)                     │            │
│
├─────────────────────────────┼─────────────────────────┼────────────┼───────────────
───────┤
│ concatenate_3               │ (None, 11, 11,          │          0 │ conv2d_21[0][0],
│
```

(Concatenate)	512)		conv2d_23[0][0], conv2d_25[0][0], conv2d_26[0][0]
conv2d_28 (Conv2D)	(None, 11, 11, 128)	65,664	concatenate_3[0][0]
conv2d_30 (Conv2D)	(None, 11, 11, 24)	12,312	concatenate_3[0][0]
max_pooling2d_7 (MaxPooling2D)	(None, 11, 11, 512)	0	concatenate_3[0][0]
conv2d_27 (Conv2D)	(None, 11, 11, 128)	65,664	concatenate_3[0][0]
conv2d_29 (Conv2D)	(None, 11, 11, 256)	295,168	conv2d_28[0][0]
conv2d_31 (Conv2D)	(None, 11, 11, 64)	38,464	conv2d_30[0][0]
conv2d_32 (Conv2D)	(None, 11, 11, 64)	32,832	max_pooling2d_7[0][…

```
──────┤
│ concatenate_4        │ (None, 11, 11,    │       0 │ conv2d_27[0][0],
│                      │                   │         │
│ (Concatenate)        │ 512)              │         │ conv2d_29[0][0],
│                      │                   │         │
│                      │                   │         │ conv2d_31[0][0],
│                      │                   │         │
│                      │                   │         │ conv2d_32[0][0]
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_34 (Conv2D)   │ (None, 11, 11,    │  73,872 │ concatenate_4[0]
[0]  │
│                      │ 144)              │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_36 (Conv2D)   │ (None, 11, 11,    │  16,416 │ concatenate_4[0]
[0]  │
│                      │ 32)               │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ max_pooling2d_8      │ (None, 11, 11,    │       0 │ concatenate_4[0]
[0]  │
│ (MaxPooling2D)       │ 512)              │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_33 (Conv2D)   │ (None, 11, 11,    │  57,456 │ concatenate_4[0]
[0]  │
│                      │ 112)              │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_35 (Conv2D)   │ (None, 11, 11,    │ 373,536 │ conv2d_34[0][0]
│                      │                   │         │
│                      │ 288)              │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_37 (Conv2D)   │ (None, 11, 11,    │  51,264 │ conv2d_36[0][0]
│                      │                   │         │
│                      │ 64)               │         │
│                      │                   │         │
├──────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
│ conv2d_38 (Conv2D)   │ (None, 11, 11,    │  32,832 │
max_pooling2d_8[0][… │
```

```
|                       | 64)                 |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| concatenate_5         | (None, 11, 11,      |         0 | conv2d_33[0][0],
|
| (Concatenate)         | 528)                |           | conv2d_35[0][0],
|
|                       |                     |           | conv2d_37[0][0],
|
|                       |                     |           | conv2d_38[0][0]
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| conv2d_40 (Conv2D)    | (None, 11, 11,      |  84,640 | concatenate_5[0]
[0]   |
|                       | 160)                |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| conv2d_42 (Conv2D)    | (None, 11, 11,      |  16,928 | concatenate_5[0]
[0]   |
|                       | 32)                 |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| max_pooling2d_9       | (None, 11, 11,      |         0 | concatenate_5[0]
[0]   |
| (MaxPooling2D)        | 528)                |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| conv2d_39 (Conv2D)    | (None, 11, 11,      | 135,424 | concatenate_5[0]
[0]   |
|                       | 256)                |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| conv2d_41 (Conv2D)    | (None, 11, 11,      | 461,120 | conv2d_40[0][0]
|
|                       | 320)                |           |
|
|-----------------------|---------------------|-----------|-----------------------
-------|
| conv2d_43 (Conv2D)    | (None, 11, 11,      | 102,528 | conv2d_42[0][0]
|
|                       | 128)                |           |
|
|-----------------------|---------------------|-----------|-----------------------
```

