BCHENNU_ASSIGNMENT_1

July 7, 2024

0.0.1 The IMDB Implementation

Loading the IMDB dataset

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

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

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

[ ]:
```
[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]
```

[ ]:

```
train_labels[0]
```

[ ]:

```
1
```

[ ]:

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

[ ]:

```
9999
```

Decoding reviews back to text

[ ]:

```
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]])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/imdb_word_index.json
1641221/1641221 [==============================] - 1s 0us/step
```

0.0.2 Preparing the data

Encoding the integer sequences via multi-hot encoding

[ ]:

```
import numpy as np
def vectorize_sequences(sequences, dimension=10000):
    results = np.zeros((len(sequences), dimension))
    for i, sequence in enumerate(sequences):
        for j in sequence:
            results[i, j] = 1.
    return results
x_train = vectorize_sequences(train_data)
x_test = vectorize_sequences(test_data)
```

[ ]:

```
x_train[0]
```

[ ]:

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

[ ]:

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

0.0.3 Building your model

Model definition

[ ]:
```
from tensorflow import keras
from tensorflow.keras import layers

model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
model
```

[ ]:
```
<keras.src.engine.sequential.Sequential at 0x7d83cbd17df0>
```

Compiling the model

[ ]:
```
model.compile(optimizer="rmsprop",
              loss="binary_crossentropy",
              metrics=["accuracy"])

model
```

[ ]:
```
<keras.src.engine.sequential.Sequential at 0x7d83cbd17df0>
```

0.0.4 Validating your approach

Setting aside a validation set

[ ]:
```
import random
random.seed(10)

x_val = x_train[:10000]
partial_x_train = x_train[10000:]
y_val = y_train[:10000]
partial_y_train = y_train[10000:]
```

Training your model

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

```
Epoch 1/20
30/30 [==============================] - 4s 63ms/step - loss: 0.5131 - accuracy:
0.7745 - val_loss: 0.3918 - val_accuracy: 0.8542
```

```
Epoch 2/20
30/30 [==============================] - 0s 17ms/step - loss: 0.3150 - accuracy:
0.8963 - val_loss: 0.3269 - val_accuracy: 0.8705
Epoch 3/20
30/30 [==============================] - 1s 17ms/step - loss: 0.2360 - accuracy:
0.9213 - val_loss: 0.2824 - val_accuracy: 0.8884
Epoch 4/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1871 - accuracy:
0.9389 - val_loss: 0.2743 - val_accuracy: 0.8906
Epoch 5/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1580 - accuracy:
0.9475 - val_loss: 0.3411 - val_accuracy: 0.8676
Epoch 6/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1354 - accuracy:
0.9556 - val_loss: 0.3288 - val_accuracy: 0.8712
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1157 - accuracy:
0.9633 - val_loss: 0.2969 - val_accuracy: 0.8863
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0985 - accuracy:
0.9709 - val_loss: 0.3286 - val_accuracy: 0.8780
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0857 - accuracy:
0.9743 - val_loss: 0.3282 - val_accuracy: 0.8825
Epoch 10/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0717 - accuracy:
0.9802 - val_loss: 0.3502 - val_accuracy: 0.8788
Epoch 11/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0637 - accuracy:
0.9829 - val_loss: 0.3737 - val_accuracy: 0.8759
Epoch 12/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0529 - accuracy:
0.9879 - val_loss: 0.3911 - val_accuracy: 0.8758
Epoch 13/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0447 - accuracy:
0.9897 - val_loss: 0.4096 - val_accuracy: 0.8765
Epoch 14/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0376 - accuracy:
0.9923 - val_loss: 0.4326 - val_accuracy: 0.8738
Epoch 15/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0358 - accuracy:
0.9914 - val_loss: 0.4565 - val_accuracy: 0.8730
Epoch 16/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0268 - accuracy:
0.9956 - val_loss: 0.4753 - val_accuracy: 0.8729
Epoch 17/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0259 - accuracy:
0.9945 - val_loss: 0.5020 - val_accuracy: 0.8717
```

```
Epoch 18/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0213 - accuracy:
0.9964 - val_loss: 0.5172 - val_accuracy: 0.8715
Epoch 19/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0192 - accuracy:
0.9965 - val_loss: 0.5389 - val_accuracy: 0.8701
Epoch 20/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0108 - accuracy:
0.9995 - val_loss: 0.5891 - val_accuracy: 0.8683
```

[ ]:

```python
history_dict = history.history
history_dict.keys()
```

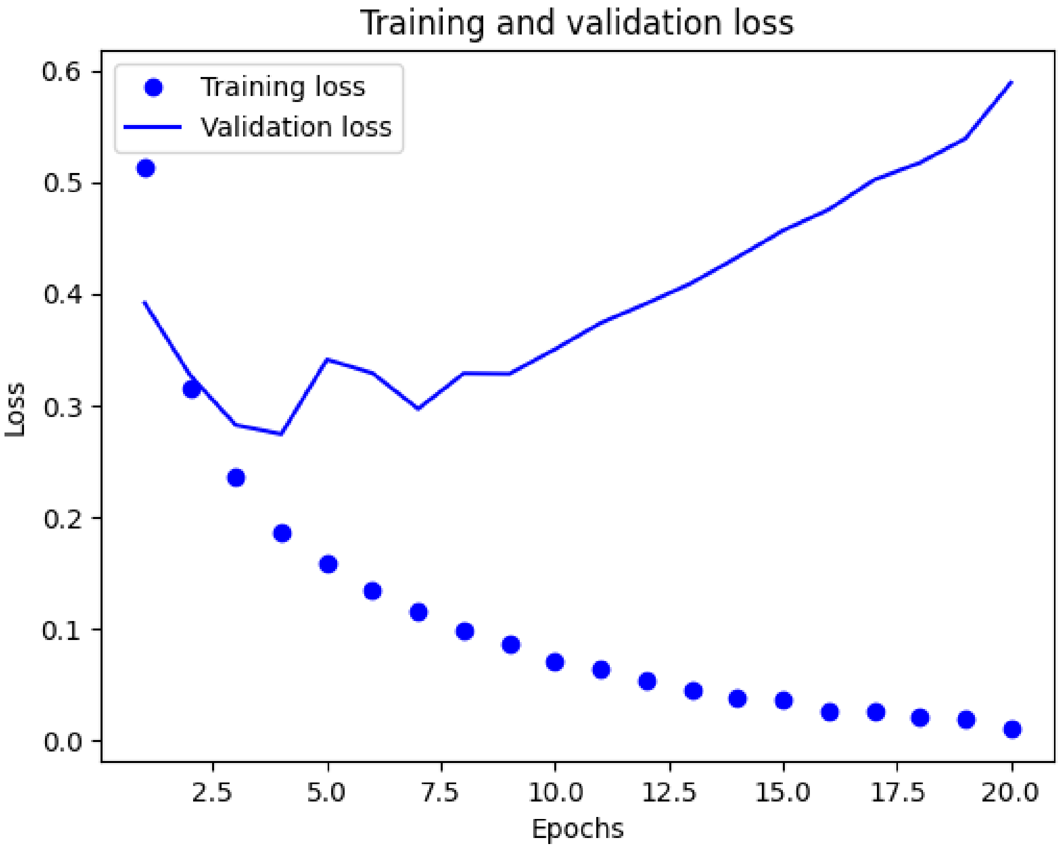
[ ]:

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

Plotting the training and validation loss

[ ]:

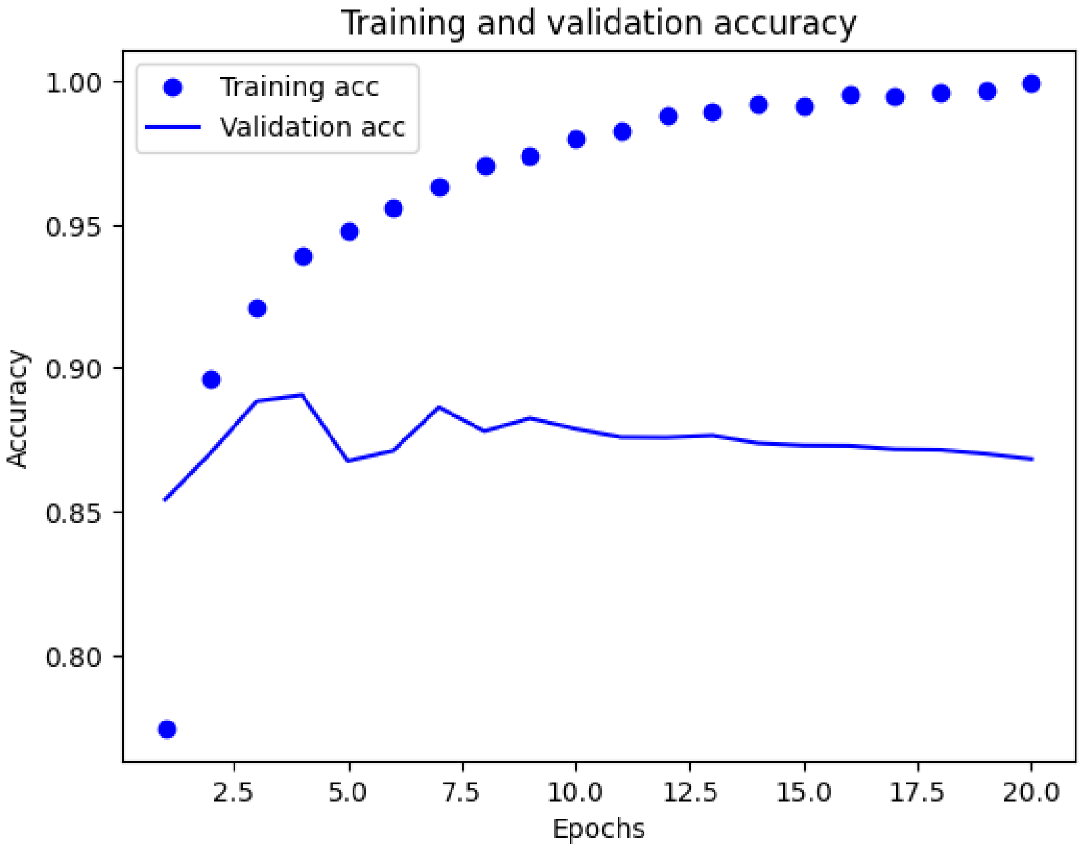
```python
import matplotlib.pyplot as plt
history_dict = history.history
loss_values = history_dict["loss"]
val_loss_values = history_dict["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "bo", label="Training loss")
plt.plot(epochs, val_loss_values, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```



Plotting the training and validation accuracy

[ ]:

```
plt.clf()
acc = history_dict["accuracy"]
val_acc = 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("Accuracy")
plt.legend()
plt.show()
```



Retraining a model from scratch

[ ]:

```
model = keras.Sequential([
    layers.Dense(16, activation="relu"),
    layers.Dense(16, activation="relu"),
    layers.Dense(1, activation="sigmoid")
])
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
49/49 [==============================] - 1s 10ms/step - loss: 0.4699 - accuracy:
0.8105
Epoch 2/4
49/49 [==============================] - 0s 10ms/step - loss: 0.2772 - accuracy:
0.9012
Epoch 3/4
```

```
49/49 [==============================] - 0s 10ms/step - loss: 0.2190 - accuracy:
0.9214
Epoch 4/4
49/49 [==============================] - 0s 10ms/step - loss: 0.1859 - accuracy:
0.9340
782/782 [==============================] - 2s 2ms/step - loss: 0.2816 -
accuracy: 0.8870
```

```
[ ]: results
```

```
[ ]: [0.28161880373954773, 0.8869600296020508]
```

The model yeilds 88% accuracy with loss of 28.1%

```
[ ]: model.predict(x_test)
```

```
782/782 [==============================] - 1s 2ms/step
```

```
[ ]: array([[0.23986444],
            [0.9989255 ],
            [0.91693425],
            …,
            [0.09661709],
            [0.07553425],
            [0.6417989 ]], dtype=float32)
```

Building model with 1 Layer

```
[ ]: model_1_layer = keras.Sequential([
      layers.Dense(16, activation="relu"),
      layers.Dense(1, activation="sigmoid")
     ])
     model_1_layer.compile(optimizer="rmsprop",
      loss="binary_crossentropy",
      metrics=["accuracy"])
     x_val1 = x_train[:10000]
     partial_x_train = x_train[10000:]
     y_val1 = y_train[:10000]
     partial_y_train = y_train[10000:]
     history1_layer = model_1_layer.fit(partial_x_train,
      partial_y_train,
      epochs=20,
     batch_size=512,
     validation_data=(x_val1, y_val1))
```

```
Epoch 1/20
30/30 [==============================] - 2s 58ms/step - loss: 0.5044 - accuracy:
0.7829 - val_loss: 0.4020 - val_accuracy: 0.8498
Epoch 2/20
```

```
30/30 [==============================] - 1s 17ms/step - loss: 0.3232 - accuracy:
0.8985 - val_loss: 0.3312 - val_accuracy: 0.8734
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2567 - accuracy:
0.9172 - val_loss: 0.2941 - val_accuracy: 0.8862
Epoch 4/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2171 - accuracy:
0.9312 - val_loss: 0.2820 - val_accuracy: 0.8875
Epoch 5/20
30/30 [==============================] - 1s 18ms/step - loss: 0.1879 - accuracy:
0.9409 - val_loss: 0.2771 - val_accuracy: 0.8873
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1668 - accuracy:
0.9482 - val_loss: 0.2803 - val_accuracy: 0.8842
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1496 - accuracy:
0.9557 - val_loss: 0.2878 - val_accuracy: 0.8819
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1349 - accuracy:
0.9609 - val_loss: 0.3019 - val_accuracy: 0.8821
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1228 - accuracy:
0.9649 - val_loss: 0.2928 - val_accuracy: 0.8841
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1131 - accuracy:
0.9691 - val_loss: 0.3069 - val_accuracy: 0.8830
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1033 - accuracy:
0.9731 - val_loss: 0.3035 - val_accuracy: 0.8831
Epoch 12/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0953 - accuracy:
0.9760 - val_loss: 0.3083 - val_accuracy: 0.8820
Epoch 13/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0867 - accuracy:
0.9790 - val_loss: 0.3163 - val_accuracy: 0.8817
Epoch 14/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0805 - accuracy:
0.9815 - val_loss: 0.3687 - val_accuracy: 0.8662
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0749 - accuracy:
0.9824 - val_loss: 0.3534 - val_accuracy: 0.8712
Epoch 16/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0672 - accuracy:
0.9864 - val_loss: 0.3523 - val_accuracy: 0.8730
Epoch 17/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0630 - accuracy:
0.9887 - val_loss: 0.3542 - val_accuracy: 0.8779
Epoch 18/20
```

