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# This Python 3 environment comes with many helpful analytics
libraries installed
# It is defined by the kaggle/python Docker image:
https://github.com/kaggle/docker-python
# For example, here's several helpful packages to load

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt
from sklearn.metrics import classification_report, accuracy_score
from tensorflow.keras.preprocessing.image import ImageDataGenerator,
load_img, img_to_array
from tensorflow.keras.applications.vgg16 import VGG16,
preprocess_input
from tensorflow.keras import layers, models
from tensorflow.keras.utils import to_categorical

# Input data files are available in the read-only "../input/"
directory
# For example, running this (by clicking run or pressing Shift+Enter)
will list all files under the input directory

import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

# You can write up to 20GB to the current directory (/kaggle/working/)
that gets preserved as output when you create a version using "Save &
Run All"
# You can also write temporary files to /kaggle/temp/, but they won't
be saved outside of the current session

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/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_226.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_25.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_48.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_29.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_78.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_28.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_181.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_81.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_174.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_172.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_132.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_230.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_188.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_271.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_292.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_87.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_296.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_213.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_138.bmp

[illegible]

Data/train/Crazing/Cr_244.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_151.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_221.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_42.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_67.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_18.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_125.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_71.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_224.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_2.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_156.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_13.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_6.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_142.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_91.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_95.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_153.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_281.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_223.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_69.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_276.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_147.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_203.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_61.bmp
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects
Data/train/Crazing/Cr_74.bmp

```
/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects Data/train/Crazing/Cr_30.bmp
```

```
# Set the path to the root directory of your dataset
```

```
train_data_dir = '/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects Data/train'
```

```
test_data_dir = '/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects Data/test'
```

```
valid_data_dir = '/kaggle/input/neu-metal-surface-defects-data/NEU Metal Surface Defects Data/valid'
```

```
# Define the image size for resizing (VGG16 requires input size of 224x224)
```

```
image_size = (224, 224)
```

```
# Batch size for training
```

```
batch_size = 32
```

```
# Function to preprocess a single image
```

```
def preprocess_image(image_path):
```

```
    img = load_img(image_path, target_size=image_size) # Load image and resize
```

```
    img_array = img_to_array(img) # Convert image to NumPy array
```

```
    img_array = img_array.reshape((1,) + img_array.shape) # Reshape to (1, width, height, channels)
```

```
    img_array = preprocess_input(img_array) # Preprocess the image according to VGG16 requirements
```

```
    return img_array
```

```
# Function to preprocess an entire dataset
```

```
def preprocess_dataset(data_dir):
```

```
    image_list = []
```

```
    labels = []
```

```
    class_names = sorted(os.listdir(data_dir))
```

```
    for class_index, class_name in enumerate(class_names):
```

```
        class_dir = os.path.join(data_dir, class_name)
```

```
        for image_file in os.listdir(class_dir):
```

```
            image_path = os.path.join(class_dir, image_file)
```

```
            img_array = preprocess_image(image_path)
```

```
            image_list.append(img_array)
```

```
            labels.append(class_index)
```

```
# Convert image list and labels to NumPy arrays
```

```
images = np.concatenate(image_list, axis=0)
```

```
labels = np.array(labels)
```

```
return images, labels
```

```
# Preprocess training data
```

```
train_images, train_labels = preprocess_dataset(train_data_dir)
```

```

# Preprocess validation data
valid_images, valid_labels = preprocess_dataset(valid_data_dir)

# Preprocess testing data
test_images, test_labels = preprocess_dataset(test_data_dir)

# Create an ImageDataGenerator for data augmentation and preprocessing
train_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,
    rescale=1.0 / 255
)

# Create ImageDataGenerators for validation and testing (only
# rescaling, no augmentation)
valid_datagen = ImageDataGenerator(rescale=1.0 / 255)
test_datagen = ImageDataGenerator(rescale=1.0 / 255)

# Define the number of classes in your dataset
num_classes = len(os.listdir(train_data_dir))
print(num_classes)

6

# Load the pre-trained VGG16 model
vgg16_model = VGG16(weights='imagenet', include_top=False,
input_shape=(224, 224, 3))

# Freeze the layers of the pre-trained VGG16 model
for layer in vgg16_model.layers:
    layer.trainable = False

# Create your own classification layers
model = models.Sequential()
model.add(vgg16_model)
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dropout(0.5))
# Replace num_classes with the number of classes in your dataset
model.add(layers.Dense(num_classes, activation='softmax'))

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

