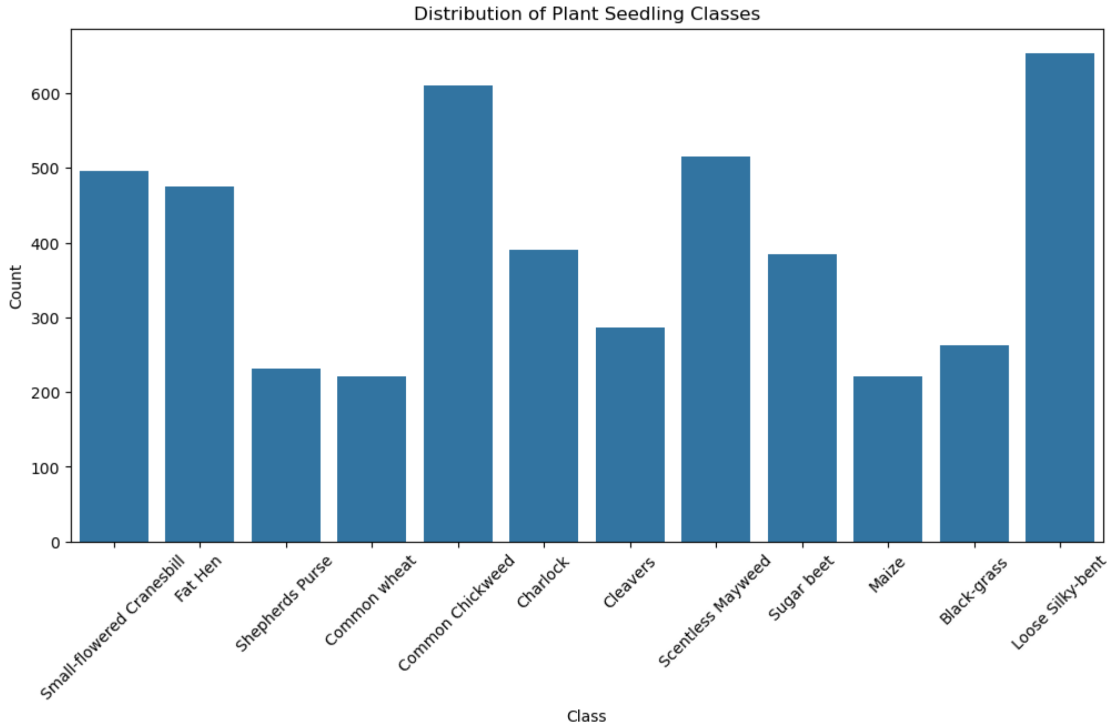
plant_seedling_classification

June 19, 2025

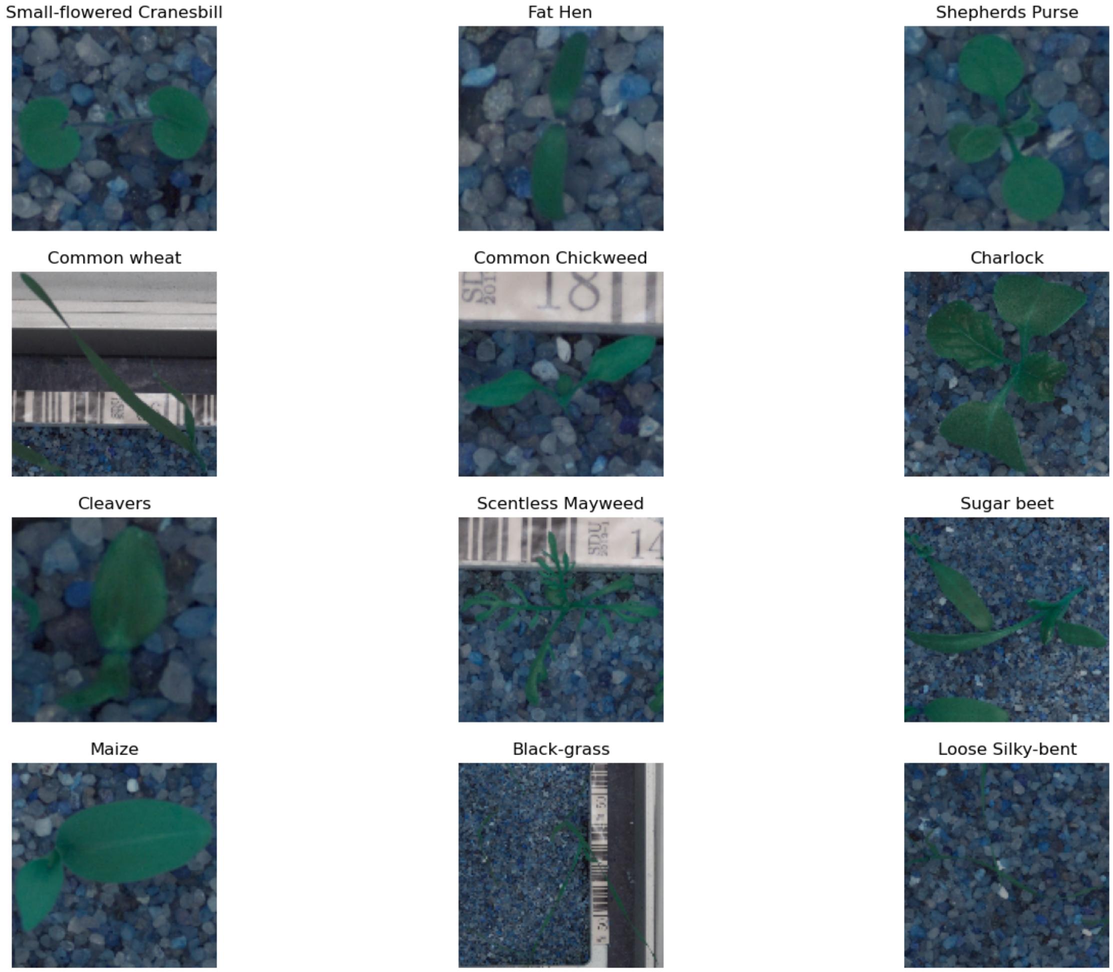
[1]:
```
# Import necessary libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Input, Conv2D, MaxPooling2D, Flatten,␣
 ↪Dense, Dropout
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.callbacks import EarlyStopping
from sklearn.metrics import confusion_matrix, classification_report
import tensorflow as tf
```

[2]:
```
# Load data
images = np.load("images.npy")
labels = pd.read_csv("labels.csv")
class_names = labels['Label'].unique()
```

[3]:
```
# Visualize class distribution
plt.figure(figsize=(12, 6))
sns.countplot(x=labels['Label'], order=class_names)
plt.title('Distribution of Plant Seedling Classes')
plt.xlabel('Class')
plt.ylabel('Count')
plt.xticks(rotation=45)
plt.savefig('class_distribution.png')
plt.show()
```



[4]:
```python
# Visualize sample images (all 12 classes)
plt.figure(figsize=(16, 12))
for i, label in enumerate(class_names):
    idx = labels[labels['Label'] == label].index[0]
    plt.subplot(4, 3, i+1)
    plt.imshow(images[idx])
    plt.title(label)
    plt.axis('off')
plt.savefig('sample_images.png')
plt.show()
```



[5]:
```
# Downsample images to 64x64 and convert to float16
images_resized = tf.image.resize(images, [64, 64]).numpy()
images_resized = images_resized.astype('float16') / 255.0

# Split data
X_train, X_temp, y_train, y_temp = train_test_split(images_resized, labels['Label'], test_size=0.3, random_state=42)
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.5, random_state=42)

# Encode labels
label_encoder = LabelEncoder()
y_train_encoded = to_categorical(label_encoder.fit_transform(y_train))
y_val_encoded = to_categorical(label_encoder.transform(y_val))
y_test_encoded = to_categorical(label_encoder.transform(y_test))
```

