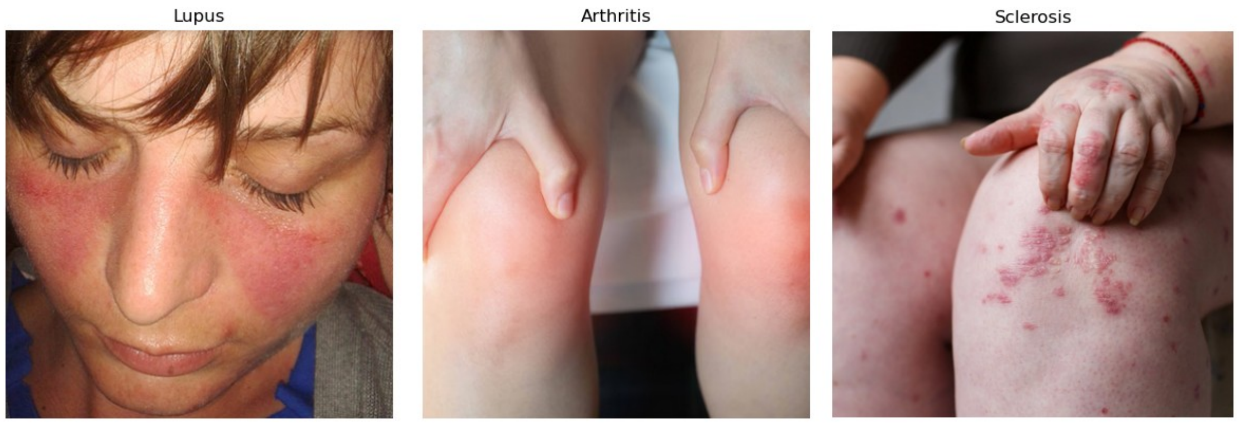
Quantitative Analysis of Histopathological Images for Autoimmune Diseases Diagnosis

Brief about the Autoimmune diseases

```python
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

# Load images
img_lupus = mpimg.imread('Medical/Disease Images/Lupus.png')
img_arthritis = mpimg.imread('Medical/Disease Images/Arthritis.png')
img_sclerosis = mpimg.imread('Medical/Disease Images/Sclerosis.png')

# Create a figure with a single row and three columns
fig, axs = plt.subplots(1, 3, figsize=(12, 4))

# Display each image
axs[0].imshow(img_lupus)
axs[0].set_title('Lupus')
axs[0].axis('off')

axs[1].imshow(img_arthritis)
axs[1].set_title('Arthritis')
axs[1].axis('off')

axs[2].imshow(img_sclerosis)
axs[2].set_title('Sclerosis')
axs[2].axis('off')

# Adjust layout and display
plt.tight_layout()
plt.show()
```

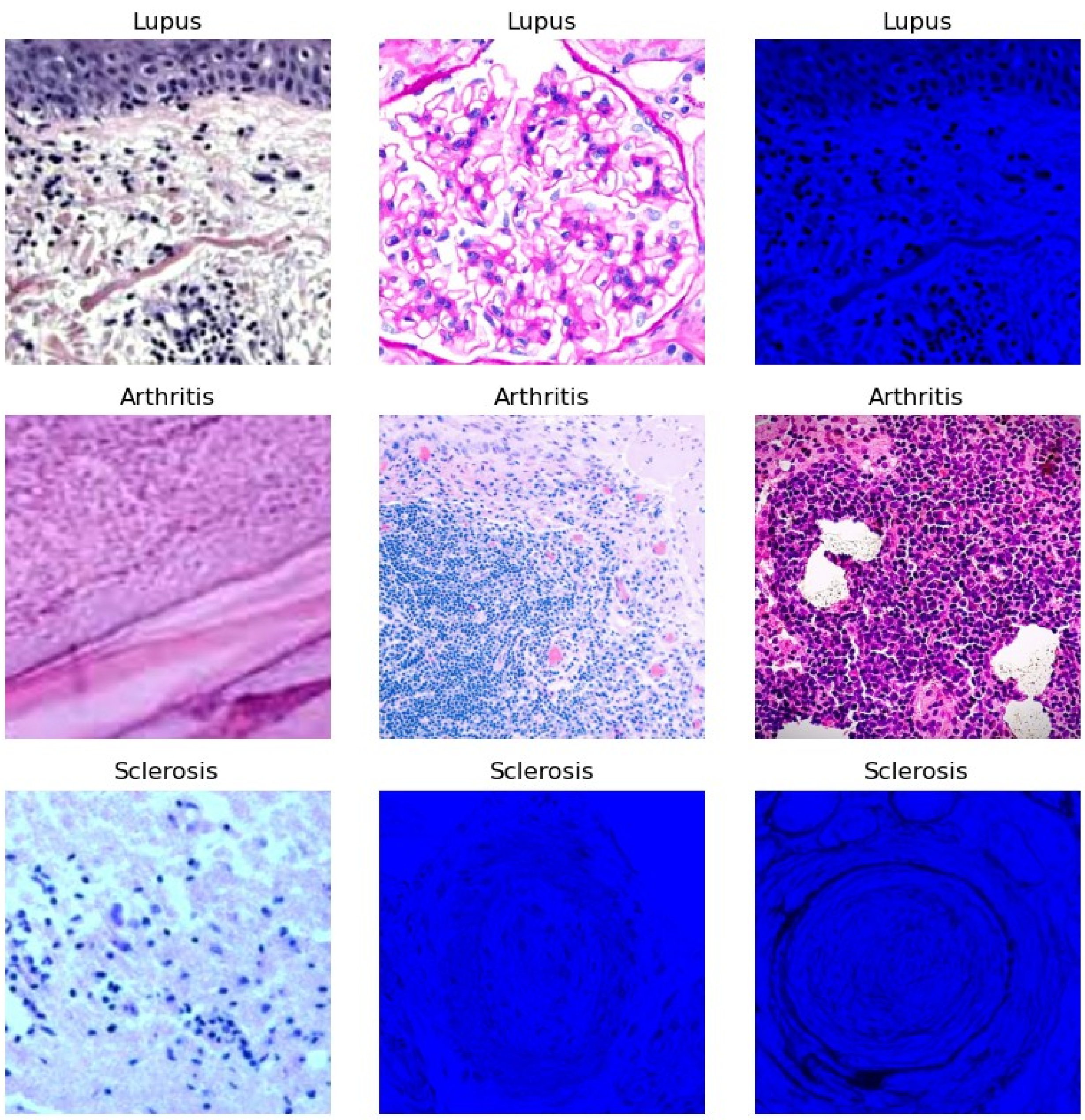


Importing Libraries

```python
import os
import cv2
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.applications import VGG16
from tensorflow.keras.applications.vgg16 import preprocess_input
from tensorflow.keras.models import Model, Sequential
from tensorflow.keras.layers import Dense, Dropout, Flatten
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.layers import  GlobalAveragePooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from sklearn.metrics import classification_report, confusion_matrix
from tensorflow.keras.applications import ResNet50
from tensorflow.keras.applications.resnet import preprocess_input
import seaborn as sns
import warnings
warnings.filterwarnings('always')
warnings.filterwarnings('ignore')
```