```

```

# Convert the labels to integers if they are not already
train_labels = np.array(train_labels, dtype='int32')
valid_labels = np.array(valid_labels, dtype='int32')
test_labels = np.array(test_labels, dtype='int32')

# Assuming train_labels, valid_labels, and test_labels are integer
labels

train_labels = to_categorical(train_labels, num_classes)
valid_labels = to_categorical(valid_labels, num_classes)
test_labels = to_categorical(test_labels, num_classes)

# Function to convert labels to class names
def get_class_name(label):
    class_names = sorted(os.listdir(train_data_dir))
    return class_names[label]

# Visualize some images from the dataset
def visualize_images(images, labels, num_samples=5):
    plt.figure(figsize=(12, 8))
    for i in range(num_samples):
        plt.subplot(1, num_samples, i + 1)
        plt.imshow(images[i])
        plt.title(get_class_name(np.argmax(labels[i]))) # Convert
one-hot encoded labels back to integers
    plt.axis('off')
    plt.show()

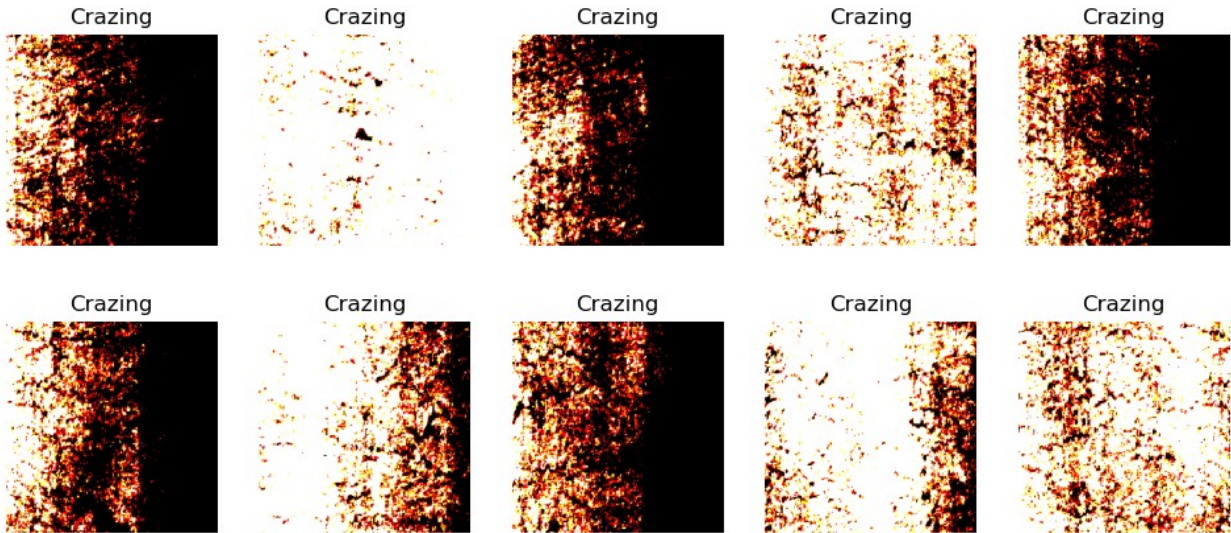
# Visualize some images from the training data
visualize_images(train_images, train_labels)

# Visualize some images from the validation data
visualize_images(valid_images, valid_labels)

# Visualize some images from the testing data
visualize_images(test_images, test_labels)