```
──────┤
| conv2d_44 (Conv2D)  | (None, 11, 11,    |  67,712 |
max_pooling2d_9[0][… |
|                     | 128)              |         |
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| concatenate_6       | (None, 11, 11,    |       0 | conv2d_39[0][0],
|
| (Concatenate)       | 832)              |         | conv2d_41[0][0],
|
|                     |                   |         | conv2d_43[0][0],
|
|                     |                   |         | conv2d_44[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| max_pooling2d_10    | (None, 6, 6, 832) |       0 | concatenate_6[0]
[0]  |
| (MaxPooling2D)      |                   |         |
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| conv2d_46 (Conv2D)  | (None, 6, 6, 160) | 133,280 |
max_pooling2d_10[0]… |
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| conv2d_48 (Conv2D)  | (None, 6, 6, 32)  |  26,656 |
max_pooling2d_10[0]… |
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| max_pooling2d_11    | (None, 6, 6, 832) |       0 |
max_pooling2d_10[0]… |
| (MaxPooling2D)      |                   |         |
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| conv2d_45 (Conv2D)  | (None, 6, 6, 256) | 213,248 |
max_pooling2d_10[0]… |
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| conv2d_47 (Conv2D)  | (None, 6, 6, 320) | 461,120 | conv2d_46[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
| conv2d_49 (Conv2D)  | (None, 6, 6, 128) | 102,528 | conv2d_48[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
──────┤
```

```
| conv2d_50 (Conv2D)  | (None, 6, 6, 128) | 106,624 |
max_pooling2d_11[0]… |
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| concatenate_7       | (None, 6, 6, 832) |       0 | conv2d_45[0][0],
|
| (Concatenate)       |                   |         | conv2d_47[0][0],
|
|                     |                   |         | conv2d_49[0][0],
|
|                     |                   |         | conv2d_50[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_52 (Conv2D)  | (None, 6, 6, 192) | 159,936 | concatenate_7[0]
[0]  |
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_54 (Conv2D)  | (None, 6, 6, 48)  |  39,984 | concatenate_7[0]
[0]  |
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| max_pooling2d_12    | (None, 6, 6, 832) |       0 | concatenate_7[0]
[0]  |
| (MaxPooling2D)      |                   |         |
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_51 (Conv2D)  | (None, 6, 6, 384) | 319,872 | concatenate_7[0]
[0]  |
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_53 (Conv2D)  | (None, 6, 6, 384) | 663,936 | conv2d_52[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_55 (Conv2D)  | (None, 6, 6, 128) | 153,728 | conv2d_54[0][0]
|
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| conv2d_56 (Conv2D)  | (None, 6, 6, 128) | 106,624 |
max_pooling2d_12[0]… |
├─────────────────────┼───────────────────┼─────────┼──────────────────
─────┤
| concatenate_8       | (None, 6, 6,      |       0 | conv2d_51[0][0],
|
| (Concatenate)       | 1024)             |         | conv2d_53[0][0],
|
|                     |                   |         | conv2d_55[0][0],
|
```

```
│                      │                     │          │ conv2d_56[0][0]
│                      │                     │          │
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
│ average_pooling2d    │ (None, 4, 4,        │        0 │ concatenate_8[0]
[0]   │
│ (AveragePooling2D)   │ 1024)               │          │
│                      │                     │          │
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
│ dropout (Dropout)    │ (None, 4, 4,        │        0 │
average_pooling2d[0… │
│                      │ 1024)               │          │
│                      │                     │          │
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
│ flatten (Flatten)    │ (None, 16384)       │        0 │ dropout[0][0]
│                      │                     │          │
├──────────────────────┼─────────────────────┼──────────┼──────────────────
──────┤
│ dense (Dense)        │ (None, 3)           │   49,155 │ flatten[0][0]
│                      │                     │          │
└──────────────────────┴─────────────────────┴──────────┴──────────────────
──────┘