Data Collection

```python
# Data directories
data_dir = 'Medical'
subdirectories = ['Lupus', 'Arthritis', 'Sclerosis']

fig, axs = plt.subplots(len(subdirectories), 3, figsize=(8, 8))

for i, subdir in enumerate(subdirectories):
    subdir_path = os.path.join(data_dir, subdir)
    for j in range(3):
        filename = os.listdir(subdir_path)[j]
        img_path = os.path.join(subdir_path, filename)
        img = cv2.imread(img_path)
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        axs[i, j].imshow(img)
        axs[i, j].set_title(subdir)
        axs[i, j].axis('off')

plt.tight_layout()
plt.show()
```

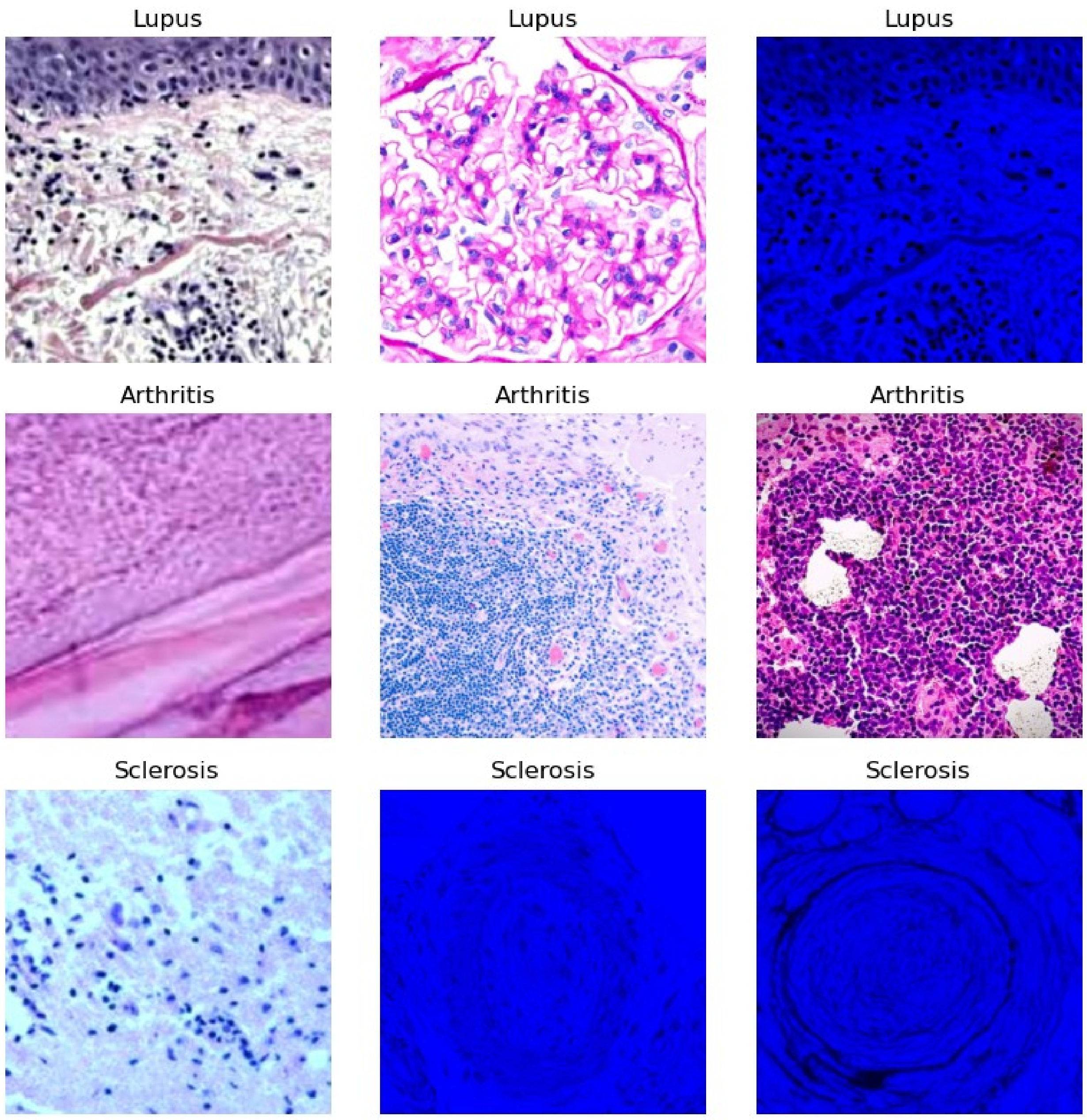


Data Preprocessing

```python
cleaned_images = []

for subdir in subdirectories:
    subdir_path = os.path.join(data_dir, subdir)
    for filename in os.listdir(subdir_path):
        img_path = os.path.join(subdir_path, filename)
        img = cv2.imread(img_path)
        if img is not None:
            # Apply Gaussian blur for noise removal
            cleaned_img = cv2.GaussianBlur(img, (5, 5), 0)
            cleaned_images.append((cleaned_img, subdir))
        else:
            print(f"Could not read image: {img_path}")

# Preprocessing Function
def preprocess_image(img):
    # Resize the image to a desired size (e.g., 224x224)
    resized_img = cv2.resize(img, (224, 224))
    return resized_img

# Apply Preprocessing to Cleaned Images
preprocessed_images = []
labels = []

for img, label in cleaned_images:
    preprocessed_img = preprocess_image(img)
    preprocessed_images.append(preprocessed_img)
    labels.append(label)
```

Data Visualization

```
# Display preprocessed images after Gaussian blur
fig, axs = plt.subplots(len(subdirectories), 3, figsize=(8, 8))

for i, subdir in enumerate(subdirectories):
    subdir_preprocessed_images = [img for img, label in cleaned_images
if label == subdir]
    for j in range(3):
        img = subdir_preprocessed_images[j]
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)  # Convert BGR to
RGB for displaying with matplotlib
        axs[i, j].imshow(img)
        axs[i, j].set_title(subdir)
        axs[i, j].axis('off')

plt.tight_layout()
plt.show()
```



```
# Convert lists to numpy arrays
preprocessed_images = np.array(preprocessed_images)
labels = np.array(labels)

# Encode labels as integers
label_encoder = LabelEncoder()
encoded_labels = label_encoder.fit_transform(labels)

# Convert encoded labels to categorical (one-hot encoding)
categorical_labels = to_categorical(encoded_labels)
```

```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test =
train_test_split(preprocessed_images, categorical_labels,
test_size=0.2, random_state=42)

# Create an ImageDataGenerator for data augmentation
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest',
    preprocessing_function=preprocess_input
)

# Apply data augmentation only to training data
train_generator = datagen.flow(X_train, y_train, batch_size=32)
```