```
30/30 [==============================] - 0s 16ms/step - loss: 0.0583 - accuracy:
0.9895 - val_loss: 0.3605 - val_accuracy: 0.8763
Epoch 19/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0541 - accuracy:
0.9907 - val_loss: 0.3705 - val_accuracy: 0.8761
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0493 - accuracy:
0.9928 - val_loss: 0.3956 - val_accuracy: 0.8731
```

[ ]:

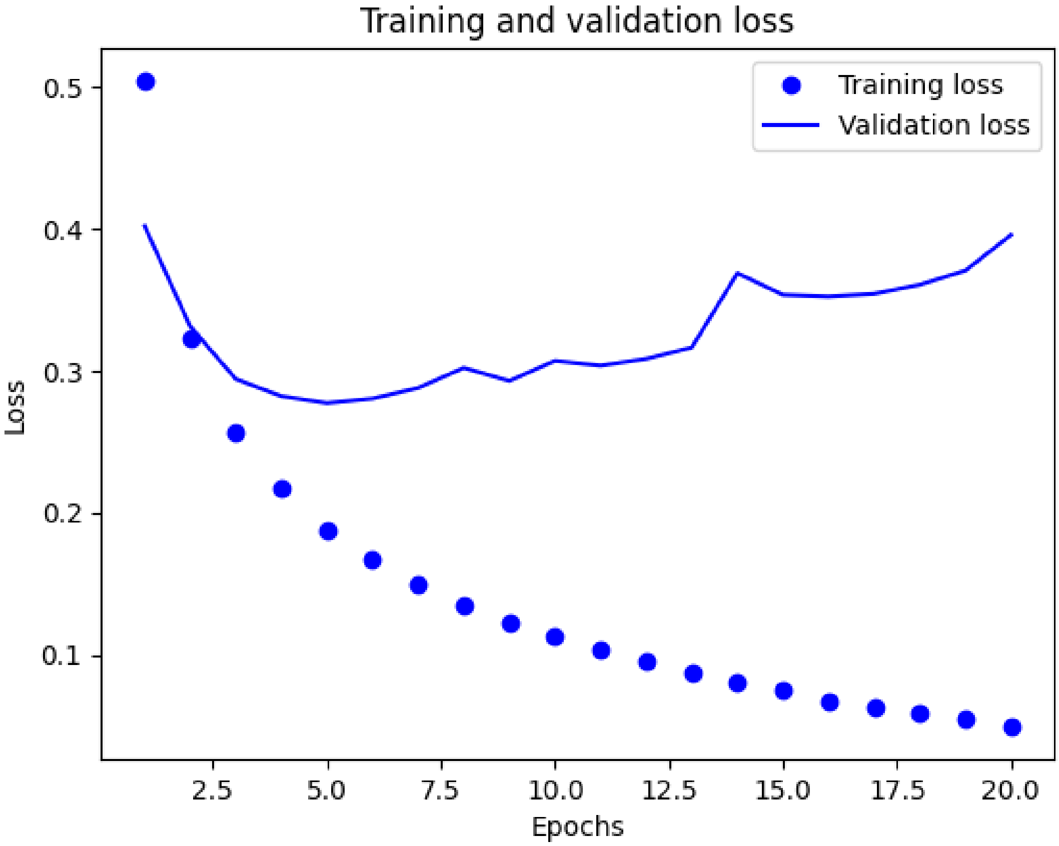
```python
history_dict1 = history1_layer.history
history_dict1.keys()
```

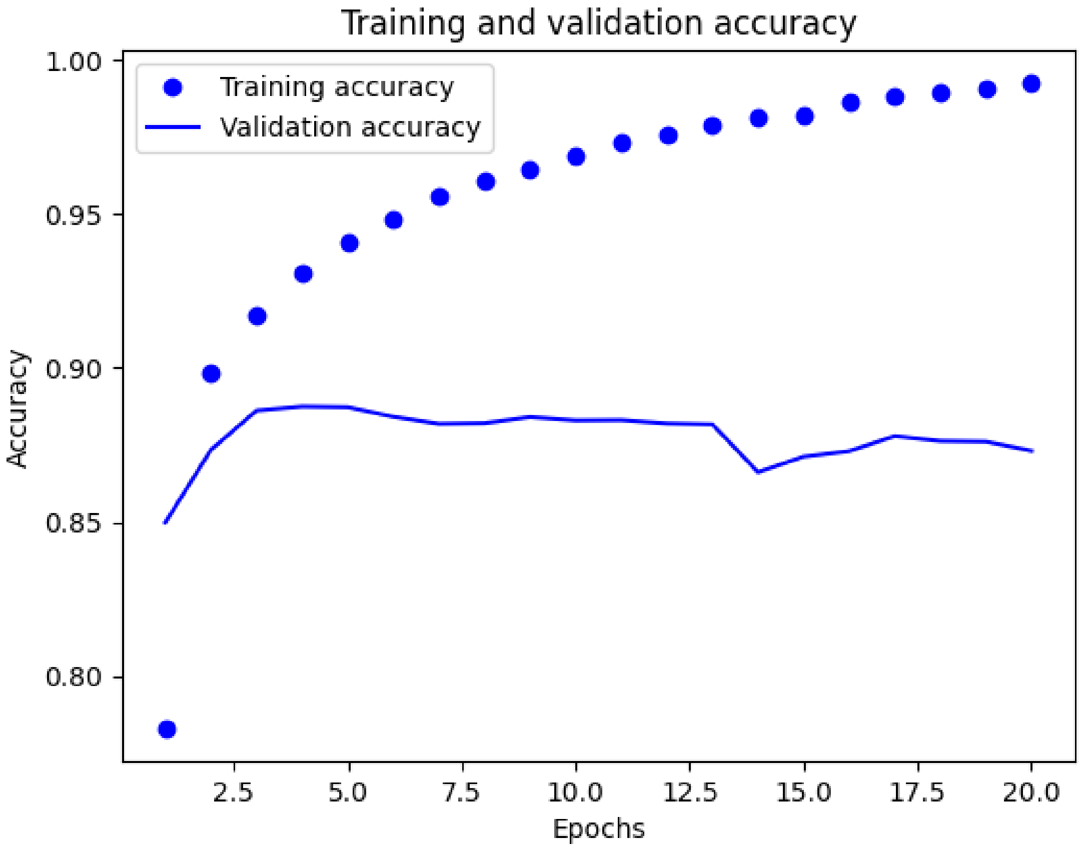
[ ]:

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

[ ]:

```python
import matplotlib.pyplot as plt
history_dict1 = history1_layer.history
loss_value1 = history_dict1["loss"]
val_loss_value1 = history_dict1["val_loss"]
epochs1 = range(1, len(loss_value1) + 1)
#Plotting graph of Training and Validation loss
plt.plot(epochs1, loss_value1, "bo", label="Training loss")
plt.plot(epochs1, val_loss_value1, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
#Plotting graph of Training and Validation Accuracy
plt.clf()
accuracy1 = history_dict1["accuracy"]
val_accuracy1 = history_dict1["val_accuracy"]
plt.plot(epochs1, accuracy1, "bo", label="Training accuracy")
plt.plot(epochs1, val_accuracy1, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```


Training and validation loss
Training loss
Validation loss
0.5
0.4
0.3
0.2
0.1
Loss
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Epochs



```
[ ]: #Creating the model
model_1_layer = keras.Sequential([
 layers.Dense(16, activation="relu"),
 layers.Dense(1, activation="sigmoid")
])
model_1_layer.compile(optimizer="rmsprop",
 loss="binary_crossentropy",
 metrics=["accuracy"])
model_1_layer.fit(x_train, y_train, epochs=5, batch_size=512)
result_1_layer = model_1_layer.evaluate(x_test, y_test)
```

```
Epoch 1/5
49/49 [==============================] - 2s 9ms/step - loss: 0.4541 - accuracy:
0.8205
Epoch 2/5
49/49 [==============================] - 0s 10ms/step - loss: 0.2906 - accuracy:
0.9000
Epoch 3/5
49/49 [==============================] - 0s 9ms/step - loss: 0.2352 - accuracy:
0.9186
```

```
Epoch 4/5
49/49 [==============================] - 0s 9ms/step - loss: 0.2043 - accuracy:
0.9282
Epoch 5/5
49/49 [==============================] - 0s 9ms/step - loss: 0.1843 - accuracy:
0.9361
782/782 [==============================] - 2s 2ms/step - loss: 0.2859 -
accuracy: 0.8840
```

```
[ ]: print(result_1_layer)
```

```
[0.28585559129714966, 0.8840399980545044]
```

Building Model with 3 layers

```
[ ]: model_1_layer.predict(x_test)
```

```
782/782 [==============================] - 1s 2ms/step
```

```
[ ]: array([[0.19017002],
            [0.99967957],
            [0.7475893 ],
            …,
            [0.08527051],
            [0.06520567],
            [0.4953189 ]], dtype=float32)
```

```
[ ]: model_3_layers = keras.Sequential([
      layers.Dense(16, activation="relu"),
      layers.Dense(16, activation="relu"),
      layers.Dense(16, activation="relu"),
      layers.Dense(1, activation="sigmoid")
     ])
     model_3_layers.compile(optimizer="rmsprop",
      loss="binary_crossentropy",
      metrics=["accuracy"])
     x_val3 = x_train[:10000]
     partial_x_train = x_train[10000:]
     y_val3 = y_train[:10000]
     partial_y_train = y_train[10000:]
     history_3_layers = model_3_layers.fit(partial_x_train,
      partial_y_train,
     epochs=20,
      batch_size=512,
     validation_data=(x_val3, y_val3))
```

```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.5707 - accuracy:
0.7555 - val_loss: 0.4506 - val_accuracy: 0.8510
```

```
Epoch 2/20
30/30 [==============================] - 0s 16ms/step - loss: 0.3611 - accuracy:
0.8849 - val_loss: 0.3267 - val_accuracy: 0.8812
Epoch 3/20
30/30 [==============================] - 1s 17ms/step - loss: 0.2499 - accuracy:
0.9157 - val_loss: 0.2950 - val_accuracy: 0.8822
Epoch 4/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1958 - accuracy:
0.9318 - val_loss: 0.2888 - val_accuracy: 0.8843
Epoch 5/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1591 - accuracy:
0.9465 - val_loss: 0.2845 - val_accuracy: 0.8878
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1330 - accuracy:
0.9560 - val_loss: 0.3244 - val_accuracy: 0.8768
Epoch 7/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1151 - accuracy:
0.9633 - val_loss: 0.3359 - val_accuracy: 0.8766
Epoch 8/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0910 - accuracy:
0.9731 - val_loss: 0.3478 - val_accuracy: 0.8782
Epoch 9/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0782 - accuracy:
0.9767 - val_loss: 0.3607 - val_accuracy: 0.8768
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0631 - accuracy:
0.9828 - val_loss: 0.3934 - val_accuracy: 0.8762
Epoch 11/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0530 - accuracy:
0.9869 - val_loss: 0.4612 - val_accuracy: 0.8662
Epoch 12/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0443 - accuracy:
0.9888 - val_loss: 0.5314 - val_accuracy: 0.8570
Epoch 13/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0425 - accuracy:
0.9881 - val_loss: 0.4822 - val_accuracy: 0.8682
Epoch 14/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0340 - accuracy:
0.9913 - val_loss: 0.4938 - val_accuracy: 0.8697
Epoch 15/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0313 - accuracy:
0.9921 - val_loss: 0.5215 - val_accuracy: 0.8690
Epoch 16/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0153 - accuracy:
0.9981 - val_loss: 0.7102 - val_accuracy: 0.8462
Epoch 17/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0180 - accuracy:
0.9965 - val_loss: 0.5753 - val_accuracy: 0.8679
```

```
Epoch 18/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0300 - accuracy:
0.9914 - val_loss: 0.5987 - val_accuracy: 0.8677
Epoch 19/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0076 - accuracy:
0.9993 - val_loss: 0.6394 - val_accuracy: 0.8671
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0194 - accuracy:
0.9940 - val_loss: 0.6559 - val_accuracy: 0.8681
```

[ ]:

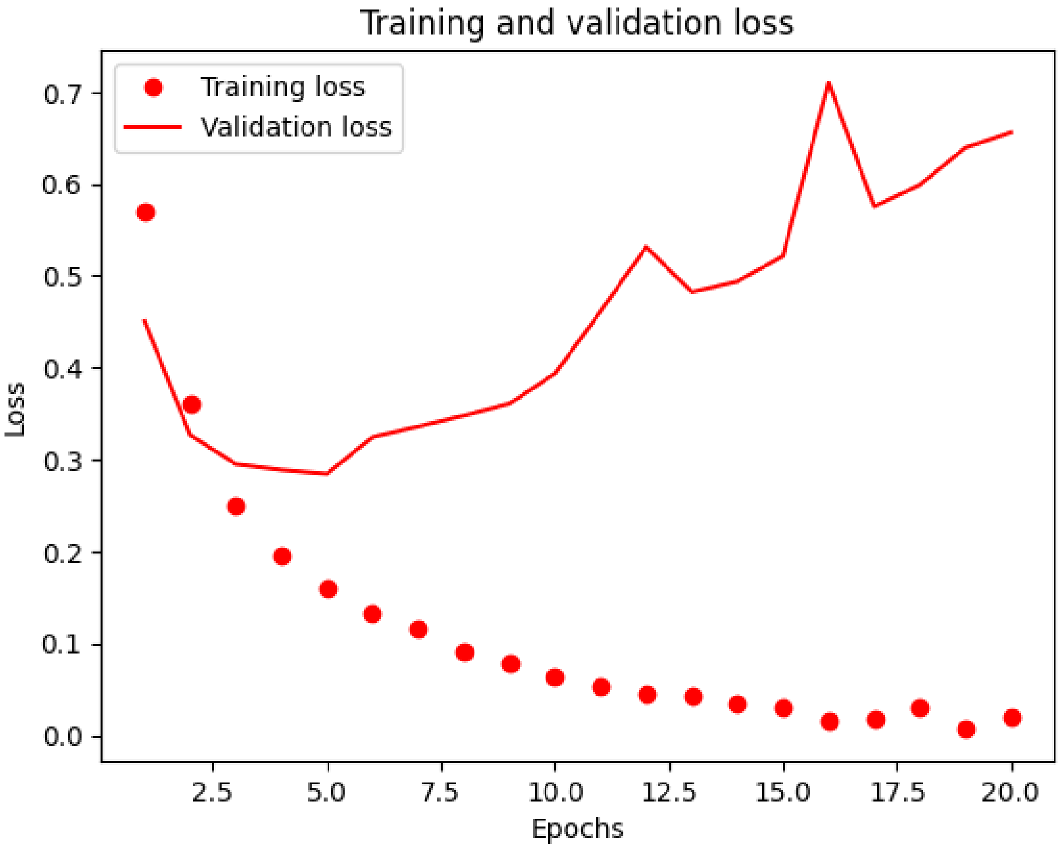
```python
history_dict_3 = history_3_layers.history
history_dict_3.keys()
```

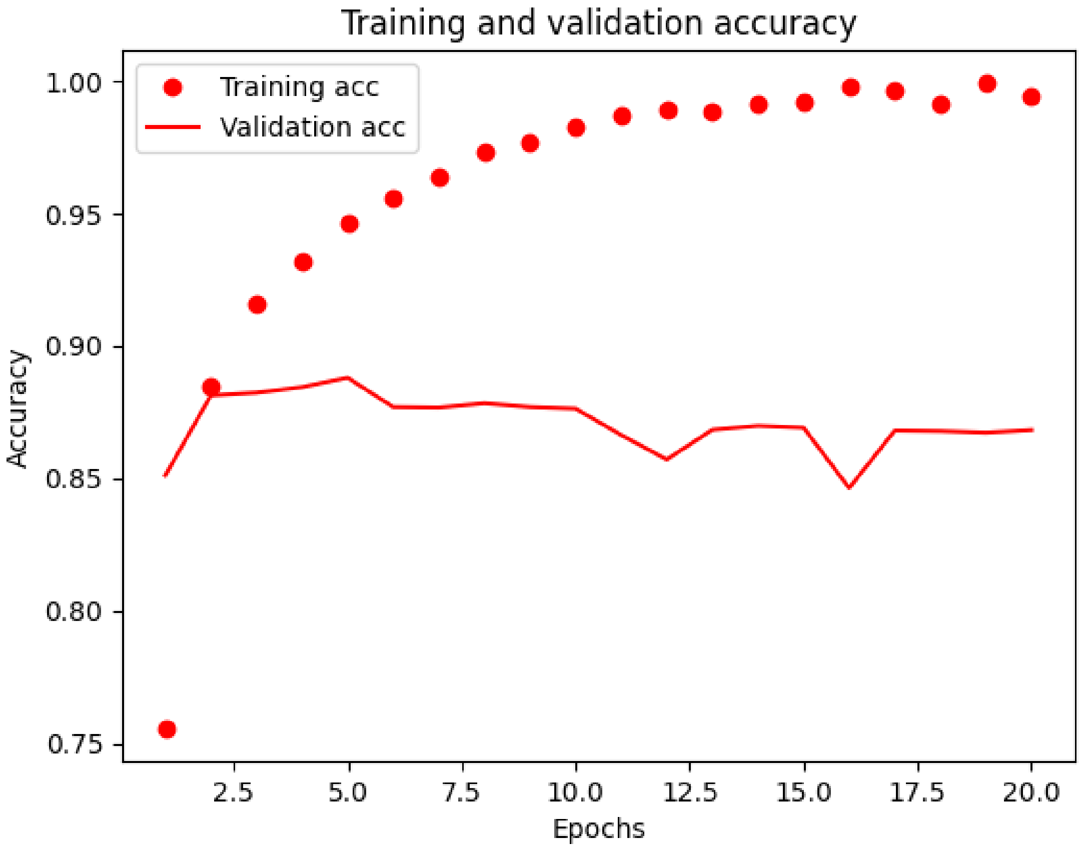
[ ]:

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

[ ]:

```python
loss_val3 = history_dict_3["loss"]
val_loss_val3 = history_dict_3["val_loss"]
epochs3 = range(1, len(loss_val3) + 1)
plt.plot(epochs3, loss_val3, "ro", label="Training loss")
plt.plot(epochs3, val_loss_val3, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf() #clear figure
accuracy3 = history_dict_3["accuracy"]
val_accuracy3 = history_dict_3["val_accuracy"]
plt.plot(epochs3, accuracy3, "ro", label="Training acc")
plt.plot(epochs3, val_accuracy3, "r", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```


Training and validation loss
● Training loss
Validation loss
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Loss
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Epochs



[ ]:
```
model_3_layers = keras.Sequential([
 layers.Dense(16, activation="relu"),
 layers.Dense(16, activation="relu"),
 layers.Dense(16, activation="relu"),
 layers.Dense(1, activation="sigmoid")
])
model_3_layers.compile(optimizer='rmsprop',
 loss='binary_crossentropy',
 metrics=['accuracy'])
model_3_layers.fit(x_train, y_train, epochs=5, batch_size=512)
results_3_layers = model_3_layers.evaluate(x_test, y_test)
```

```
Epoch 1/5
49/49 [==============================] - 1s 10ms/step - loss: 0.5414 - accuracy:
0.7844
Epoch 2/5
49/49 [==============================] - 0s 10ms/step - loss: 0.3032 - accuracy:
0.8936
Epoch 3/5
49/49 [==============================] - 0s 10ms/step - loss: 0.2277 - accuracy:
```

```
0.9164
Epoch 4/5
49/49 [==============================] - 0s 10ms/step - loss: 0.1914 - accuracy:
0.9299
Epoch 5/5
49/49 [==============================] - 0s 10ms/step - loss: 0.1650 - accuracy:
0.9396
782/782 [==============================] - 2s 2ms/step - loss: 0.2993 -
accuracy: 0.8831
```

[ ]:
```
print(results_3_layers)
model_3_layers.predict(x_test)
```

