CS156 (Introduction to AI), Spring 2022

Homework 8 submission

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Any special notes or anything you would like to communicate to me about this homework submission goes in here.

References and sources

List all your references and sources here. This includes all sites/discussion boards/blogs/posts/etc. where you grabbed some code examples.

Solution

Load libraries and set random number generator seed

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import os
import matplotlib.pyplot as plt
from skimage import io
import numpy as np
```

```
np.random.seed(42)
```

```
image_size = (180, 180)
batch_size = 32
```

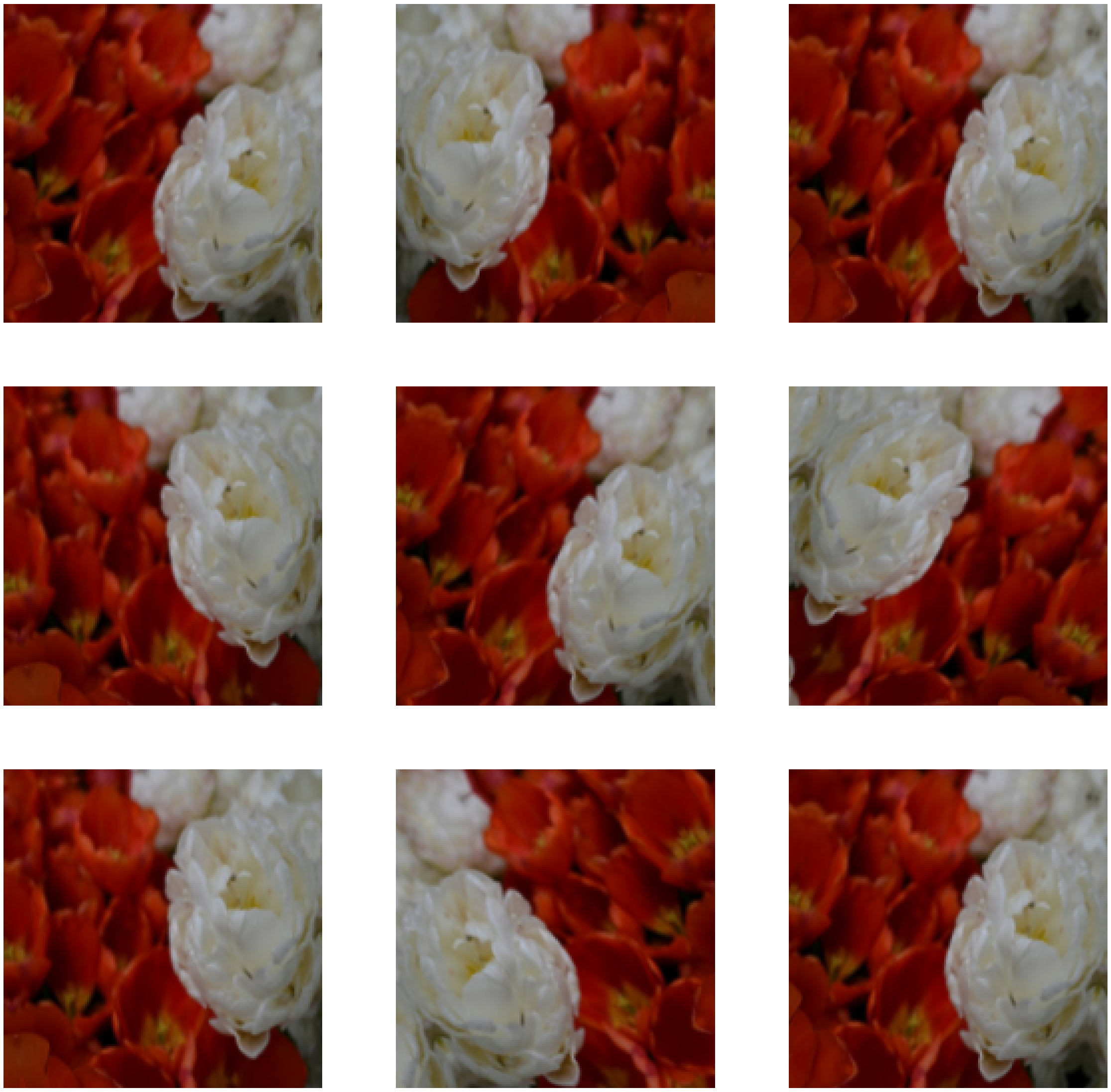
```
train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "./flowers/training",
    validation_split=0.2,
    subset="training",
    seed=42,

