In [1]:

```
from keras.datasets import imdb
(train_data, train_labels), (test_data, test_labels) = imdb.load_data(num_words = 10000)
train_data[0]
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/imdb.np
z
17464789/17464789 [==============================] - 1s 0us/step
```

Out[1]:

```
[1,
 14,
 22,
 16,
 43,
 530,
 973,
 1622,
 1385,
 65,
 458,
 4468,
 66,
 3941,
 4,
 173,
 36,
 256,
 5,
 25,
 100,
 43,
 838,
 112,
 50,
 670,
 2,
 9,
 35,
 480,
 284,
 5,
 150,
 4,
 172,
 112,
 167,
 2,
 336,
 385,
 39,
 4,
 172,
 4536,
 1111,
 17,
 546,
 38,
 13,
 447,
 4,
 192,
 50,
 16,
 6,
 147,
 2025,
 19,
```

14,
22,
4,
1920,
4613,
469,
4,
22,
71,
87,
12,
16,
43,
530,
38,
76,
15,
13,
1247,
4,
22,
17,
515,
17,
12,
16,
626,
18,
2,
5,
62,
386,
12,
8,
316,
8,
106,
5,
4,
2223,
5244,
16,
480,
66,
3785,
33,
4,
130,
12,
16,
38,
619,
5,
25,
124,
51,
36,
135,
48,
25,
1415,
33,
6,
22,
12,
215,
28,
77,
52,
5,
14,
407,

16,
82,
2,
8,
4,
107,
117,
5952,
15,
256,
4,
2,
7,
3766,
5,
723,
36,
71,
43,
530,
476,
26,
400,
317,
46,
7,
4,
2,
1029,
13,
104,
88,
4,
381,
15,
297,
98,
32,
2071,
56,
26,
141,
6,
194,
7486,
18,
4,
226,
22,
21,
134,
476,
26,
480,
5,
144,
30,
5535,
18,
51,
36,
28,
224,
92,
25,
104,
4,
226,
65,
16,
38,
1334,

```
 88,
 12,
 16,
 283,
 5,
 16,
 4472,
 113,
 103,
 32,
 15,
 16,
 5345,
 19,
 178,
 32]
```

In [2]:

```
train_labels[0]
```

Out[2]:

```
1
```

In [3]:

```
word_index = imdb.get_word_index()

reverse_word_index = dict([(value, key) for (key, value) in word_index.items()])

decoded_review = ' '.join([reverse_word_index.get(i-3, '?') for i in train_data[0]])

decoded_review
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/imdb_wo
rd_index.json
1641221/1641221 [==============================] - 0s 0us/step
```

Out[3]:

```
"? this film was just brilliant casting location scenery story direction everyone's reall
y suited the part they played and you could just imagine being there robert ? is an amazi
ng actor and now the same being director ? father came from the same scottish island as m
yself so i loved the fact there was a real connection with this film the witty remarks th
roughout the film were great it was just brilliant so much that i bought the film as soon
as it was released for ? and would recommend it to everyone to watch and the fly fishing
was amazing really cried at the end it was so sad and you know what they say if you cry at
a film it must have been good and this definitely was also ? to the two little boy's that
played the ? of norman and paul they were just brilliant children are often left out of t
he ? list i think because the stars that play them all grown up are such a big profile fo
r the whole film but these children are amazing and should be praised for what they have
done don't you think the whole story was so lovely because it was true and was someone's
life after all that was shared with us all"
```

In [5]:

```
import numpy as np

def vectorize_sequences(sequences, dimension=10000):
    results = np.zeros((len(sequences), dimension))
    for i,sequence in enumerate(sequences):
        results[i,sequence] = 1
    return results

X_train = vectorize_sequences(train_data)

X_test = vectorize_sequences(test_data)

X_train[0]
```

Out[5]:

```
array([0., 1., 1., ..., 0., 0., 0.])
```

In [6]:

```
y_train = np.asarray(train_labels).astype('float32')
y_test  = np.asarray(test_labels).astype('float32')
```

In [7]:

```
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'))
```

In [8]:

```
from keras import optimizers
from keras import losses
from keras import metrics

model.compile(optimizer=optimizers.RMSprop(lr=0.001),
              loss = losses.binary_crossentropy,
              metrics = [metrics.binary_accuracy])
```

```
/usr/local/lib/python3.8/dist-packages/keras/optimizers/optimizer_v2/rmsprop.py:143: User
Warning: The `lr` argument is deprecated, use `learning_rate` instead.
  super().__init__(name, **kwargs)
```

In [9]:

```
X_val = X_train[:10000]
partial_X_train = X_train[10000:]

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

In [11]:

```
history = model.fit(partial_X_train, partial_y_train, epochs=200, batch_size=512, valida
tion_data=(X_val, y_val))
```

