Exercise-2

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1) Import libraries.

```
[ ]: import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications import Xception
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense, Dropout
from tensorflow.keras.models import Sequential
import matplotlib.pyplot as plt
```

2) Load and preprocess data.

```
[ ]: # Load and preprocess data
train_datagen = ImageDataGenerator(rescale=1./255, validation_split=0.2)
test_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
    r'images\train',
    target_size=(299, 299),  # Xception requires input images to be at least␣
 ↪299x299
    batch_size=32,
    class_mode='binary',  # or 'categorical' if more than two classes
    subset='training'
)

validation_generator = train_datagen.flow_from_directory(
    r'images\train',
    target_size=(299, 299),
    batch_size=32,
    class_mode='binary',
    subset='validation'
)
```

```
Found 80 images belonging to 2 classes.
Found 20 images belonging to 2 classes.
```

3) Define graph function.

[ ]:
```
# Define function to plot performance metrics
def plot_performance(history, title):
    plt.figure(figsize=(12, 6))

    # Plot training & validation accuracy values
    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'])
    plt.plot(history.history['val_accuracy'])
    plt.title('Model Accuracy ' + title)
    plt.ylabel('Accuracy')
    plt.xlabel('Epoch')
    plt.legend(['Train', 'Validation'], loc='upper left')

    # Plot training & validation loss values
    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'])
    plt.plot(history.history['val_loss'])
    plt.title('Model Loss ' + title)
    plt.ylabel('Loss')
    plt.xlabel('Epoch')
    plt.legend(['Train', 'Validation'], loc='upper left')

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

4) Define and Train model.

[ ]:
```
# Define the Xception model
base_model = Xception(weights='imagenet', include_top=False, input_shape=(299,
 ↪299, 3))

# Freeze the convolutional base
base_model.trainable = False

# Add classification head
model = Sequential([
    base_model,
    GlobalAveragePooling2D(),
    Dense(512, activation='relu'),  # Add a fully connected layer with 512
 ↪units and ReLU activation
    Dropout(0.5),  # Add a dropout layer with dropout rate of 0.5 to reduce
 ↪overfitting
    Dense(256, activation='relu'),  # Add another fully connected layer with
 ↪256 units and ReLU activation
    Dropout(0.5),  # Add another dropout layer
    Dense(1, activation='sigmoid')  # Final output layer for binary
 ↪classification
```

```python
])

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

# Print model summary
model.summary()

# Train the model
history = model.fit(train_generator, epochs=10,␣
↪validation_data=validation_generator)
```

```
Model: "sequential_6"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 xception (Functional)       (None, 10, 10, 2048)      20861480

 global_average_pooling2d_6  (None, 2048)              0
  (GlobalAveragePooling2D)


_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 xception (Functional)       (None, 10, 10, 2048)      20861480

 global_average_pooling2d_6  (None, 2048)              0
  (GlobalAveragePooling2D)

 dense_18 (Dense)            (None, 512)               1049088

 dropout_12 (Dropout)        (None, 512)               0

 dense_19 (Dense)            (None, 256)               131328

 dropout_13 (Dropout)        (None, 256)               0

 dense_20 (Dense)            (None, 1)                 257

=================================================================
Total params: 22042153 (84.08 MB)
Trainable params: 1180673 (4.50 MB)
Non-trainable params: 20861480 (79.58 MB)
_________________________________________________________________
Epoch 1/10
3/3 [==============================] - 18s 5s/step - loss: 0.6577 - accuracy:
0.5625 - val_loss: 0.4231 - val_accuracy: 0.9500
```

