```
#Importing required packages

import numpy as np
import pandas as pd
from pandas import Series, DataFrame

#Visualization Packages

import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

#Deep Learning Packages

from tensorflow import keras
from tensorflow.keras import models
from tensorflow.keras import layers
from tensorflow.keras import regularizers
from keras.layers import Dense
from keras.layers import Dropout
from tensorflow.python import metrics
from tensorflow.keras.utils import plot_model


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


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

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9999
```

```
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]])

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)

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

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

model.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])

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

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

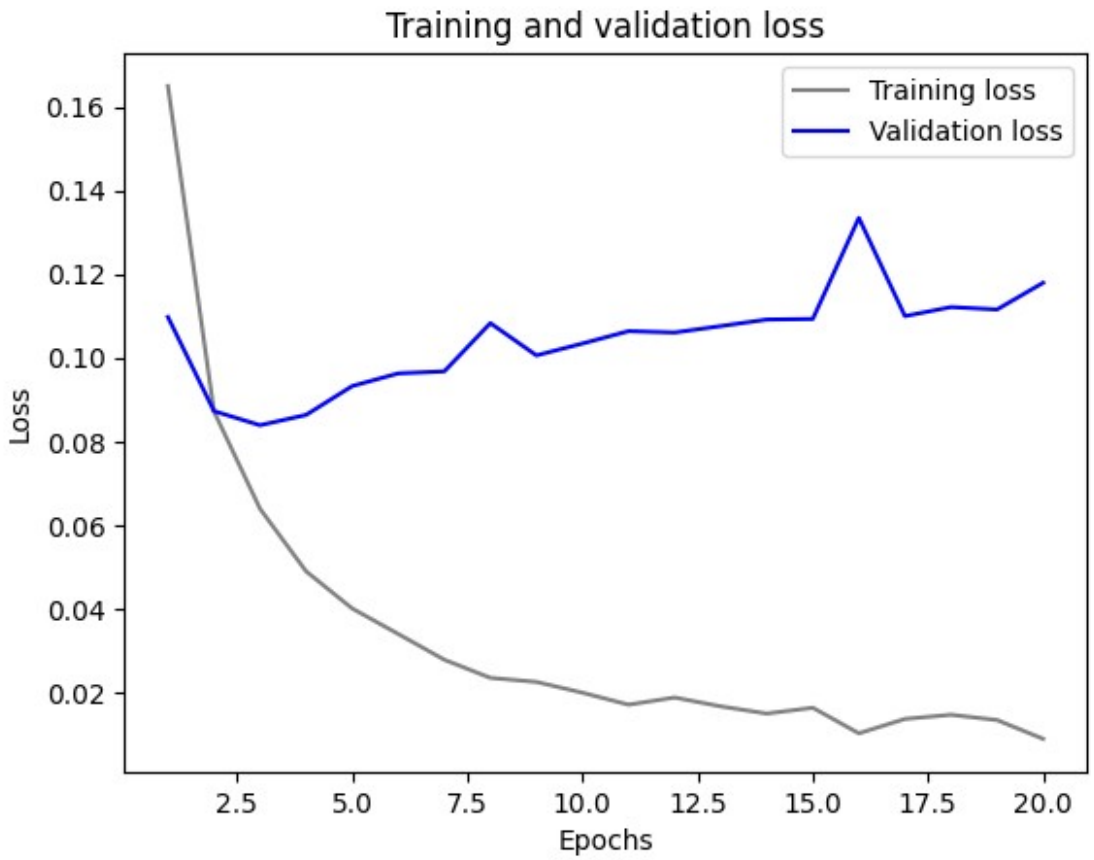
```
Epoch 1/20
30/30 [==============================] - 3s 59ms/step - loss: 0.1649 -
accuracy: 0.7693 - val_loss: 0.1097 - val_accuracy: 0.8664
Epoch 2/20
30/30 [==============================] - 1s 25ms/step - loss: 0.0872 -
accuracy: 0.8915 - val_loss: 0.0872 - val_accuracy: 0.8854
Epoch 3/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0639 -
accuracy: 0.9192 - val_loss: 0.0839 - val_accuracy: 0.8854
Epoch 4/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0489 -
accuracy: 0.9388 - val_loss: 0.0863 - val_accuracy: 0.8839
Epoch 5/20
30/30 [==============================] - 1s 19ms/step - loss: 0.0401 -
accuracy: 0.9513 - val_loss: 0.0932 - val_accuracy: 0.8762
Epoch 6/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0340 -
accuracy: 0.9597 - val_loss: 0.0962 - val_accuracy: 0.8759
Epoch 7/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0278 -
accuracy: 0.9682 - val_loss: 0.0967 - val_accuracy: 0.8769
Epoch 8/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0235 -
accuracy: 0.9726 - val_loss: 0.1083 - val_accuracy: 0.8682
Epoch 9/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0225 -
accuracy: 0.9746 - val_loss: 0.1005 - val_accuracy: 0.8772
Epoch 10/20
```