```
Epoch 1/200
30/30 [==============================] - 3s 78ms/step - loss: 0.5460 - binary_accuracy: 0
.7587 - val_loss: 0.4510 - val_binary_accuracy: 0.8200
Epoch 2/200
30/30 [==============================] - 2s 51ms/step - loss: 0.3463 - binary_accuracy: 0
.8949 - val_loss: 0.3590 - val_binary_accuracy: 0.8571
Epoch 3/200
30/30 [==============================] - 2s 64ms/step - loss: 0.2526 - binary_accuracy: 0
.9221 - val_loss: 0.3079 - val_binary_accuracy: 0.8776
Epoch 4/200
30/30 [==============================] - 1s 36ms/step - loss: 0.1923 - binary_accuracy: 0
.9394 - val_loss: 0.2874 - val_binary_accuracy: 0.8859
Epoch 5/200
30/30 [==============================] - 1s 37ms/step - loss: 0.1557 - binary_accuracy: 0
.9507 - val_loss: 0.3029 - val_binary_accuracy: 0.8798
Epoch 6/200
30/30 [==============================] - 1s 37ms/step - loss: 0.1249 - binary_accuracy: 0
.9621 - val_loss: 0.2896 - val_binary_accuracy: 0.8858
Epoch 7/200
30/30 [==============================] - 1s 37ms/step - loss: 0.1062 - binary_accuracy: 0
.9691 - val_loss: 0.3453 - val_binary_accuracy: 0.8717
Epoch 8/200
30/30 [==============================] - 1s 39ms/step - loss: 0.0883 - binary_accuracy: 0
.9750 - val_loss: 0.3124 - val_binary_accuracy: 0.8848
Epoch 9/200
30/30 [==============================] - 1s 38ms/step - loss: 0.0693 - binary_accuracy: 0
.9827 - val_loss: 0.3411 - val_binary_accuracy: 0.8814
```

```
Epoch 10/200
30/30 [==============================] - 1s 39ms/step - loss: 0.0581 - binary_accuracy: 0
.9867 - val_loss: 0.3596 - val_binary_accuracy: 0.8807
Epoch 11/200
30/30 [==============================] - 1s 39ms/step - loss: 0.0471 - binary_accuracy: 0
.9895 - val_loss: 0.4167 - val_binary_accuracy: 0.8719
Epoch 12/200
30/30 [==============================] - 2s 52ms/step - loss: 0.0384 - binary_accuracy: 0
.9913 - val_loss: 0.4099 - val_binary_accuracy: 0.8776
Epoch 13/200
30/30 [==============================] - 2s 57ms/step - loss: 0.0288 - binary_accuracy: 0
.9948 - val_loss: 0.4757 - val_binary_accuracy: 0.8669
Epoch 14/200
30/30 [==============================] - 1s 42ms/step - loss: 0.0236 - binary_accuracy: 0
.9962 - val_loss: 0.4655 - val_binary_accuracy: 0.8754
Epoch 15/200
30/30 [==============================] - 1s 38ms/step - loss: 0.0180 - binary_accuracy: 0
.9979 - val_loss: 0.5112 - val_binary_accuracy: 0.8690
Epoch 16/200
30/30 [==============================] - 1s 38ms/step - loss: 0.0143 - binary_accuracy: 0
.9984 - val_loss: 0.5302 - val_binary_accuracy: 0.8717
Epoch 17/200
30/30 [==============================] - 1s 38ms/step - loss: 0.0106 - binary_accuracy: 0
.9989 - val_loss: 0.5775 - val_binary_accuracy: 0.8684
Epoch 18/200
30/30 [==============================] - 1s 37ms/step - loss: 0.0066 - binary_accuracy: 0
.9996 - val_loss: 0.5961 - val_binary_accuracy: 0.8701
Epoch 19/200
30/30 [==============================] - 1s 39ms/step - loss: 0.0062 - binary_accuracy: 0
.9995 - val_loss: 0.6280 - val_binary_accuracy: 0.8709
Epoch 20/200
30/30 [==============================] - 1s 37ms/step - loss: 0.0056 - binary_accuracy: 0
.9992 - val_loss: 0.6603 - val_binary_accuracy: 0.8682
Epoch 21/200
30/30 [==============================] - 1s 37ms/step - loss: 0.0024 - binary_accuracy: 0
.9999 - val_loss: 0.7040 - val_binary_accuracy: 0.8690
Epoch 22/200
30/30 [==============================] - 1s 36ms/step - loss: 0.0038 - binary_accuracy: 0
.9994 - val_loss: 0.7291 - val_binary_accuracy: 0.8678
Epoch 23/200
30/30 [==============================] - 2s 68ms/step - loss: 0.0013 - binary_accuracy: 1
.0000 - val_loss: 0.7646 - val_binary_accuracy: 0.8668
Epoch 24/200
30/30 [==============================] - 1s 47ms/step - loss: 0.0073 - binary_accuracy: 0
.9982 - val_loss: 0.7977 - val_binary_accuracy: 0.8667
Epoch 25/200
30/30 [==============================] - 1s 38ms/step - loss: 7.4533e-04 - binary_accurac
y: 1.0000 - val_loss: 0.8163 - val_binary_accuracy: 0.8669
Epoch 26/200
30/30 [==============================] - 1s 41ms/step - loss: 6.2432e-04 - binary_accurac
y: 1.0000 - val_loss: 0.8515 - val_binary_accuracy: 0.8649
Epoch 27/200
30/30 [==============================] - 1s 36ms/step - loss: 0.0023 - binary_accuracy: 0
.9993 - val_loss: 0.9130 - val_binary_accuracy: 0.8618
Epoch 28/200
30/30 [==============================] - 1s 37ms/step - loss: 3.9266e-04 - binary_accurac
y: 1.0000 - val_loss: 0.9086 - val_binary_accuracy: 0.8654
Epoch 29/200
30/30 [==============================] - 1s 36ms/step - loss: 2.9007e-04 - binary_accurac
y: 1.0000 - val_loss: 0.9428 - val_binary_accuracy: 0.8647
Epoch 30/200
30/30 [==============================] - 1s 45ms/step - loss: 0.0019 - binary_accuracy: 0
.9993 - val_loss: 0.9805 - val_binary_accuracy: 0.8648
Epoch 31/200
30/30 [==============================] - 2s 52ms/step - loss: 1.5481e-04 - binary_accurac
y: 1.0000 - val_loss: 1.0003 - val_binary_accuracy: 0.8643
Epoch 32/200
30/30 [==============================] - 1s 44ms/step - loss: 1.3016e-04 - binary_accurac
y: 1.0000 - val_loss: 1.0234 - val_binary_accuracy: 0.8647
Epoch 33/200
30/30 [==============================] - 2s 66ms/step - loss: 1.0169e-04 - binary_accurac
y: 1.0000 - val_loss: 1.0676 - val_binary_accuracy: 0.8639
```