Model Evaluation

```
# Load VGG16 model without the top layer
base_model = VGG16(weights='imagenet', include_top=False,
input_shape=(224, 224, 3))
base_model.summary()

Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_2 (InputLayer)        [(None, 224, 224, 3)]     0         

 block1_conv1 (Conv2D)       (None, 224, 224, 64)      1792      

 block1_conv2 (Conv2D)       (None, 224, 224, 64)      36928     

 block1_pool (MaxPooling2D)  (None, 112, 112, 64)      0         

 block2_conv1 (Conv2D)       (None, 112, 112, 128)     73856     

 block2_conv2 (Conv2D)       (None, 112, 112, 128)     147584    

 block2_pool (MaxPooling2D)  (None, 56, 56, 128)       0         

 block3_conv1 (Conv2D)       (None, 56, 56, 256)       295168    

 block3_conv2 (Conv2D)       (None, 56, 56, 256)       590080    

 block3_conv3 (Conv2D)       (None, 56, 56, 256)       590080    
 block3_pool (MaxPooling2D)  (None, 28, 28, 256)       0

 block4_conv1 (Conv2D)       (None, 28, 28, 512)       1180160

 block4_conv2 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_conv3 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 14, 14, 512)       0

 block5_conv1 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv2 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv3 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 7, 7, 512)         0

=================================================================
Total params: 14714688 (56.13 MB)
Trainable params: 14714688 (56.13 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```python
# Extract features for each preprocessed image using VGG16
def extract_features(data, model):
    features = model.predict(data)
    return features

# Extract features for training and testing data
train_features = []
for img in X_train:
    img = np.expand_dims(img, axis=0)  # Expand dimensions to match
model input
    img = preprocess_input(img)  # Preprocess the image for VGG16
    feature = extract_features(img, base_model)
    train_features.append(feature.flatten())
```

```
1/1 [==============================] - 0s 317ms/step
1/1 [==============================] - 0s 127ms/step
1/1 [==============================] - 0s 131ms/step
1/1 [==============================] - 0s 128ms/step
1/1 [==============================] - 0s 127ms/step
1/1 [==============================] - 0s 131ms/step
1/1 [==============================] - 0s 126ms/step
1/1 [==============================] - 0s 123ms/step
1/1 [==============================] - 0s 124ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 116ms/step
```

```
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 106ms/step
1/1 [==============================] - 0s 130ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 128ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 104ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 116ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 120ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 106ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 104ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 108ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 98ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 126ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 108ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 113ms/step
```

```
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 121ms/step
1/1 [==============================] - 0s 122ms/step
1/1 [==============================] - 0s 116ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 116ms/step
1/1 [==============================] - 0s 119ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 108ms/step
1/1 [==============================] - 0s 124ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 116ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 128ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 117ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 108ms/step
1/1 [==============================] - 0s 113ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 122ms/step
1/1 [==============================] - 0s 109ms/step
1/1 [==============================] - 0s 121ms/step
```

```
test_features = []
for img in X_test:
    img = np.expand_dims(img, axis=0)  # Expand dimensions to match
model input
    img = preprocess_input(img)  # Preprocess the image for VGG16
    feature = extract_features(img, base_model)
    test_features.append(feature.flatten())
```

```
1/1 [==============================] - 0s 128ms/step
1/1 [==============================] - 0s 123ms/step
1/1 [==============================] - 0s 143ms/step
1/1 [==============================] - 0s 124ms/step
1/1 [==============================] - 0s 138ms/step
1/1 [==============================] - 0s 124ms/step
1/1 [==============================] - 0s 129ms/step
1/1 [==============================] - 0s 131ms/step
1/1 [==============================] - 0s 131ms/step
1/1 [==============================] - 0s 126ms/step
1/1 [==============================] - 0s 129ms/step
1/1 [==============================] - 0s 122ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 114ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 115ms/step
1/1 [==============================] - 0s 120ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 129ms/step
1/1 [==============================] - 0s 122ms/step
1/1 [==============================] - 0s 132ms/step
1/1 [==============================] - 0s 126ms/step
1/1 [==============================] - 0s 138ms/step
```

```python
# Convert lists to numpy arrays
train_features = np.array(train_features)
test_features = np.array(test_features)

# Define the model
model = Sequential([
    Dense(512, activation='relu', 
input_shape=(train_features.shape[1],)),
    Dropout(0.5),
    Dense(256, activation='relu'),
    Dropout(0.5),
    Dense(len(subdirectories), activation='softmax')  # Output layer 
with number of classes
])

# Compile the model
model.compile(optimizer=Adam(learning_rate=0.0001), 
loss='categorical_crossentropy', metrics=['accuracy'])

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
```

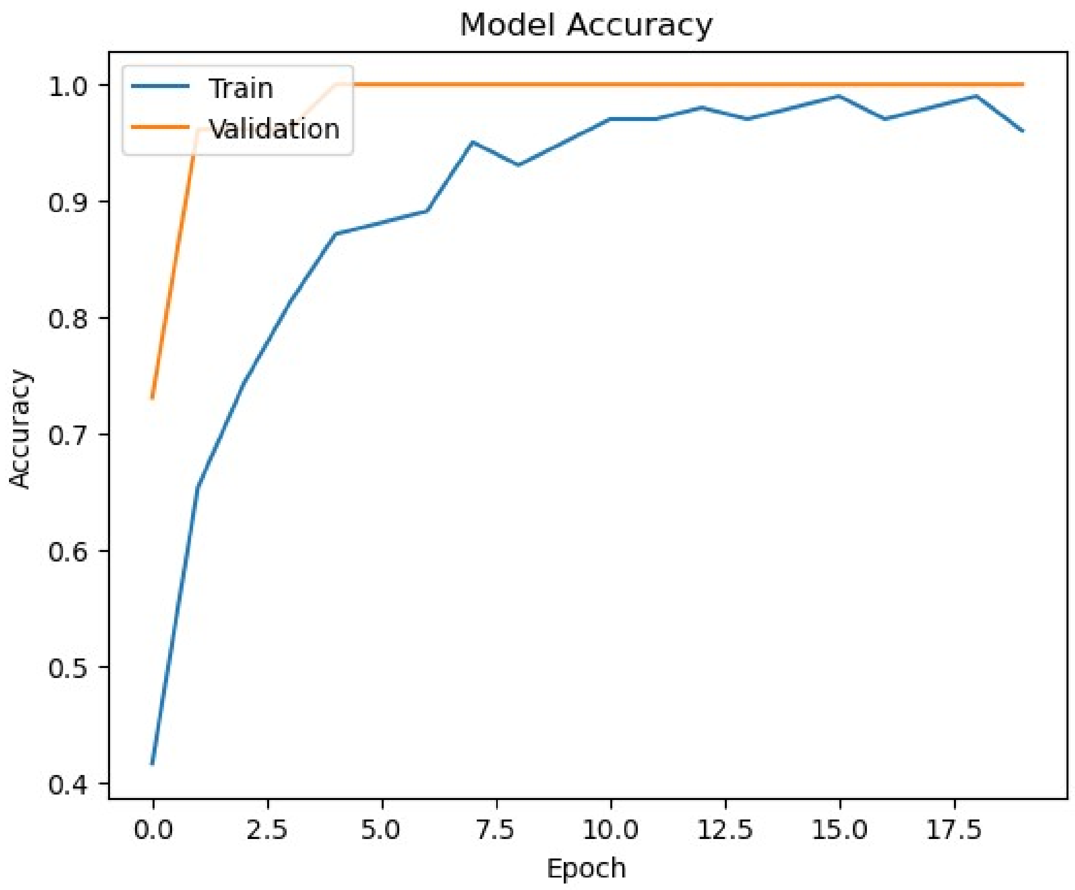
```
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 512)               12845568

 dropout (Dropout)           (None, 512)               0

 dense_1 (Dense)             (None, 256)               131328

 dropout_1 (Dropout)         (None, 256)               0

 dense_2 (Dense)             (None, 3)                 771

=================================================================
Total params: 12977667 (49.51 MB)
Trainable params: 12977667 (49.51 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
# Fit the model
history = model.fit(
    train_features, y_train,
    epochs=20,
    batch_size=30,
    validation_data=(test_features, y_test)
)
```

