Homework3

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Homework 3

[1]:
```
import warnings
warnings.filterwarnings("ignore")

import os
os.environ["KMP_DUPLICATE_LIB_OK"]="TRUE"
```

[2]:
```
import numpy as np
from datetime import datetime

import PIL
import PIL.Image
import pathlib

from matplotlib import pyplot as plt
import matplotlib as mpl
import tensorflow as tf

from sklearn.metrics import confusion_matrix
import seaborn as sns

print(tf.__version__)
```

```
2.10.0
```

[3]:
```
print(tf.config.list_physical_devices('GPU'))
print(tf.test.is_built_with_cuda)
print(tf.test.gpu_device_name())
print(tf.config.get_visible_devices())
```

```
[]
<function is_built_with_cuda at 0x000001FE6FCC7670>

[PhysicalDevice(name='/physical_device:CPU:0', device_type='CPU')]
```

Parameters

[4]:
```
AUTOTUNE = tf.data.AUTOTUNE
```

[5]:
```
batch_size = 32
img_height = 101
img_width = 101
```

Data

[6]:
```
data_dirpathname = r'C:\Users\ehven\Documents\flower_photos'
data_dir = pathlib.Path(data_dirpathname)

class_names = os.listdir(data_dir)
num_classes = len(class_names)
```

0.1 1. 2.a) Code that will count number of classes

0.2 1. 2.b) Number of images in each class

[7]:
```
images_per_class = {}
for class_name in class_names:
    images_per_class[class_name] = len(os.listdir(os.path.join(data_dir,␣
 ↪class_name)))

print("Number of classes:", num_classes)
print("Number of images in each class:", images_per_class)
```

```
Number of classes: 5
Number of images in each class: {'daisy': 633, 'dandelion': 898, 'roses': 641,
'sunflowers': 699, 'tulips': 799}
```

[8]:
```
image_count =  len(list(data_dir.glob('*/*.jpg')))
print('Image count:', image_count)
```

```
Image count: 3670
```

[9]:
```
one = list(data_dir.glob('daisy/*'))
PIL.Image.open(str(one[0]))
```

[9]:

[10]:
```
sample_image = PIL.Image.open(str(one[1]))
img = np.asarray(sample_image)
img.shape
```

[10]:
```
(313, 500, 3)
```

Setup Dataset Pipeline

[11]:
```
list_ds = tf.data.Dataset.list_files(str(data_dir/'*/*'), shuffle=False)
list_ds = list_ds.shuffle(image_count, reshuffle_each_iteration=False)
list_ds
```

[11]:
```
<ShuffleDataset element_spec=TensorSpec(shape=(), dtype=tf.string, name=None)>
```

[12]:
```
for f in list_ds.take(5):
    print(f.numpy())
```

```
b'C:\\Users\\ehven\\Documents\\flower_photos\\daisy\\4544110929_a7de65d65f_n.jpg
'
b'C:\\Users\\ehven\\Documents\\flower_photos\\tulips\\490541142_c37e2b4191_n.jpg
'
b'C:\\Users\\ehven\\Documents\\flower_photos\\sunflowers\\4933230247_a0432f01da.
jpg'
b'C:\\Users\\ehven\\Documents\\flower_photos\\sunflowers\\14741866338_bdc8bfc8d5
_n.jpg'
b'C:\\Users\\ehven\\Documents\\flower_photos\\dandelion\\2535727910_769c020c0d_n
```

```
.jpg'
```

0.3 1. 1. Data must be split in train/test and validation set

[13]:
```
test_size = int(image_count*0.2)
train_ds = list_ds.skip(test_size)
val_ds = list_ds.take(test_size)
```

[14]:
```
print(tf.data.experimental.cardinality(train_ds).numpy())
print(tf.data.experimental.cardinality(val_ds).numpy())
```

```
2936
734
```

Helper Functions

[15]:
```
def get_label(file_path):
    parts = tf.strings.split(file_path, os.path.sep)
    one_hot = parts[-2] == class_names
    return tf.argmax(one_hot)
```

[16]:
```
def decode_img(img):
    img = tf.io.decode_jpeg(img, channels=3)
    return tf.image.resize(img, [img_height, img_width])
```

[17]:
```
def process_path(file_path):
    label = get_label(file_path)
    img = tf.io.read_file(file_path)
    img = decode_img(img)
    return img, label
```

[18]:
```
# Set 'num_parallel_calls' so multiple images are loaded/processed in parallel.

train_ds = train_ds.map(process_path, num_parallel_calls=AUTOTUNE)
val_ds = val_ds.map(process_path, num_parallel_calls=AUTOTUNE)
```

0.4 1. 2.c) Image resized to 101x101xNo_Of_channels.

