assignment5.1

December 17, 2021

[2]:
```
from keras.datasets import imdb
import numpy as np
```

[3]:
```
# Loading the IMDB Data set
# num_words=10000 means keeping the top 10,000 most frequently occurring words␣
↪in the training data

(train_data, train_labels), (test_data, test_labels) = imdb.
↪load_data(num_words=10000)
```

[ ]:
```
train_data[0]
```

[ ]:
```
train_labels[0]
```

[ ]:
```
max([max(sequence) for sequence in train_data])
```

[5]:
```
# Preparing the data and making it ready to be fed into a neural network
# Encoding the integer sequences into a binary matrix

def vectorize_sequences(sequences, dimension=10000):
        # creates an all-zero matrix of shape
        results = np.zeros((len(sequences), dimension))
        for i, sequence in enumerate(sequences):
                # sets specific indices of results[i] to 1s
                results[i, sequence] = 1
        return results

# Vectorize Training data
x_train = vectorize_sequences(train_data)

#Vectorize test data
x_test = vectorize_sequences(test_data)

# Vectorize the labels
y_train = np.asarray(train_labels).astype('float32')
y_test = np.asarray(test_labels).astype('float32')
```

[16]:
```python
# The model definition

from keras import models
from keras import layers

model = models.Sequential()
model.add(layers.Dense(16, activation='relu', input_shape=(10000,)))
model.add(layers.Dense(16, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))

# compiling the model
model.compile(
        optimizer='rmsprop',
        loss='binary_crossentropy',
        metrics=['accuracy']
        )
model.fit(x_train, y_train, epochs=4, batch_size=512)
results = model.evaluate(x_test, y_test)
```

```
Epoch 1/4
25000/25000 [==============================] - 2s 82us/step - loss: 0.4362 -
accuracy: 0.8256
Epoch 2/4
25000/25000 [==============================] - 2s 73us/step - loss: 0.2516 -
accuracy: 0.9097
Epoch 3/4
25000/25000 [==============================] - 2s 69us/step - loss: 0.1953 -
accuracy: 0.9295
Epoch 4/4
25000/25000 [==============================] - 2s 69us/step - loss: 0.1664 -
accuracy: 0.9382
25000/25000 [==============================] - 3s 101us/step
```

[17]:
```python
# This fairly naive approach achieves an accuracy of 88%. With state-of-the-art␣
↪approaches, you should be able to get close to 95%.
results
```

[17]:
```
[0.29697418256759645, 0.8825600147247314]
```

[18]:
```python
# generate predictions
model.predict(x_test)
```

[18]:
```
array([[0.16538502],
       [0.9999002 ],
       [0.77290714],
       …,
       [0.09522235],
       [0.07184319],
```

```
        [0.647887  ]], dtype=float32)
```

[20]:
```python
# Validating our approach
x_val = x_train[:10000]
partial_x_train = x_train[10000:]

y_val = y_train[:10000]
partial_y_train = y_train[10000:]
```

[21]:
```python
history = model.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))
```

```
Train on 15000 samples, validate on 10000 samples
Epoch 1/20
15000/15000 [==============================] - 3s 189us/step - loss: 0.1370 -
accuracy: 0.9533 - val_loss: 0.1413 - val_accuracy: 0.9517
Epoch 2/20
15000/15000 [==============================] - 1s 96us/step - loss: 0.1115 -
accuracy: 0.9632 - val_loss: 0.1643 - val_accuracy: 0.9386
Epoch 3/20
15000/15000 [==============================] - 1s 95us/step - loss: 0.0925 -
accuracy: 0.9708 - val_loss: 0.1849 - val_accuracy: 0.9290
Epoch 4/20
15000/15000 [==============================] - 1s 93us/step - loss: 0.0779 -
accuracy: 0.9765 - val_loss: 0.2016 - val_accuracy: 0.9244
Epoch 5/20
15000/15000 [==============================] - 1s 90us/step - loss: 0.0648 -
accuracy: 0.9815 - val_loss: 0.2142 - val_accuracy: 0.9210
Epoch 6/20
15000/15000 [==============================] - 1s 91us/step - loss: 0.0529 -
accuracy: 0.9863 - val_loss: 0.2358 - val_accuracy: 0.9179
Epoch 7/20
15000/15000 [==============================] - 1s 78us/step - loss: 0.0455 -
accuracy: 0.9884 - val_loss: 0.2759 - val_accuracy: 0.9100
Epoch 8/20
15000/15000 [==============================] - 1s 82us/step - loss: 0.0369 -
accuracy: 0.9910 - val_loss: 0.2762 - val_accuracy: 0.9124
Epoch 9/20
15000/15000 [==============================] - 1s 87us/step - loss: 0.0265 -
accuracy: 0.9954 - val_loss: 0.3093 - val_accuracy: 0.9061
Epoch 10/20
15000/15000 [==============================] - 1s 88us/step - loss: 0.0241 -
accuracy: 0.9957 - val_loss: 0.3388 - val_accuracy: 0.9028
Epoch 11/20
15000/15000 [==============================] - 1s 82us/step - loss: 0.0210 -
```