 Total params: 6,022,707 (22.97 MB)

 Trainable params: 6,022,707 (22.97 MB)

 Non-trainable params: 0 (0.00 B)
```

```
# Callbacks
early_stopping = tf.keras.callbacks.EarlyStopping(
    monitor='val_accuracy',
    patience=10,
    restore_best_weights=True
)

reduce_lr = tf.keras.callbacks.ReduceLROnPlateau(
    monitor='val_loss',
    factor=0.2,
    patience=5,
    min_lr=1e-6
)

# Train the model
history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=50,
```

```
    callbacks=[early_stopping, reduce_lr]
)

Epoch 1/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 34s 1s/step - accuracy: 0.5165 - loss: 0.9858
- val_accuracy: 0.2500 - val_loss: 1.5385 - learning_rate: 1.0000e-04
Epoch 2/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 823ms/step - accuracy: 0.8642 - loss:
0.4390 - val_accuracy: 0.3438 - val_loss: 1.1913 - learning_rate:
1.0000e-04
Epoch 3/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 814ms/step - accuracy: 0.9404 - loss:
0.2199 - val_accuracy: 0.2812 - val_loss: 1.3738 - learning_rate:
1.0000e-04
Epoch 4/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 839ms/step - accuracy: 0.9540 - loss:
0.1446 - val_accuracy: 0.3438 - val_loss: 1.1969 - learning_rate:
1.0000e-04
Epoch 5/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 787ms/step - accuracy: 0.9540 - loss:
0.1026 - val_accuracy: 0.5000 - val_loss: 1.1047 - learning_rate:
1.0000e-04
Epoch 6/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 821ms/step - accuracy: 0.9582 - loss:
0.1241 - val_accuracy: 0.6250 - val_loss: 0.9834 - learning_rate:
1.0000e-04
Epoch 7/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 816ms/step - accuracy: 0.9726 - loss:
0.0694 - val_accuracy: 0.5312 - val_loss: 0.9043 - learning_rate:
1.0000e-04
Epoch 8/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 802ms/step - accuracy: 0.9747 - loss:
0.1121 - val_accuracy: 0.7188 - val_loss: 0.7819 - learning_rate:
1.0000e-04
Epoch 9/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 793ms/step - accuracy: 0.9772 - loss:
0.0656 - val_accuracy: 0.8438 - val_loss: 0.6881 - learning_rate:
1.0000e-04
Epoch 10/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 801ms/step - accuracy: 0.9772 - loss:
0.0646 - val_accuracy: 0.9688 - val_loss: 0.6080 - learning_rate:
1.0000e-04
Epoch 11/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 800ms/step - accuracy: 0.9801 - loss:
0.0583 - val_accuracy: 0.9688 - val_loss: 0.5716 - learning_rate:
1.0000e-04
Epoch 12/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 790ms/step - accuracy: 0.9837 - loss:
0.0354 - val_accuracy: 0.8125 - val_loss: 0.6366 - learning_rate:
1.0000e-04
```

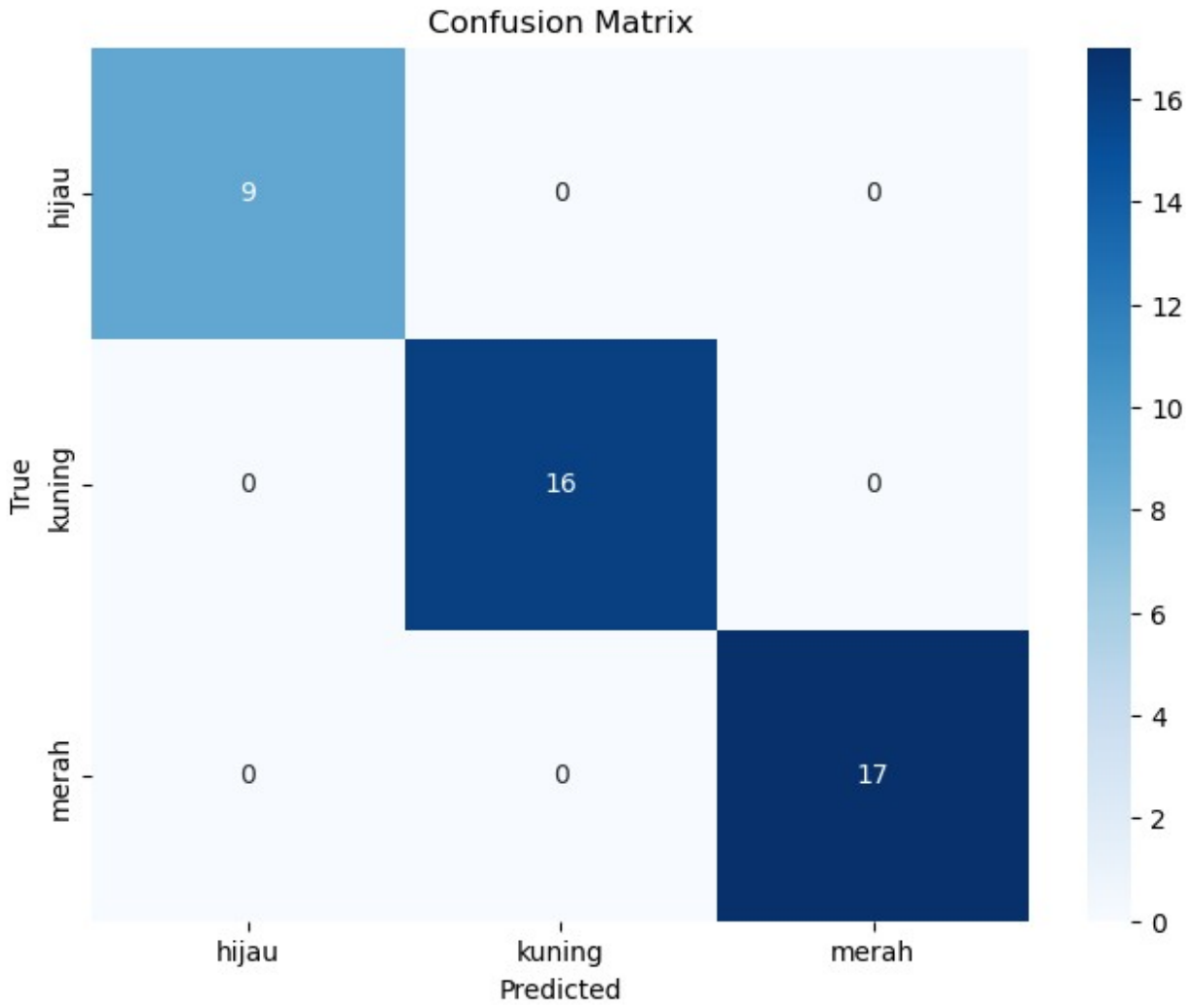