```
Epoch 34/200
30/30 [==============================] - 1s 39ms/step - loss: 0.0016 - binary_accuracy: 0
.9997 - val_loss: 1.1085 - val_binary_accuracy: 0.8612
Epoch 35/200
30/30 [==============================] - 1s 38ms/step - loss: 5.6005e-05 - binary_accurac
y: 1.0000 - val_loss: 1.1214 - val_binary_accuracy: 0.8624
Epoch 36/200
30/30 [==============================] - 1s 40ms/step - loss: 4.5256e-05 - binary_accurac
y: 1.0000 - val_loss: 1.1528 - val_binary_accuracy: 0.8624
Epoch 37/200
30/30 [==============================] - 1s 38ms/step - loss: 3.6488e-05 - binary_accurac
y: 1.0000 - val_loss: 1.1909 - val_binary_accuracy: 0.8615
Epoch 38/200
30/30 [==============================] - 1s 37ms/step - loss: 0.0011 - binary_accuracy: 0
.9997 - val_loss: 1.2460 - val_binary_accuracy: 0.8603
Epoch 39/200
30/30 [==============================] - 1s 36ms/step - loss: 2.4443e-05 - binary_accurac
y: 1.0000 - val_loss: 1.2431 - val_binary_accuracy: 0.8618
Epoch 40/200
30/30 [==============================] - 1s 41ms/step - loss: 1.7042e-05 - binary_accurac
y: 1.0000 - val_loss: 1.2596 - val_binary_accuracy: 0.8611
Epoch 41/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3660e-05 - binary_accurac
y: 1.0000 - val_loss: 1.2923 - val_binary_accuracy: 0.8601
Epoch 42/200
30/30 [==============================] - 1s 44ms/step - loss: 1.0090e-05 - binary_accurac
y: 1.0000 - val_loss: 1.3412 - val_binary_accuracy: 0.8623
Epoch 43/200
30/30 [==============================] - 2s 68ms/step - loss: 6.8555e-06 - binary_accurac
y: 1.0000 - val_loss: 1.6892 - val_binary_accuracy: 0.8448
Epoch 44/200
30/30 [==============================] - 1s 44ms/step - loss: 4.2557e-04 - binary_accurac
y: 0.9999 - val_loss: 1.4373 - val_binary_accuracy: 0.8585
Epoch 45/200
30/30 [==============================] - 1s 39ms/step - loss: 4.8367e-06 - binary_accurac
y: 1.0000 - val_loss: 1.4420 - val_binary_accuracy: 0.8597
Epoch 46/200
30/30 [==============================] - 1s 38ms/step - loss: 3.4609e-06 - binary_accurac
y: 1.0000 - val_loss: 1.4532 - val_binary_accuracy: 0.8604
Epoch 47/200
30/30 [==============================] - 1s 38ms/step - loss: 2.7394e-06 - binary_accurac
y: 1.0000 - val_loss: 1.4757 - val_binary_accuracy: 0.8613
Epoch 48/200
30/30 [==============================] - 1s 39ms/step - loss: 1.9741e-06 - binary_accurac
y: 1.0000 - val_loss: 1.5251 - val_binary_accuracy: 0.8618
Epoch 49/200
30/30 [==============================] - 1s 37ms/step - loss: 2.6215e-04 - binary_accurac
y: 0.9999 - val_loss: 1.5843 - val_binary_accuracy: 0.8581
Epoch 50/200
30/30 [==============================] - 1s 38ms/step - loss: 1.6769e-06 - binary_accurac
y: 1.0000 - val_loss: 1.5733 - val_binary_accuracy: 0.8597
Epoch 51/200
30/30 [==============================] - 1s 38ms/step - loss: 1.2269e-06 - binary_accurac
y: 1.0000 - val_loss: 1.5785 - val_binary_accuracy: 0.8603
Epoch 52/200
30/30 [==============================] - 2s 51ms/step - loss: 1.0419e-06 - binary_accurac
y: 1.0000 - val_loss: 1.5852 - val_binary_accuracy: 0.8612
Epoch 53/200
30/30 [==============================] - 2s 66ms/step - loss: 8.8423e-07 - binary_accurac
y: 1.0000 - val_loss: 1.6033 - val_binary_accuracy: 0.8620
Epoch 54/200
30/30 [==============================] - 1s 39ms/step - loss: 6.7071e-07 - binary_accurac
y: 1.0000 - val_loss: 1.6469 - val_binary_accuracy: 0.8613
Epoch 55/200
30/30 [==============================] - 1s 38ms/step - loss: 4.4588e-07 - binary_accurac
y: 1.0000 - val_loss: 1.7174 - val_binary_accuracy: 0.8602
Epoch 56/200
30/30 [==============================] - 1s 39ms/step - loss: 2.4888e-07 - binary_accurac
y: 1.0000 - val_loss: 1.7842 - val_binary_accuracy: 0.8600
Epoch 57/200
30/30 [==============================] - 1s 41ms/step - loss: 1.4155e-07 - binary_accurac
y: 1.0000 - val_loss: 1.8422 - val_binary_accuracy: 0.8613
Epoch 58/200
```