[6]:
```
# Create tf.data.Dataset
train_dataset = tf.data.Dataset.from_tensor_slices((X_train, y_train_encoded)).
 ↪batch(32).prefetch(tf.data.AUTOTUNE)
val_dataset = tf.data.Dataset.from_tensor_slices((X_val, y_val_encoded)).
 ↪batch(32).prefetch(tf.data.AUTOTUNE)
```

[7]:
```
# Save datasets
np.save('X_train.npy', X_train)
np.save('y_train_encoded.npy', y_train_encoded)
np.save('X_val.npy', X_val)
np.save('y_val_encoded.npy', y_val_encoded)
np.save('X_test.npy', X_test)
np.save('y_test_encoded.npy', y_test_encoded)
```

[8]:
```
# Build and compile model
model = Sequential([
    Input(shape=(64, 64, 3)),
    Conv2D(32, (3, 3), activation='relu'),
    MaxPooling2D((2, 2)),
    Conv2D(64, (3, 3), activation='relu'),
    MaxPooling2D((2, 2)),
    Conv2D(128, (3, 3), activation='relu'),
    MaxPooling2D((2, 2)),
    Flatten(),
    Dense(128, activation='relu'),
    Dropout(0.5),
    Dense(12, activation='softmax')
])
model.compile(optimizer='adam', loss='categorical_crossentropy',␣
 ↪metrics=['accuracy'])
```

[9]:
```
# Generate and save model summary
model.summary()
with open('model_summary.txt', 'w', encoding='utf-8') as f:
    model.summary(print_fn=lambda x: f.write(x + '\n'))
# Take screenshot of model.summary() output from notebook for model_summary.png
```

```
Model: "sequential"


 Layer (type)                          Output Shape                         ␣
↪Param #

 conv2d (Conv2D)                       (None, 62, 62, 32)                     ␣
↪896
```

```
max_pooling2d (MaxPooling2D)          (None, 31, 31, 32)                  ␣
↪   0

conv2d_1 (Conv2D)                     (None, 29, 29, 64)                ␣
↪18,496

max_pooling2d_1 (MaxPooling2D)        (None, 14, 14, 64)                  ␣
↪   0

conv2d_2 (Conv2D)                     (None, 12, 12, 128)               ␣
↪73,856

max_pooling2d_2 (MaxPooling2D)        (None, 6, 6, 128)                   ␣
↪   0

flatten (Flatten)                     (None, 4608)                        ␣
↪   0

dense (Dense)                         (None, 128)                      ␣
↪589,952

dropout (Dropout)                     (None, 128)                         ␣
↪   0

dense_1 (Dense)                       (None, 12)                         ␣
↪1,548
```

Total params: 684,748 (2.61 MB)

Trainable params: 684,748 (2.61 MB)

Non-trainable params: 0 (0.00 B)