```
[0.2993345558643341, 0.8831200003623962]
782/782 [==============================] - 1s 2ms/step
```

[ ]:
```
array([[0.19357751],
       [0.9995442 ],
       [0.8825634 ],
       …,
       [0.09561777],
       [0.05881154],
       [0.69073546]], dtype=float32)
```

Building 32 Unit 3 layer Model

[ ]:
```
model_32_units = keras.Sequential([
 layers.Dense(32, activation="relu"),
 layers.Dense(32, activation="relu"),
 layers.Dense(32, activation="relu"),
 layers.Dense(1, activation="sigmoid")
])
#model compilation
model_32_units.compile(optimizer="rmsprop",
 loss="binary_crossentropy",
 metrics=["accuracy"])
#model validation
x_val_32 = x_train[:10000]
partial_x_train = x_train[10000:]
y_val_32 = y_train[:10000]
partial_y_train = y_train[10000:]
history_32_units = model_32_units.fit(partial_x_train,
 partial_y_train,
epochs=20,
 batch_size=512,
validation_data=(x_val_32, y_val_32))
```

```
Epoch 1/20
```

```
30/30 [==============================] - 3s 61ms/step - loss: 0.5280 - accuracy:
0.7408 - val_loss: 0.3677 - val_accuracy: 0.8627
Epoch 2/20
30/30 [==============================] - 1s 18ms/step - loss: 0.2995 - accuracy:
0.8889 - val_loss: 0.2897 - val_accuracy: 0.8851
Epoch 3/20
30/30 [==============================] - 1s 18ms/step - loss: 0.2129 - accuracy:
0.9248 - val_loss: 0.2867 - val_accuracy: 0.8864
Epoch 4/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1845 - accuracy:
0.9308 - val_loss: 0.3156 - val_accuracy: 0.8768
Epoch 5/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1311 - accuracy:
0.9545 - val_loss: 0.3508 - val_accuracy: 0.8671
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1164 - accuracy:
0.9578 - val_loss: 0.3252 - val_accuracy: 0.8793
Epoch 7/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0858 - accuracy:
0.9708 - val_loss: 0.4400 - val_accuracy: 0.8541
Epoch 8/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0794 - accuracy:
0.9723 - val_loss: 0.3710 - val_accuracy: 0.8780
Epoch 9/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0621 - accuracy:
0.9803 - val_loss: 0.3905 - val_accuracy: 0.8796
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0486 - accuracy:
0.9842 - val_loss: 0.4156 - val_accuracy: 0.8770
Epoch 11/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0198 - accuracy:
0.9962 - val_loss: 0.6828 - val_accuracy: 0.8454
Epoch 12/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0195 - accuracy:
0.9957 - val_loss: 0.5126 - val_accuracy: 0.8738
Epoch 13/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0402 - accuracy:
0.9885 - val_loss: 0.5193 - val_accuracy: 0.8748
Epoch 14/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0054 - accuracy:
0.9997 - val_loss: 0.5696 - val_accuracy: 0.8768
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0424 - accuracy:
0.9887 - val_loss: 0.5770 - val_accuracy: 0.8740
Epoch 16/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0027 - accuracy:
0.9999 - val_loss: 0.6092 - val_accuracy: 0.8733
Epoch 17/20
```

```
30/30 [==============================] - 0s 16ms/step - loss: 0.0369 - accuracy:
0.9895 - val_loss: 0.6243 - val_accuracy: 0.8713
Epoch 18/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0019 - accuracy:
0.9999 - val_loss: 0.6400 - val_accuracy: 0.8749
Epoch 19/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0013 - accuracy:
0.9999 - val_loss: 0.6790 - val_accuracy: 0.8736
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0179 - accuracy:
0.9953 - val_loss: 0.7406 - val_accuracy: 0.8633
```

[ ]:

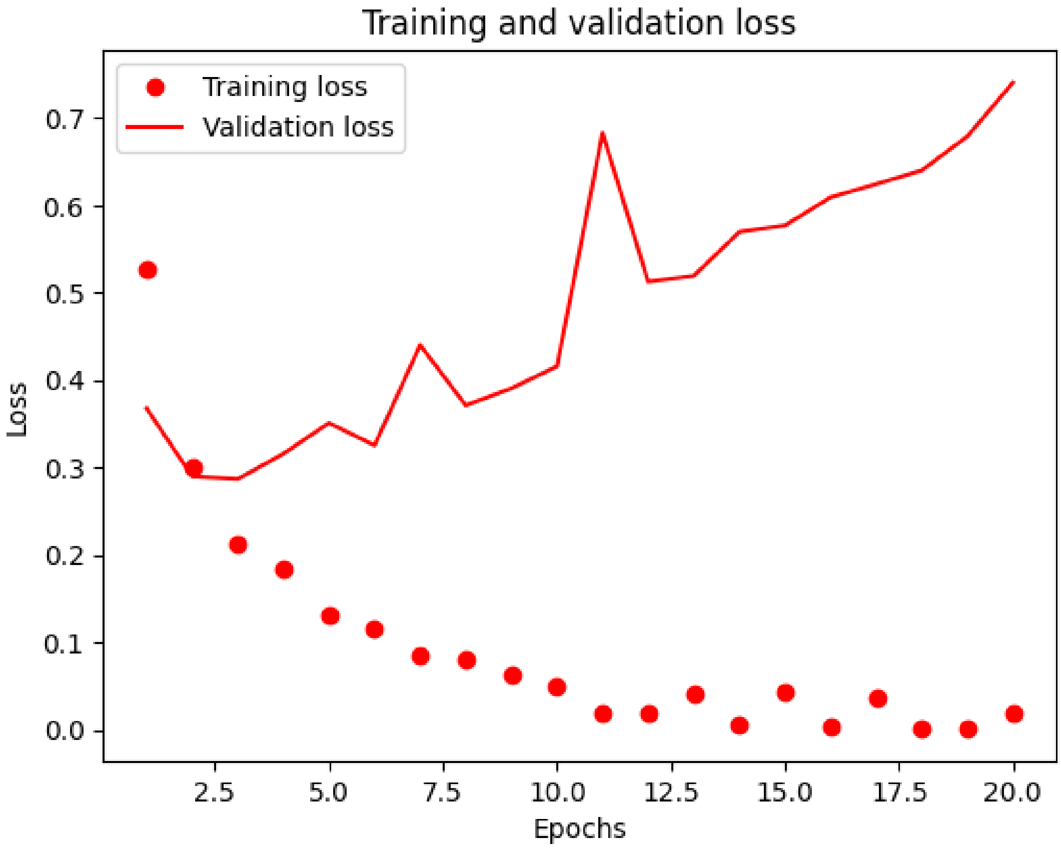
```
history_dict_32 = history_32_units.history
history_dict_32.keys()
```

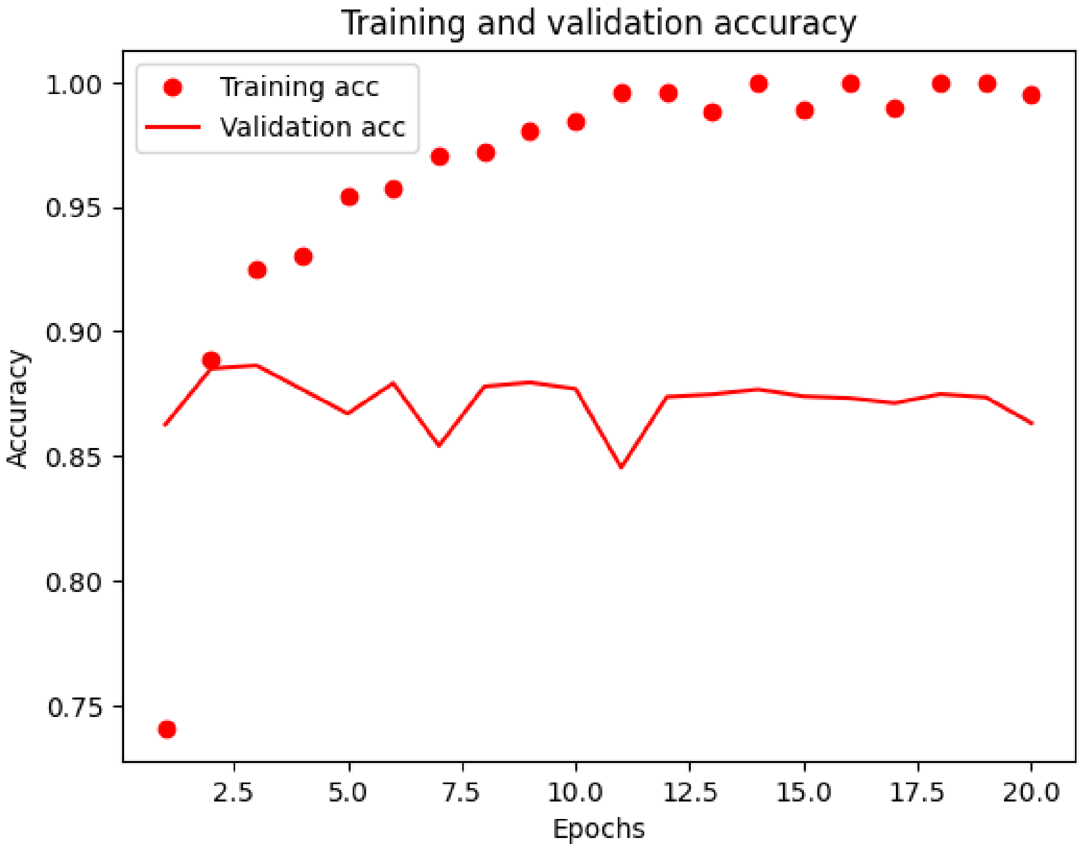
[ ]:

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

[ ]:

```
loss_value_32 = history_dict_32["loss"]
val_loss_value_32 = history_dict_32["val_loss"]
epochs_32 = range(1, len(loss_value_32) + 1)
plt.plot(epochs_32, loss_value_32, "ro", label="Training loss")
plt.plot(epochs_32, val_loss_value_32, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf() #clear figure
accuracy_32 = history_dict_32["accuracy"]
val_accuracy_32 = history_dict_32["val_accuracy"]
plt.plot(epochs_32, accuracy_32, "ro", label="Training acc")
plt.plot(epochs_32, val_accuracy_32, "r", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```


Training and validation loss
● Training loss
— Validation loss
Loss
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Epochs
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0



```
[ ]: history_32_units = model_32_units.fit(x_train, y_train, epochs=5,␣
       ↪batch_size=512)
     results_32_units = model_32_units.evaluate(x_test, y_test)
     results_32_units
```

```
Epoch 1/5
49/49 [==============================] - 1s 10ms/step - loss: 0.1977 - accuracy:
0.9483
Epoch 2/5
49/49 [==============================] - 1s 10ms/step - loss: 0.1068 - accuracy:
0.9674
Epoch 3/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0683 - accuracy:
0.9794
Epoch 4/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0445 - accuracy:
0.9874
Epoch 5/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0292 - accuracy:
0.9918
```

```
782/782 [==============================] - 2s 2ms/step - loss: 0.5277 -
accuracy: 0.8653
```

```
[ ]: [0.5276642441749573, 0.8652799725532532]
```

```
[ ]: print(results_32_units)
```

```
[0.5276642441749573, 0.8652799725532532]
```

Building 64 Unit 3 Layer model

```
[ ]: model_64_units = keras.Sequential([
      layers.Dense(64, activation="relu"),
      layers.Dense(64, activation="relu"),
      layers.Dense(64, activation="relu"),
      layers.Dense(1, activation="sigmoid")
     ])
     model_64_units.compile(optimizer="rmsprop",
                            loss="binary_crossentropy",
                            metrics=["accuracy"])
     # validation
     x_val_64 = x_train[:10000]
     partial_x_train = x_train[10000:]
     y_val_64 = y_train[:10000]
     partial_y_train = y_train[10000:]
     history_64 = model_64_units.fit(partial_x_train,
      partial_y_train,
     epochs=20,
     batch_size=512,
     validation_data=(x_val_64, y_val_64))
```

```
Epoch 1/20
30/30 [==============================] - 3s 60ms/step - loss: 0.5300 - accuracy:
0.7269 - val_loss: 0.3638 - val_accuracy: 0.8557
Epoch 2/20
30/30 [==============================] - 1s 17ms/step - loss: 0.3000 - accuracy:
0.8831 - val_loss: 0.3355 - val_accuracy: 0.8632
Epoch 3/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2350 - accuracy:
0.9087 - val_loss: 0.3267 - val_accuracy: 0.8694
Epoch 4/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1722 - accuracy:
0.9351 - val_loss: 0.2931 - val_accuracy: 0.8866
Epoch 5/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1534 - accuracy:
0.9425 - val_loss: 0.2999 - val_accuracy: 0.8858
Epoch 6/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1115 - accuracy:
0.9606 - val_loss: 0.5105 - val_accuracy: 0.8246
```

```
Epoch 7/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0870 - accuracy:
0.9699 - val_loss: 0.3521 - val_accuracy: 0.8829
Epoch 8/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0698 - accuracy:
0.9776 - val_loss: 0.3997 - val_accuracy: 0.8806
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0699 - accuracy:
0.9795 - val_loss: 0.3992 - val_accuracy: 0.8813
Epoch 10/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0155 - accuracy:
0.9979 - val_loss: 0.4781 - val_accuracy: 0.8796
Epoch 11/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0598 - accuracy:
0.9851 - val_loss: 0.4756 - val_accuracy: 0.8781
Epoch 12/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0057 - accuracy:
0.9993 - val_loss: 0.5712 - val_accuracy: 0.8771
Epoch 13/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0657 - accuracy:
0.9850 - val_loss: 0.5266 - val_accuracy: 0.8769
Epoch 14/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0030 - accuracy:
0.9998 - val_loss: 0.5817 - val_accuracy: 0.8750
Epoch 15/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0333 - accuracy:
0.9918 - val_loss: 0.7049 - val_accuracy: 0.8509
Epoch 16/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0038 - accuracy:
0.9994 - val_loss: 0.6140 - val_accuracy: 0.8748
Epoch 17/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0010 - accuracy:
1.0000 - val_loss: 0.6689 - val_accuracy: 0.8735
Epoch 18/20
30/30 [==============================] - 1s 17ms/step - loss: 5.6923e-04 -
accuracy: 1.0000 - val_loss: 0.7661 - val_accuracy: 0.8752
Epoch 19/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0670 - accuracy:
0.9868 - val_loss: 0.6681 - val_accuracy: 0.8757
Epoch 20/20
30/30 [==============================] - 1s 18ms/step - loss: 5.8852e-04 -
accuracy: 1.0000 - val_loss: 0.7015 - val_accuracy: 0.8752
```

[ ]:

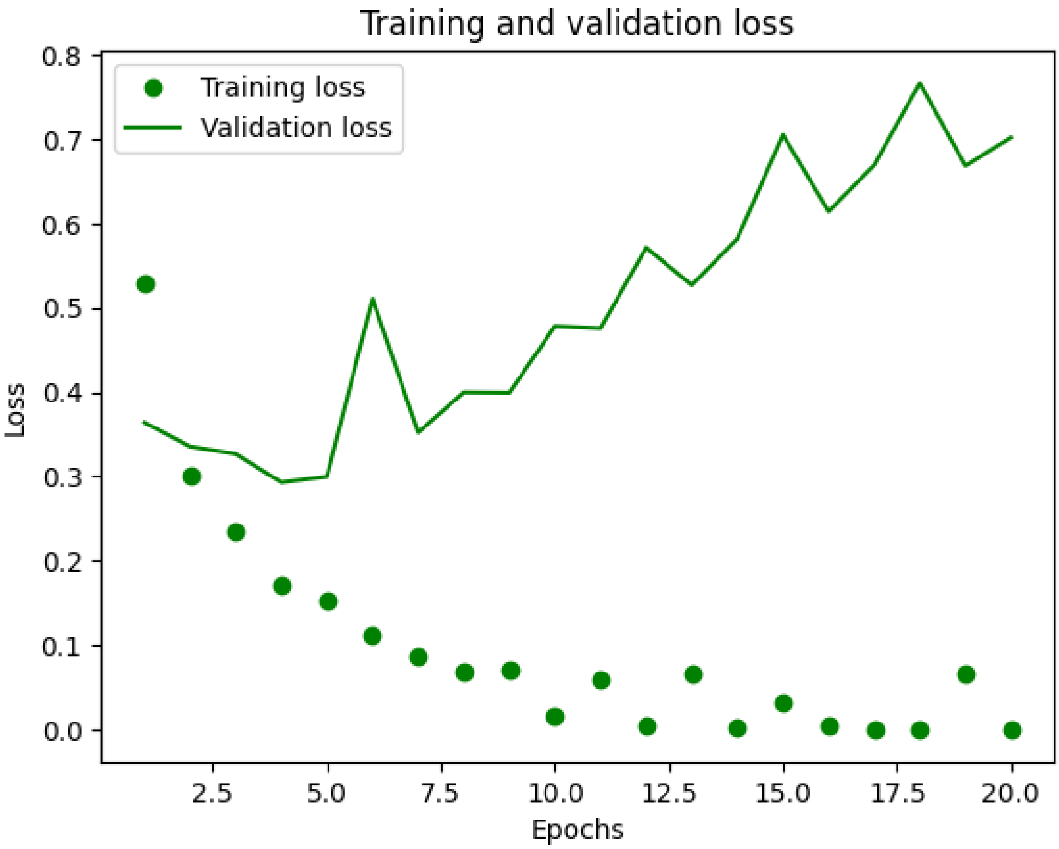
```
history_dict_64 = history_64.history
history_dict_64.keys()
```