```
Epoch 58/200
30/30 [==============================] - 1s 38ms/step - loss: 8.7729e-08 - binary_accurac
y: 1.0000 - val_loss: 1.8966 - val_binary_accuracy: 0.8607
Epoch 59/200
30/30 [==============================] - 1s 41ms/step - loss: 5.5967e-08 - binary_accurac
y: 1.0000 - val_loss: 1.9443 - val_binary_accuracy: 0.8610
Epoch 60/200
30/30 [==============================] - 1s 39ms/step - loss: 3.9662e-08 - binary_accurac
y: 1.0000 - val_loss: 1.9871 - val_binary_accuracy: 0.8605
Epoch 61/200
30/30 [==============================] - 1s 38ms/step - loss: 2.9172e-08 - binary_accurac
y: 1.0000 - val_loss: 2.0179 - val_binary_accuracy: 0.8610
Epoch 62/200
30/30 [==============================] - 2s 58ms/step - loss: 2.2962e-08 - binary_accurac
y: 1.0000 - val_loss: 2.0446 - val_binary_accuracy: 0.8602
Epoch 63/200
30/30 [==============================] - 2s 59ms/step - loss: 1.8687e-08 - binary_accurac
y: 1.0000 - val_loss: 2.0705 - val_binary_accuracy: 0.8597
Epoch 64/200
30/30 [==============================] - 1s 38ms/step - loss: 1.5608e-08 - binary_accurac
y: 1.0000 - val_loss: 2.0891 - val_binary_accuracy: 0.8605
Epoch 65/200
30/30 [==============================] - 1s 39ms/step - loss: 1.3279e-08 - binary_accurac
y: 1.0000 - val_loss: 2.1098 - val_binary_accuracy: 0.8596
Epoch 66/200
30/30 [==============================] - 1s 38ms/step - loss: 1.1606e-08 - binary_accurac
y: 1.0000 - val_loss: 2.1249 - val_binary_accuracy: 0.8603
Epoch 67/200
30/30 [==============================] - 1s 39ms/step - loss: 1.0184e-08 - binary_accurac
y: 1.0000 - val_loss: 2.1404 - val_binary_accuracy: 0.8596
Epoch 68/200
30/30 [==============================] - 1s 39ms/step - loss: 9.1640e-09 - binary_accurac
y: 1.0000 - val_loss: 2.1558 - val_binary_accuracy: 0.8602
Epoch 69/200
30/30 [==============================] - 1s 40ms/step - loss: 8.3319e-09 - binary_accurac
y: 1.0000 - val_loss: 2.1690 - val_binary_accuracy: 0.8600
Epoch 70/200
30/30 [==============================] - 1s 38ms/step - loss: 7.5633e-09 - binary_accurac
y: 1.0000 - val_loss: 2.1764 - val_binary_accuracy: 0.8601
Epoch 71/200
30/30 [==============================] - 1s 40ms/step - loss: 6.9276e-09 - binary_accurac
y: 1.0000 - val_loss: 2.1871 - val_binary_accuracy: 0.8600
Epoch 72/200
30/30 [==============================] - 2s 57ms/step - loss: 6.4226e-09 - binary_accurac
y: 1.0000 - val_loss: 2.1978 - val_binary_accuracy: 0.8598
Epoch 73/200
30/30 [==============================] - 2s 66ms/step - loss: 5.9912e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2052 - val_binary_accuracy: 0.8603
Epoch 74/200
30/30 [==============================] - 1s 40ms/step - loss: 5.5725e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2147 - val_binary_accuracy: 0.8596
Epoch 75/200
30/30 [==============================] - 1s 37ms/step - loss: 5.2664e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2232 - val_binary_accuracy: 0.8598
Epoch 76/200
30/30 [==============================] - 1s 36ms/step - loss: 4.9950e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2293 - val_binary_accuracy: 0.8596
Epoch 77/200
30/30 [==============================] - 1s 38ms/step - loss: 4.7112e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2363 - val_binary_accuracy: 0.8598
Epoch 78/200
30/30 [==============================] - 1s 39ms/step - loss: 4.4979e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2426 - val_binary_accuracy: 0.8598
Epoch 79/200
30/30 [==============================] - 1s 40ms/step - loss: 4.2916e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2489 - val_binary_accuracy: 0.8597
Epoch 80/200
30/30 [==============================] - 1s 38ms/step - loss: 4.1007e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2547 - val_binary_accuracy: 0.8596
Epoch 81/200
30/30 [==============================] - 1s 40ms/step - loss: 3.9173e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2607 - val_binary_accuracy: 0.8599
```