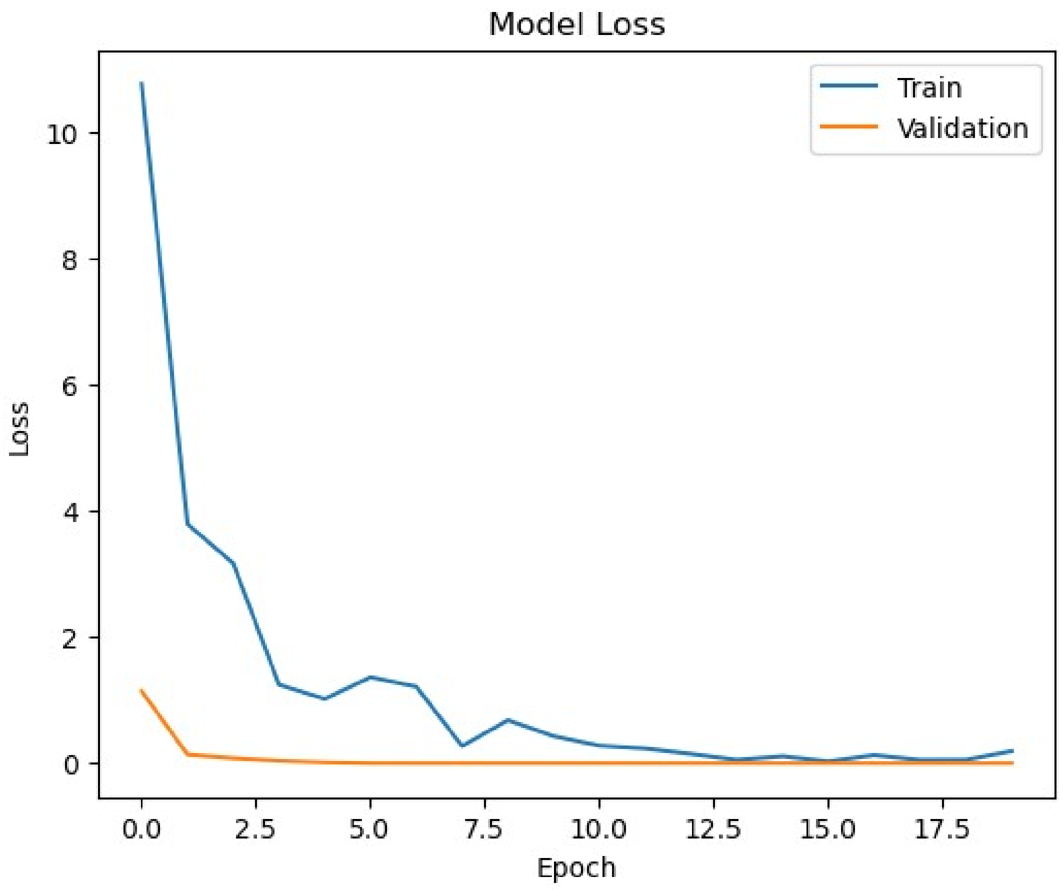
```
Epoch 1/20
WARNING:tensorflow:From D:\New folder\lib\site-packages\keras\src\
utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue is
deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From D:\New folder\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.

4/4 [==============================] - 2s 208ms/step - loss: 10.7744 -
accuracy: 0.4158 - val_loss: 1.1427 - val_accuracy: 0.7308
Epoch 2/20
4/4 [==============================] - 1s 139ms/step - loss: 3.7946 -
accuracy: 0.6535 - val_loss: 0.1382 - val_accuracy: 0.9615
Epoch 3/20
4/4 [==============================] - 1s 141ms/step - loss: 3.1719 -
accuracy: 0.7426 - val_loss: 0.0805 - val_accuracy: 0.9615
Epoch 4/20
4/4 [==============================] - 1s 142ms/step - loss: 1.2455 -
accuracy: 0.8119 - val_loss: 0.0381 - val_accuracy: 0.9615
Epoch 5/20
4/4 [==============================] - 1s 135ms/step - loss: 1.0193 -
accuracy: 0.8713 - val_loss: 0.0125 - val_accuracy: 1.0000
```

```
Epoch 6/20
4/4 [==============================] - 1s 134ms/step - loss: 1.3641 -
accuracy: 0.8812 - val_loss: 8.7064e-04 - val_accuracy: 1.0000
Epoch 7/20
4/4 [==============================] - 1s 132ms/step - loss: 1.2144 -
accuracy: 0.8911 - val_loss: 7.6326e-05 - val_accuracy: 1.0000
Epoch 8/20
4/4 [==============================] - 1s 131ms/step - loss: 0.2709 -
accuracy: 0.9505 - val_loss: 3.7903e-05 - val_accuracy: 1.0000
Epoch 9/20
4/4 [==============================] - 1s 133ms/step - loss: 0.6817 -
accuracy: 0.9307 - val_loss: 3.0863e-05 - val_accuracy: 1.0000
Epoch 10/20
4/4 [==============================] - 1s 139ms/step - loss: 0.4291 -
accuracy: 0.9505 - val_loss: 1.6670e-05 - val_accuracy: 1.0000
Epoch 11/20
4/4 [==============================] - 1s 135ms/step - loss: 0.2779 -
accuracy: 0.9703 - val_loss: 7.4227e-06 - val_accuracy: 1.0000
Epoch 12/20
4/4 [==============================] - 1s 143ms/step - loss: 0.2326 -
accuracy: 0.9703 - val_loss: 1.6047e-06 - val_accuracy: 1.0000
Epoch 13/20
4/4 [==============================] - 1s 138ms/step - loss: 0.1471 -
accuracy: 0.9802 - val_loss: 2.3979e-06 - val_accuracy: 1.0000
Epoch 14/20
4/4 [==============================] - 1s 140ms/step - loss: 0.0544 -
accuracy: 0.9703 - val_loss: 3.8191e-06 - val_accuracy: 1.0000
Epoch 15/20
4/4 [==============================] - 1s 136ms/step - loss: 0.1105 -
accuracy: 0.9802 - val_loss: 3.4294e-06 - val_accuracy: 1.0000
Epoch 16/20
4/4 [==============================] - 1s 136ms/step - loss: 0.0302 -
accuracy: 0.9901 - val_loss: 2.5217e-06 - val_accuracy: 1.0000
Epoch 17/20
4/4 [==============================] - 1s 130ms/step - loss: 0.1286 -
accuracy: 0.9703 - val_loss: 2.6821e-06 - val_accuracy: 1.0000
Epoch 18/20
4/4 [==============================] - 1s 130ms/step - loss: 0.0526 -
accuracy: 0.9802 - val_loss: 4.4426e-06 - val_accuracy: 1.0000
Epoch 19/20
4/4 [==============================] - 1s 131ms/step - loss: 0.0547 -
accuracy: 0.9901 - val_loss: 4.3463e-06 - val_accuracy: 1.0000
Epoch 20/20
4/4 [==============================] - 1s 136ms/step - loss: 0.1899 -
accuracy: 0.9604 - val_loss: 1.3021e-06 - val_accuracy: 1.0000
```

```python
plt.figure(figsize=(14, 5))

plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
plt.figure(figsize=(14, 5))
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(['Train', 'Validation'], loc='upper right')
plt.show()
```