```
Epoch 2/10
3/3 [==============================] - 14s 5s/step - loss: 0.3251 - accuracy:
0.9250 - val_loss: 0.2081 - val_accuracy: 0.9500
Epoch 3/10
3/3 [==============================] - 14s 6s/step - loss: 0.1542 - accuracy:
1.0000 - val_loss: 0.1043 - val_accuracy: 0.9500
Epoch 4/10
3/3 [==============================] - 14s 6s/step - loss: 0.0831 - accuracy:
0.9500 - val_loss: 0.0948 - val_accuracy: 0.9500
Epoch 5/10
3/3 [==============================] - 14s 5s/step - loss: 0.0432 - accuracy:
0.9875 - val_loss: 0.0996 - val_accuracy: 1.0000
Epoch 6/10
3/3 [==============================] - 14s 5s/step - loss: 0.0558 - accuracy:
0.9750 - val_loss: 0.0777 - val_accuracy: 0.9500
Epoch 7/10
3/3 [==============================] - 14s 5s/step - loss: 0.0048 - accuracy:
1.0000 - val_loss: 0.1121 - val_accuracy: 0.9500
Epoch 8/10
3/3 [==============================] - 14s 6s/step - loss: 0.0030 - accuracy:
1.0000 - val_loss: 0.1729 - val_accuracy: 0.9500
Epoch 9/10
3/3 [==============================] - 16s 6s/step - loss: 0.0075 - accuracy:
1.0000 - val_loss: 0.1852 - val_accuracy: 0.9500
Epoch 10/10
3/3 [==============================] - 16s 7s/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.1733 - val_accuracy: 0.9500
```

5) Evaluate the model.

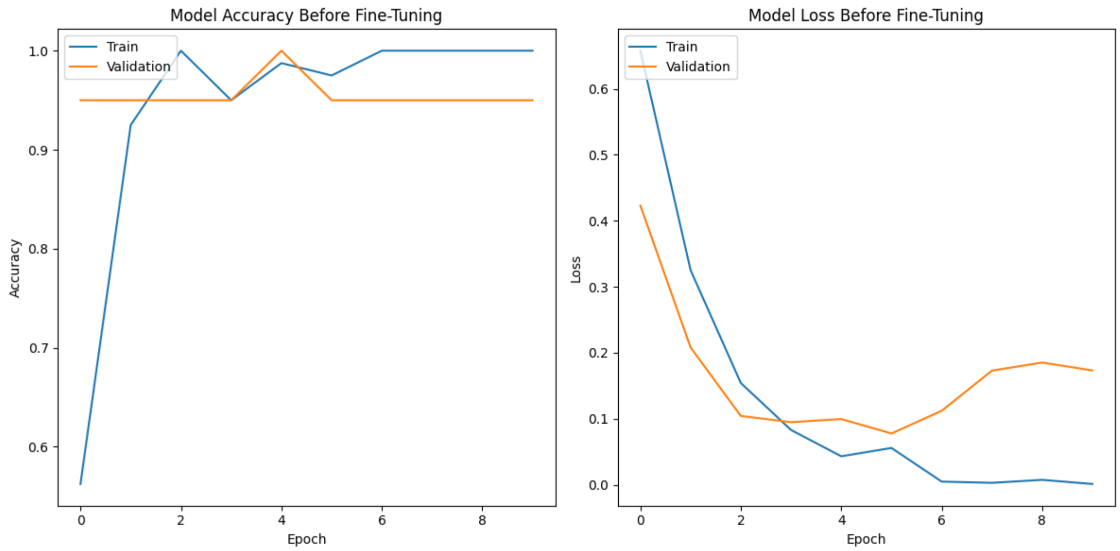
[ ]:
```python
# Evaluate the model
test_generator = test_datagen.flow_from_directory(
    r'images\test',
    target_size=(299, 299),
    batch_size=32,
    class_mode='binary'
)

test_loss, test_acc = model.evaluate(test_generator)
print('Test accuracy:', test_acc)
```

```
Found 10 images belonging to 2 classes.
```

```
1/1 [==============================] - 2s 2s/step - loss: 0.0617 - accuracy:
1.0000
1/1 [==============================] - 2s 2s/step - loss: 0.0617 - accuracy:
1.0000
Test accuracy: 1.0
```

6) Plot model performance.

```
[ ]: plot_performance(history, 'Before Fine-Tuning')
```



7) Fine-tune the model.

```
[ ]: # Unfreeze some layers of the base model
base_model.trainable = True

# It's important to recompile the model after unfreezing the base model
model.compile(optimizer=tf.keras.optimizers.Adam(1e-5),  # Lower learning rate␣
 ↪for fine-tuning
              loss='binary_crossentropy',
              metrics=['accuracy'])

history_fine = model.fit(train_generator, epochs=5,␣
 ↪validation_data=validation_generator)
```

```
Epoch 1/5
3/3 [==============================] - 71s 18s/step - loss: 0.0432 - accuracy:
0.9875 - val_loss: 0.1676 - val_accuracy: 0.9500
Epoch 2/5
3/3 [==============================] - 59s 19s/step - loss: 0.0060 - accuracy:
1.0000 - val_loss: 0.1651 - val_accuracy: 0.9500
Epoch 3/5
3/3 [==============================] - 55s 17s/step - loss: 0.0098 - accuracy:
1.0000 - val_loss: 0.1627 - val_accuracy: 0.9500
Epoch 4/5
3/3 [==============================] - 54s 17s/step - loss: 0.0054 - accuracy:
1.0000 - val_loss: 0.1619 - val_accuracy: 0.9500
Epoch 5/5
```

3/3 [==============================] - 54s 17s/step - loss: 0.0607 - accuracy: 0.9875 - val_loss: 0.1600 - val_accuracy: 0.9500

8) Evaluate Fine-tuned model.

[ ]:
```
# Evaluate the model
test_generator = test_datagen.flow_from_directory(
    r'images\test',
    target_size=(299, 299),
    batch_size=32,
    class_mode='binary'
)

test_loss, test_acc = model.evaluate(test_generator)
print('Test accuracy:', test_acc)
```

```
Found 10 images belonging to 2 classes.
1/1 [==============================] - 2s 2s/step - loss: 0.0555 - accuracy: 1.0000
1/1 [==============================] - 2s 2s/step - loss: 0.0555 - accuracy: 1.0000
Test accuracy: 1.0
```

9) Plot model performance

[ ]:
```
plot_performance(history_fine, 'After Fine-Tuning')
```