```
30/30 [==============================] - 1s 24ms/step - loss: 0.0199 -
accuracy: 0.9773 - val_loss: 0.1034 - val_accuracy: 0.8767
Epoch 11/20
30/30 [==============================] - 1s 28ms/step - loss: 0.0171 -
accuracy: 0.9817 - val_loss: 0.1063 - val_accuracy: 0.8734
Epoch 12/20
30/30 [==============================] - 1s 29ms/step - loss: 0.0188 -
accuracy: 0.9795 - val_loss: 0.1060 - val_accuracy: 0.8723
Epoch 13/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0167 -
accuracy: 0.9822 - val_loss: 0.1076 - val_accuracy: 0.8724
Epoch 14/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0150 -
accuracy: 0.9841 - val_loss: 0.1091 - val_accuracy: 0.8716
Epoch 15/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0163 -
accuracy: 0.9820 - val_loss: 0.1093 - val_accuracy: 0.8738
Epoch 16/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0102 -
accuracy: 0.9900 - val_loss: 0.1334 - val_accuracy: 0.8463
Epoch 17/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0137 -
accuracy: 0.9853 - val_loss: 0.1099 - val_accuracy: 0.8743
Epoch 18/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0147 -
accuracy: 0.9841 - val_loss: 0.1121 - val_accuracy: 0.8705
Epoch 19/20
30/30 [==============================] - 1s 19ms/step - loss: 0.0134 -
accuracy: 0.9855 - val_loss: 0.1115 - val_accuracy: 0.8721
Epoch 20/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0089 -
accuracy: 0.9913 - val_loss: 0.1179 - val_accuracy: 0.8657

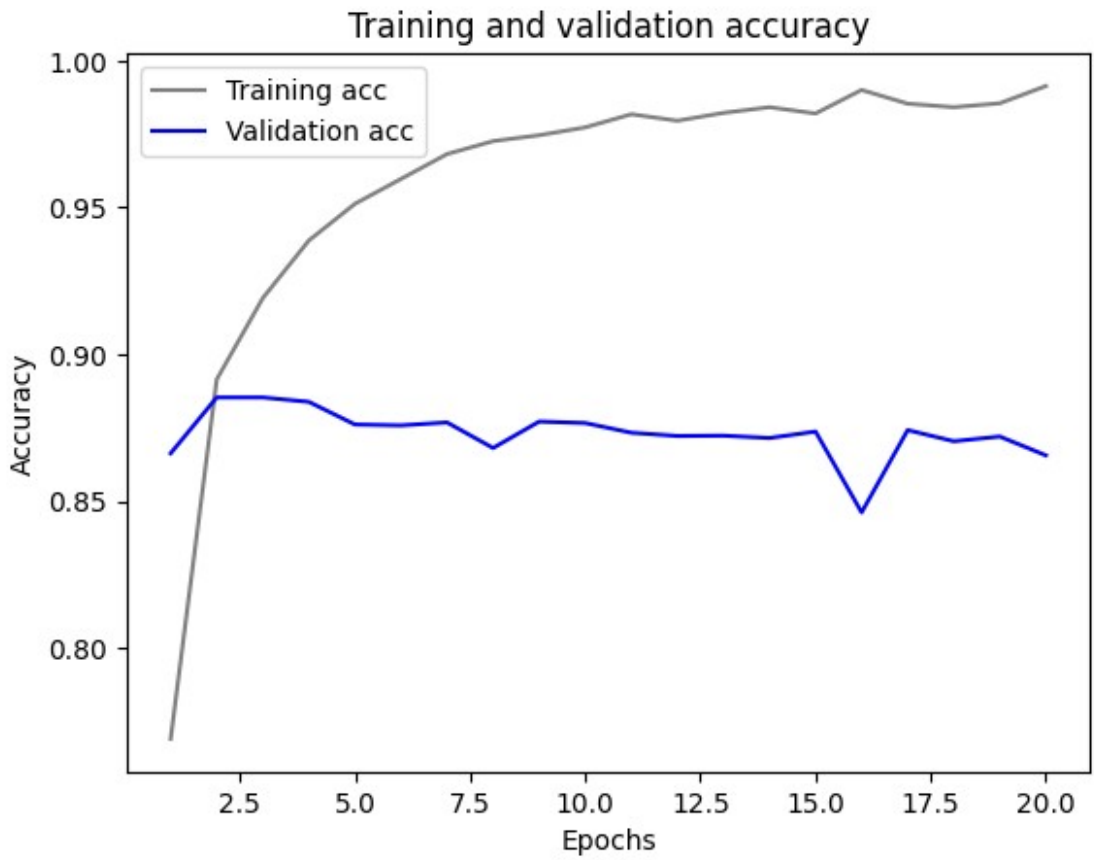
history_dict_1 = history.history
history_dict_1.keys()