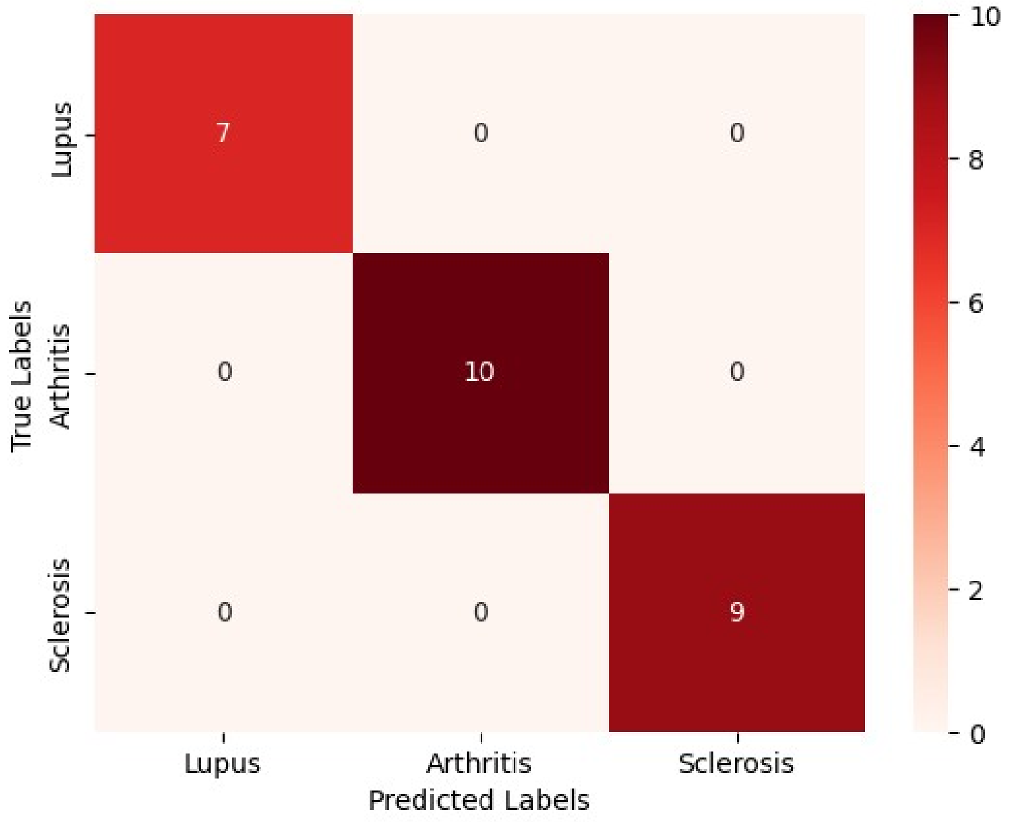


```
# Classification report and confusion matrix
y_pred = model.predict(test_features)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true_classes = np.argmax(y_test, axis=1)

print(classification_report(y_true_classes, y_pred_classes,
target_names=subdirectories))
```

```
1/1 [==============================] - 0s 78ms/step
              precision    recall  f1-score   support

       Lupus       1.00      1.00      1.00         7
   Arthritis       1.00      1.00      1.00        10
   Sclerosis       1.00      1.00      1.00         9

    accuracy                           1.00        26
   macro avg       1.00      1.00      1.00        26
weighted avg       1.00      1.00      1.00        26
```

```
conf_matrix = confusion_matrix(y_true_classes, y_pred_classes)
sns.heatmap(conf_matrix, annot=True, xticklabels=subdirectories,
yticklabels=subdirectories, cmap="Reds")
```

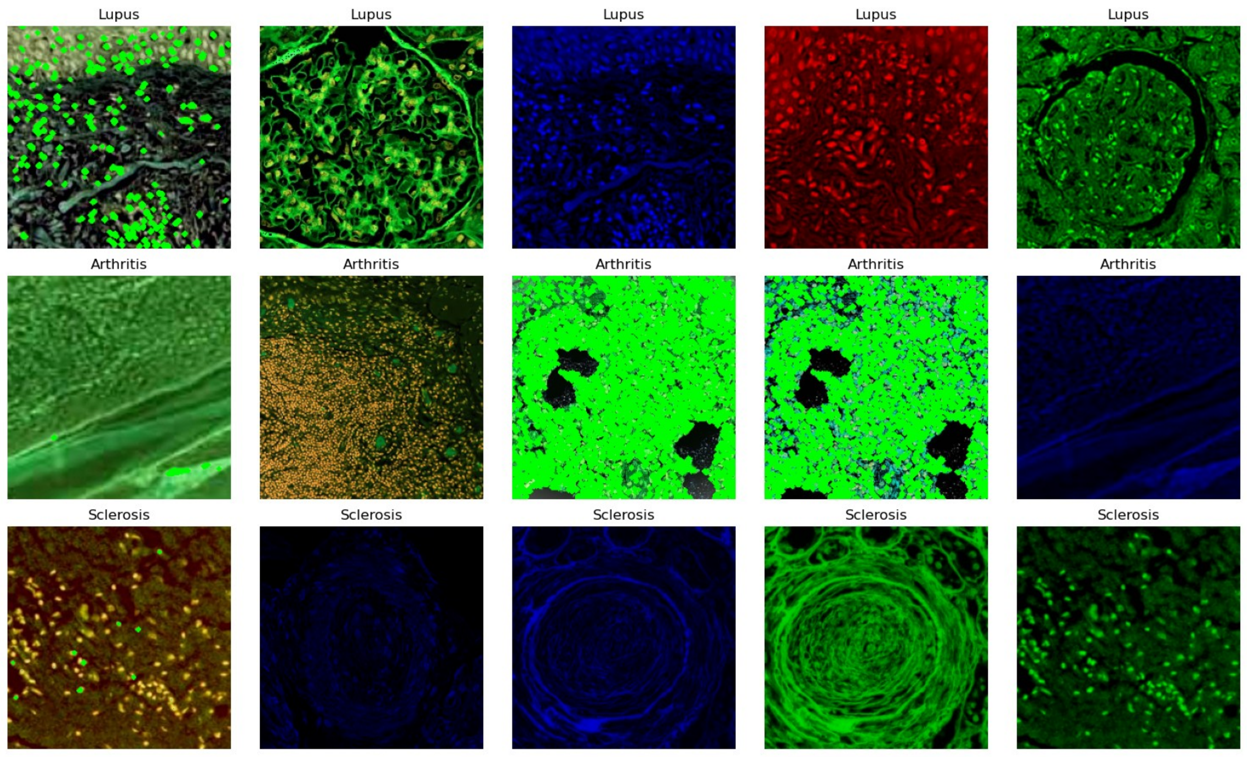
```
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.show()
```