```
Epoch 82/200
30/30 [==============================] - 2s 52ms/step - loss: 3.7778e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2659 - val_binary_accuracy: 0.8599
Epoch 83/200
30/30 [==============================] - 2s 64ms/step - loss: 3.6320e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2711 - val_binary_accuracy: 0.8597
Epoch 84/200
30/30 [==============================] - 1s 38ms/step - loss: 3.4941e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2770 - val_binary_accuracy: 0.8599
Epoch 85/200
30/30 [==============================] - 1s 36ms/step - loss: 3.3921e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2820 - val_binary_accuracy: 0.8597
Epoch 86/200
30/30 [==============================] - 1s 36ms/step - loss: 3.2619e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2869 - val_binary_accuracy: 0.8598
Epoch 87/200
30/30 [==============================] - 1s 40ms/step - loss: 3.1766e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2900 - val_binary_accuracy: 0.8597
Epoch 88/200
30/30 [==============================] - 1s 40ms/step - loss: 3.0557e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2963 - val_binary_accuracy: 0.8599
Epoch 89/200
30/30 [==============================] - 1s 40ms/step - loss: 2.9884e-09 - binary_accurac
y: 1.0000 - val_loss: 2.2992 - val_binary_accuracy: 0.8598
Epoch 90/200
30/30 [==============================] - 1s 38ms/step - loss: 2.9103e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3030 - val_binary_accuracy: 0.8598
Epoch 91/200
30/30 [==============================] - 1s 39ms/step - loss: 2.8210e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3075 - val_binary_accuracy: 0.8598
Epoch 92/200
30/30 [==============================] - 2s 53ms/step - loss: 2.7564e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3107 - val_binary_accuracy: 0.8598
Epoch 93/200
30/30 [==============================] - 2s 57ms/step - loss: 2.6974e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3134 - val_binary_accuracy: 0.8598
Epoch 94/200
30/30 [==============================] - 1s 42ms/step - loss: 2.6133e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3171 - val_binary_accuracy: 0.8599
Epoch 95/200
30/30 [==============================] - 1s 39ms/step - loss: 2.5608e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3206 - val_binary_accuracy: 0.8598
Epoch 96/200
30/30 [==============================] - 1s 41ms/step - loss: 2.5105e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3240 - val_binary_accuracy: 0.8598
Epoch 97/200
30/30 [==============================] - 1s 42ms/step - loss: 2.4602e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3274 - val_binary_accuracy: 0.8597
Epoch 98/200
30/30 [==============================] - 1s 39ms/step - loss: 2.4293e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3298 - val_binary_accuracy: 0.8597
Epoch 99/200
30/30 [==============================] - 1s 42ms/step - loss: 2.3661e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3336 - val_binary_accuracy: 0.8596
Epoch 100/200
30/30 [==============================] - 1s 38ms/step - loss: 2.3357e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3372 - val_binary_accuracy: 0.8596
Epoch 101/200
30/30 [==============================] - 1s 37ms/step - loss: 2.2862e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3403 - val_binary_accuracy: 0.8594
Epoch 102/200
30/30 [==============================] - 2s 57ms/step - loss: 2.2612e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3422 - val_binary_accuracy: 0.8595
Epoch 103/200
30/30 [==============================] - 2s 64ms/step - loss: 2.2137e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3450 - val_binary_accuracy: 0.8595
Epoch 104/200
30/30 [==============================] - 1s 38ms/step - loss: 2.1838e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3474 - val_binary_accuracy: 0.8594
Epoch 105/200
30/30 [==============================] - 1s 38ms/step - loss: 2.1375e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3499 - val_binary_accuracy: 0.8594
Epoch 106/200
```