[10]:
```
# Define early stopping
early_stopping = EarlyStopping(monitor='val_loss', patience=5,␣
 ↪restore_best_weights=True)

# Train model
history = model.fit(train_dataset,
                    validation_data=val_dataset,
                    epochs=50,
                    callbacks=[early_stopping])
```

```
Epoch 1/50
104/104            10s 62ms/step -
accuracy: 0.1715 - loss: 2.3981 - val_accuracy: 0.4045 - val_loss: 1.8910
Epoch 2/50
104/104            6s 56ms/step -
accuracy: 0.3416 - loss: 1.8871 - val_accuracy: 0.4607 - val_loss: 1.5709
Epoch 3/50
104/104            6s 57ms/step -
accuracy: 0.4149 - loss: 1.6645 - val_accuracy: 0.5604 - val_loss: 1.2870
Epoch 4/50
104/104            4s 36ms/step -
accuracy: 0.5092 - loss: 1.4077 - val_accuracy: 0.6222 - val_loss: 1.1329
Epoch 5/50
104/104            4s 43ms/step -
accuracy: 0.5647 - loss: 1.2630 - val_accuracy: 0.6728 - val_loss: 0.9734
Epoch 6/50
104/104            5s 43ms/step -
accuracy: 0.5971 - loss: 1.1590 - val_accuracy: 0.6138 - val_loss: 1.0688
Epoch 7/50
104/104            4s 40ms/step -
accuracy: 0.6269 - loss: 1.0837 - val_accuracy: 0.7219 - val_loss: 0.8485
Epoch 8/50
104/104            4s 41ms/step -
accuracy: 0.6734 - loss: 0.9561 - val_accuracy: 0.7121 - val_loss: 0.8630
Epoch 9/50
104/104            4s 40ms/step -
accuracy: 0.6806 - loss: 0.9075 - val_accuracy: 0.7093 - val_loss: 0.8273
Epoch 10/50
104/104            4s 41ms/step -
accuracy: 0.6944 - loss: 0.8575 - val_accuracy: 0.7528 - val_loss: 0.7717
Epoch 11/50
104/104            4s 39ms/step -
accuracy: 0.7197 - loss: 0.7873 - val_accuracy: 0.7683 - val_loss: 0.7025
Epoch 12/50
104/104            4s 41ms/step -
accuracy: 0.7440 - loss: 0.7620 - val_accuracy: 0.7879 - val_loss: 0.6723
Epoch 13/50
104/104            4s 39ms/step -
accuracy: 0.7488 - loss: 0.7090 - val_accuracy: 0.7500 - val_loss: 0.7408
Epoch 14/50
104/104            4s 39ms/step -
accuracy: 0.7327 - loss: 0.7320 - val_accuracy: 0.7725 - val_loss: 0.7177
Epoch 15/50
104/104            4s 41ms/step -
accuracy: 0.7710 - loss: 0.6406 - val_accuracy: 0.8020 - val_loss: 0.6541
Epoch 16/50
104/104            4s 41ms/step -
accuracy: 0.7674 - loss: 0.6492 - val_accuracy: 0.7851 - val_loss: 0.6632
```

```
Epoch 17/50
104/104          4s 42ms/step -
accuracy: 0.7811 - loss: 0.6002 - val_accuracy: 0.8048 - val_loss: 0.6182
Epoch 18/50
104/104          4s 40ms/step -
accuracy: 0.7922 - loss: 0.5729 - val_accuracy: 0.7879 - val_loss: 0.6368
Epoch 19/50
104/104          4s 41ms/step -
accuracy: 0.7936 - loss: 0.5414 - val_accuracy: 0.7907 - val_loss: 0.6646
Epoch 20/50
104/104          4s 39ms/step -
accuracy: 0.8121 - loss: 0.5264 - val_accuracy: 0.7879 - val_loss: 0.6229
Epoch 21/50
104/104          4s 38ms/step -
accuracy: 0.8036 - loss: 0.5284 - val_accuracy: 0.7992 - val_loss: 0.6287
Epoch 22/50
104/104          4s 38ms/step -
accuracy: 0.8273 - loss: 0.4792 - val_accuracy: 0.7935 - val_loss: 0.6676
```

[11]:

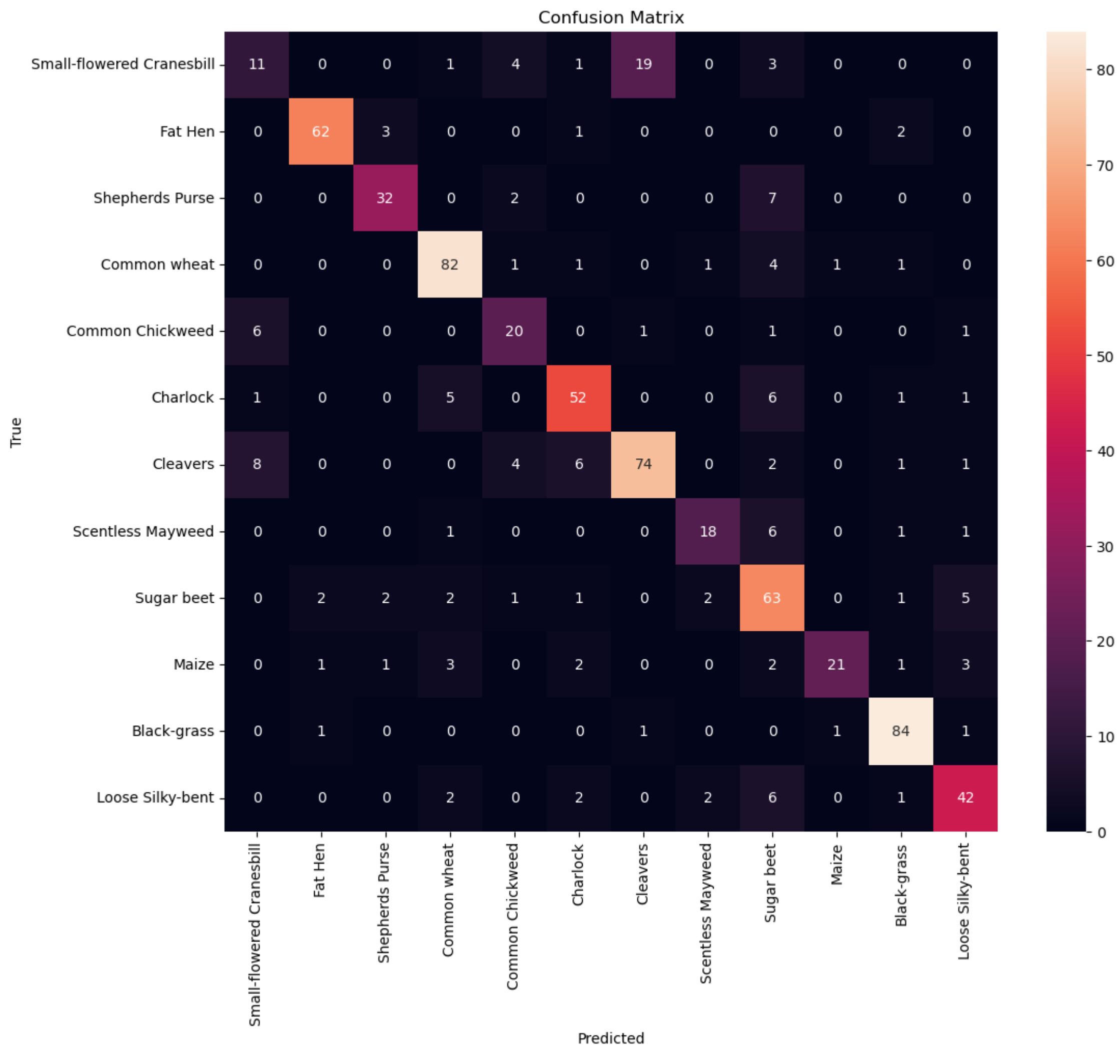
```
# Evaluate model
test_loss, test_accuracy = model.evaluate(X_test, y_test_encoded)
print(f"Test accuracy: {test_accuracy}")
```

```
23/23          0s 12ms/step -
accuracy: 0.7959 - loss: 0.6575
Test accuracy: 0.7868162989616394
```

[12]:

```
# Generate and save confusion matrix
y_pred = model.predict(X_test)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true_classes = np.argmax(y_test_encoded, axis=1)
cm = confusion_matrix(y_true_classes, y_pred_classes)
plt.figure(figsize=(12, 10))
sns.heatmap(cm, annot=True, fmt='d', xticklabels=class_names,␣
 ↪yticklabels=class_names)
plt.title('Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.savefig('confusion_matrix.png')
plt.show()
```

```
23/23          0s 13ms/step
```