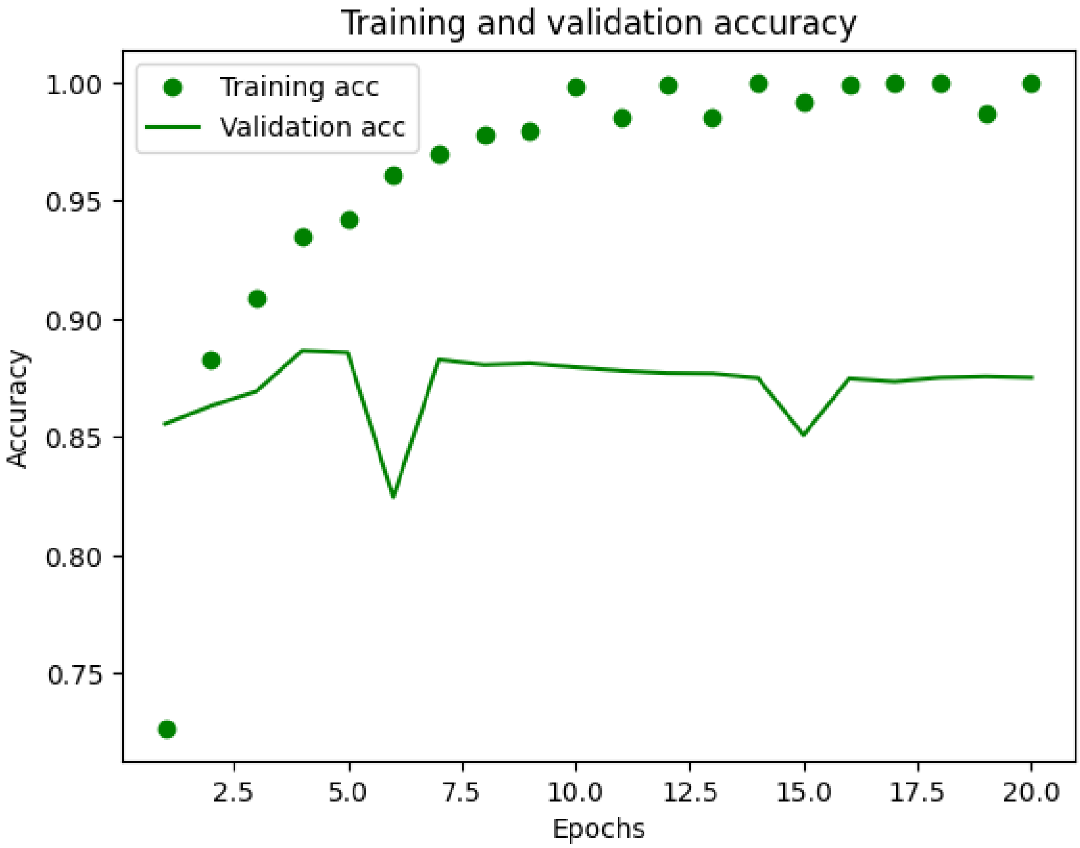
[ ]:

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

[ ]:

```
loss_value64 = history_dict_64["loss"]
val_loss_value64 = history_dict_64["val_loss"]
epochs_64 = range(1, len(loss_value64) + 1)
plt.plot(epochs_64, loss_value64, "go", label="Training loss")
plt.plot(epochs_64, val_loss_value64, "g", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf()
accuracy_64 = history_dict_64["accuracy"]
val_accuracy_64 = history_dict_64["val_accuracy"]
plt.plot(epochs_64, accuracy_64, "go", label="Training acc")
plt.plot(epochs_64, val_accuracy_64, "g", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```





```
[ ]: history_64 = model_64_units.fit(x_train, y_train, epochs=5, batch_size=512)
     results_64_units = model_64_units.evaluate(x_test, y_test)
     results_64_units
```

```
Epoch 1/5
49/49 [==============================] - 1s 10ms/step - loss: 0.1845 - accuracy:
0.9441
Epoch 2/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0937 - accuracy:
0.9698
Epoch 3/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0508 - accuracy:
0.9845
Epoch 4/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0277 - accuracy:
0.9917
Epoch 5/5
49/49 [==============================] - 0s 10ms/step - loss: 0.0217 - accuracy:
0.9930
782/782 [==============================] - 2s 2ms/step - loss: 0.5333 -
```

```
accuracy: 0.8694
```

[ ]:

```
[0.533331036567688, 0.8693600296974182]
```

Building 128 unit 3 Layer model

[ ]:

```python
model_128units = keras.Sequential([
 layers.Dense(128, activation="relu"),
 layers.Dense(128, activation="relu"),
 layers.Dense(128, activation="relu"),
 layers.Dense(1, activation="sigmoid")
])
model_128units.compile(optimizer="rmsprop",
 loss="binary_crossentropy",
 metrics=["accuracy"])
# validation
x_val_128 = x_train[:10000]
partial_x_train = x_train[10000:]
y_val_128 = y_train[:10000]
partial_y_train = y_train[10000:]
history_128 = model_128units.fit(partial_x_train,
 partial_y_train,
 epochs=20,
batch_size=512,
validation_data=(x_val_128, y_val_128))
```

```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.5476 - accuracy:
0.7191 - val_loss: 0.3728 - val_accuracy: 0.8447
Epoch 2/20
30/30 [==============================] - 1s 17ms/step - loss: 0.3168 - accuracy:
0.8705 - val_loss: 0.2879 - val_accuracy: 0.8824
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2221 - accuracy:
0.9113 - val_loss: 0.2756 - val_accuracy: 0.8906
Epoch 4/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1713 - accuracy:
0.9349 - val_loss: 0.2999 - val_accuracy: 0.8841
Epoch 5/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1323 - accuracy:
0.9503 - val_loss: 0.3115 - val_accuracy: 0.8854
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0994 - accuracy:
0.9679 - val_loss: 0.5022 - val_accuracy: 0.8388
Epoch 7/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0817 - accuracy:
0.9732 - val_loss: 0.3804 - val_accuracy: 0.8778
Epoch 8/20
```

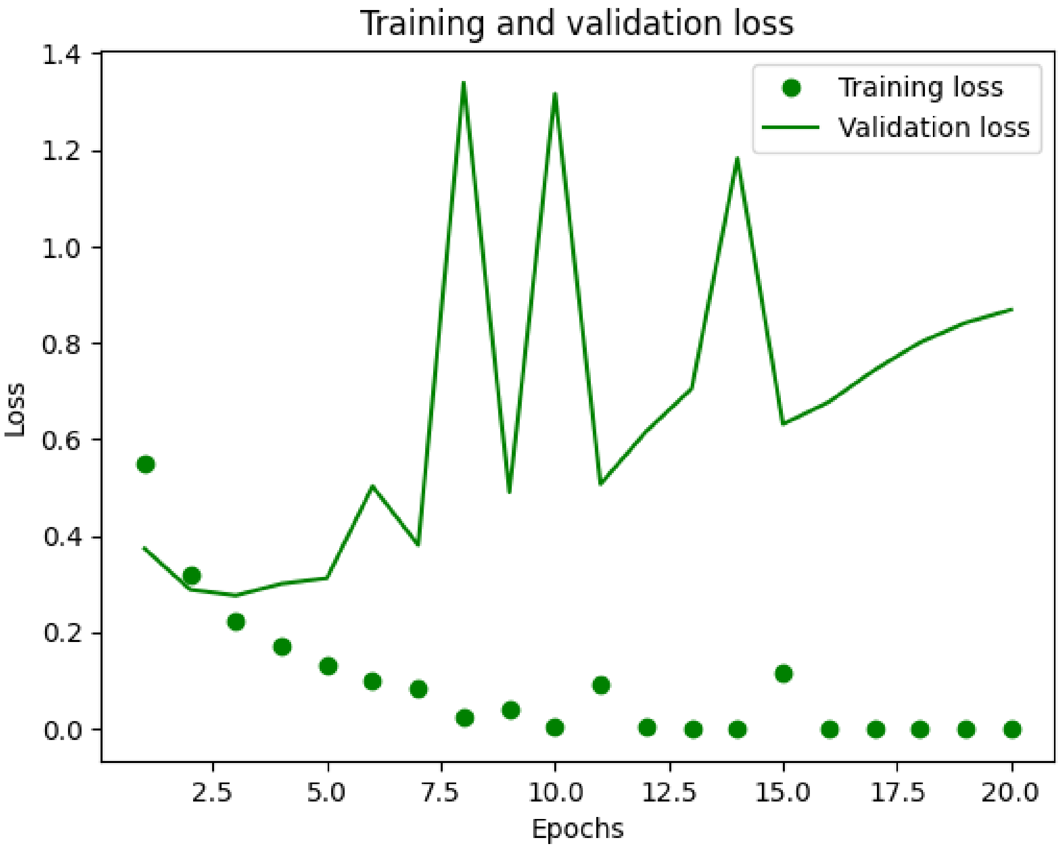
```
30/30 [==============================] - 0s 16ms/step - loss: 0.0250 - accuracy:
0.9937 - val_loss: 1.3384 - val_accuracy: 0.7223
Epoch 9/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0410 - accuracy:
0.9907 - val_loss: 0.4899 - val_accuracy: 0.8800
Epoch 10/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0043 - accuracy:
0.9994 - val_loss: 1.3157 - val_accuracy: 0.7773
Epoch 11/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0894 - accuracy:
0.9817 - val_loss: 0.5067 - val_accuracy: 0.8786
Epoch 12/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0019 - accuracy:
0.9999 - val_loss: 0.6158 - val_accuracy: 0.8804
Epoch 13/20
30/30 [==============================] - 0s 16ms/step - loss: 7.3892e-04 -
accuracy: 0.9999 - val_loss: 0.7049 - val_accuracy: 0.8770
Epoch 14/20
30/30 [==============================] - 0s 16ms/step - loss: 3.6577e-04 -
accuracy: 1.0000 - val_loss: 1.1821 - val_accuracy: 0.8403
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1160 - accuracy:
0.9831 - val_loss: 0.6310 - val_accuracy: 0.8804
Epoch 16/20
30/30 [==============================] - 0s 16ms/step - loss: 5.5550e-04 -
accuracy: 1.0000 - val_loss: 0.6766 - val_accuracy: 0.8803
Epoch 17/20
30/30 [==============================] - 0s 17ms/step - loss: 3.1018e-04 -
accuracy: 1.0000 - val_loss: 0.7429 - val_accuracy: 0.8811
Epoch 18/20
30/30 [==============================] - 1s 17ms/step - loss: 1.7571e-04 -
accuracy: 1.0000 - val_loss: 0.8002 - val_accuracy: 0.8799
Epoch 19/20
30/30 [==============================] - 0s 17ms/step - loss: 1.1259e-04 -
accuracy: 1.0000 - val_loss: 0.8411 - val_accuracy: 0.8800
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 8.0374e-05 -
accuracy: 1.0000 - val_loss: 0.8683 - val_accuracy: 0.8813
```

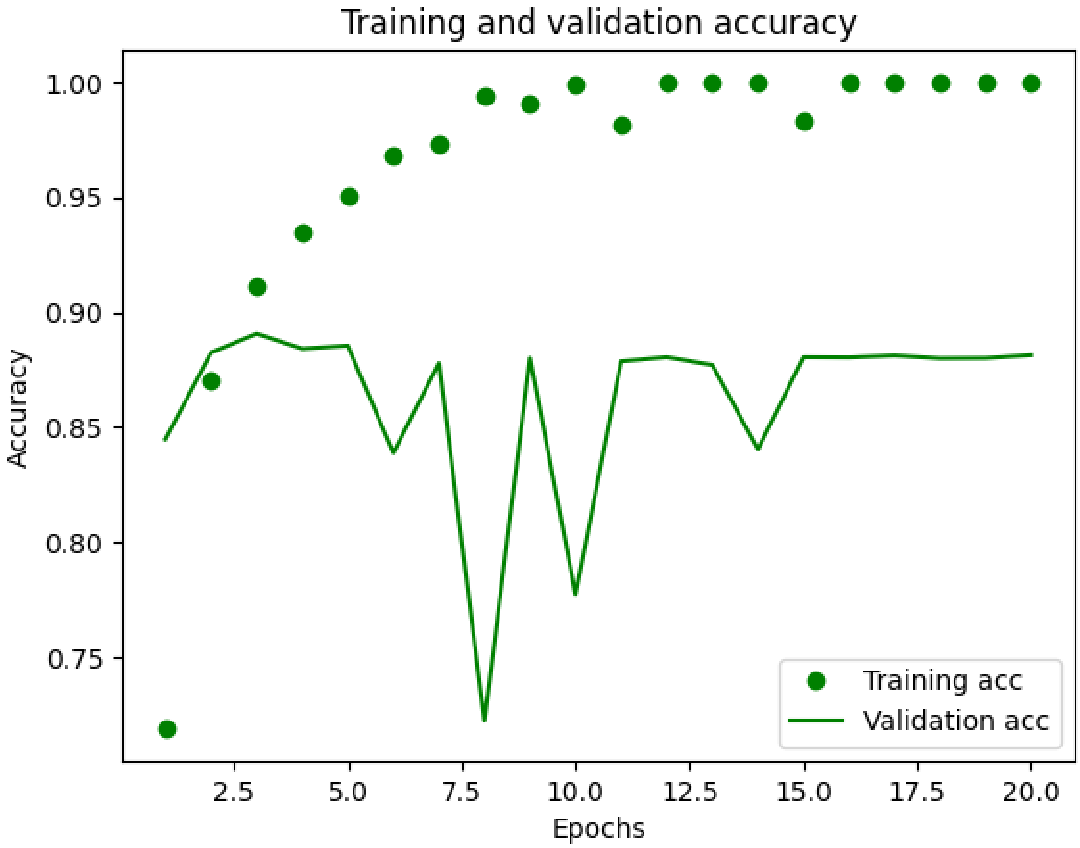
```
[ ]: history_dict_128 = history_128.history
     history_dict_128.keys()
```

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

```
[ ]: loss_value128 = history_dict_128["loss"]
     val_loss_value128 = history_dict_128["val_loss"]
     epochs_128 = range(1, len(loss_value128) + 1)
```

```
plt.plot(epochs_128, loss_value128, "go", label="Training loss")
plt.plot(epochs_128, val_loss_value128, "g", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf()
accuracy_128 = history_dict_128["accuracy"]
val_accuracy_128 = history_dict_128["val_accuracy"]
plt.plot(epochs_128, accuracy_128, "go", label="Training acc")
plt.plot(epochs_128, val_accuracy_128, "g", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```





[ ]:

```
history_128 = model_128units.fit(x_train, y_train, epochs=4, batch_size=512)
results_128_units = model_128units.evaluate(x_test, y_test)
results_128_units
```

```
Epoch 1/4
49/49 [==============================] - 0s 10ms/step - loss: 0.1827 - accuracy:
0.9423
Epoch 2/4
49/49 [==============================] - 0s 10ms/step - loss: 0.0817 - accuracy:
0.9733
Epoch 3/4
49/49 [==============================] - 0s 9ms/step - loss: 0.0402 - accuracy:
0.9881
Epoch 4/4
49/49 [==============================] - 0s 10ms/step - loss: 0.0344 - accuracy:
0.9906
782/782 [==============================] - 2s 2ms/step - loss: 0.4531 -
accuracy: 0.8765
```

[ ]:

```
[0.4530925452709198, 0.8765199780464172]
```

MSE Loss Function

[ ]:

```
MSE_model = keras.Sequential([
 layers.Dense(16, activation="relu"),
 layers.Dense(16, activation="relu"),
 layers.Dense(16, activation="relu"),
 layers.Dense(1, activation="sigmoid")
])
# compilation of model
MSE_model.compile(optimizer="rmsprop",
 loss="mse",
 metrics=["accuracy"])
# validation of model
x_val_MSE = x_train[:10000]
partial_x_train = x_train[10000:]
y_val_MSE = y_train[:10000]
partial_y_train = y_train[10000:]
# Model Fit
history_MSE = MSE_model.fit(partial_x_train,
 partial_y_train,
epochs=20,
 batch_size=512,
validation_data=(x_val_MSE, y_val_MSE))
```

```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.1791 - accuracy:
0.7647 - val_loss: 0.1271 - val_accuracy: 0.8506
Epoch 2/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0993 - accuracy:
0.8892 - val_loss: 0.0951 - val_accuracy: 0.8848
Epoch 3/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0722 - accuracy:
0.9161 - val_loss: 0.0955 - val_accuracy: 0.8704
Epoch 4/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0585 - accuracy:
0.9330 - val_loss: 0.0856 - val_accuracy: 0.8852
Epoch 5/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0471 - accuracy:
0.9465 - val_loss: 0.0888 - val_accuracy: 0.8784
Epoch 6/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0418 - accuracy:
0.9533 - val_loss: 0.0862 - val_accuracy: 0.8823
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0327 - accuracy:
0.9669 - val_loss: 0.0988 - val_accuracy: 0.8659
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0288 - accuracy:
0.9695 - val_loss: 0.0877 - val_accuracy: 0.8806
```

```
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0269 - accuracy:
0.9712 - val_loss: 0.0938 - val_accuracy: 0.8773
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0198 - accuracy:
0.9822 - val_loss: 0.1015 - val_accuracy: 0.8653
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0190 - accuracy:
0.9827 - val_loss: 0.0930 - val_accuracy: 0.8767
Epoch 12/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0179 - accuracy:
0.9821 - val_loss: 0.0939 - val_accuracy: 0.8782
Epoch 13/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0143 - accuracy:
0.9862 - val_loss: 0.0953 - val_accuracy: 0.8767
Epoch 14/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0142 - accuracy:
0.9853 - val_loss: 0.0962 - val_accuracy: 0.8765
Epoch 15/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0087 - accuracy:
0.9929 - val_loss: 0.0990 - val_accuracy: 0.8763
Epoch 16/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0108 - accuracy:
0.9895 - val_loss: 0.0990 - val_accuracy: 0.8763
Epoch 17/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0116 - accuracy:
0.9868 - val_loss: 0.0998 - val_accuracy: 0.8753
Epoch 18/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0064 - accuracy:
0.9945 - val_loss: 0.1163 - val_accuracy: 0.8571
Epoch 19/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0099 - accuracy:
0.9897 - val_loss: 0.1022 - val_accuracy: 0.8731
Epoch 20/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0103 - accuracy:
0.9884 - val_loss: 0.1030 - val_accuracy: 0.8744
```

