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Plant Leaf Disease Detection and Classification Based on CNN with LVQ Algorithm

```
# Before running this file, make sure to install dependencies in the bash:
# pip install tensorflow keras numpy opencv-python matplotlib scikit-learn

import os
import cv2
import numpy as np
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.models import Sequential, Model
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt

# Set dataset path
dataset_path = "dataset"
img_size = (128, 128)

# Load images and labels
X, y = [], []
labels = sorted(os.listdir(dataset_path))  # Get folder names

for label in labels:
    label_path = os.path.join(dataset_path, label)
    for img_name in os.listdir(label_path):
        img_path = os.path.join(label_path, img_name)
        img = cv2.imread(img_path)
        img = cv2.resize(img, img_size)
        X.append(img)
        y.append(label)

# Convert to numpy arrays
X = np.array(X, dtype="float32") / 255.0  # Normalize
y = np.array(y)

# Encode labels
label_encoder = LabelEncoder()
y_encoded = label_encoder.fit_transform(y)

# Train-test split
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X_train, X_test, y_train, y_test = train_test_split(X, y_encoded,
test_size=0.2, random_state=42)

# CNN Model
cnn_model = Sequential([
    Conv2D(32, (9,9), activation='relu', input_shape=(128, 128, 3)),
    MaxPooling2D((2, 2)),

    Conv2D(64, (9,9), activation='relu'),
    MaxPooling2D((2, 2)),

    Conv2D(128, (5,5), activation='relu'),
    MaxPooling2D((2, 2)),

    Conv2D(256, (5,5), activation='relu'),
    MaxPooling2D((2, 2)),

    Flatten(),
    Dense(128, activation='relu'),
    Dropout(0.5),
    Dense(len(labels), activation='softmax')  # Output layer
])

cnn_model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy', metrics=['accuracy'])
cnn_model.summary()
```

```
WARNING:tensorflow:From c:\Users\Abhishek Kumar\anaconda3\Lib\site-
packages\keras\src\backend.py:873: The name tf.get_default_graph is
deprecated. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From c:\Users\Abhishek Kumar\anaconda3\Lib\site-
packages\keras\src\layers\pooling\max_pooling2d.py:161: The name
tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instead.

WARNING:tensorflow:From c:\Users\Abhishek Kumar\anaconda3\Lib\site-
packages\keras\src\optimizers\__init__.py:309: The name
tf.train.Optimizer is deprecated. Please use
tf.compat.v1.train.Optimizer instead.

Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 120, 120, 32)      7808

 max_pooling2d (MaxPooling2  (None, 60, 60, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 52, 52, 64)        165952
```