```
Epoch 106/200
30/30 [==============================] - 1s 37ms/step - loss: 2.1178e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3524 - val_binary_accuracy: 0.8594
Epoch 107/200
30/30 [==============================] - 1s 38ms/step - loss: 2.0880e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3551 - val_binary_accuracy: 0.8596
Epoch 108/200
30/30 [==============================] - 1s 36ms/step - loss: 2.0593e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3575 - val_binary_accuracy: 0.8596
Epoch 109/200
30/30 [==============================] - 1s 36ms/step - loss: 2.0251e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3604 - val_binary_accuracy: 0.8598
Epoch 110/200
30/30 [==============================] - 1s 38ms/step - loss: 2.0158e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3624 - val_binary_accuracy: 0.8595
Epoch 111/200
30/30 [==============================] - 1s 40ms/step - loss: 1.9875e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3647 - val_binary_accuracy: 0.8597
Epoch 112/200
30/30 [==============================] - 1s 47ms/step - loss: 1.9628e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3670 - val_binary_accuracy: 0.8597
Epoch 113/200
30/30 [==============================] - 2s 67ms/step - loss: 1.9403e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3693 - val_binary_accuracy: 0.8597
Epoch 114/200
30/30 [==============================] - 1s 39ms/step - loss: 1.9268e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3711 - val_binary_accuracy: 0.8597
Epoch 115/200
30/30 [==============================] - 1s 38ms/step - loss: 1.8845e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3736 - val_binary_accuracy: 0.8595
Epoch 116/200
30/30 [==============================] - 1s 38ms/step - loss: 1.8810e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3752 - val_binary_accuracy: 0.8596
Epoch 117/200
30/30 [==============================] - 1s 37ms/step - loss: 1.8540e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3775 - val_binary_accuracy: 0.8595
Epoch 118/200
30/30 [==============================] - 1s 36ms/step - loss: 1.8403e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3799 - val_binary_accuracy: 0.8596
Epoch 119/200
30/30 [==============================] - 1s 37ms/step - loss: 1.8213e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3819 - val_binary_accuracy: 0.8597
Epoch 120/200
30/30 [==============================] - 1s 39ms/step - loss: 1.8046e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3838 - val_binary_accuracy: 0.8597
Epoch 121/200
30/30 [==============================] - 1s 37ms/step - loss: 1.7903e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3851 - val_binary_accuracy: 0.8595
Epoch 122/200
30/30 [==============================] - 2s 52ms/step - loss: 1.7599e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3876 - val_binary_accuracy: 0.8597
Epoch 123/200
30/30 [==============================] - 2s 64ms/step - loss: 1.7622e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3892 - val_binary_accuracy: 0.8597
Epoch 124/200
30/30 [==============================] - 1s 37ms/step - loss: 1.7466e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3905 - val_binary_accuracy: 0.8597
Epoch 125/200
30/30 [==============================] - 1s 37ms/step - loss: 1.7258e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3928 - val_binary_accuracy: 0.8597
Epoch 126/200
30/30 [==============================] - 1s 40ms/step - loss: 1.7155e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3949 - val_binary_accuracy: 0.8597
Epoch 127/200
30/30 [==============================] - 1s 40ms/step - loss: 1.7085e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3959 - val_binary_accuracy: 0.8595
Epoch 128/200
30/30 [==============================] - 1s 37ms/step - loss: 1.6861e-09 - binary_accurac
y: 1.0000 - val_loss: 2.3981 - val_binary_accuracy: 0.8597
Epoch 129/200
30/30 [==============================] - 1s 40ms/step - loss: 1.6807e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4000 - val_binary_accuracy: 0.8597
```