0.5 1. 2.d) Automatic data label extraction based on sub-directory name.

0.6 1. 2.e) Display one batch of image/label using the dataset api.

[19]:
```
for image, label in train_ds.take(1):
    print("Image shape:", image.numpy().shape)
    print("Label:", class_names[label.numpy()])
```

```
Image shape: (101, 101, 3)
Label: roses
```

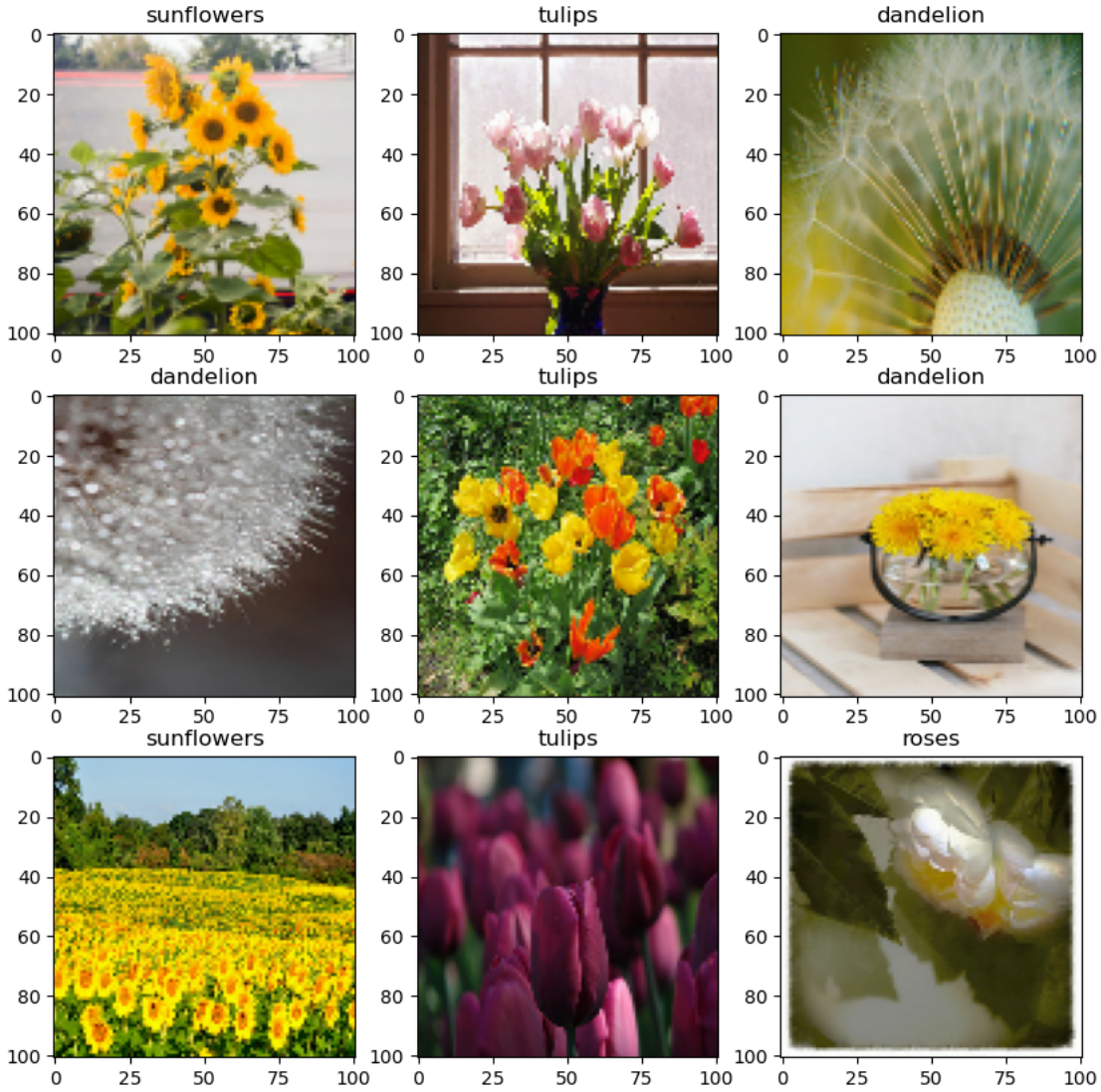
[20]:
```
def configure_for_performance(ds):
    ds = ds.cache()
    ds = ds.shuffle(buffer_size=1000)
    ds = ds.batch(batch_size=64)
    return ds
```