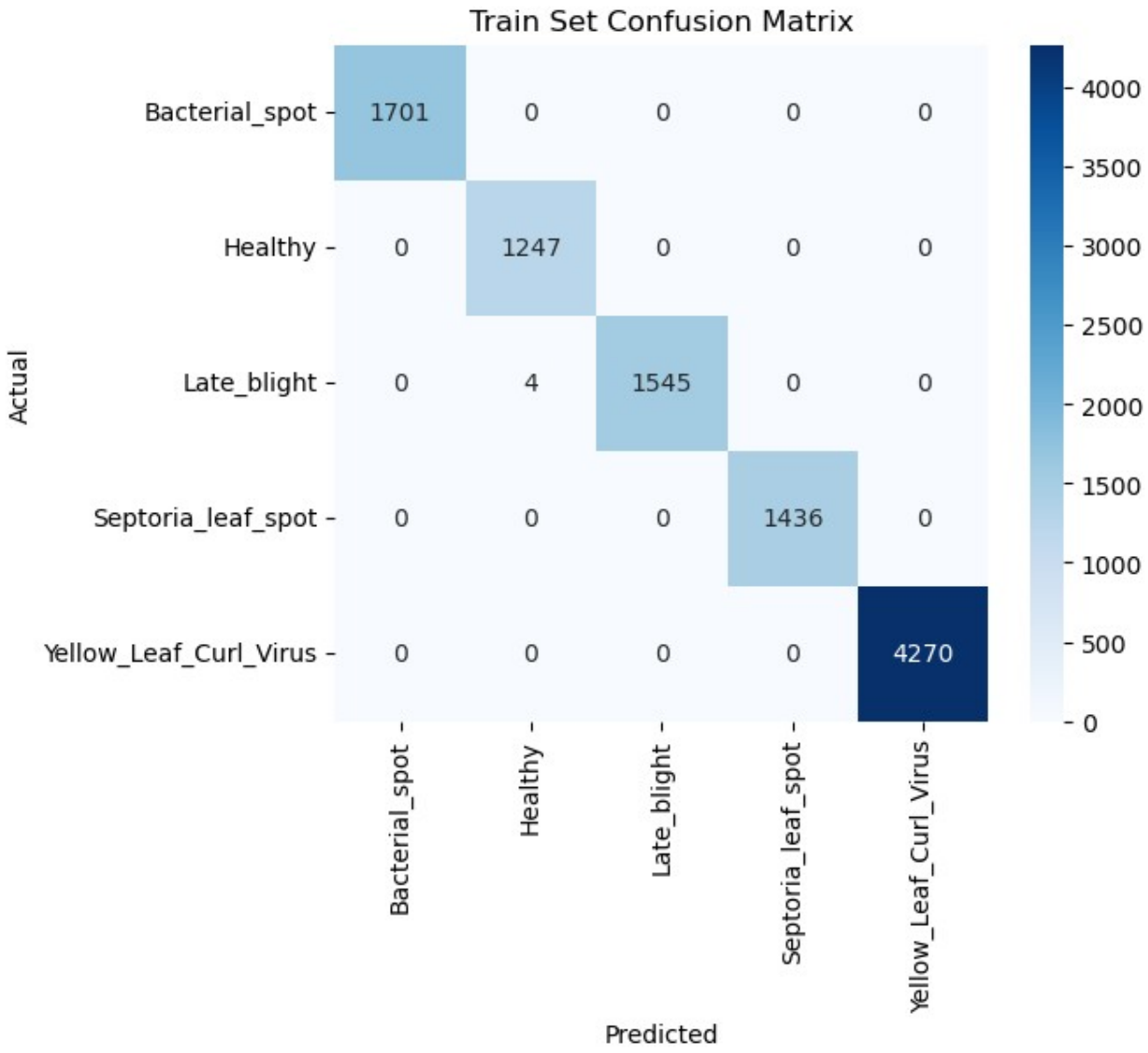
```
 max_pooling2d_1 (MaxPoolin  (None, 26, 26, 64)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 22, 22, 128)       204928

 max_pooling2d_2 (MaxPoolin  (None, 11, 11, 128)       0
 g2D)

 conv2d_3 (Conv2D)           (None, 7, 7, 256)         819456

 max_pooling2d_3 (MaxPoolin  (None, 3, 3, 256)         0
 g2D)

 flatten (Flatten)           (None, 2304)              0