    labels='inferred',
    label_mode='categorical',

    image_size=image_size,
    batch_size=batch_size,
)
val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "./flowers/training",
    validation_split=0.2,
    subset="validation",
    seed=42,

    labels='inferred',
    label_mode='categorical',

    image_size=image_size,
    batch_size=batch_size,
)
test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "./flowers/test",
    seed=42,

    labels='inferred',
    label_mode='categorical',

    image_size=image_size,
    batch_size=1,
)
```

```
Found 3456 files belonging to 5 classes.
Using 2765 files for training.
Found 3456 files belonging to 5 classes.
Using 691 files for validation.
Found 861 files belonging to 5 classes.
```

```
data_augmentation = keras.Sequential(
    [
        layers.experimental.preprocessing.RandomFlip("horizontal"),
        layers.experimental.preprocessing.RandomRotation(0.1),
    ]
)
```

```
plt.figure(figsize=(10, 10))
```

```
for images, _ in train_ds.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(augmented_images[0].numpy().astype("uint8"))
        plt.axis("off")
```



```
train_ds = train_ds.prefetch(buffer_size=32)
val_ds = val_ds.prefetch(buffer_size=32)

def make_model(input_shape, num_classes):
    inputs = keras.Input(shape=input_shape)
    # Image augmentation block
    x = data_augmentation(inputs)

    # Entry block
    x = layers.experimental.preprocessing.Rescaling(1.0 / 255)(x)
    x = layers.Conv2D(32, 3, strides=2, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.Conv2D(64, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    previous_block_activation = x  # Set aside residual

    for size in [128, 256, 512, 728]:
        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

        # Project residual
        residual = layers.Conv2D(size, 1, strides=2, padding="same")(
            previous_block_activation
        )
        x = layers.add([x, residual])  # Add back residual
        previous_block_activation = x  # Set aside next residual

    x = layers.SeparableConv2D(1024, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.GlobalAveragePooling2D()(x)
    if num_classes == 2:
        activation = "sigmoid"
        units = 1
    else:
        activation = "softmax"
        units = num_classes

    x = layers.Dropout(0.5)(x)
    outputs = layers.Dense(units, activation=activation)(x)
    return keras.Model(inputs, outputs)


model = make_model(input_shape=image_size + (3,), num_classes=5)
#keras.utils.plot_model(model, show_shapes=True)
model.summary()
```

```
 add_1 (Add)                     (None, 23, 23, 256)  0           max_pooling2d_1[0][0
                                                                  conv2d_3[0][0]