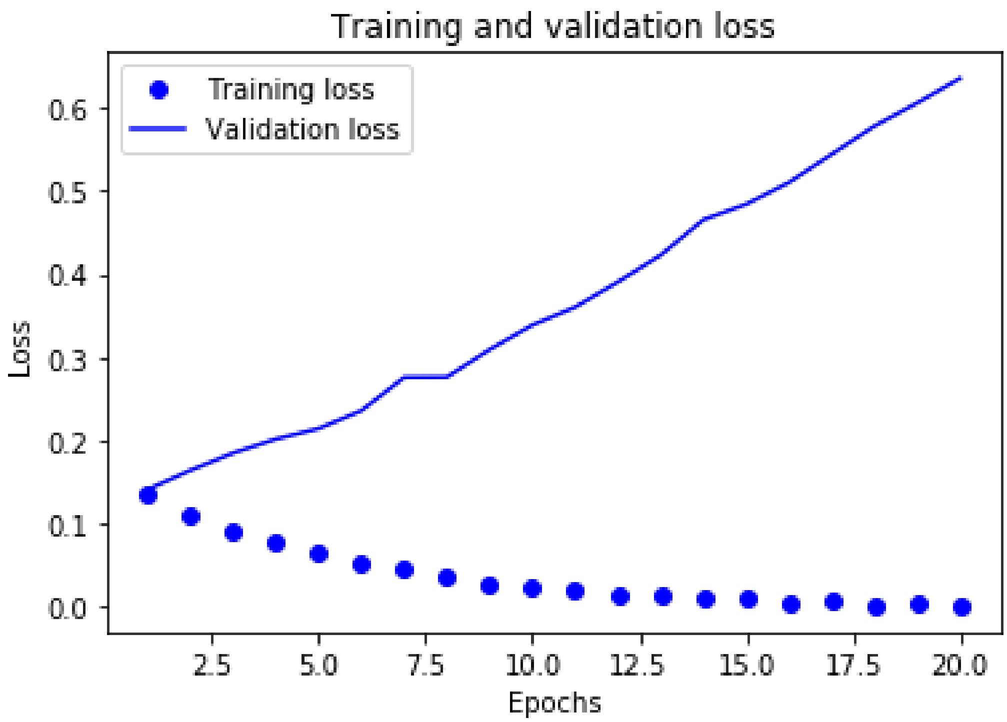
```
accuracy: 0.9955 - val_loss: 0.3602 - val_accuracy: 0.9017
Epoch 12/20
15000/15000 [==============================] - 1s 77us/step - loss: 0.0142 -
accuracy: 0.9984 - val_loss: 0.3905 - val_accuracy: 0.9002
Epoch 13/20
15000/15000 [==============================] - 1s 78us/step - loss: 0.0152 -
accuracy: 0.9971 - val_loss: 0.4226 - val_accuracy: 0.8974
Epoch 14/20
15000/15000 [==============================] - 1s 77us/step - loss: 0.0096 -
accuracy: 0.9991 - val_loss: 0.4653 - val_accuracy: 0.8921
Epoch 15/20
15000/15000 [==============================] - 1s 86us/step - loss: 0.0102 -
accuracy: 0.9978 - val_loss: 0.4838 - val_accuracy: 0.8924
Epoch 16/20
15000/15000 [==============================] - 1s 88us/step - loss: 0.0043 -
accuracy: 0.9998 - val_loss: 0.5099 - val_accuracy: 0.8905
Epoch 17/20
15000/15000 [==============================] - 1s 77us/step - loss: 0.0076 -
accuracy: 0.9983 - val_loss: 0.5439 - val_accuracy: 0.8889
Epoch 18/20
15000/15000 [==============================] - 1s 83us/step - loss: 0.0024 -
accuracy: 0.9999 - val_loss: 0.5777 - val_accuracy: 0.8877
Epoch 19/20
15000/15000 [==============================] - 1s 76us/step - loss: 0.0050 -
accuracy: 0.9990 - val_loss: 0.6057 - val_accuracy: 0.8860
Epoch 20/20
15000/15000 [==============================] - 1s 76us/step - loss: 0.0014 -
accuracy: 1.0000 - val_loss: 0.6349 - val_accuracy: 0.8853
```