Analysis Using Patterns

```
# Function to identify patterns
def identify_patterns(img):
    # Convert image to grayscale
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    # Threshold the image
    _, thresh = cv2.threshold(gray, 200, 255, cv2.THRESH_BINARY)
    # Find contours
    contours, _ = cv2.findContours(thresh, cv2.RETR_EXTERNAL, 
cv2.CHAIN_APPROX_SIMPLE)
    # Draw contours on the original image
    pattern_img = cv2.drawContours(img.copy(), contours, -1, (0, 255, 
0), 3)
    return pattern_img

# Function to display identified patterns
num_images_per_directory = 5
# Calculate number of rows and columns for subplots
num_rows = len(subdirectories)
```

```
num_cols = num_images_per_directory

fig, axs = plt.subplots(num_rows, num_cols, figsize=(3 * num_cols, 3 *
num_rows))

for i, subdir in enumerate(subdirectories):
    subdir_images = preprocessed_images[labels == subdir]
[:num_images_per_directory]
    for j in range(num_images_per_directory):
        img = subdir_images[j]
        pattern_img = identify_patterns(cv2.cvtColor((img *
255).astype(np.uint8), cv2.COLOR_RGB2BGR))

        axs[i, j].imshow(pattern_img, cmap='gray')  # Display pattern
image in grayscale
        axs[i, j].set_title(f'{subdir}')
        axs[i, j].axis('off')

# Hide empty subplots (not necessary since we ensure the number of
images matches the subplots)
for i in range(num_rows):
    for j in range(num_images_per_directory, num_cols):
        axs[i, j].axis('off')

plt.tight_layout()
plt.show()
```



```python
# Load the base ResNet50 model without the top layer
base_model = ResNet50(weights='imagenet', include_top=False,
input_shape=(224, 224, 3))

# Add custom layers on top of the base model
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(512, activation='relu')(x)
x = Dropout(0.5)(x)
x = Dense(256, activation='relu')(x)
x = Dropout(0.5)(x)
predictions = Dense(len(subdirectories), activation='softmax')(x)
```

Model Evaluation

```python
# Create the complete model
model = Model(inputs=base_model.input, outputs=predictions)

# Compile the model
model.compile(optimizer=Adam(learning_rate=0.0001),
loss='categorical_crossentropy', metrics=['accuracy'])

model.summary()
```

```
Model: "model"
______________________________________________________________________
____________________________
 Layer (type)                Output Shape                 Param #
Connected to
======================================================================
============================
 input_3 (InputLayer)        [(None, 224, 224, 3)]        0          []



 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_3[0][0]']


 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']


 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)



 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']
```

```
 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']


 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']


 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)



 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)



 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)



 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)



 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)



 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)



 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)
 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)



 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)



 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)



 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',

'conv2_block1_3_bn[0][0]']


 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)



 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)



 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)



 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)



 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
```

```
 D)



 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)



 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)



 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)



 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)



 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',

'conv2_block2_3_bn[0][0]']


 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)



 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)



 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)
 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)



 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)



 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)



 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)



 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)



 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)



 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',

'conv2_block3_3_bn[0][0]']


 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)



 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
```

```
 D)



 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)



 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)



 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)



 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)



 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)



 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)



 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)



 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)
 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)



 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',

'conv3_block1_3_bn[0][0]']


 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)



 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)



 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)



 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)



 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)



 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)



 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
```

```
 ation)



 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)



 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)



 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',

'conv3_block2_3_bn[0][0]']


 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)



 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)



 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)



 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)



 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)
 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)



 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)



 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)



 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)



 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',

'conv3_block3_3_bn[0][0]']


 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)



 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)



 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)



 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
```

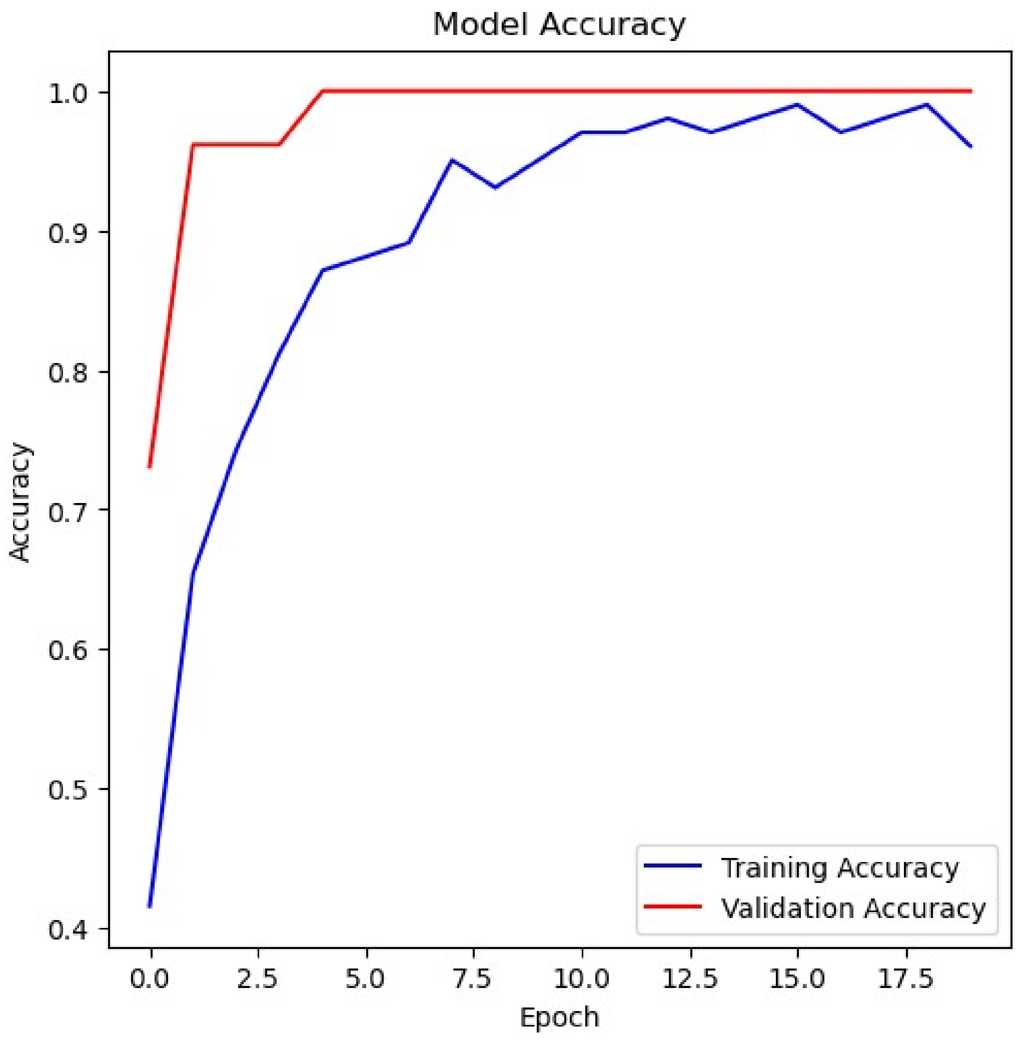
```
 ation)



 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)



 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)



 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)



 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)



 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)



 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',

'conv3_block4_3_bn[0][0]']


 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)



 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)
 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)


 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)


 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)


 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)


 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)


 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)


 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)


 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)


 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
```

```
 rmalization)



 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',

'conv4_block1_3_bn[0][0]']


 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)



 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)



 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)



 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)



 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)



 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)



 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)
 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)



 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)



 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',

'conv4_block2_3_bn[0][0]']


 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)



 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)



 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)



 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)



 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)



 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
```