 dense (Dense)               (None, 128)               295040

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 5)                 645

=================================================================
Total params: 1493829 (5.70 MB)
Trainable params: 1493829 (5.70 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

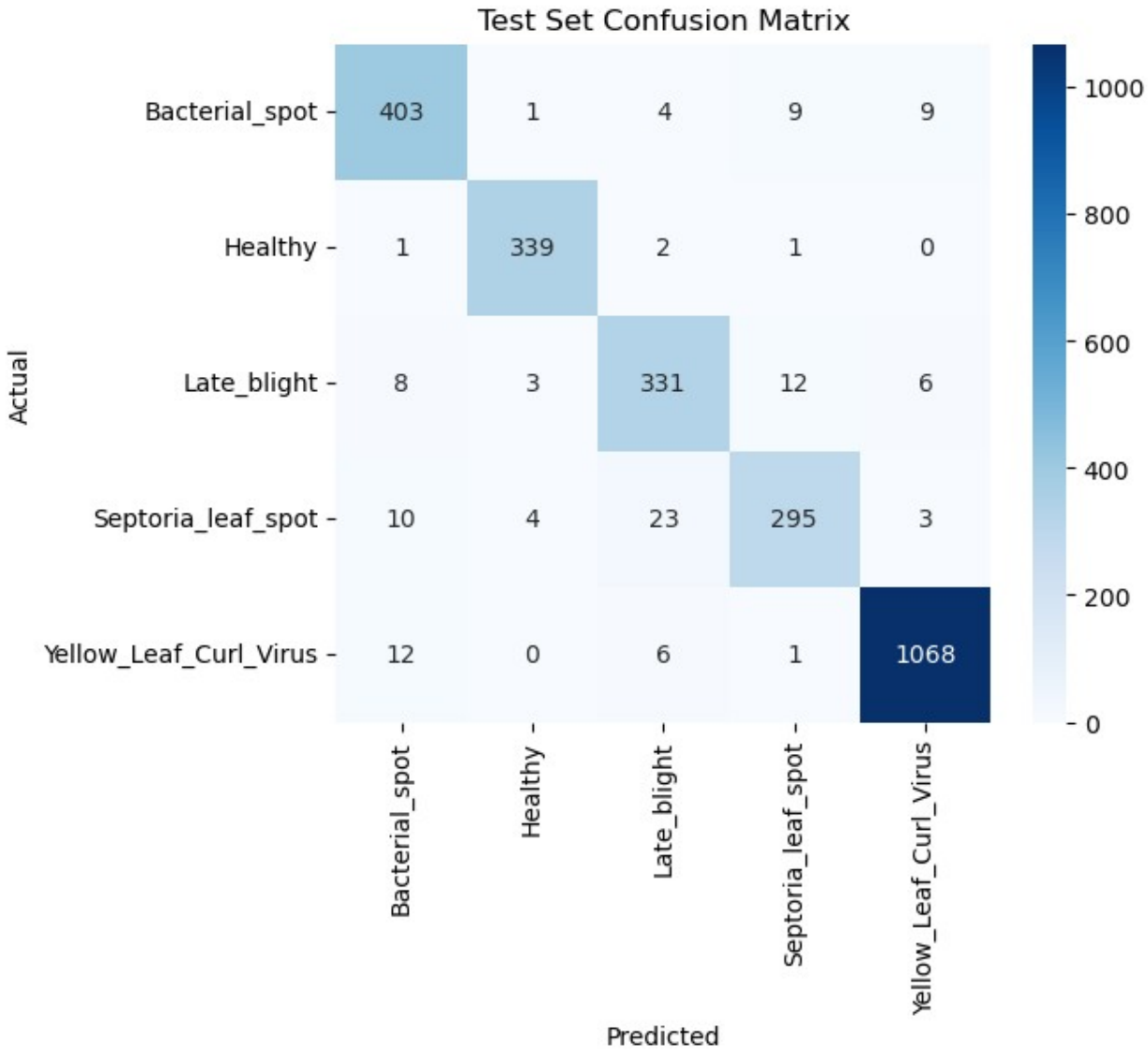
```
cnn_model.fit(X_train, y_train, epochs=10, batch_size=32,
validation_data=(X_test, y_test))
```