```
Epoch 13/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 824ms/step - accuracy: 0.9841 - loss:
0.0362 - val_accuracy: 0.8125 - val_loss: 0.5945 - learning_rate:
1.0000e-04
Epoch 14/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 795ms/step - accuracy: 0.9858 - loss:
0.0362 - val_accuracy: 0.9062 - val_loss: 0.4869 - learning_rate:
1.0000e-04
Epoch 15/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 802ms/step - accuracy: 0.9889 - loss:
0.0347 - val_accuracy: 0.9062 - val_loss: 0.4395 - learning_rate:
1.0000e-04
Epoch 16/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 785ms/step - accuracy: 0.9846 - loss:
0.0334 - val_accuracy: 0.9375 - val_loss: 0.4069 - learning_rate:
1.0000e-04
Epoch 17/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 802ms/step - accuracy: 0.9837 - loss:
0.0292 - val_accuracy: 1.0000 - val_loss: 0.3471 - learning_rate:
1.0000e-04
Epoch 18/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 802ms/step - accuracy: 0.9960 - loss:
0.0235 - val_accuracy: 0.9688 - val_loss: 0.3119 - learning_rate:
1.0000e-04
Epoch 19/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 787ms/step - accuracy: 0.9972 - loss:
0.0166 - val_accuracy: 1.0000 - val_loss: 0.2919 - learning_rate:
1.0000e-04
Epoch 20/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 784ms/step - accuracy: 1.0000 - loss:
0.0187 - val_accuracy: 0.9688 - val_loss: 0.3157 - learning_rate:
1.0000e-04
Epoch 21/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 806ms/step - accuracy: 0.9930 - loss:
0.0334 - val_accuracy: 1.0000 - val_loss: 0.2783 - learning_rate:
1.0000e-04
Epoch 22/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 787ms/step - accuracy: 0.9974 - loss:
0.0098 - val_accuracy: 0.9688 - val_loss: 0.2573 - learning_rate:
1.0000e-04
Epoch 23/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 795ms/step - accuracy: 0.9901 - loss:
0.0270 - val_accuracy: 0.9375 - val_loss: 0.3070 - learning_rate:
1.0000e-04
Epoch 24/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 7s 879ms/step - accuracy: 0.9888 - loss:
0.0236 - val_accuracy: 0.9062 - val_loss: 0.3025 - learning_rate:
1.0000e-04
Epoch 25/50
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 793ms/step - accuracy: 1.0000 - loss:
0.0137 - val_accuracy: 0.8750 - val_loss: 0.3496 - learning_rate:
1.0000e-04
Epoch 26/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 812ms/step - accuracy: 0.9936 - loss:
0.0341 - val_accuracy: 0.9375 - val_loss: 0.1910 - learning_rate:
1.0000e-04
Epoch 27/50
8/8 ━━━━━━━━━━━━━━━━━━━━ 6s 815ms/step - accuracy: 1.0000 - loss:
0.0126 - val_accuracy: 1.0000 - val_loss: 0.1331 - learning_rate:
1.0000e-04
```