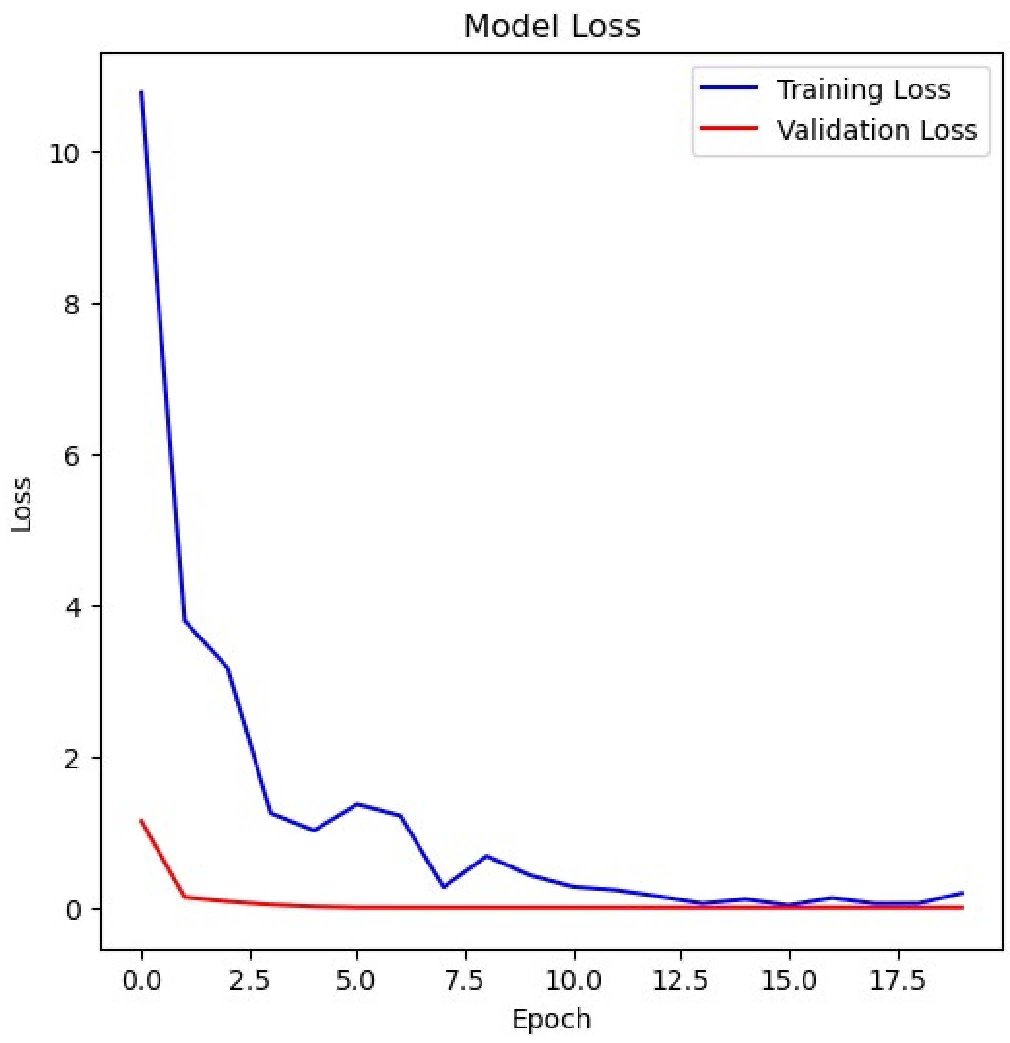
```
 rmalization)



 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)



 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)



 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)



 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',

'conv4_block3_3_bn[0][0]']



 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)



 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)



 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)



 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)
 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)



 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)



 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)



 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)



 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)



 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',

'conv4_block4_3_bn[0][0]']


 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)



 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)



 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)



 conv4_block5_1_relu (Activ  (None, 14, 14, 256)         0
['conv4_block5_1_bn[0][0]']
 ation)



 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)         590080
['conv4_block5_1_relu[0][0]']
 D)



 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)         1024
['conv4_block5_2_conv[0][0]']
 rmalization)



 conv4_block5_2_relu (Activ  (None, 14, 14, 256)         0
['conv4_block5_2_bn[0][0]']
 ation)



 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)        263168
['conv4_block5_2_relu[0][0]']
 D)



 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)        4096
['conv4_block5_3_conv[0][0]']
 rmalization)



 conv4_block5_add (Add)      (None, 14, 14, 1024)        0
['conv4_block4_out[0][0]',

'conv4_block5_3_bn[0][0]']


 conv4_block5_out (Activati  (None, 14, 14, 1024)        0
['conv4_block5_add[0][0]']
 on)
 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)



 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)



 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)



 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)



 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)



 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)



 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']

 D)



 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)
 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',

'conv4_block6_3_bn[0][0]']


 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)



 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)



 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)



 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)



 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)



 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)



 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)



 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)
 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)



 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)



 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)



 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',

'conv5_block1_3_bn[0][0]']


 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)



 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)



 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)



 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)
 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)



 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)



 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)



 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)



 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)



 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',

'conv5_block2_3_bn[0][0]']


 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)



 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)



 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)
 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)



 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)



 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)



 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)



 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)



 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)



 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',

'conv5_block3_3_bn[0][0]']


 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)
 global_average_pooling2d (  (None, 2048)                 0
['conv5_block3_out[0][0]']
 GlobalAveragePooling2D)



 dense_3 (Dense)             (None, 512)                  1049088
['global_average_pooling2d[0][

0]']


 dropout_2 (Dropout)         (None, 512)                  0
['dense_3[0][0]']


 dense_4 (Dense)             (None, 256)                  131328
['dropout_2[0][0]']


 dropout_3 (Dropout)         (None, 256)                  0
['dense_4[0][0]']


 dense_5 (Dense)             (None, 3)                    771
['dropout_3[0][0]']


======================================================================
============================
Total params: 24768899 (94.49 MB)
Trainable params: 24715779 (94.28 MB)
Non-trainable params: 53120 (207.50 KB)
______________________________________________________________________
____________________________

# Train the model
model.fit(X_train, y_train, epochs=10, batch_size=20,
validation_data=(X_test, y_test))

Epoch 1/10
6/6 [==============================] - 35s 3s/step - loss: 1.5559 -
accuracy: 0.3465 - val_loss: 1.0340 - val_accuracy: 0.4615
Epoch 2/10
6/6 [==============================] - 15s 2s/step - loss: 1.0155 -
accuracy: 0.5743 - val_loss: 0.9058 - val_accuracy: 0.6154
Epoch 3/10
6/6 [==============================] - 14s 2s/step - loss: 0.5106 -
accuracy: 0.8218 - val_loss: 0.8206 - val_accuracy: 0.7308
Epoch 4/10
```

```
6/6 [==============================] - 14s 2s/step - loss: 0.4620 -
accuracy: 0.8020 - val_loss: 0.7433 - val_accuracy: 0.6923
Epoch 5/10
6/6 [==============================] - 13s 2s/step - loss: 0.3201 -
accuracy: 0.9208 - val_loss: 0.6899 - val_accuracy: 0.6923
Epoch 6/10
6/6 [==============================] - 18s 3s/step - loss: 0.2311 -
accuracy: 0.9406 - val_loss: 0.6339 - val_accuracy: 0.7692
Epoch 7/10
6/6 [==============================] - 21s 3s/step - loss: 0.3107 -
accuracy: 0.9109 - val_loss: 0.6055 - val_accuracy: 0.8077
Epoch 8/10
6/6 [==============================] - 15s 2s/step - loss: 0.1658 -
accuracy: 0.9406 - val_loss: 0.5857 - val_accuracy: 0.7692
Epoch 9/10
6/6 [==============================] - 14s 2s/step - loss: 0.1353 -
accuracy: 0.9604 - val_loss: 0.5616 - val_accuracy: 0.7692
Epoch 10/10
6/6 [==============================] - 14s 2s/step - loss: 0.1197 -
accuracy: 0.9703 - val_loss: 0.5063 - val_accuracy: 0.8077

<keras.src.callbacks.History at 0x1d19b61e890>
```

```
plt.figure(figsize=(6, 6))
plt.plot(history.history['accuracy'], color='blue', label='Training
Accuracy')
plt.plot(history.history['val_accuracy'], color='red',
label='Validation Accuracy')
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



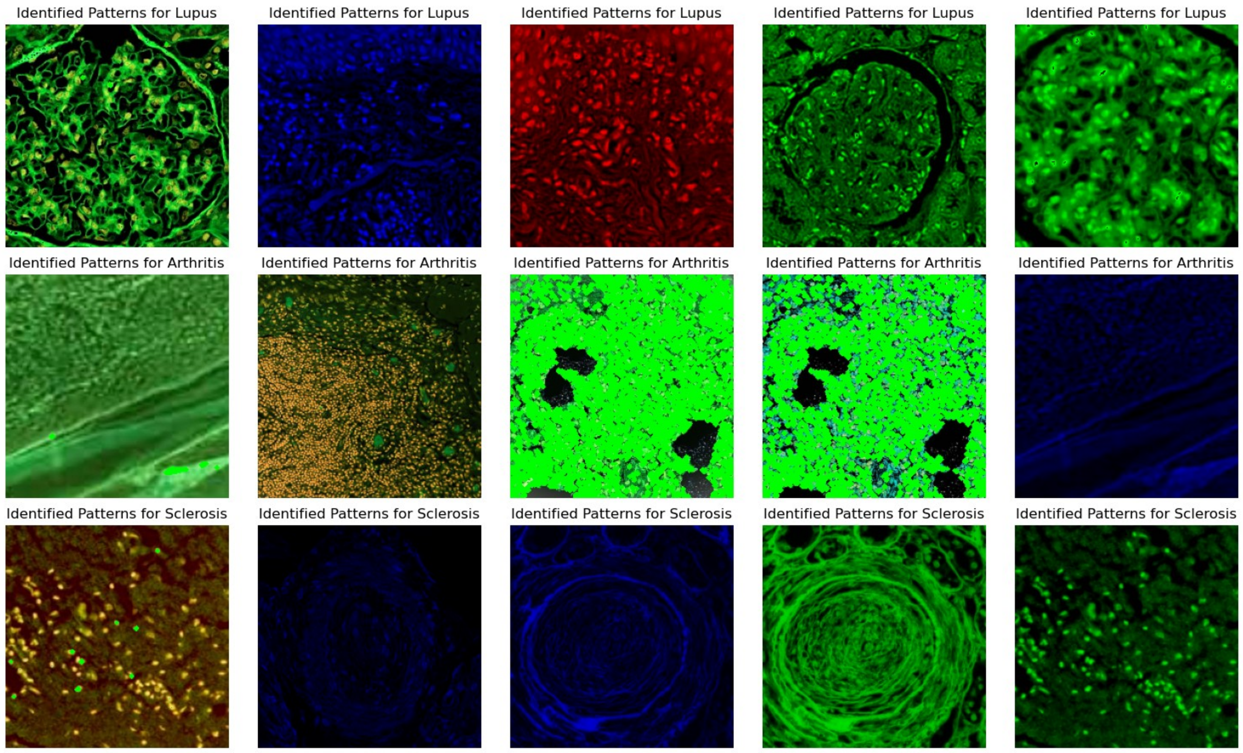
```
plt.figure(figsize=(6, 6))
plt.plot(history.history['loss'], color='blue', label='Training Loss')
plt.plot(history.history['val_loss'], color='red', label='Validation
Loss')
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```



```python
# Prepare to identify correct predictions
correct_images_per_dir = {subdir: [] for subdir in subdirectories}

# Predict and identify correct images
for subdir in subdirectories:
    subdir_images = [img for img, label in zip(preprocessed_images, 
labels) if label == subdir][:50]

    if len(subdir_images) == 0:
        continue

    subdir_images = np.array(subdir_images)
    predictions = model.predict(subdir_images)

    for img, prediction in zip(subdir_images, predictions):
        predicted_label = 
label_encoder.inverse_transform([np.argmax(prediction)])[0]
        if predicted_label == subdir:
            correct_images_per_dir[subdir].append(img)
        if len(correct_images_per_dir[subdir]) >= 5:
            break

2/2 [==============================] - 3s 593ms/step
2/2 [==============================] - 2s 429ms/step
2/2 [==============================] - 2s 391ms/step
```