 activation_6 (Activation)       (None, 23, 23, 256)  0           add_1[0][0]
```

```
__________________________________________________________________________________________________
separable_conv2d_4 (SeparableCo (None, 23, 23, 512)  133888      activation_6[0][0]
__________________________________________________________________________________________________
batch_normalization_6 (BatchNor (None, 23, 23, 512)  2048        separable_conv2d_4[0
__________________________________________________________________________________________________
activation_7 (Activation)       (None, 23, 23, 512)  0           batch_normalization_
__________________________________________________________________________________________________
separable_conv2d_5 (SeparableCo (None, 23, 23, 512)  267264      activation_7[0][0]
__________________________________________________________________________________________________
batch_normalization_7 (BatchNor (None, 23, 23, 512)  2048        separable_conv2d_5[0
__________________________________________________________________________________________________
max_pooling2d_2 (MaxPooling2D)  (None, 12, 12, 512)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 12, 12, 512)  131584      add_1[0][0]
__________________________________________________________________________________________________
add_2 (Add)                     (None, 12, 12, 512)  0           max_pooling2d_2[0][0
                                                                 conv2d_4[0][0]
__________________________________________________________________________________________________
activation_8 (Activation)       (None, 12, 12, 512)  0           add_2[0][0]
__________________________________________________________________________________________________
separable_conv2d_6 (SeparableCo (None, 12, 12, 728)  378072      activation_8[0][0]
__________________________________________________________________________________________________
batch_normalization_8 (BatchNor (None, 12, 12, 728)  2912        separable_conv2d_6[0
__________________________________________________________________________________________________
activation_9 (Activation)       (None, 12, 12, 728)  0           batch_normalization_
__________________________________________________________________________________________________
separable_conv2d_7 (SeparableCo (None, 12, 12, 728)  537264      activation_9[0][0]
__________________________________________________________________________________________________
batch_normalization_9 (BatchNor (None, 12, 12, 728)  2912        separable_conv2d_7[0
__________________________________________________________________________________________________
max_pooling2d_3 (MaxPooling2D)  (None, 6, 6, 728)    0           batch_normalization_
__________________________________________________________________________________________________
conv2d_5 (Conv2D)               (None, 6, 6, 728)    373464      add_2[0][0]
__________________________________________________________________________________________________
add_3 (Add)                     (None, 6, 6, 728)    0           max_pooling2d_3[0][0
                                                                 conv2d_5[0][0]
__________________________________________________________________________________________________
separable_conv2d_8 (SeparableCo (None, 6, 6, 1024)   753048      add_3[0][0]
__________________________________________________________________________________________________
batch_normalization_10 (BatchNo (None, 6, 6, 1024)   4096        separable_conv2d_8[0
__________________________________________________________________________________________________
activation_10 (Activation)      (None, 6, 6, 1024)   0           batch_normalization_
__________________________________________________________________________________________________
global_average_pooling2d (Globa (None, 1024)         0           activation_10[0][0]
__________________________________________________________________________________________________
dropout (Dropout)               (None, 1024)         0           global_average_pooli
__________________________________________________________________________________________________
dense (Dense)                   (None, 5)            5125        dropout[0][0]
==================================================================================================
Total params: 2,786,749
Trainable params: 2,778,013
Non-trainable params: 8,736
```

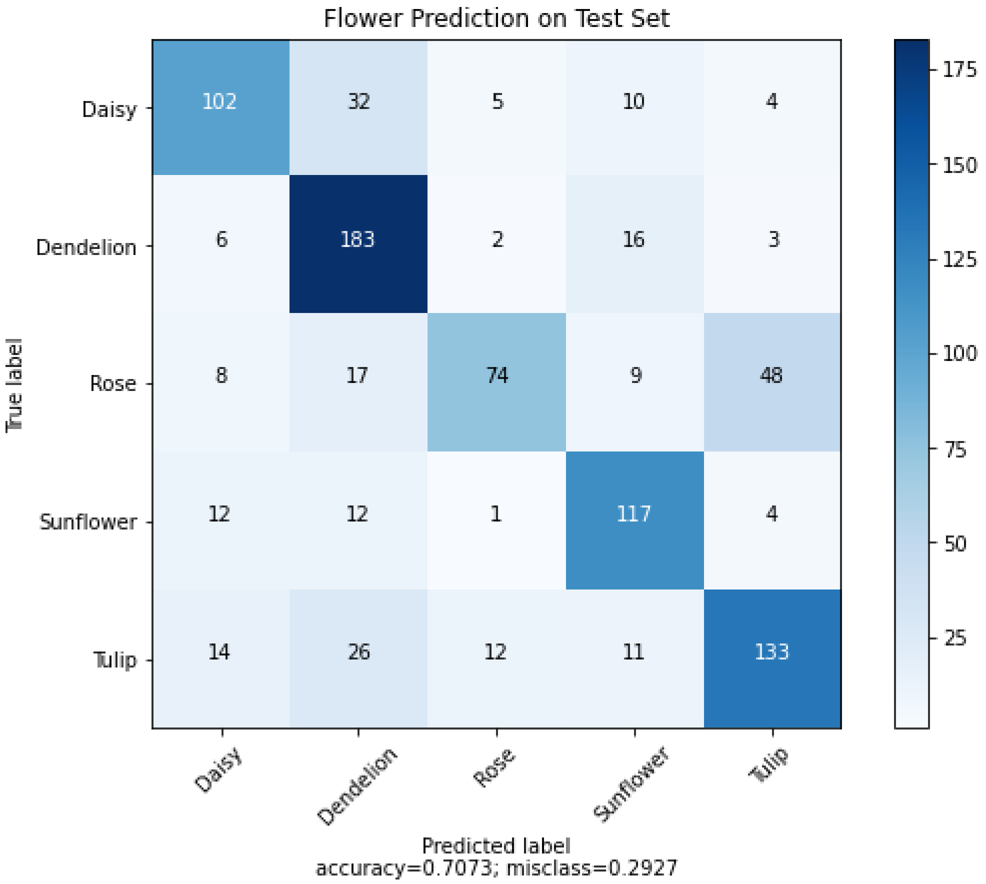
```
epochs = 20
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint("save_at_{epoch}.h5"),
]
model.compile(
    optimizer=keras.optimizers.Adam(1e-3),
    loss="categorical_crossentropy",
    metrics=["accuracy"],
)
model.fit(
    train_ds, epochs=epochs, callbacks=callbacks, validation_data=val_ds,
)
```