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

import matplotlib.pyplot as plt
history_dict_1 = history.history
loss_values = history_dict_1["loss"]
val_loss_values = history_dict_1["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "blue", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```




```
plt.clf()
acc = history_dict_1["accuracy"]
val_acc = history_dict_1["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
plt.plot(epochs, val_acc, "blue", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




```
model = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
model.compile(optimizer="rmsprop",
              loss="mse",
              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 [==============================] - 2s 15ms/step - loss: 0.1381 -
accuracy: 0.8134
Epoch 2/4
49/49 [==============================] - 1s 13ms/step - loss: 0.0739 -
accuracy: 0.9036
Epoch 3/4
49/49 [==============================] - 1s 13ms/step - loss: 0.0597 -
accuracy: 0.9232
Epoch 4/4
49/49 [==============================] - 1s 12ms/step - loss: 0.0498 -
```

```
accuracy: 0.9374
782/782 [==============================] - 1s 2ms/step - loss: 0.0903
- accuracy: 0.8818

results

[0.09148842096328735, 0.8804399967193604]

model.predict(x_test)

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

array([[0.05463035],
       [0.9976006 ],
       [0.840027  ],
       ...,
       [0.15193418],
       [0.04029947],
       [0.70021635]], dtype=float32)

model_1 = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])

model_1.compile(optimizer="rmsprop",
                loss="mse",
                metrics=["accuracy"])

x_val = x_train[:10000]
partial_x_train = x_train[10000:]

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


history_1 = model_1.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))

Epoch 1/20
30/30 [==============================] - 2s 39ms/step - loss: 0.1717 -
accuracy: 0.7770 - val_loss: 0.1278 - val_accuracy: 0.8420
Epoch 2/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0962 -
accuracy: 0.8893 - val_loss: 0.0956 - val_accuracy: 0.8761
Epoch 3/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0702 -
```