```
Epoch 1/10
WARNING:tensorflow:From c:\Users\Abhishek Kumar\anaconda3\Lib\site-
packages\keras\src\utils\tf_utils.py:492: The name
tf.ragged.RaggedTensorValue is deprecated. Please use
tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From c:\Users\Abhishek Kumar\anaconda3\Lib\site-
packages\keras\src\engine\base_layer_utils.py:384: The name
tf.executing_eagerly_outside_functions is deprecated. Please use
tf.compat.v1.executing_eagerly_outside_functions instead.

319/319 [==============================] - 152s 471ms/step - loss:
1.0218 - accuracy: 0.5838 - val_loss: 0.6415 - val_accuracy: 0.7605
Epoch 2/10
319/319 [==============================] - 158s 496ms/step - loss:
0.6635 - accuracy: 0.7499 - val_loss: 0.5082 - val_accuracy: 0.8118
Epoch 3/10
319/319 [==============================] - 176s 551ms/step - loss:
0.4927 - accuracy: 0.8171 - val_loss: 0.3953 - val_accuracy: 0.8538
```

```
Epoch 4/10
319/319 [==============================] - 152s 475ms/step - loss:
0.3802 - accuracy: 0.8613 - val_loss: 0.2803 - val_accuracy: 0.8981
Epoch 5/10
319/319 [==============================] - 159s 499ms/step - loss:
0.3047 - accuracy: 0.8897 - val_loss: 0.2789 - val_accuracy: 0.9020
Epoch 6/10
319/319 [==============================] - 192s 601ms/step - loss:
0.2678 - accuracy: 0.9056 - val_loss: 0.2738 - val_accuracy: 0.9044
Epoch 7/10
319/319 [==============================] - 183s 575ms/step - loss:
0.2137 - accuracy: 0.9232 - val_loss: 0.1793 - val_accuracy: 0.9392
Epoch 8/10
319/319 [==============================] - 171s 535ms/step - loss:
0.1683 - accuracy: 0.9418 - val_loss: 0.1680 - val_accuracy: 0.9424
Epoch 9/10
319/319 [==============================] - 159s 500ms/step - loss:
0.1569 - accuracy: 0.9472 - val_loss: 0.1626 - val_accuracy: 0.9498
Epoch 10/10
319/319 [==============================] - 151s 474ms/step - loss:
0.1363 - accuracy: 0.9543 - val_loss: 0.2074 - val_accuracy: 0.9326

<keras.src.callbacks.History at 0x2497dffbb90>

feature_extractor = Model(inputs=cnn_model.input,
outputs=cnn_model.layers[-3].output)

X_train_features = feature_extractor.predict(X_train)
X_test_features = feature_extractor.predict(X_test)

319/319 [==============================] - 50s 155ms/step
80/80 [==============================] - 12s 154ms/step

lvq_model = MLPClassifier(hidden_layer_sizes=(128,), max_iter=500,
activation='relu', solver='adam')
lvq_model.fit(X_train_features, y_train)

# Evaluate on test set
accuracy = lvq_model.score(X_test_features, y_test)
print(f"LVQ Test Accuracy: {accuracy * 100:.2f}%")

LVQ Test Accuracy: 95.49%

def plot_confusion_matrix(y_true, y_pred, title):
    cm = confusion_matrix(y_true, y_pred)
    plt.figure(figsize=(6,5))
    sns.heatmap(cm, annot=True, fmt="d", cmap="Blues",
xticklabels=label_encoder.classes_,
yticklabels=label_encoder.classes_)
    plt.xlabel("Predicted")
    plt.ylabel("Actual")
```

```
    plt.title(title)
    plt.show()

# Predictions on train and test datasets
y_train_pred = lvq_model.predict(X_train_features)
y_test_pred = lvq_model.predict(X_test_features)

# Plot confusion matrices
plot_confusion_matrix(y_train, y_train_pred, "Train Set Confusion
Matrix")
plot_confusion_matrix(y_test, y_test_pred, "Test Set Confusion
Matrix")
```






```python
def predict_image(img_path):
    img = cv2.imread(img_path)
    img = cv2.resize(img, img_size)
    img = np.expand_dims(img, axis=0) / 255.0  # Normalize

    # Extract CNN features
    features = feature_extractor.predict(img)

    # Predict using LVQ
    prediction = lvq_model.predict(features)
    class_name = label_encoder.inverse_transform(prediction)[0]

    return class_name
```

```python
# Test an image
test_img = "test_leaf_2.jpg"
print("Predicted class:", predict_image(test_img))
```

```
1/1 [==============================] - 0s 28ms/step
Predicted class: Septoria_leaf_spot
```