```
Epoch 130/200
30/30 [==============================] - 1s 38ms/step - loss: 1.6747e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4016 - val_binary_accuracy: 0.8596
Epoch 131/200
30/30 [==============================] - 1s 36ms/step - loss: 1.6626e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4035 - val_binary_accuracy: 0.8597
Epoch 132/200
30/30 [==============================] - 1s 43ms/step - loss: 1.6560e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4046 - val_binary_accuracy: 0.8596
Epoch 133/200
30/30 [==============================] - 2s 64ms/step - loss: 1.6480e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4059 - val_binary_accuracy: 0.8596
Epoch 134/200
30/30 [==============================] - 1s 45ms/step - loss: 1.6311e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4083 - val_binary_accuracy: 0.8595
Epoch 135/200
30/30 [==============================] - 1s 39ms/step - loss: 1.6265e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4095 - val_binary_accuracy: 0.8594
Epoch 136/200
30/30 [==============================] - 1s 38ms/step - loss: 1.6206e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4102 - val_binary_accuracy: 0.8597
Epoch 137/200
30/30 [==============================] - 1s 39ms/step - loss: 1.5845e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4125 - val_binary_accuracy: 0.8595
Epoch 138/200
30/30 [==============================] - 1s 38ms/step - loss: 1.6004e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4139 - val_binary_accuracy: 0.8594
Epoch 139/200
30/30 [==============================] - 1s 41ms/step - loss: 1.5857e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4153 - val_binary_accuracy: 0.8596
Epoch 140/200
30/30 [==============================] - 1s 41ms/step - loss: 1.5833e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4172 - val_binary_accuracy: 0.8595
Epoch 141/200
30/30 [==============================] - 1s 41ms/step - loss: 1.5710e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4182 - val_binary_accuracy: 0.8596
Epoch 142/200
30/30 [==============================] - 1s 41ms/step - loss: 1.5682e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4190 - val_binary_accuracy: 0.8594
Epoch 143/200
30/30 [==============================] - 2s 64ms/step - loss: 1.5531e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4211 - val_binary_accuracy: 0.8594
Epoch 144/200
30/30 [==============================] - 1s 45ms/step - loss: 1.5552e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4226 - val_binary_accuracy: 0.8595
Epoch 145/200
30/30 [==============================] - 1s 42ms/step - loss: 1.5430e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4238 - val_binary_accuracy: 0.8595
Epoch 146/200
30/30 [==============================] - 1s 42ms/step - loss: 1.5379e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4250 - val_binary_accuracy: 0.8595
Epoch 147/200
30/30 [==============================] - 1s 40ms/step - loss: 1.5363e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4263 - val_binary_accuracy: 0.8596
Epoch 148/200
30/30 [==============================] - 1s 40ms/step - loss: 1.5277e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4278 - val_binary_accuracy: 0.8596
Epoch 149/200
30/30 [==============================] - 1s 40ms/step - loss: 1.5249e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4289 - val_binary_accuracy: 0.8596
Epoch 150/200
30/30 [==============================] - 1s 42ms/step - loss: 1.5214e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4300 - val_binary_accuracy: 0.8596
Epoch 151/200
30/30 [==============================] - 1s 39ms/step - loss: 1.5157e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4311 - val_binary_accuracy: 0.8596
Epoch 152/200
30/30 [==============================] - 2s 52ms/step - loss: 1.5111e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4327 - val_binary_accuracy: 0.8597
Epoch 153/200
30/30 [==============================] - 2s 66ms/step - loss: 1.5046e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4334 - val_binary_accuracy: 0.8596
Epoch 154/200
```

```
Epoch 154/200
30/30 [==============================] - 1s 40ms/step - loss: 1.4973e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4348 - val_binary_accuracy: 0.8598
Epoch 155/200
30/30 [==============================] - 1s 36ms/step - loss: 1.4956e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4359 - val_binary_accuracy: 0.8598
Epoch 156/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4945e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4369 - val_binary_accuracy: 0.8598
Epoch 157/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4893e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4381 - val_binary_accuracy: 0.8598
Epoch 158/200
30/30 [==============================] - 1s 42ms/step - loss: 1.4770e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4392 - val_binary_accuracy: 0.8597
Epoch 159/200
30/30 [==============================] - 1s 39ms/step - loss: 1.4744e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4407 - val_binary_accuracy: 0.8598
Epoch 160/200
30/30 [==============================] - 1s 40ms/step - loss: 1.4719e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4417 - val_binary_accuracy: 0.8598
Epoch 161/200
30/30 [==============================] - 1s 40ms/step - loss: 1.4698e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4427 - val_binary_accuracy: 0.8598
Epoch 162/200
30/30 [==============================] - 2s 55ms/step - loss: 1.4668e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4438 - val_binary_accuracy: 0.8596
Epoch 163/200
30/30 [==============================] - 2s 64ms/step - loss: 1.4636e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4447 - val_binary_accuracy: 0.8597
Epoch 164/200
30/30 [==============================] - 1s 39ms/step - loss: 1.4601e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4458 - val_binary_accuracy: 0.8596
Epoch 165/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4486e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4467 - val_binary_accuracy: 0.8596
Epoch 166/200
30/30 [==============================] - 1s 41ms/step - loss: 1.4505e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4478 - val_binary_accuracy: 0.8595
Epoch 167/200
30/30 [==============================] - 1s 37ms/step - loss: 1.4493e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4490 - val_binary_accuracy: 0.8593
Epoch 168/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4429e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4500 - val_binary_accuracy: 0.8594
Epoch 169/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4376e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4507 - val_binary_accuracy: 0.8593
Epoch 170/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4363e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4517 - val_binary_accuracy: 0.8593
Epoch 171/200
30/30 [==============================] - 1s 37ms/step - loss: 1.4399e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4525 - val_binary_accuracy: 0.8595
Epoch 172/200
30/30 [==============================] - 1s 47ms/step - loss: 1.4326e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4535 - val_binary_accuracy: 0.8595
Epoch 173/200
30/30 [==============================] - 2s 56ms/step - loss: 1.4284e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4540 - val_binary_accuracy: 0.8596
Epoch 174/200
30/30 [==============================] - 1s 45ms/step - loss: 1.4236e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4553 - val_binary_accuracy: 0.8594
Epoch 175/200
30/30 [==============================] - 1s 41ms/step - loss: 1.4238e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4566 - val_binary_accuracy: 0.8593
Epoch 176/200
30/30 [==============================] - 1s 40ms/step - loss: 1.4189e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4574 - val_binary_accuracy: 0.8595
Epoch 177/200
30/30 [==============================] - 1s 36ms/step - loss: 1.4167e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4582 - val_binary_accuracy: 0.8593
```