```
accuracy: 0.9161 - val_loss: 0.0899 - val_accuracy: 0.8792
Epoch 4/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0568 -
accuracy: 0.9317 - val_loss: 0.0824 - val_accuracy: 0.8897
Epoch 5/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0458 -
accuracy: 0.9455 - val_loss: 0.0869 - val_accuracy: 0.8810
Epoch 6/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0373 -
accuracy: 0.9571 - val_loss: 0.0862 - val_accuracy: 0.8832
Epoch 7/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0339 -
accuracy: 0.9609 - val_loss: 0.0891 - val_accuracy: 0.8802
Epoch 8/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0285 -
accuracy: 0.9685 - val_loss: 0.0944 - val_accuracy: 0.8754
Epoch 9/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0228 -
accuracy: 0.9757 - val_loss: 0.0987 - val_accuracy: 0.8738
Epoch 10/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0206 -
accuracy: 0.9777 - val_loss: 0.0970 - val_accuracy: 0.8764
Epoch 11/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0212 -
accuracy: 0.9769 - val_loss: 0.0988 - val_accuracy: 0.8749
Epoch 12/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0178 -
accuracy: 0.9818 - val_loss: 0.1017 - val_accuracy: 0.8747
Epoch 13/20
30/30 [==============================] - 1s 27ms/step - loss: 0.0153 -
accuracy: 0.9842 - val_loss: 0.1026 - val_accuracy: 0.8753
Epoch 14/20
30/30 [==============================] - 1s 25ms/step - loss: 0.0151 -
accuracy: 0.9837 - val_loss: 0.1052 - val_accuracy: 0.8726
Epoch 15/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0139 -
accuracy: 0.9851 - val_loss: 0.1053 - val_accuracy: 0.8748
Epoch 16/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0134 -
accuracy: 0.9857 - val_loss: 0.1063 - val_accuracy: 0.8729
Epoch 17/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0103 -
accuracy: 0.9900 - val_loss: 0.1098 - val_accuracy: 0.8703
Epoch 18/20
30/30 [==============================] - 1s 19ms/step - loss: 0.0079 -
accuracy: 0.9927 - val_loss: 0.1088 - val_accuracy: 0.8695
Epoch 19/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0128 -
accuracy: 0.9857 - val_loss: 0.1094 - val_accuracy: 0.8709
```

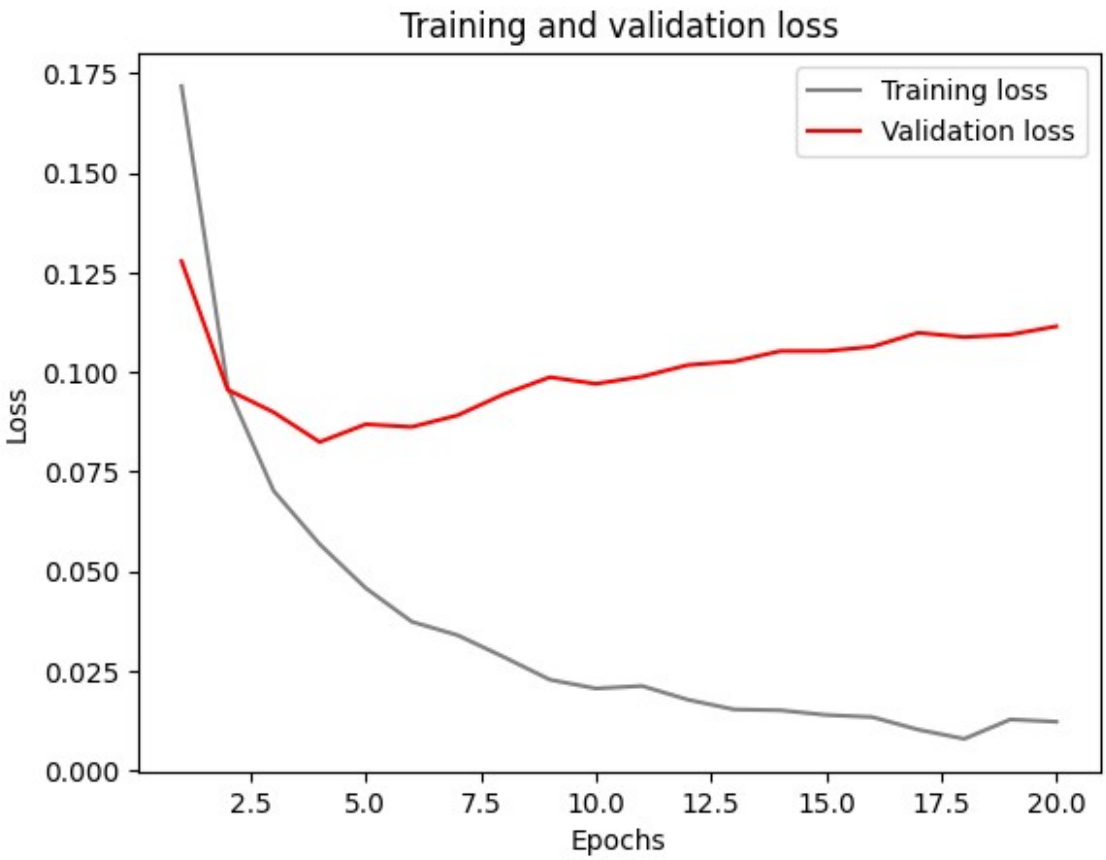
```
Epoch 20/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0122 -
accuracy: 0.9864 - val_loss: 0.1115 - val_accuracy: 0.8690