```





```
# Define the number of training epochs
num_epochs = 10

# Train the model
train_loss_values = []
train_accuracy_values = []
val_loss_values = []
val_accuracy_values = []

for epoch in range(num_epochs):
    print(f"Epoch {epoch + 1}/{num_epochs}")
    history = model.fit(train_datagen.flow(train_images, train_labels,
                                           batch_size=batch_size),
                        steps_per_epoch=len(train_images) //
                        batch_size, epochs=1,

                        validation_data=valid_datagen.flow(valid_images, valid_labels,
                                                           batch_size=batch_size),
                        validation_steps=len(valid_images) //
                        batch_size)

    train_loss_values.append(history.history['loss'][0])
    train_accuracy_values.append(history.history['accuracy'][0])
    val_loss_values.append(history.history['val_loss'][0])
    val_accuracy_values.append(history.history['val_accuracy'][0])

Epoch 1/10
51/51 [=====] - 20s 362ms/step - loss: 1.1362
- accuracy: 0.6736 - val_loss: 0.1599 - val_accuracy: 0.9844
Epoch 2/10
51/51 [=====] - 18s 347ms/step - loss: 0.4389
- accuracy: 0.8584 - val_loss: 0.1837 - val_accuracy: 0.9219
Epoch 3/10
```

```

51/51 [=====] - 18s 362ms/step - loss: 0.3567
- accuracy: 0.8750 - val_loss: 0.0928 - val_accuracy: 0.9844
Epoch 4/10
51/51 [=====] - 19s 369ms/step - loss: 0.3299
- accuracy: 0.8947 - val_loss: 0.0621 - val_accuracy: 0.9844
Epoch 5/10
51/51 [=====] - 18s 360ms/step - loss: 0.2919
- accuracy: 0.8959 - val_loss: 0.0440 - val_accuracy: 1.0000
Epoch 6/10
51/51 [=====] - 19s 371ms/step - loss: 0.2515
- accuracy: 0.9187 - val_loss: 0.0628 - val_accuracy: 0.9844
Epoch 7/10
51/51 [=====] - 18s 360ms/step - loss: 0.2305
- accuracy: 0.9249 - val_loss: 0.0381 - val_accuracy: 0.9844
Epoch 8/10
51/51 [=====] - 19s 368ms/step - loss: 0.2185
- accuracy: 0.9286 - val_loss: 0.0282 - val_accuracy: 1.0000
Epoch 9/10
51/51 [=====] - 19s 368ms/step - loss: 0.2154
- accuracy: 0.9273 - val_loss: 0.0326 - val_accuracy: 1.0000
Epoch 10/10
51/51 [=====] - 18s 347ms/step - loss: 0.2018
- accuracy: 0.9323 - val_loss: 0.0320 - val_accuracy: 0.9844

# Evaluate the model on the test data
test_loss, test_accuracy =
model.evaluate(test_datagen.flow(test_images, test_labels,
batch_size=batch_size),
                steps=len(test_images) //
batch_size)

print(f'Test loss: {test_loss}, Test accuracy: {test_accuracy}')

# Make predictions on the test data
y_pred = model.predict(test_images)
y_pred_classes = np.argmax(y_pred, axis=1)

# Convert one-hot encoded test_labels back to integers
test_labels_int = np.argmax(test_labels, axis=1)

# Calculate precision, recall, F1 score, and accuracy
report = classification_report(test_labels_int, y_pred_classes,
zero_division=1)
accuracy = accuracy_score(test_labels_int, y_pred_classes)

print("Classification Report:")
print(report)

print("Test Accuracy:", accuracy)

```



```
2/2 [=====] - 0s 74ms/step - loss: 0.0903 - accuracy: 0.9688
```

```
Test loss: 0.09026608616113663, Test accuracy: 0.96875
```

```
3/3 [=====] - 0s 61ms/step
```

```
Classification Report:
```

	precision	recall	f1-score	support
0	1.00	0.00	0.00	12
1	1.00	0.00	0.00	12
2	0.29	1.00	0.45	12
3	0.67	0.33	0.44	12
4	1.00	0.00	0.00	12
5	0.44	0.92	0.59	12

accuracy			0.38	72
macro avg	0.73	0.38	0.25	72
weighted avg	0.73	0.38	0.25	72

```
Test Accuracy: 0.375
```

```
# Plot accuracy and loss curves
```

```
epochs_range = range(1, num_epochs + 1)
```

```
plt.figure(figsize=(12, 5))
```

```
plt.subplot(1, 2, 1)
```

```
plt.plot(epochs_range, train_accuracy_values, label='Training Accuracy')
```

```
plt.plot(epochs_range, val_accuracy_values, label='Validation Accuracy')
```

```
plt.xlabel('Epochs')
```

```
plt.ylabel('Accuracy')
```

```
plt.title('Training and Validation Accuracy')
```

```
plt.legend()
```

```
plt.subplot(1, 2, 2)
```

```
plt.plot(epochs_range, train_loss_values, label='Training Loss')
```

```
plt.plot(epochs_range, val_loss_values, label='Validation Loss')
```

```
plt.xlabel('Epochs')
```

```
plt.ylabel('Loss')
```

```
plt.title('Training and Validation Loss')
```

```
plt.legend()
```

```
plt.tight_layout()
```

```
plt.show()
```