```
Epoch 178/200
30/30 [==============================] - 1s 39ms/step - loss: 1.4119e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4589 - val_binary_accuracy: 0.8594
Epoch 179/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4137e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4603 - val_binary_accuracy: 0.8592
Epoch 180/200
30/30 [==============================] - 1s 37ms/step - loss: 1.4078e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4605 - val_binary_accuracy: 0.8594
Epoch 181/200
30/30 [==============================] - 1s 40ms/step - loss: 1.4033e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4622 - val_binary_accuracy: 0.8592
Epoch 182/200
30/30 [==============================] - 1s 38ms/step - loss: 1.4008e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4631 - val_binary_accuracy: 0.8591
Epoch 183/200
30/30 [==============================] - 2s 55ms/step - loss: 1.3935e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4638 - val_binary_accuracy: 0.8591
Epoch 184/200
30/30 [==============================] - 2s 64ms/step - loss: 1.3967e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4643 - val_binary_accuracy: 0.8592
Epoch 185/200
30/30 [==============================] - 1s 37ms/step - loss: 1.3943e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4651 - val_binary_accuracy: 0.8591
Epoch 186/200
30/30 [==============================] - 1s 37ms/step - loss: 1.3909e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4657 - val_binary_accuracy: 0.8593
Epoch 187/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3852e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4665 - val_binary_accuracy: 0.8592
Epoch 188/200
30/30 [==============================] - 1s 37ms/step - loss: 1.3878e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4677 - val_binary_accuracy: 0.8590
Epoch 189/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3817e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4689 - val_binary_accuracy: 0.8588
Epoch 190/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3844e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4694 - val_binary_accuracy: 0.8589
Epoch 191/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3818e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4698 - val_binary_accuracy: 0.8590
Epoch 192/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3811e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4705 - val_binary_accuracy: 0.8591
Epoch 193/200
30/30 [==============================] - 2s 54ms/step - loss: 1.3789e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4713 - val_binary_accuracy: 0.8591
Epoch 194/200
30/30 [==============================] - 2s 55ms/step - loss: 1.3700e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4720 - val_binary_accuracy: 0.8591
Epoch 195/200
30/30 [==============================] - 1s 42ms/step - loss: 1.3665e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4738 - val_binary_accuracy: 0.8589
Epoch 196/200
30/30 [==============================] - 1s 40ms/step - loss: 1.3627e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4738 - val_binary_accuracy: 0.8590
Epoch 197/200
30/30 [==============================] - 1s 39ms/step - loss: 1.3650e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4746 - val_binary_accuracy: 0.8588
Epoch 198/200
30/30 [==============================] - 1s 39ms/step - loss: 1.3654e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4754 - val_binary_accuracy: 0.8588
Epoch 199/200
30/30 [==============================] - 1s 41ms/step - loss: 1.3638e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4759 - val_binary_accuracy: 0.8588
Epoch 200/200
30/30 [==============================] - 1s 38ms/step - loss: 1.3642e-09 - binary_accurac
y: 1.0000 - val_loss: 2.4766 - val_binary_accuracy: 0.8588
```

In [12]:

```
mse_nn, mae_nn = model.evaluate(X_test, y_test)

print('Mean squared error on test data is: ', mse_nn)
print('Mean absolute error on test data is: ', mae_nn)
```

```
782/782 [==============================] - 2s 2ms/step - loss: 2.6892 - binary_accuracy:
0.8452
Mean squared error on test data is:  2.68922758102417
Mean absolute error on test data is:  0.8452000021934509
```