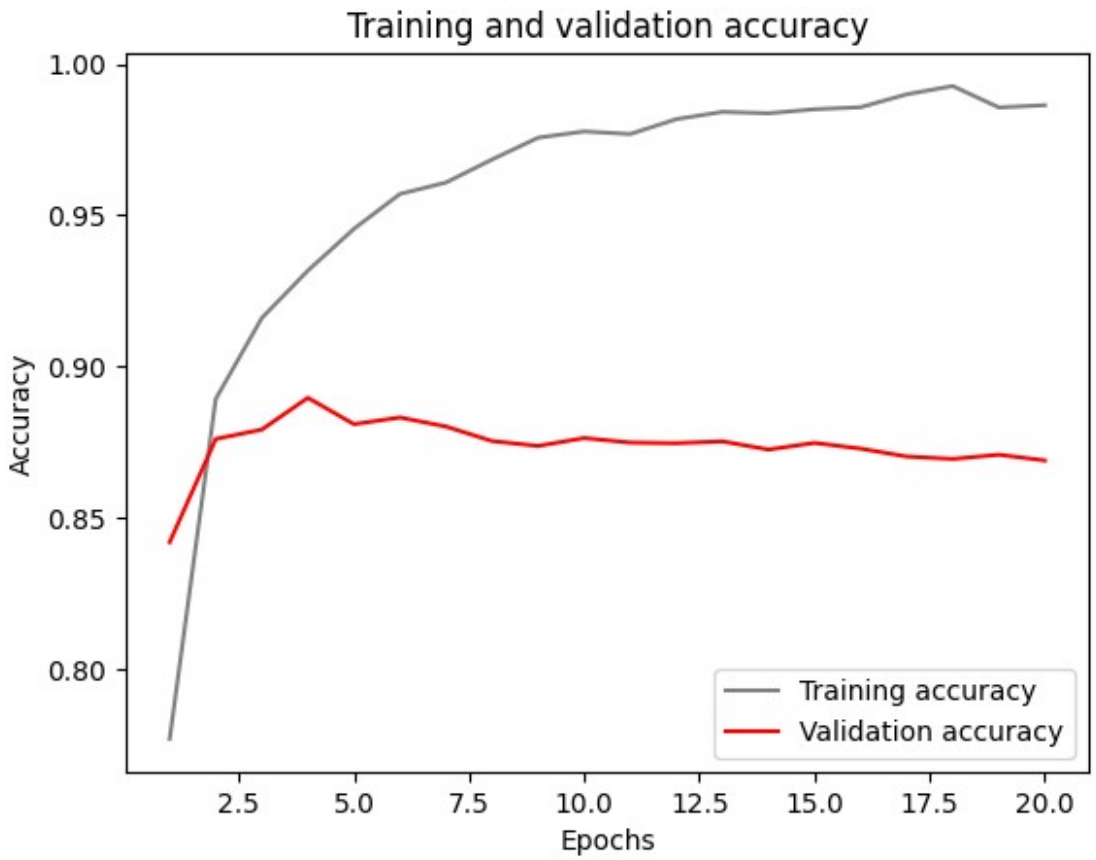
history_dict_2 = history_1.history
history_dict_2.keys()

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

import matplotlib.pyplot as plt
history_dict_2 = history_1.history
loss_values = history_dict_2["loss"]
val_loss_values = history_dict_2["val_loss"]
epochs = range(1, len(loss_values) + 1)
#Plotting graph between Training and Validation loss
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "red", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()