[21]:
```
train_ds = configure_for_performance(train_ds)
val_ds = configure_for_performance(val_ds)
```

Test Dataset Pipeline

[22]:
```
image_batch, label_batch = next(iter(train_ds))
```

[23]:
```
plt.figure(figsize=(10,10))
for i in range(9):
    ax = plt.subplot(3, 3, i+1)
    plt.imshow(image_batch[i].numpy().astype("uint8"))
    label = label_batch[i]
    plt.title(class_names[label])
```



0.7 2. Model

[24]:
```
model = tf.keras.Sequential([
    tf.keras.layers.InputLayer(input_shape=(img_height, img_width, 3),␣
 ↪name='Input_Shape_Layer'),
    tf.keras.layers.Rescaling(1./255),  # Normalize pixel values
    tf.keras.layers.Conv2D(32, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Conv2D(64, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(num_classes, activation='softmax')
```

```
])
```

[25]:
```
tf.keras.utils.plot_model(model=model, rankdir="LR", dpi=72, show_shapes=True)
```

[25]:

[26]:
```
model.compile(
    optimizer='adam',
    loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
    metrics=['accuracy']
)
```

0.7.1 Training / Validation Cycle

[27]:
```
logdir = "logs/" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=logdir)
```

0.8 3. Train/Validation

0.9 3. 1. Early stopping

[28]:
```
early_stopping_callback = tf.keras.callbacks.
 ↪EarlyStopping(monitor='val_accuracy', mode='max', patience=20)
```

[29]:
```
model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=11,
    callbacks=[tensorboard_callback, early_stopping_callback],
    verbose=1
)
```

```
Epoch 1/11
46/46 [==============================] - 7s 139ms/step - loss: 1.3649 -
accuracy: 0.4016 - val_loss: 1.1319 - val_accuracy: 0.5668
Epoch 2/11
46/46 [==============================] - 5s 114ms/step - loss: 0.9609 -
accuracy: 0.6301 - val_loss: 1.0494 - val_accuracy: 0.6063
Epoch 3/11
46/46 [==============================] - 5s 116ms/step - loss: 0.7218 -
accuracy: 0.7337 - val_loss: 1.0819 - val_accuracy: 0.5981
Epoch 4/11
46/46 [==============================] - 5s 120ms/step - loss: 0.5314 -
accuracy: 0.8127 - val_loss: 0.9899 - val_accuracy: 0.6240
Epoch 5/11
46/46 [==============================] - 6s 125ms/step - loss: 0.3349 -
```

```
accuracy: 0.8971 - val_loss: 1.1749 - val_accuracy: 0.6185
Epoch 6/11
46/46 [==============================] - 5s 116ms/step - loss: 0.2011 -
accuracy: 0.9401 - val_loss: 1.1928 - val_accuracy: 0.6172
Epoch 7/11
46/46 [==============================] - 6s 122ms/step - loss: 0.1048 -
accuracy: 0.9738 - val_loss: 1.4686 - val_accuracy: 0.6131
Epoch 8/11
46/46 [==============================] - 5s 119ms/step - loss: 0.0661 -
accuracy: 0.9867 - val_loss: 1.4002 - val_accuracy: 0.6322
Epoch 9/11
46/46 [==============================] - 5s 119ms/step - loss: 0.0491 -
accuracy: 0.9908 - val_loss: 1.5965 - val_accuracy: 0.6035
Epoch 10/11
46/46 [==============================] - 6s 123ms/step - loss: 0.0546 -
accuracy: 0.9888 - val_loss: 1.9385 - val_accuracy: 0.5899
Epoch 11/11
46/46 [==============================] - 5s 120ms/step - loss: 0.0379 -
accuracy: 0.9939 - val_loss: 1.7957 - val_accuracy: 0.6172
```