[ ]:

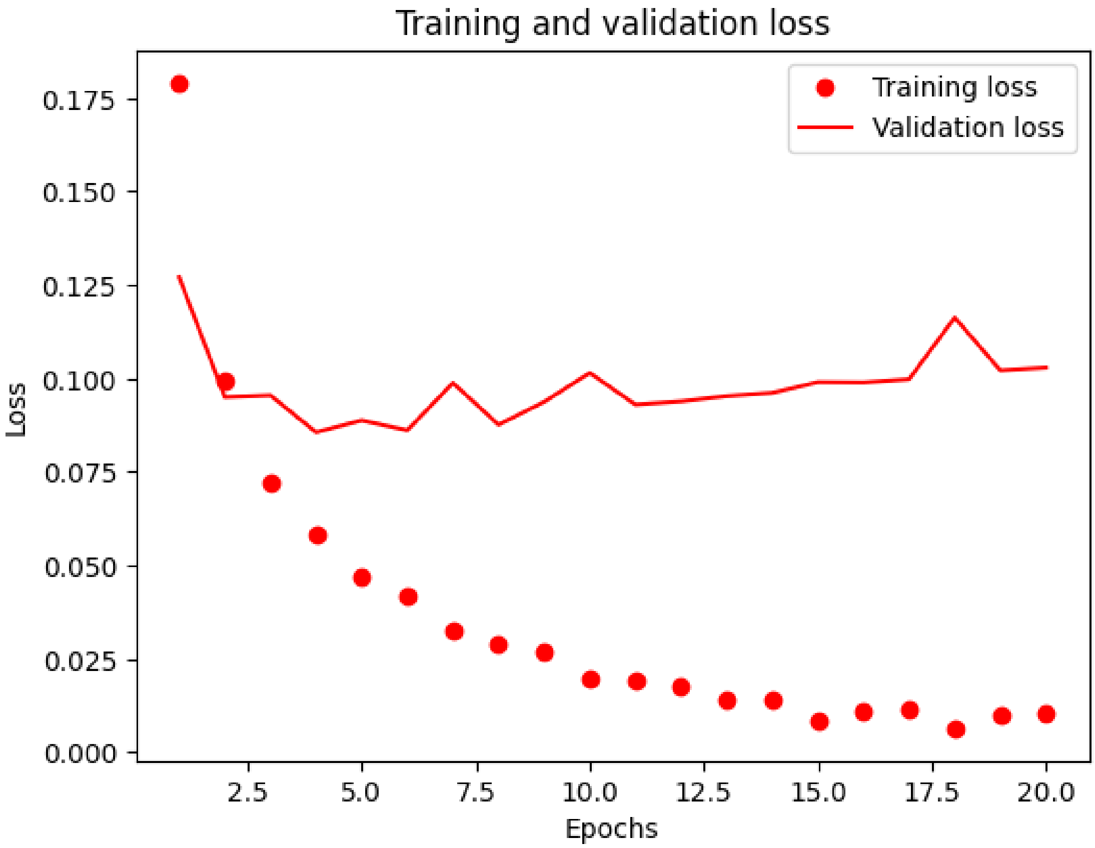
```
historydict_MSE = history_MSE.history
historydict_MSE.keys()
```

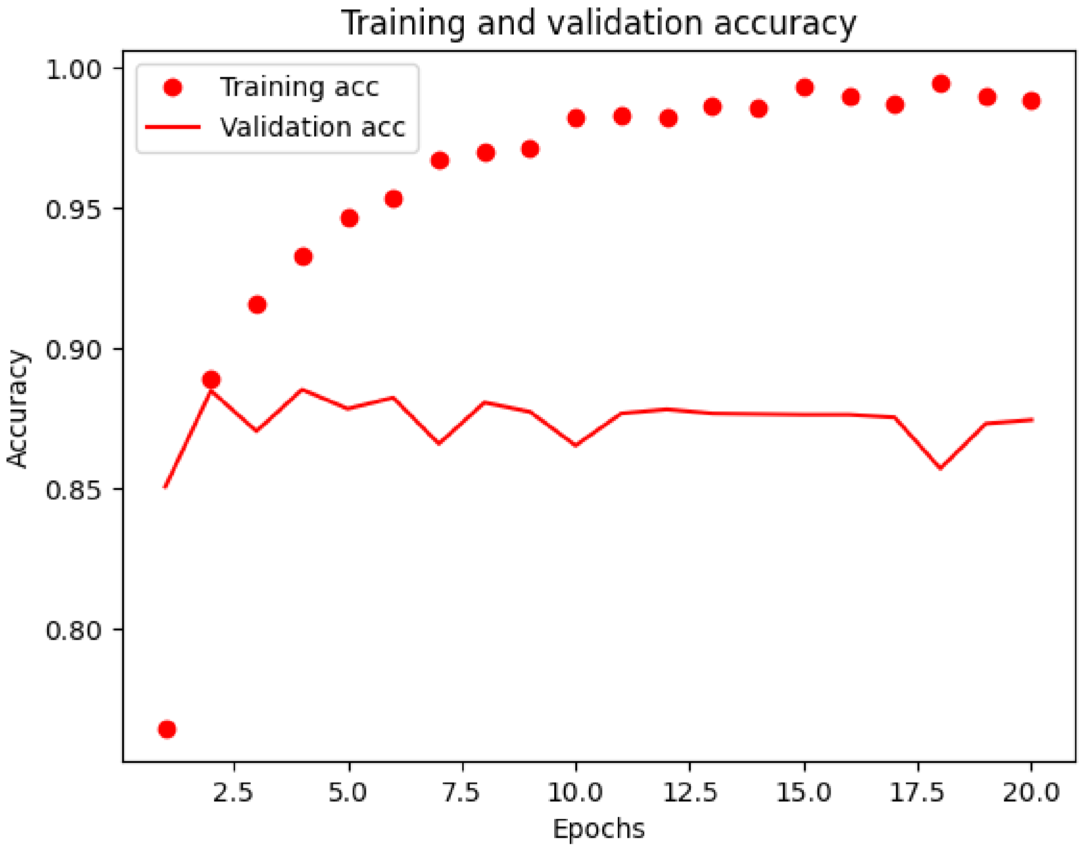
[ ]:

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

[ ]:

```
import matplotlib.pyplot as plt
loss_value_MSE = historydict_MSE["loss"]
val_loss_value_MSE = historydict_MSE["val_loss"]
epochs_MSE = range(1, len(loss_value_MSE) + 1)
plt.plot(epochs_MSE, loss_value_MSE, "ro", label="Training loss")
plt.plot(epochs_MSE, val_loss_value_MSE, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf()
acc_MSE = historydict_MSE["accuracy"]
val_acc_MSE = historydict_MSE["val_accuracy"]
plt.plot(epochs_MSE, acc_MSE, "ro", label="Training acc")
plt.plot(epochs_MSE, val_acc_MSE, "r", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```





```
[ ]: MSE_model.fit(x_train, y_train, epochs=8, batch_size=512)
     results_MSE = MSE_model.evaluate(x_test, y_test)
     results_MSE
```

```
Epoch 1/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0457 - accuracy:
0.9457
Epoch 2/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0359 - accuracy:
0.9592
Epoch 3/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0293 - accuracy:
0.9668
Epoch 4/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0259 - accuracy:
0.9719
Epoch 5/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0225 - accuracy:
0.9763
Epoch 6/8
```

```
49/49 [==============================] - 0s 10ms/step - loss: 0.0196 - accuracy:
0.9803
Epoch 7/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0194 - accuracy:
0.9798
Epoch 8/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0165 - accuracy:
0.9835
782/782 [==============================] - 2s 2ms/step - loss: 0.1124 -
accuracy: 0.8667
```

[ ]:
```
[0.11238150298595428, 0.8666800260543823]
```

TANH Activation

[ ]:
```python
tanh = keras.Sequential([
 layers.Dense(16, activation="tanh"),
 layers.Dense(1, activation="sigmoid")
])
tanh.compile(optimizer='rmsprop',
 loss='mse',
 metrics=['accuracy'])
x_val_tanh = x_train[:10000]
partial_x_train = x_train[10000:]
y_val_tanh = y_train[:10000]
partial_y_train = y_train[10000:]
historytanh_model = tanh.fit(partial_x_train,
 partial_y_train,
 epochs=20,
batch_size=512,
validation_data=(x_val_tanh, y_val_tanh))
```

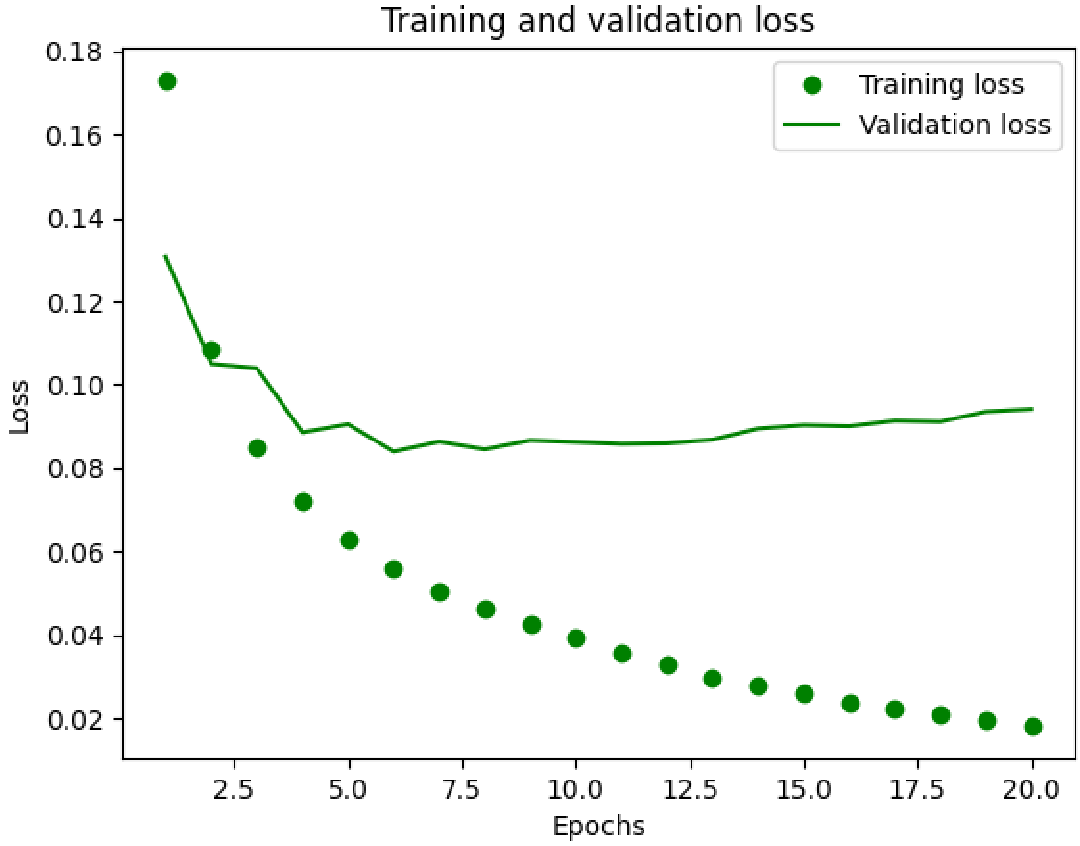
```
Epoch 1/20
30/30 [==============================] - 2s 57ms/step - loss: 0.1730 - accuracy:
0.7841 - val_loss: 0.1306 - val_accuracy: 0.8634
Epoch 2/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1083 - accuracy:
0.8895 - val_loss: 0.1050 - val_accuracy: 0.8805
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0847 - accuracy:
0.9121 - val_loss: 0.1039 - val_accuracy: 0.8632
Epoch 4/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0720 - accuracy:
0.9238 - val_loss: 0.0885 - val_accuracy: 0.8868
Epoch 5/20
30/30 [==============================] - 0s 15ms/step - loss: 0.0630 - accuracy:
0.9322 - val_loss: 0.0905 - val_accuracy: 0.8784
Epoch 6/20
```

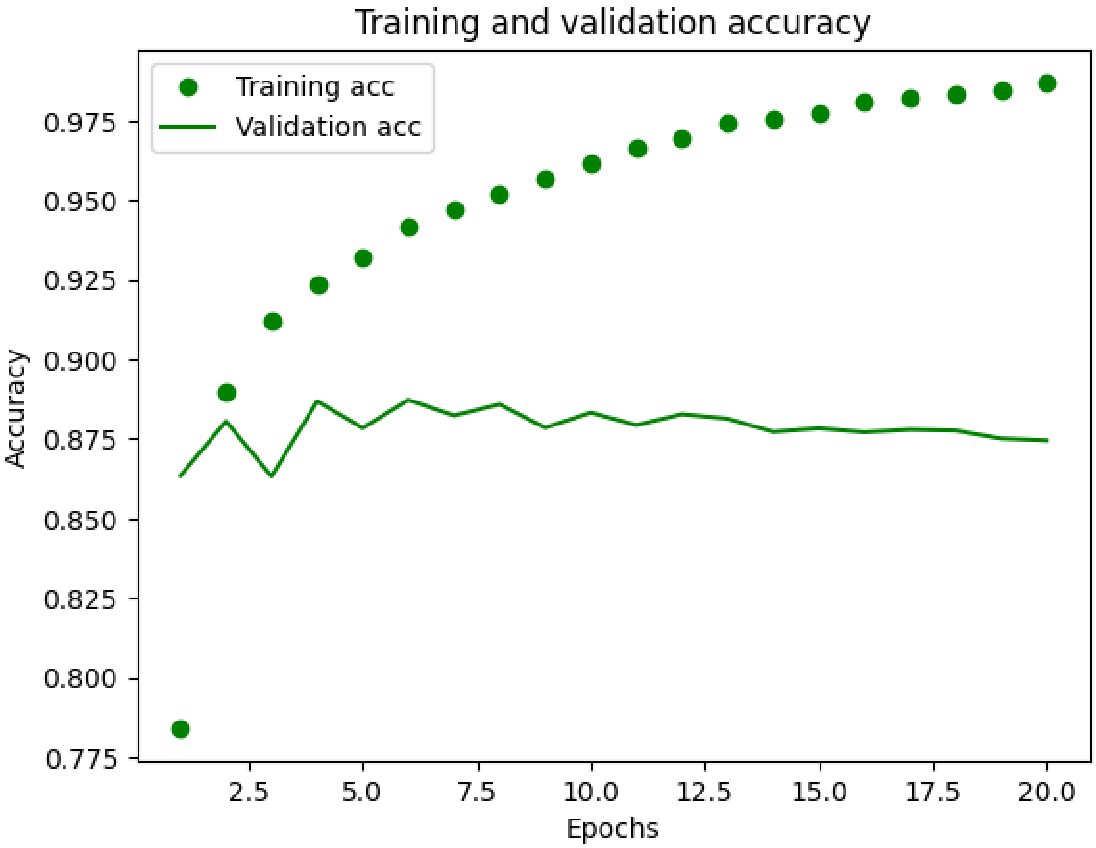
```
30/30 [==============================] - 0s 16ms/step - loss: 0.0561 - accuracy:
0.9417 - val_loss: 0.0839 - val_accuracy: 0.8872
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0506 - accuracy:
0.9471 - val_loss: 0.0863 - val_accuracy: 0.8823
Epoch 8/20
30/30 [==============================] - 0s 15ms/step - loss: 0.0462 - accuracy:
0.9517 - val_loss: 0.0845 - val_accuracy: 0.8858
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0425 - accuracy:
0.9570 - val_loss: 0.0866 - val_accuracy: 0.8785
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0391 - accuracy:
0.9615 - val_loss: 0.0862 - val_accuracy: 0.8832
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0356 - accuracy:
0.9665 - val_loss: 0.0858 - val_accuracy: 0.8793
Epoch 12/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0329 - accuracy:
0.9697 - val_loss: 0.0859 - val_accuracy: 0.8827
Epoch 13/20
30/30 [==============================] - 0s 15ms/step - loss: 0.0297 - accuracy:
0.9743 - val_loss: 0.0868 - val_accuracy: 0.8813
Epoch 14/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0281 - accuracy:
0.9753 - val_loss: 0.0894 - val_accuracy: 0.8772
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0261 - accuracy:
0.9773 - val_loss: 0.0903 - val_accuracy: 0.8783
Epoch 16/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0239 - accuracy:
0.9807 - val_loss: 0.0900 - val_accuracy: 0.8771
Epoch 17/20
30/30 [==============================] - 0s 15ms/step - loss: 0.0221 - accuracy:
0.9820 - val_loss: 0.0913 - val_accuracy: 0.8779
Epoch 18/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0211 - accuracy:
0.9835 - val_loss: 0.0911 - val_accuracy: 0.8776
Epoch 19/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0195 - accuracy:
0.9848 - val_loss: 0.0935 - val_accuracy: 0.8751
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0182 - accuracy:
0.9870 - val_loss: 0.0941 - val_accuracy: 0.8745
```

[ ]:

```
historydict_tanh = historytanh_model.history
historydict_tanh.keys()
```

```
loss_value_tanh= historydict_tanh["loss"]
val_loss_value_tanh = historydict_tanh["val_loss"]
epochs_tanh = range(1, len(loss_value_tanh) + 1)
plt.plot(epochs_tanh, loss_value_tanh, "go", label="Training loss")
plt.plot(epochs_tanh, val_loss_value_tanh, "g", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf()
acc_tanh = historydict_tanh["accuracy"]
val_acc_tanh = historydict_tanh["val_accuracy"]
plt.plot(epochs_tanh, acc_tanh, "go", label="Training acc")
plt.plot(epochs_tanh, val_acc_tanh, "g", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```





```
[ ]: tanh.fit(x_train, y_train, epochs=8, batch_size=512)
     results_tanh = tanh.evaluate(x_test, y_test)
     results_tanh
```

```
Epoch 1/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0475 - accuracy:
0.9434
Epoch 2/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0411 - accuracy:
0.9532
Epoch 3/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0361 - accuracy:
0.9596
Epoch 4/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0340 - accuracy:
0.9630
Epoch 5/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0313 - accuracy:
0.9670
Epoch 6/8
```

```
49/49 [==============================] - 0s 9ms/step - loss: 0.0293 - accuracy:
0.9699
Epoch 7/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0275 - accuracy:
0.9723
Epoch 8/8
49/49 [==============================] - 0s 9ms/step - loss: 0.0264 - accuracy:
0.9741
782/782 [==============================] - 2s 2ms/step - loss: 0.1045 -
accuracy: 0.8680
```

```
[ ]: [0.10449386388063431, 0.8679599761962891]
```

Adam Operator

```
[ ]: adam = keras.Sequential([
      layers.Dense(16, activation="relu"),
      layers.Dense(16, activation="relu"),
      layers.Dense(16, activation="relu"),
      layers.Dense(1, activation="sigmoid")
     ])
     adam.compile(optimizer='adam',
      loss='binary_crossentropy',
      metrics=['accuracy'])
     x_adam = x_train[:10000]
     partial_x_train = x_train[10000:]
     y_adam = y_train[:10000]
     partial_y_train = y_train[10000:]
     historyadam = adam.fit(partial_x_train,
      partial_y_train,
     epochs=20,
      batch_size=512,
     validation_data=(x_adam, y_adam))
```

```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.5778 - accuracy:
0.7550 - val_loss: 0.4218 - val_accuracy: 0.8589
Epoch 2/20
30/30 [==============================] - 0s 17ms/step - loss: 0.3146 - accuracy:
0.9003 - val_loss: 0.2953 - val_accuracy: 0.8857
Epoch 3/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2020 - accuracy:
0.9311 - val_loss: 0.2914 - val_accuracy: 0.8829
Epoch 4/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1478 - accuracy:
0.9502 - val_loss: 0.2873 - val_accuracy: 0.8861
Epoch 5/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1076 - accuracy:
```

```
0.9681 - val_loss: 0.3119 - val_accuracy: 0.8817
Epoch 6/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0782 - accuracy:
0.9799 - val_loss: 0.3389 - val_accuracy: 0.8800
Epoch 7/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0565 - accuracy:
0.9880 - val_loss: 0.3754 - val_accuracy: 0.8771
Epoch 8/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0401 - accuracy:
0.9929 - val_loss: 0.4178 - val_accuracy: 0.8746
Epoch 9/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0277 - accuracy:
0.9966 - val_loss: 0.4643 - val_accuracy: 0.8748
Epoch 10/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0195 - accuracy:
0.9983 - val_loss: 0.5078 - val_accuracy: 0.8726
Epoch 11/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0135 - accuracy:
0.9995 - val_loss: 0.5496 - val_accuracy: 0.8702
Epoch 12/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0096 - accuracy:
0.9997 - val_loss: 0.5858 - val_accuracy: 0.8702
Epoch 13/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0071 - accuracy:
0.9999 - val_loss: 0.6208 - val_accuracy: 0.8691
Epoch 14/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0055 - accuracy:
0.9999 - val_loss: 0.6513 - val_accuracy: 0.8694
Epoch 15/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0043 - accuracy:
0.9999 - val_loss: 0.6793 - val_accuracy: 0.8683
Epoch 16/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0035 - accuracy:
0.9999 - val_loss: 0.7028 - val_accuracy: 0.8668
Epoch 17/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0029 - accuracy:
0.9999 - val_loss: 0.7254 - val_accuracy: 0.8672
Epoch 18/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0025 - accuracy:
0.9999 - val_loss: 0.7459 - val_accuracy: 0.8668
Epoch 19/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0021 - accuracy:
0.9999 - val_loss: 0.7655 - val_accuracy: 0.8663
Epoch 20/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0018 - accuracy:
0.9999 - val_loss: 0.7839 - val_accuracy: 0.8667
```

[ ]:

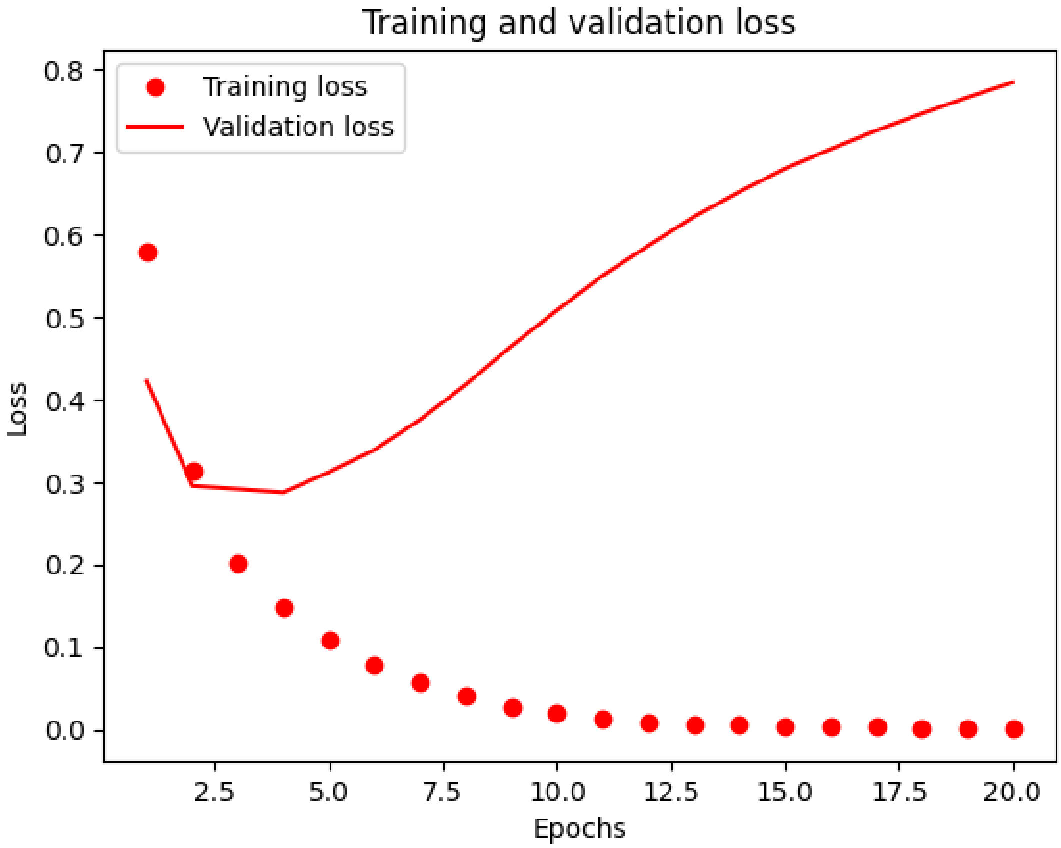
```python
historydict_adam = historyadam.history
historydict_adam.keys()
```

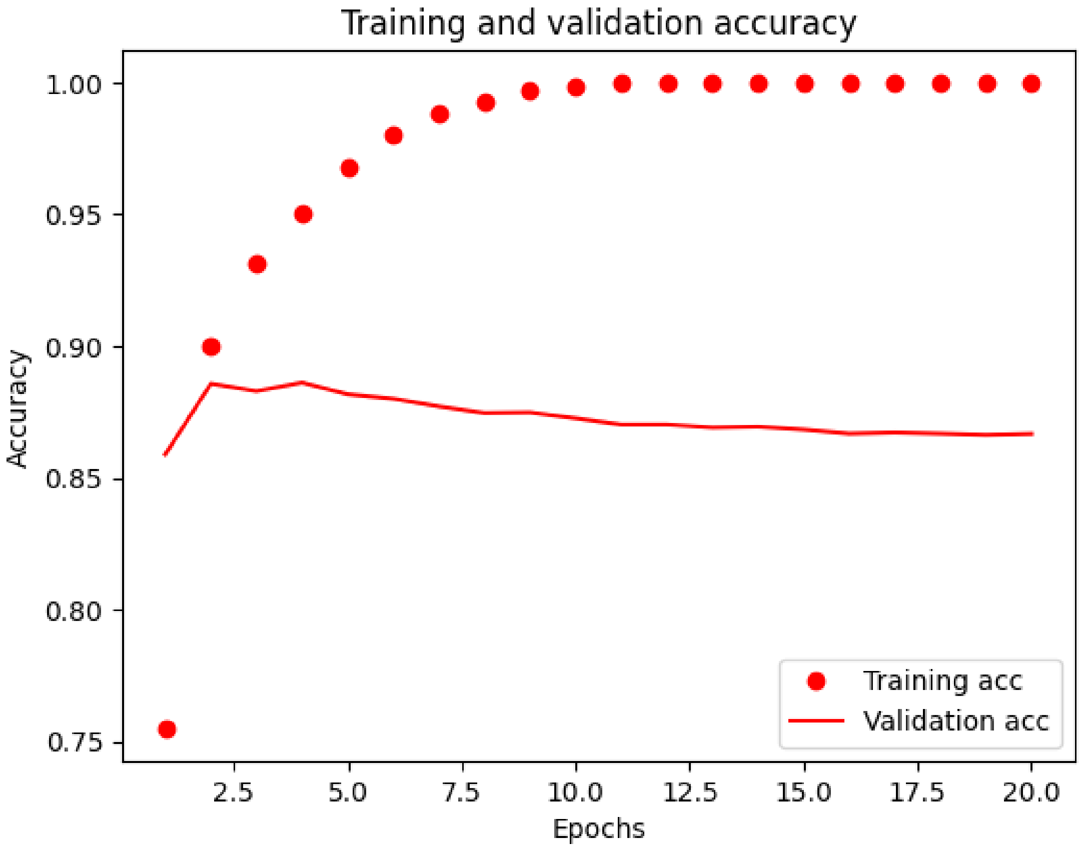
[ ]:

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

[ ]:

```python
loss_value_adam = historydict_adam["loss"]
val_loss_value_adam = historydict_adam["val_loss"]
epochs_adam = range(1, len(loss_value_adam) + 1)
plt.plot(epochs_adam, loss_value_adam, "ro", label="Training loss")
plt.plot(epochs_adam, val_loss_value_adam, "r", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
plt.clf()
acc_adam = historydict_adam["accuracy"]
val_acc_adam = historydict_adam["val_accuracy"]
plt.plot(epochs_adam, acc_adam, "ro", label="Training acc")
plt.plot(epochs_adam, val_acc_adam, "r", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```


Training and validation loss
Training loss
Validation loss
Loss
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Epochs
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0



[ ]:

```
adam.fit(x_train, y_train, epochs=8, batch_size=512)
results_adam = adam.evaluate(x_test, y_test)
results_adam
```

```
Epoch 1/8
49/49 [==============================] - 1s 11ms/step - loss: 0.2532 - accuracy:
0.9371
Epoch 2/8
49/49 [==============================] - 1s 11ms/step - loss: 0.1166 - accuracy:
0.9635
Epoch 3/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0806 - accuracy:
0.9770
Epoch 4/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0583 - accuracy:
0.9855
Epoch 5/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0426 - accuracy:
0.9910
Epoch 6/8
```

```
49/49 [==============================] - 1s 11ms/step - loss: 0.0310 - accuracy:
0.9946
Epoch 7/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0239 - accuracy:
0.9963
Epoch 8/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0172 - accuracy:
0.9977
782/782 [==============================] - 2s 2ms/step - loss: 0.7540 -
accuracy: 0.8501
```

```
[ ]: [0.7539851069450378, 0.8500800132751465]
```

0.0.5 Adding Dropout and Regularization techniques

Regularization with 16 units, 2 Layers

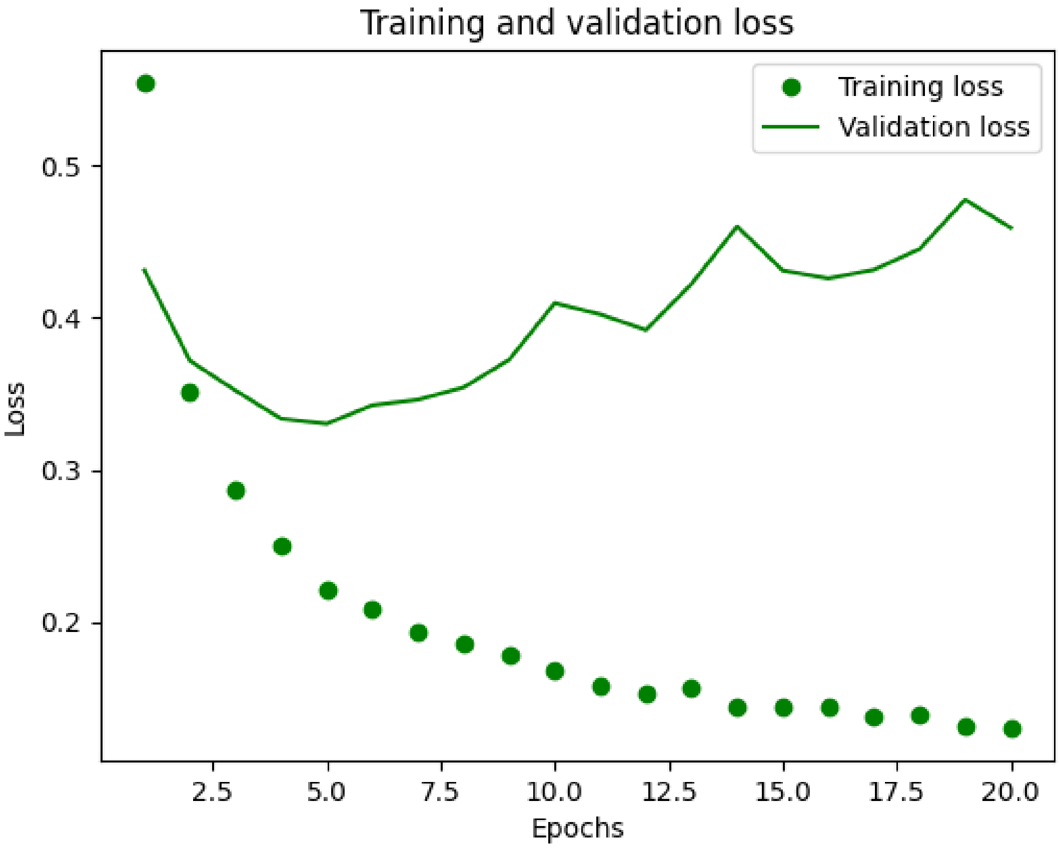
```
[ ]: from tensorflow.keras import regularizers
     regularization = keras.Sequential([
      layers.Dense(16, activation="relu",kernel_regularizer=regularizers.l2(0.001)),
      layers.Dense(16, activation="relu",kernel_regularizer=regularizers.l2(0.001)),
      layers.Dense(1, activation="sigmoid")
     ])
     regularization.compile(optimizer="rmsprop",
      loss="binary_crossentropy",
      metrics=["accuracy"])
     history_regularization = regularization.fit(partial_x_train,
      partial_y_train,
     epochs=20,
     batch_size=512,
      validation_data=(x_val, y_val))
     historydict_regularization = history_regularization.history
     historydict_regularization.keys()
```

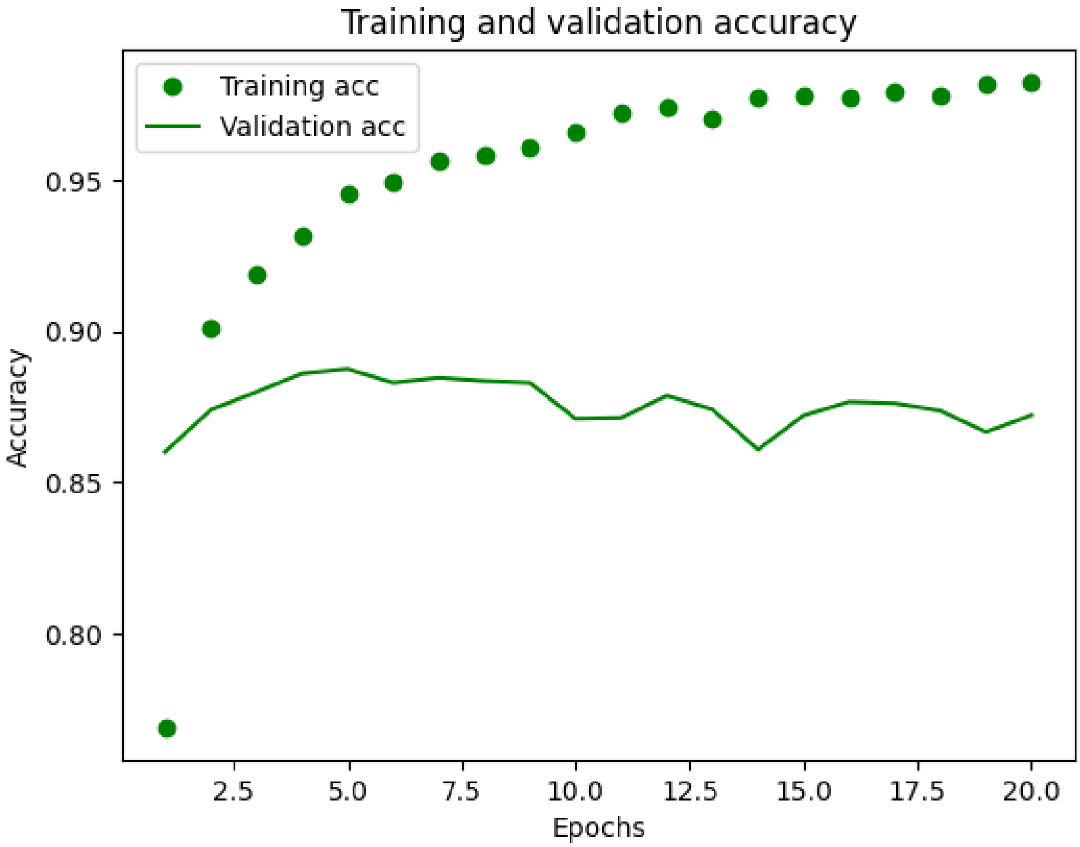
```
Epoch 1/20
30/30 [==============================] - 2s 58ms/step - loss: 0.5550 - accuracy:
0.7687 - val_loss: 0.4314 - val_accuracy: 0.8601
Epoch 2/20
30/30 [==============================] - 0s 16ms/step - loss: 0.3509 - accuracy:
0.9008 - val_loss: 0.3718 - val_accuracy: 0.8740
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2865 - accuracy:
0.9191 - val_loss: 0.3522 - val_accuracy: 0.8799
Epoch 4/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2500 - accuracy:
0.9319 - val_loss: 0.3336 - val_accuracy: 0.8860
Epoch 5/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2208 - accuracy:
```