[24]:
```
history_dict = history.history
history_dict.keys()
```

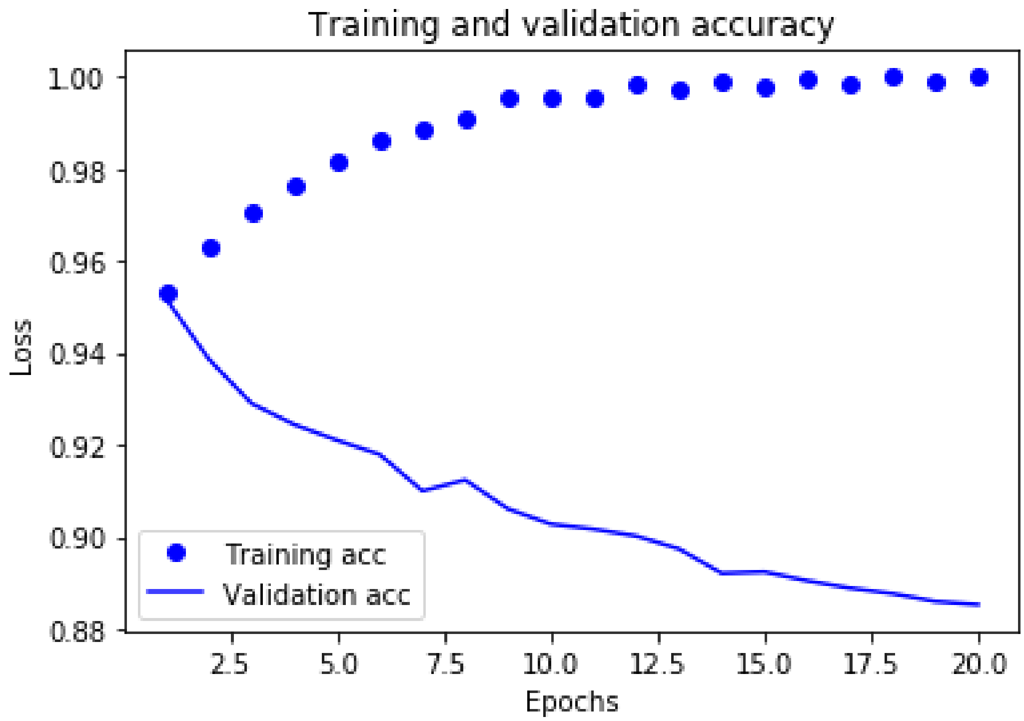
[24]:
```
dict_keys(['val_loss', 'val_accuracy', 'loss', 'accuracy'])
```

[26]:
```
# plotting the training and validation loss
import matplotlib.pyplot as plt

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)

# "bo" is for "blue dot"
plt.plot(epochs, loss, 'bo', label='Training loss')
# b is for "solid blue line"
plt.plot(epochs, val_loss, 'b', label='Validation loss')
```

```
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



[27]:
```
plt.clf()   # clear figure
acc_values = history_dict['accuracy']
val_acc_values = history_dict['val_accuracy']

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



[6]:
```
# Further  experiments
# 1) Using 3 hidden layers instead of 2

from keras import models
from keras import layers

model_1 = models.Sequential()
model_1.add(layers.Dense(16, activation='relu', input_shape=(10000,)))
model_1.add(layers.Dense(16, activation='relu'))
model_1.add(layers.Dense(16, activation='relu'))
model_1.add(layers.Dense(1, activation='sigmoid'))

# compiling the model
model_1.compile(
        optimizer='rmsprop',
        loss='binary_crossentropy',
        metrics=['accuracy']
)
model_1.fit(x_train, y_train, epochs=4, batch_size=512)
results_1 = model_1.evaluate(x_test, y_test)
results_1
```

```
Epoch 1/4
25000/25000 [==============================] - 2s 85us/step - loss: 0.4849 -
```

```
accuracy: 0.8049
Epoch 2/4
25000/25000 [==============================] - 2s 69us/step - loss: 0.2714 -
accuracy: 0.9062
Epoch 3/4
25000/25000 [==============================] - 2s 67us/step - loss: 0.2008 -
accuracy: 0.9303 0s - loss: 0
Epoch 4/4
25000/25000 [==============================] - 2s 63us/step - loss: 0.1661 -
accuracy: 0.9428
25000/25000 [==============================] - 2s 99us/step
```

[6]: [0.30356411926269533, 0.8831999897956848]

[7]:
```python
# Further  experiments
# 1) using 3 hidden layers still
# 2) additionally using layers with more hidden units: 64

from keras import models
from keras import layers

model_2 = models.Sequential()
model_2.add(layers.Dense(64, activation='relu', input_shape=(10000,)))
model_2.add(layers.Dense(64, activation='relu'))
model_2.add(layers.Dense(64, activation='relu'))
model_2.add(layers.Dense(1, activation='sigmoid'))

# compiling the model
model_2.compile(
        optimizer='rmsprop',
        loss='binary_crossentropy',
        metrics=['accuracy']
)
model_2.fit(x_train, y_train, epochs=4, batch_size=512)
results_2 = model_2.evaluate(x_test, y_test)
results_2
```

```
Epoch 1/4
25000/25000 [==============================] - 2s 84us/step - loss: 0.4303 -
accuracy: 0.8077
Epoch 2/4
25000/25000 [==============================] - 2s 71us/step - loss: 0.2391 -
accuracy: 0.9075
Epoch 3/4
25000/25000 [==============================] - 2s 73us/step - loss: 0.1802 -
accuracy: 0.9316
Epoch 4/4
25000/25000 [==============================] - 2s 74us/step - loss: 0.1372 -
```

```
accuracy: 0.9484
25000/25000 [==============================] - 3s 139us/step
```

[7]:
```
[0.3471760097694397, 0.8767600059509277]
```