[29]:
```
<keras.callbacks.History at 0x1fe0851f2e0>
```

Evaluate Trained Model

0.10 4. Model Evaluation

0.11 4. 2. Accuracy Metrics

[30]:
```
test_loss, test_acc = model.evaluate(val_ds, verbose=2)
print('\nTest Accuracy:', test_acc)
```

```
12/12 - 0s - loss: 1.7957 - accuracy: 0.6172 - 407ms/epoch - 34ms/step

Test Accuracy: 0.6171662211418152
```

[31]:
```
all_predictions = []
all_labels = []
```

0.12 4. 1. Confusion Matrix

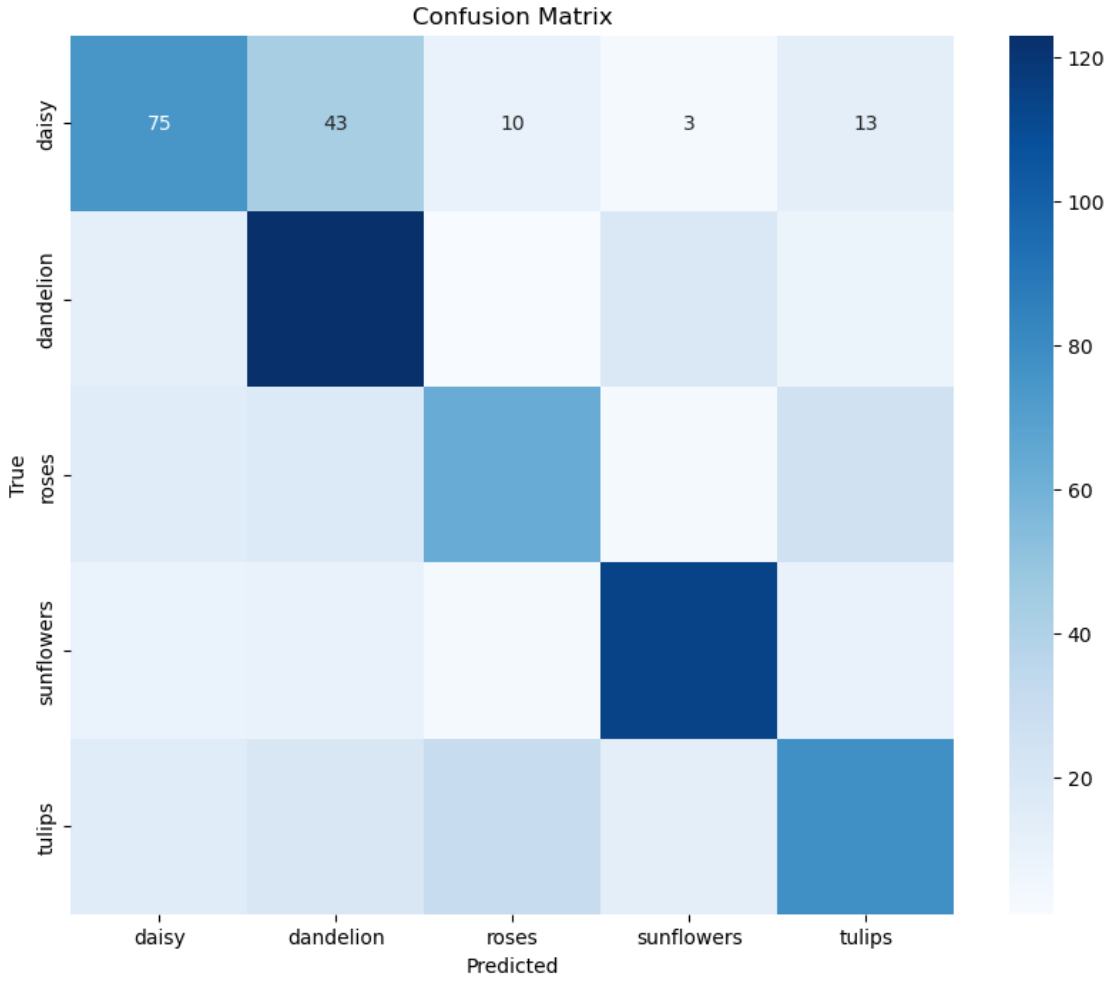
[32]:
```
for images, labels in val_ds:
    predictions = model.predict(images)
    predicted_classes = np.argmax(predictions, axis=1)
    true_classes = labels.numpy()

    all_predictions.extend(predicted_classes)
    all_labels.extend(true_classes)
```

```
2/2 [==============================] - 0s 26ms/step
2/2 [==============================] - 0s 26ms/step
2/2 [==============================] - 0s 28ms/step
2/2 [==============================] - 0s 24ms/step
2/2 [==============================] - 0s 25ms/step
2/2 [==============================] - 0s 35ms/step
2/2 [==============================] - 0s 53ms/step
2/2 [==============================] - 0s 22ms/step
2/2 [==============================] - 0s 30ms/step
2/2 [==============================] - 0s 27ms/step
2/2 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 126ms/step
```