```
0.9459 - val_loss: 0.3303 - val_accuracy: 0.8875
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2084 - accuracy:
0.9496 - val_loss: 0.3425 - val_accuracy: 0.8829
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1932 - accuracy:
0.9564 - val_loss: 0.3462 - val_accuracy: 0.8846
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1851 - accuracy:
0.9581 - val_loss: 0.3542 - val_accuracy: 0.8835
Epoch 9/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1779 - accuracy:
0.9611 - val_loss: 0.3724 - val_accuracy: 0.8829
Epoch 10/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1686 - accuracy:
0.9661 - val_loss: 0.4098 - val_accuracy: 0.8710
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1582 - accuracy:
0.9725 - val_loss: 0.4024 - val_accuracy: 0.8713
Epoch 12/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1523 - accuracy:
0.9744 - val_loss: 0.3921 - val_accuracy: 0.8787
Epoch 13/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1565 - accuracy:
0.9703 - val_loss: 0.4224 - val_accuracy: 0.8741
Epoch 14/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1441 - accuracy:
0.9773 - val_loss: 0.4602 - val_accuracy: 0.8608
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1434 - accuracy:
0.9781 - val_loss: 0.4312 - val_accuracy: 0.8721
Epoch 16/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1435 - accuracy:
0.9775 - val_loss: 0.4260 - val_accuracy: 0.8766
Epoch 17/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1377 - accuracy:
0.9793 - val_loss: 0.4317 - val_accuracy: 0.8761
Epoch 18/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1382 - accuracy:
0.9784 - val_loss: 0.4453 - val_accuracy: 0.8737
Epoch 19/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1317 - accuracy:
0.9818 - val_loss: 0.4778 - val_accuracy: 0.8666
Epoch 20/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1301 - accuracy:
0.9826 - val_loss: 0.4594 - val_accuracy: 0.8722
```

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

```
[ ]: loss_valu = historydict_regularization["loss"]
     val_loss_value_r = historydict_regularization["val_loss"]
     epochs_r = range(1, len(loss_valu) + 1)
     plt.plot(epochs_r, loss_valu, "go", label="Training loss")
     plt.plot(epochs_r, val_loss_value_r, "g", label="Validation loss")
     plt.title("Training and validation loss")
     plt.xlabel("Epochs")
     plt.ylabel("Loss")
     plt.legend()
     plt.show()
     plt.clf()
     acc_r = historydict_regularization["accuracy"]
     val_acc_r = historydict_regularization["val_accuracy"]
     plt.plot(epochs_r, acc_r, "go", label="Training acc")
     plt.plot(epochs_r, val_acc_r, "g", label="Validation acc")
     plt.title("Training and validation accuracy")
     plt.xlabel("Epochs")
     plt.ylabel("Accuracy")
     plt.legend()
     plt.show()
```





[ ]:
```
regularization.fit(x_train, y_train, epochs=8, batch_size=512)
results_regularization = regularization.evaluate(x_test, y_test)
results_regularization
```

```
Epoch 1/8
49/49 [==============================] - 1s 10ms/step - loss: 0.2544 - accuracy:
0.9366
Epoch 2/8
49/49 [==============================] - 0s 10ms/step - loss: 0.2127 - accuracy:
0.9470
Epoch 3/8
49/49 [==============================] - 0s 9ms/step - loss: 0.1941 - accuracy:
0.9528
Epoch 4/8
49/49 [==============================] - 0s 10ms/step - loss: 0.1840 - accuracy:
0.9567
Epoch 5/8
49/49 [==============================] - 0s 10ms/step - loss: 0.1797 - accuracy:
```

```
0.9569
Epoch 6/8
49/49 [==============================] - 0s 10ms/step - loss: 0.1708 - accuracy:
0.9614
Epoch 7/8
49/49 [==============================] - 1s 10ms/step - loss: 0.1694 - accuracy:
0.9624
Epoch 8/8
49/49 [==============================] - 0s 10ms/step - loss: 0.1622 - accuracy:
0.9659
782/782 [==============================] - 2s 2ms/step - loss: 0.4396 -
accuracy: 0.8665
```

```
[ ]: [0.4396273195743561, 0.8664799928665161]
```

Dropout with 16 units, 2 layers

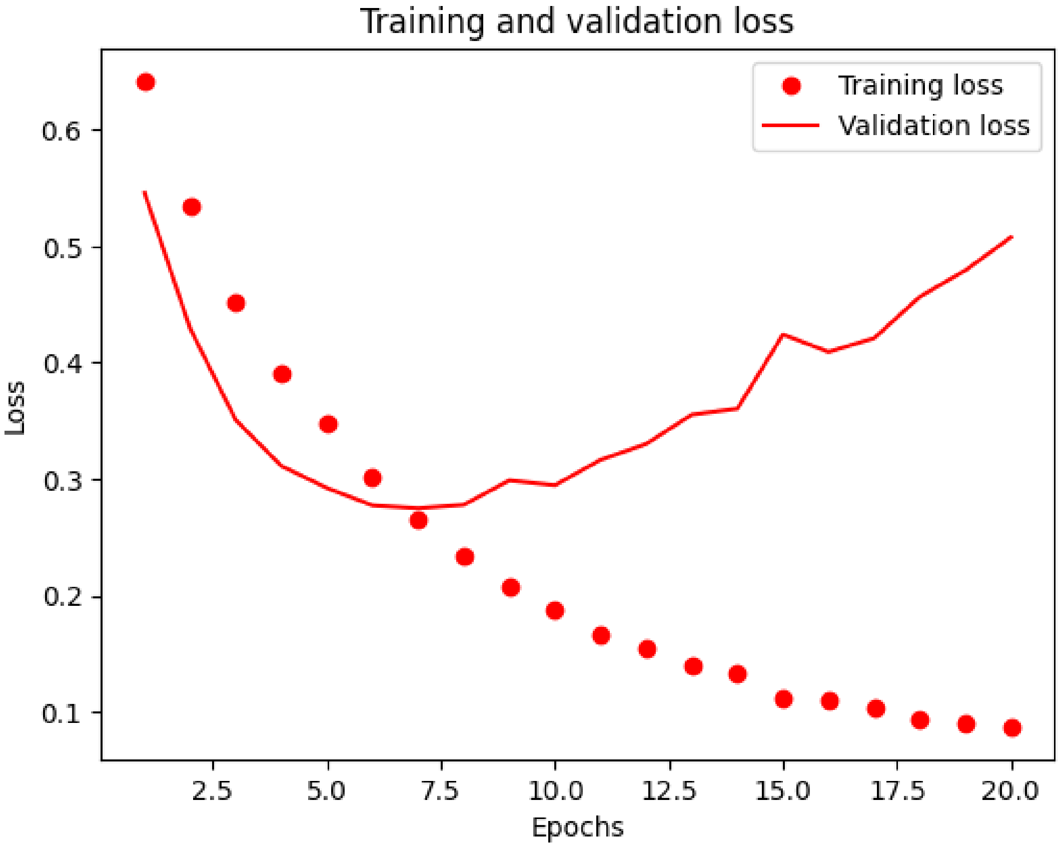
```
[ ]: from tensorflow.keras import regularizers
     Dropout = keras.Sequential([
      layers.Dense(16, activation="relu"),
      layers.Dropout(0.5),
      layers.Dense(16, activation="relu"),
      layers.Dropout(0.5),
      layers.Dense(1, activation="sigmoid")
     ])
     Dropout.compile(optimizer="rmsprop",
      loss="binary_crossentropy",
      metrics=["accuracy"])
     history_Dropout = Dropout.fit(partial_x_train,
      partial_y_train,
     epochs=20,
     batch_size=512,
      validation_data=(x_val, y_val))
     historydict_Dropout = history_Dropout.history
     historydict_Dropout.keys()
```

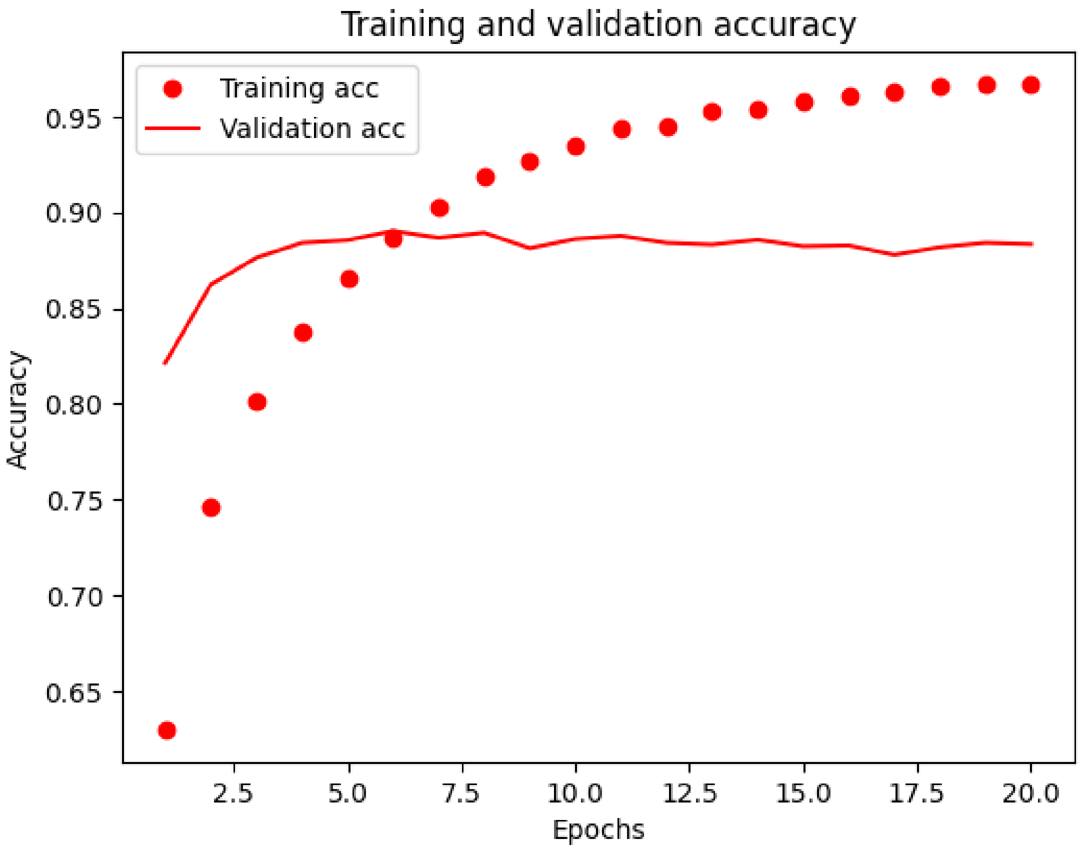
```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.6418 - accuracy:
0.6301 - val_loss: 0.5457 - val_accuracy: 0.8214
Epoch 2/20
30/30 [==============================] - 1s 17ms/step - loss: 0.5347 - accuracy:
0.7467 - val_loss: 0.4294 - val_accuracy: 0.8623
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.4520 - accuracy:
0.8019 - val_loss: 0.3508 - val_accuracy: 0.8763
Epoch 4/20
30/30 [==============================] - 0s 16ms/step - loss: 0.3913 - accuracy:
0.8377 - val_loss: 0.3114 - val_accuracy: 0.8841
```

```
Epoch 5/20
30/30 [==============================] - 1s 17ms/step - loss: 0.3479 - accuracy:
0.8657 - val_loss: 0.2924 - val_accuracy: 0.8855
Epoch 6/20
30/30 [==============================] - 0s 16ms/step - loss: 0.3017 - accuracy:
0.8867 - val_loss: 0.2775 - val_accuracy: 0.8902
Epoch 7/20
30/30 [==============================] - 0s 17ms/step - loss: 0.2660 - accuracy:
0.9025 - val_loss: 0.2751 - val_accuracy: 0.8867
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2334 - accuracy:
0.9187 - val_loss: 0.2781 - val_accuracy: 0.8893
Epoch 9/20
30/30 [==============================] - 0s 16ms/step - loss: 0.2084 - accuracy:
0.9272 - val_loss: 0.2990 - val_accuracy: 0.8813
Epoch 10/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1884 - accuracy:
0.9351 - val_loss: 0.2948 - val_accuracy: 0.8861
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1670 - accuracy:
0.9438 - val_loss: 0.3166 - val_accuracy: 0.8877
Epoch 12/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1557 - accuracy:
0.9449 - val_loss: 0.3303 - val_accuracy: 0.8841
Epoch 13/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1398 - accuracy:
0.9528 - val_loss: 0.3555 - val_accuracy: 0.8832
Epoch 14/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1330 - accuracy:
0.9535 - val_loss: 0.3606 - val_accuracy: 0.8857
Epoch 15/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1124 - accuracy:
0.9584 - val_loss: 0.4242 - val_accuracy: 0.8823
Epoch 16/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1105 - accuracy:
0.9606 - val_loss: 0.4093 - val_accuracy: 0.8827
Epoch 17/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1037 - accuracy:
0.9629 - val_loss: 0.4211 - val_accuracy: 0.8778
Epoch 18/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0939 - accuracy:
0.9659 - val_loss: 0.4566 - val_accuracy: 0.8818
Epoch 19/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0900 - accuracy:
0.9665 - val_loss: 0.4793 - val_accuracy: 0.8841
Epoch 20/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0875 - accuracy:
0.9670 - val_loss: 0.5077 - val_accuracy: 0.8834
```

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

```
[ ]: loss_val = historydict_Dropout["loss"]
     val_loss_val_d = historydict_Dropout["val_loss"]
     epochs_d = range(1, len(loss_val) + 1)
     plt.plot(epochs_d, loss_val, "ro", label="Training loss")
     plt.plot(epochs_d, val_loss_val_d, "r", label="Validation loss")
     plt.title("Training and validation loss")
     plt.xlabel("Epochs")
     plt.ylabel("Loss")
     plt.legend()
     plt.show()
     plt.clf()
     acc_d = historydict_Dropout["accuracy"]
     val_acc_d = historydict_Dropout["val_accuracy"]
     plt.plot(epochs_d, acc_d, "ro", label="Training acc")
     plt.plot(epochs_d, val_acc_d, "r", label="Validation acc")
     plt.title("Training and validation accuracy")
     plt.xlabel("Epochs")
     plt.ylabel("Accuracy")
     plt.legend()
     plt.show()
```





```
[ ]: Dropout.fit(x_train, y_train, epochs=10, batch_size=512)
     results_Dropout = Dropout.evaluate(x_test, y_test)
     results_Dropout
```