#Plotting graph between Training and Validation Accuracy
plt.clf()
acc = history_dict_2["accuracy"]
val_acc = history_dict_2["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training accuracy")
plt.plot(epochs, val_acc, "red", 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
Loss
Epochs
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0




```
np.random.seed(111)
model_1 = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])

model_1.compile(optimizer="rmsprop",
                loss="mse",
                metrics=["accuracy"])
model_1.fit(x_train, y_train, epochs=5, batch_size=512)
results_1 = model_1.evaluate(x_test, y_test)
```

```
Epoch 1/5
49/49 [==============================] - 1s 13ms/step - loss: 0.1466 -
accuracy: 0.8141
Epoch 2/5
49/49 [==============================] - 1s 17ms/step - loss: 0.0791 -
accuracy: 0.9008
Epoch 3/5
49/49 [==============================] - 1s 17ms/step - loss: 0.0609 -
accuracy: 0.9231
Epoch 4/5
```

```
49/49 [==============================] - 1s 14ms/step - loss: 0.0526 -
accuracy: 0.9337
Epoch 5/5
49/49 [==============================] - 1s 12ms/step - loss: 0.0458 -
accuracy: 0.9438
782/782 [==============================] - 1s 1ms/step - loss: 0.0957
- accuracy: 0.8738

results_1

[0.09259252995252609, 0.8767200112342834]

model_1.predict(x_test)

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

array([[0.03866682],
       [0.999194  ],
       [0.7924226 ],
       ...,
       [0.08738354],
       [0.02610279],
       [0.63774586]], dtype=float32)

np.random.seed(222)
model_2 = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
model_2.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])
x_val = x_train[:10000]
partial_x_train = x_train[10000:]

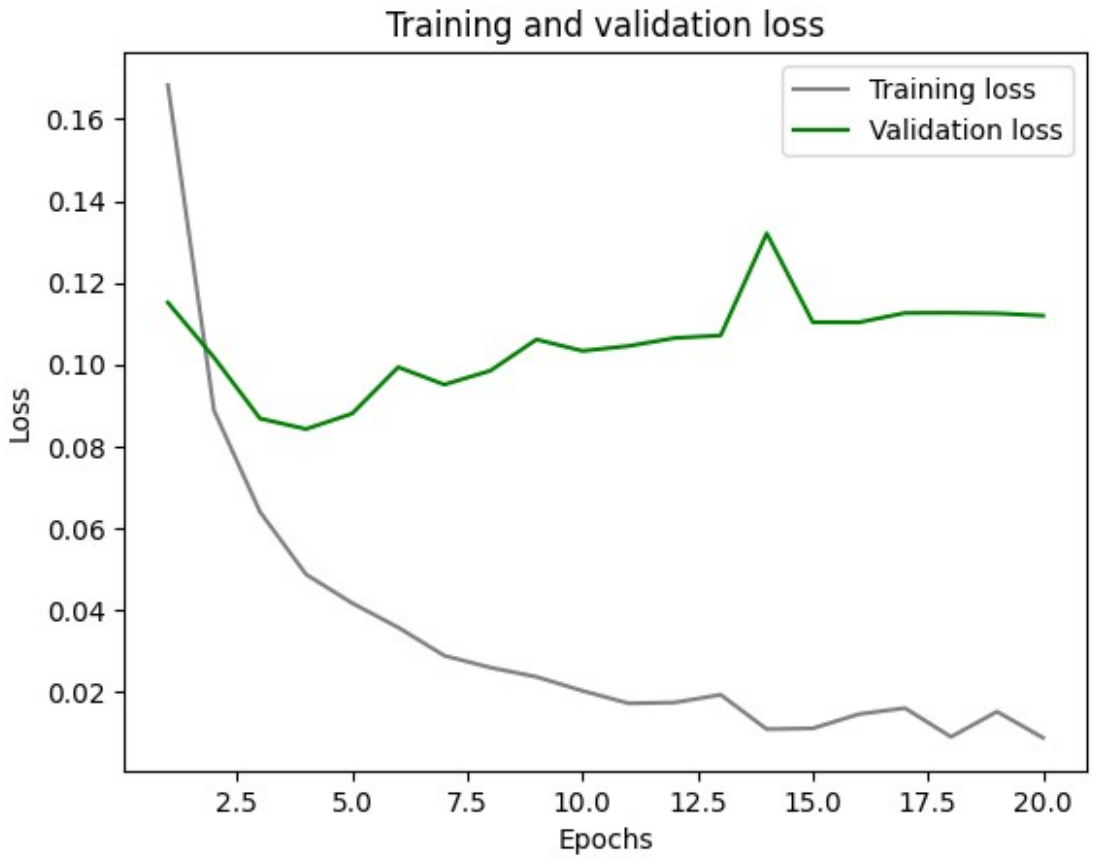
y_val = y_train[:10000]
partial_y_train = y_train[10000:]

history_2 = model_2.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))

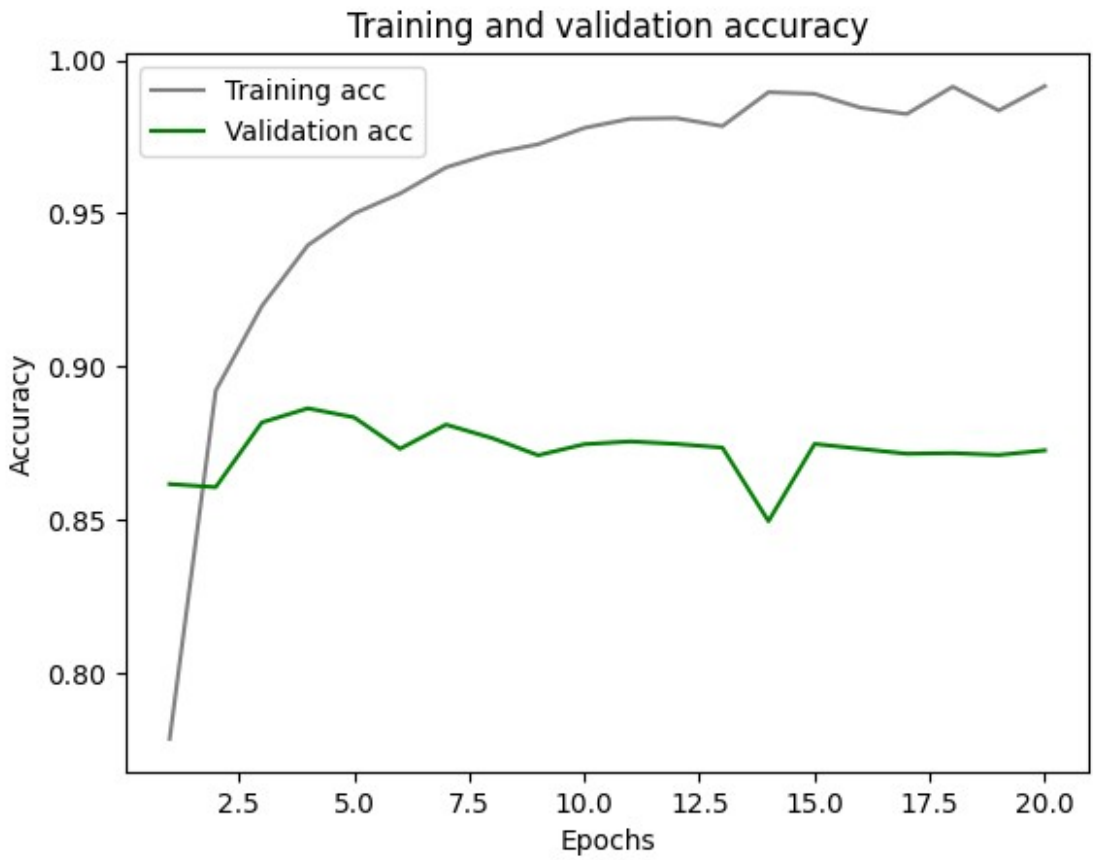
history_dict_3 = history_2.history
history_dict_3.keys()

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