[33]:
```
cm = confusion_matrix(all_labels, all_predictions)
class_names_array = np.array(class_names)
```

[34]:
```
plt.figure(figsize=(10, 8))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',␣
 ↪xticklabels=class_names_array, yticklabels=class_names_array)
plt.xlabel('Predicted')
plt.ylabel('True')
plt.title('Confusion Matrix')
plt.show()
```



Make Predictions

[35]:
```
probability_model = tf.keras.Sequential([model, tf.keras.layers.Softmax()])
```

[36]:
```
predictions = probability_model.predict(val_ds)
```

```
12/12 [==============================] - 1s 36ms/step
```

[37]:
```
predictions[0]
```

[37]:
```
array([0.14884903, 0.40460443, 0.1488484 , 0.14884825, 0.14884984],
      dtype=float32)
```

[38]:
```
class_names[np.argmax(predictions[0])]
```

[38]:
```
'dandelion'
```

[39]:
```
image_batch, label_batch = next(iter(val_ds))
```

[40]:
```
label_batch
```

[40]:
```
<tf.Tensor: shape=(64,), dtype=int64, numpy=
array([3, 1, 0, 4, 4, 4, 4, 2, 2, 3, 4, 3, 1, 4, 3, 4, 3, 4, 1, 1, 4, 2,
       0, 3, 4, 0, 3, 0, 0, 2, 2, 2, 0, 4, 3, 4, 0, 4, 4, 4, 3, 0, 0, 2,
       0, 0, 3, 2, 3, 3, 2, 0, 2, 0, 4, 1, 3, 1, 0, 4, 3, 2, 2, 0],
      dtype=int64)>
```

[41]:
```
predictions = probability_model.predict(image_batch)
```

```
2/2 [==============================] - 0s 27ms/step
```

[42]:
```
np.argmax(predictions, axis=1)
```

[42]:
```
array([3, 1, 0, 4, 4, 1, 4, 1, 1, 3, 2, 3, 1, 2, 0, 4, 0, 4, 1, 1, 1, 1,
       0, 3, 4, 1, 0, 0, 1, 2, 2, 2, 0, 2, 3, 0, 2, 2, 3, 1, 1, 0, 0, 2,
       1, 4, 4, 4, 3, 3, 4, 0, 4, 0, 4, 1, 3, 1, 1, 4, 1, 1, 2, 0],
      dtype=int64)
```

[43]:
```
image_batch[0].shape
```

[43]:
```
TensorShape([101, 101, 3])
```

[44]:
```
predictions_prob = probability_model.predict(image_batch)
predictions = np.argmax(predictions_prob, axis=1)
```

```
2/2 [==============================] - 0s 26ms/step
```

0.13 5. Model Predictions

[45]:
```
plt.figure(figsize=(20, 20))
mpl.rcParams['axes.titlesize'] = 10
mpl.rcParams['axes.titlepad'] = 5

for i in range(16):
    ax = plt.subplot(4, 4, i+1)
    plt.imshow(image_batch[i].numpy().astype("uint8"))
    true_label = class_names[label_batch[i]]
    predicted_label = class_names[predictions[i]]
    title_text = f'actual={true_label},  predicted={predicted_label}'
    plt.title(title_text, wrap=True, backgroundcolor='white', fontsize=18)
    plt.axis('off')

plt.tight_layout(pad=1.0)
plt.show()
```

0.14 3. 2. Tensorboard

[46]:
```
%load_ext tensorboard
%tensorboard --logdir {logdir}
```

```
<IPython.core.display.HTML object>
```

[ ]:
```

```