```
Epoch 1/10
49/49 [==============================] - 1s 10ms/step - loss: 0.2527 - accuracy:
0.9195
Epoch 2/10
49/49 [==============================] - 1s 10ms/step - loss: 0.2099 - accuracy:
0.9294
Epoch 3/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1861 - accuracy:
0.9349
Epoch 4/10
49/49 [==============================] - 1s 10ms/step - loss: 0.1687 - accuracy:
0.9407
Epoch 5/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1563 - accuracy:
```

```
0.9462
Epoch 6/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1456 - accuracy:
0.9498
Epoch 7/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1426 - accuracy:
0.9497
Epoch 8/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1345 - accuracy:
0.9514
Epoch 9/10
49/49 [==============================] - 1s 10ms/step - loss: 0.1293 - accuracy:
0.9538
Epoch 10/10
49/49 [==============================] - 0s 10ms/step - loss: 0.1177 - accuracy:
0.9560
782/782 [==============================] - 2s 2ms/step - loss: 0.5223 -
accuracy: 0.8763
```

[ ]:

```
[0.5222946405410767, 0.8762800097465515]
```

Hyper Tuned parameters

[ ]:

```python
from tensorflow.keras import regularizers
Hyper = keras.Sequential([
 layers.Dense(32, activation="relu",kernel_regularizer=regularizers.l2(0.0001)),
 layers.Dropout(0.5),
 layers.Dense(32, activation="relu",kernel_regularizer=regularizers.l2(0.0001)),
 layers.Dropout(0.5),
 layers.Dense(16, activation="relu",kernel_regularizer=regularizers.l2(0.0001)),
 layers.Dropout(0.5),
 layers.Dense(1, activation="sigmoid")
])
Hyper.compile(optimizer="rmsprop",
 loss="mse",
 metrics=["accuracy"])
history_Hyper = Hyper.fit(partial_x_train,
 partial_y_train,
epochs=20,
batch_size=512,
validation_data=(x_val, y_val))
history_dictHyper = history_Hyper.history
history_dictHyper.keys()
```

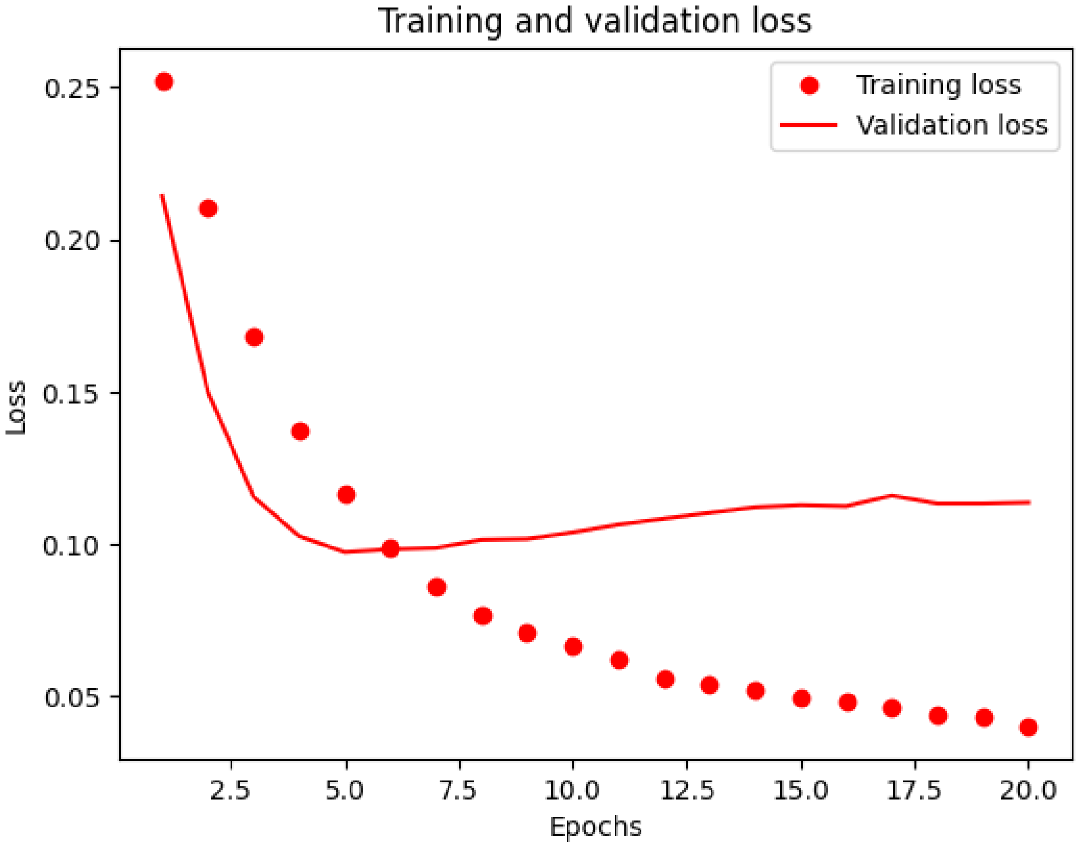
```
Epoch 1/20
30/30 [==============================] - 3s 60ms/step - loss: 0.2522 - accuracy:
0.5679 - val_loss: 0.2143 - val_accuracy: 0.8197
Epoch 2/20
```

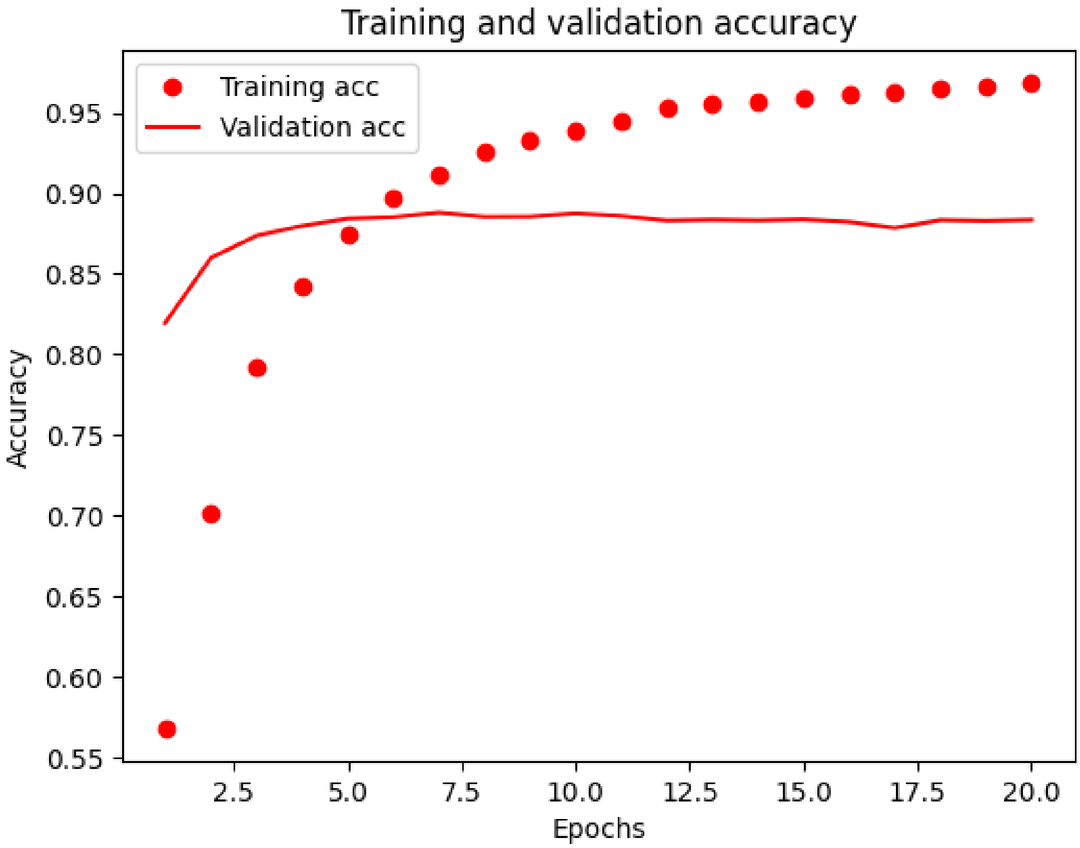
```
30/30 [==============================] - 0s 17ms/step - loss: 0.2104 - accuracy:
0.7015 - val_loss: 0.1500 - val_accuracy: 0.8599
Epoch 3/20
30/30 [==============================] - 0s 16ms/step - loss: 0.1680 - accuracy:
0.7923 - val_loss: 0.1156 - val_accuracy: 0.8737
Epoch 4/20
30/30 [==============================] - 0s 17ms/step - loss: 0.1372 - accuracy:
0.8423 - val_loss: 0.1026 - val_accuracy: 0.8798
Epoch 5/20
30/30 [==============================] - 1s 17ms/step - loss: 0.1162 - accuracy:
0.8742 - val_loss: 0.0974 - val_accuracy: 0.8843
Epoch 6/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0989 - accuracy:
0.8967 - val_loss: 0.0984 - val_accuracy: 0.8853
Epoch 7/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0864 - accuracy:
0.9120 - val_loss: 0.0988 - val_accuracy: 0.8881
Epoch 8/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0769 - accuracy:
0.9261 - val_loss: 0.1014 - val_accuracy: 0.8855
Epoch 9/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0712 - accuracy:
0.9325 - val_loss: 0.1017 - val_accuracy: 0.8856
Epoch 10/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0665 - accuracy:
0.9395 - val_loss: 0.1039 - val_accuracy: 0.8876
Epoch 11/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0623 - accuracy:
0.9443 - val_loss: 0.1064 - val_accuracy: 0.8860
Epoch 12/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0559 - accuracy:
0.9526 - val_loss: 0.1084 - val_accuracy: 0.8831
Epoch 13/20
30/30 [==============================] - 0s 16ms/step - loss: 0.0540 - accuracy:
0.9551 - val_loss: 0.1103 - val_accuracy: 0.8836
Epoch 14/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0521 - accuracy:
0.9573 - val_loss: 0.1122 - val_accuracy: 0.8832
Epoch 15/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0494 - accuracy:
0.9593 - val_loss: 0.1128 - val_accuracy: 0.8838
Epoch 16/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0482 - accuracy:
0.9611 - val_loss: 0.1125 - val_accuracy: 0.8823
Epoch 17/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0464 - accuracy:
0.9623 - val_loss: 0.1160 - val_accuracy: 0.8785
Epoch 18/20
```

```
30/30 [==============================] - 0s 17ms/step - loss: 0.0441 - accuracy:
0.9646 - val_loss: 0.1134 - val_accuracy: 0.8834
Epoch 19/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0436 - accuracy:
0.9658 - val_loss: 0.1134 - val_accuracy: 0.8829
Epoch 20/20
30/30 [==============================] - 0s 17ms/step - loss: 0.0402 - accuracy:
0.9688 - val_loss: 0.1137 - val_accuracy: 0.8835
```

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

```
[ ]: loss_va_h = history_dictHyper["loss"]
     val_loss_va_h = history_dictHyper["val_loss"]
     epochs_h = range(1, len(loss_va_h) + 1)
     plt.plot(epochs_h, loss_va_h, "ro", label="Training loss")
     plt.plot(epochs_h, val_loss_va_h, "r", label="Validation loss")
     plt.title("Training and validation loss")
     plt.xlabel("Epochs")
     plt.ylabel("Loss")
     plt.legend()
     plt.show()
     plt.clf()
     acc_h = history_dictHyper["accuracy"]
     val_acc_h = history_dictHyper["val_accuracy"]
     plt.plot(epochs_h, acc_h, "ro", label="Training acc")
     plt.plot(epochs_h, val_acc_h, "r", label="Validation acc")
     plt.title("Training and validation accuracy")
     plt.xlabel("Epochs")
     plt.ylabel("Accuracy")
     plt.legend()
     plt.show()
```


Training and validation loss
Training loss
Validation loss
Loss
0.25
0.20
0.15
0.10
0.05
Epochs
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0



[ ]:

```
Hyper.fit(x_train, y_train, epochs=8, batch_size=512)
results_Hyper = Hyper.evaluate(x_test, y_test)
results_Hyper
```

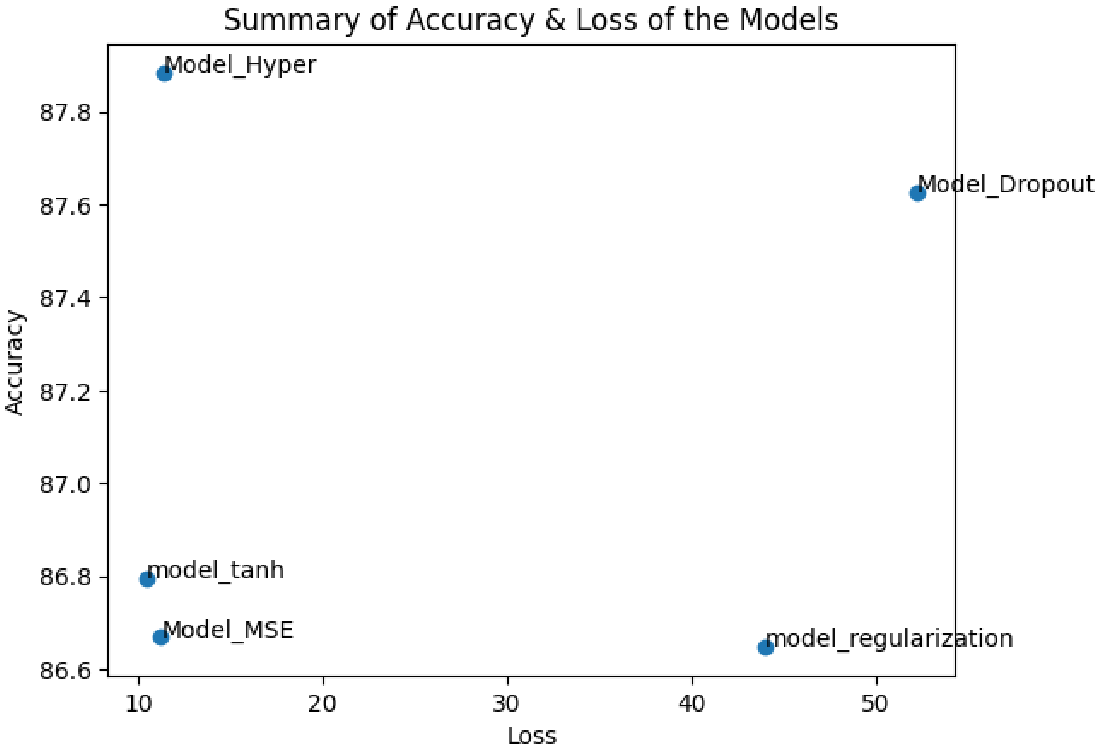
```
Epoch 1/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0738 - accuracy:
0.9277
Epoch 2/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0668 - accuracy:
0.9355
Epoch 3/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0628 - accuracy:
0.9392
Epoch 4/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0605 - accuracy:
0.9434
Epoch 5/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0590 - accuracy:
0.9438
Epoch 6/8
```

```
49/49 [==============================] - 0s 10ms/step - loss: 0.0546 - accuracy:
0.9498
Epoch 7/8
49/49 [==============================] - 1s 10ms/step - loss: 0.0532 - accuracy:
0.9515
Epoch 8/8
49/49 [==============================] - 0s 10ms/step - loss: 0.0516 - accuracy:
0.9524
782/782 [==============================] - 2s 2ms/step - loss: 0.1139 -
accuracy: 0.8788
```

[ ]:
```
[0.1139034777879715, 0.8788400292396545]
```

[ ]:
```python
Models_Loss= np.
 ↪array([results_Dropout[0],results_Hyper[0],results_MSE[0],results_regularization[0],results
Models_Loss
Models_Accuracy= np.
 ↪array([results_Dropout[1],results_Hyper[1],results_MSE[1],results_regularization[1],results
Models_Accuracy
Labels=['Model_Dropout','Model_Hyper','Model_MSE','model_regularization','model_tanh']
plt.clf()
fig, ax = plt.subplots()
ax.scatter(Models_Loss,Models_Accuracy)
for i, txt in enumerate(Labels):
 ax.annotate(txt, (Models_Loss[i],Models_Accuracy[i] ))
plt.title("Summary of Accuracy & Loss of the Models")
plt.ylabel("Accuracy")
plt.xlabel("Loss")
plt.show()
```

```
<Figure size 640x480 with 0 Axes>
```



1 Summary

From the results obtained it can be observed that a neural network model for IMDB dataset have,

Right number of hidden layers, if the layers are less the model capability will be reduced and if the layers are more even then the capability will be reduced. In this model 2 layers are considered.

Right unit size based on the dataset, If the dataset is not too complex or dataset is less the unit size should be less. Here in this model unit size of 16 is optimal.

Proper selection of loss function. It can be observed that loss function binary cross entropy has higher accuracy rate than mean square error loss function.

Relu activation function has high capability of finding the non-linear relationship between datapoints rather than tanh activation function

To improve the original, regularization and dropout techniques are used. With the technique used, validation loss has been decreased slightly and accuracy is increased. These additions have improved the model slightly by 2%.

2 Conclusion

Neural network models with different configurations showed different patterns of sensitivity and loss. Among these, the Model_Hyper tuning. Overall, the performance of the models was much enhanced by the addition of dropout regularization, with Model hyper being the most accurate