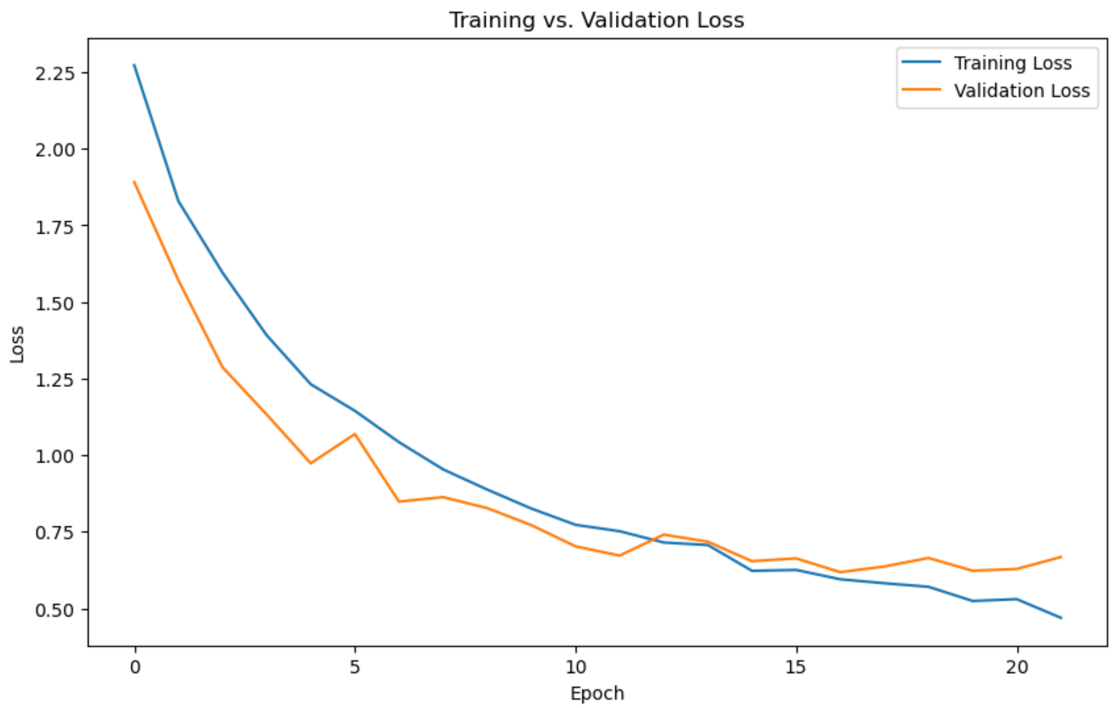
[13]:
```python
# Generate and save classification report
report = classification_report(y_true_classes, y_pred_classes,
 ↪target_names=class_names)
with open('classification_report.txt', 'w', encoding='utf-8') as f:
    f.write(report)
print(report)  # Screenshot this output for classification_report.png
```

```
                           precision    recall  f1-score   support

Small-flowered Cranesbill       0.42      0.28      0.34        39
                  Fat Hen       0.94      0.91      0.93        68
          Shepherds Purse       0.84      0.78      0.81        41
             Common wheat       0.85      0.90      0.88        91
         Common Chickweed       0.62      0.69      0.66        29
                 Charlock       0.79      0.79      0.79        66
```

Cleavers	0.78	0.77	0.77	96
Scentless Mayweed	0.78	0.67	0.72	27
Sugar beet	0.63	0.80	0.70	79
Maize	0.91	0.62	0.74	34
Black-grass	0.90	0.95	0.93	88
Loose Silky-bent	0.76	0.76	0.76	55
accuracy			0.79	713
macro avg	0.77	0.74	0.75	713
weighted avg	0.79	0.79	0.78	713

[14]:
```
# Generate and save loss plot
plt.figure(figsize=(10, 6))
plt.plot(history.history['loss'], label='Training Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.title('Training vs. Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.savefig('loss_plot.png')
plt.show()
```



[15]:
```python
# Save model
model.save('plant_seedling_cnn.keras')
```