```python
import seaborn as sns

# Predict on test dataset
test_predictions = []
test_labels = []

for images, labels in test_ds:
    predictions = model.predict(images)
    test_predictions.extend(np.argmax(predictions, axis=1))
    test_labels.extend(labels.numpy())

# Convert to numpy arrays
test_predictions = np.array(test_predictions)
test_labels = np.array(test_labels)

# Create confusion matrix
conf_matrix = tf.math.confusion_matrix(test_labels, test_predictions)

# Calculate metrics
accuracy = np.sum(np.diag(conf_matrix)) / np.sum(conf_matrix)
precision = np.diag(conf_matrix) / np.sum(conf_matrix, axis=0)
recall = np.diag(conf_matrix) / np.sum(conf_matrix, axis=1)
f1 = 2 * (precision * recall) / (precision + recall)

# Visualize confusion matrix
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues',
            xticklabels=class_names,
            yticklabels=class_names)
plt.title('Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()

# Print metrics
print("Confusion Matrix:\n", conf_matrix)
print("\nAccuracy:", accuracy)
print("Precision:", precision)
```

```
print("Recall:", recall)
print("F1 Score:", f1)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 910ms/step
```




```
Confusion Matrix:
 tf.Tensor(
[[ 9  0  0]
 [ 0 16  0]
 [ 0  0 17]], shape=(3, 3), dtype=int32)

Accuracy: 1.0
Precision: [1. 1. 1.]
Recall: [1. 1. 1.]
F1 Score: [1. 1. 1.]

model_save_path = 'googlenet_paprika_model.h5'
```

```
print("Josua Waraney William Lantang / 220712071 / Seaborn/ Perbedaan Paprika Merah, Kuning Hijau Menggunakan GoogleNet")
```

```
Josua Waraney William Lantang / 220712071 / Seaborn/ Perbedaan Paprika Merah, Kuning Hijau Menggunakan GoogleNet
```