Final Results

```
# Display the first 5 correctly identified images with patterns from
each directory
num_images_per_directory = 5

fig, axs = plt.subplots(len(subdirectories), num_images_per_directory,
figsize=(3 * num_images_per_directory, 3 * len(subdirectories)))

for i, subdir in enumerate(subdirectories):
    for j, img in enumerate(correct_images_per_dir[subdir]):
        pattern_img = identify_patterns(cv2.cvtColor((img *
255).astype(np.uint8), cv2.COLOR_RGB2BGR))

        axs[i, j].imshow(pattern_img, cmap='gray')  # Display pattern
image in grayscale
        axs[i, j].set_title(f'Identified Patterns for {subdir}')
        axs[i, j].axis('off')

    # Hide empty subplots
    for j in range(len(correct_images_per_dir[subdir]),
num_images_per_directory):
        axs[i, j].axis('off')

plt.tight_layout()
plt.show()
```


Identified Patterns for Lupus
Identified Patterns for Lupus
Identified Patterns for Lupus
Identified Patterns for Lupus
Identified Patterns for Lupus
Identified Patterns for Arthritis
Identified Patterns for Arthritis
Identified Patterns for Arthritis
Identified Patterns for Arthritis
Identified Patterns for Arthritis
Identified Patterns for Sclerosis
Identified Patterns for Sclerosis
Identified Patterns for Sclerosis
Identified Patterns for Sclerosis
Identified Patterns for Sclerosis