```
Epoch 1/20
87/87 [==============================] - 262s 3s/step - loss: 1.2626 - accuracy: 0.5342
Epoch 2/20
/Users/nicholas_dave/opt/anaconda3/lib/python3.8/site-packages/keras/utils/generic_util
  warnings.warn('Custom mask layers require a config and must override '
87/87 [==============================] - 268s 3s/step - loss: 1.0034 - accuracy: 0.6253
Epoch 3/20
87/87 [==============================] - 262s 3s/step - loss: 0.8878 - accuracy: 0.6723
Epoch 4/20
87/87 [==============================] - 263s 3s/step - loss: 0.8245 - accuracy: 0.6890
Epoch 5/20
87/87 [==============================] - 262s 3s/step - loss: 0.7971 - accuracy: 0.7016
Epoch 6/20
87/87 [==============================] - 264s 3s/step - loss: 0.7587 - accuracy: 0.7226
Epoch 7/20
87/87 [==============================] - 254s 3s/step - loss: 0.6805 - accuracy: 0.7392
Epoch 8/20
87/87 [==============================] - 257s 3s/step - loss: 0.6724 - accuracy: 0.7552
Epoch 9/20
87/87 [==============================] - 254s 3s/step - loss: 0.6049 - accuracy: 0.7790
Epoch 10/20
87/87 [==============================] - 256s 3s/step - loss: 0.5778 - accuracy: 0.7892
Epoch 11/20
87/87 [==============================] - 259s 3s/step - loss: 0.5569 - accuracy: 0.7920
Epoch 12/20
87/87 [==============================] - 256s 3s/step - loss: 0.5252 - accuracy: 0.8004
Epoch 13/20
87/87 [==============================] - 240s 3s/step - loss: 0.5277 - accuracy: 0.8098
Epoch 14/20
87/87 [==============================] - 257s 3s/step - loss: 0.4938 - accuracy: 0.8145
Epoch 15/20
87/87 [==============================] - 256s 3s/step - loss: 0.4899 - accuracy: 0.8137
Epoch 16/20
87/87 [==============================] - 257s 3s/step - loss: 0.4733 - accuracy: 0.8181
Epoch 17/20
87/87 [==============================] - 255s 3s/step - loss: 0.4302 - accuracy: 0.8401
Epoch 18/20
87/87 [==============================] - 255s 3s/step - loss: 0.4362 - accuracy: 0.8445
Epoch 19/20
87/87 [==============================] - 255s 3s/step - loss: 0.4000 - accuracy: 0.8499
Epoch 20/20
```

```
87/87 [==============================] - 256s 3s/step - loss: 0.3901 - accuracy: 0.8590
<keras.callbacks.History at 0x7ff4da34d8b0>
```

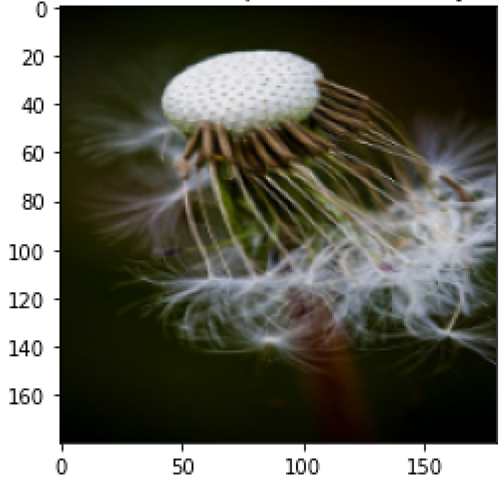
```
true_labels = []
predicted_labels = []
#x = image, y = label
for x, y in test_ds:
    pred = model.predict(x)
    true_labels.append(np.where(y == 1.)[1][0])
    predicted_labels.append(np.where(pred == np.amax(pred))[1][0])


def plot_confusion_matrix(cm,
                          target_names,
                          title='Confusion matrix',
                          cmap=None,
                          normalize=True):

    import matplotlib.pyplot as plt
    import numpy as np
    import itertools

    accuracy = np.trace(cm) / float(np.sum(cm))
    misclass = 1 - accuracy

    if cmap is None:
        cmap = plt.get_cmap('Blues')

    plt.figure(figsize=(8, 6))
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()

    if target_names is not None:
        tick_marks = np.arange(len(target_names))
        plt.xticks(tick_marks, target_names, rotation=45)
        plt.yticks(tick_marks, target_names)

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]


    thresh = cm.max() / 1.5 if normalize else cm.max() / 2
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        if normalize:
            plt.text(j, i, "{:0.4f}".format(cm[i, j]),
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")
        else:
            plt.text(j, i, "{:,}".format(cm[i, j]),
                         horizontalalignment="center",
                         color="white" if cm[i, j] > thresh else "black")


    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label\naccuracy={:0.4f}; misclass={:0.4f}'.format(accuracy, misclas
    plt.show()


plot_confusion_matrix(cm = tf.math.confusion_matrix(labels=true_labels, predictions=predictec
                      normalize    = False,
                      target_names = ['Daisy', 'Dendelion', 'Rose', 'Sunflower', 'Tulip'],
                      title        = "Flower Prediction on Test Set")
```



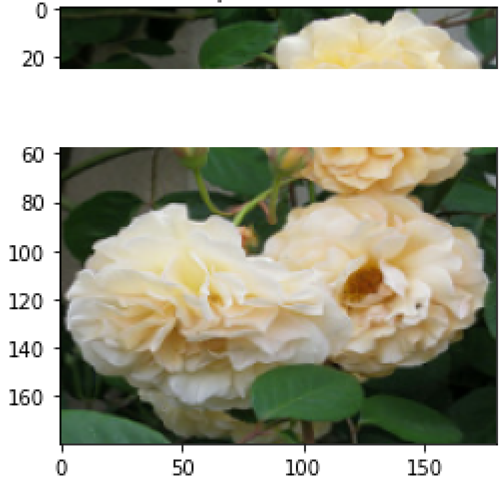
	Daisy	Dendelion	Rose	Sunflower	Tulip
Daisy	102	32	5	10	4
Dendelion	6	183	2	16	3
Rose	8	17	74	9	48
Sunflower	12	12	1	117	4
Tulip	14	26	12	11	133

```
def target_translator (input_number) :

    if (input_number == 0) :
        return 'Daisy'

    elif (input_number == 1) :
        return 'Dendelion'

    elif (input_number == 2) :
        return 'Rose'
    elif (input_number == 3) :
        return 'Sunflower'

    elif (input_number == 4) :
        return 'Tulip'



breaker = 0


for counter in range (100) :
    if (true_labels[counter] != predicted_labels[counter]) :

        plt.title(target_translator(true_labels[counter]) + ' is predicted as ' + target_tran

        plt.imshow(images[counter].numpy().astype("uint8"))

        plt.show()

        breaker = breaker + 1

    if (breaker > 2) :
        break
```

Dendelion is predicted as Daisy



Sunflower is predicted as Dendelion



Tulip is predicted as Dendelion