```
loss_values = history_dict_3["loss"]
val_loss_values = history_dict_3["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "green", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```




```
plt.clf()
acc = history_dict_3["accuracy"]
val_acc = history_dict_3["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
plt.plot(epochs, val_acc, "green", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




```
np.random.seed(333)
model_3 = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(16, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])


model_3.compile(optimizer='rmsprop',
                loss='mse',
                metrics=['accuracy'])

model_3.fit(x_train, y_train, epochs=3, batch_size=512)
results_3 = model_3.evaluate(x_test, y_test)
```

```
Epoch 1/3
49/49 [==============================] - 2s 17ms/step - loss: 0.1483 -
accuracy: 0.8106
Epoch 2/3
49/49 [==============================] - 1s 16ms/step - loss: 0.0765 -
accuracy: 0.9014
Epoch 3/3
```

```
49/49 [==============================] - 1s 18ms/step - loss: 0.0585 -
accuracy: 0.9259
782/782 [==============================] - 1s 1ms/step - loss: 0.0869
- accuracy: 0.8833

results_3

[0.08689894527196884, 0.8833199739456177]

model_3.predict(x_test)

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

array([[0.09682493],
       [0.99060297],
       [0.9412493 ],
       ...,
       [0.08179896],
       [0.0655608 ],
       [0.7950641 ]], dtype=float32)

np.random.seed(444)
model_32 = keras.Sequential([
    layers.Dense(32, activation="tanh"),
    layers.Dense(32, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
#compiling the model
model_32.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])
# validating the model
x_val = x_train[:10000]
partial_x_train = x_train[10000:]

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

#Model fit
np.random.seed(444)
history_32 = model_32.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))

Epoch 1/20
30/30 [==============================] - 2s 51ms/step - loss: 0.1594 -
accuracy: 0.7735 - val_loss: 0.1258 - val_accuracy: 0.8283
Epoch 2/20
30/30 [==============================] - 1s 31ms/step - loss: 0.0876 -
```

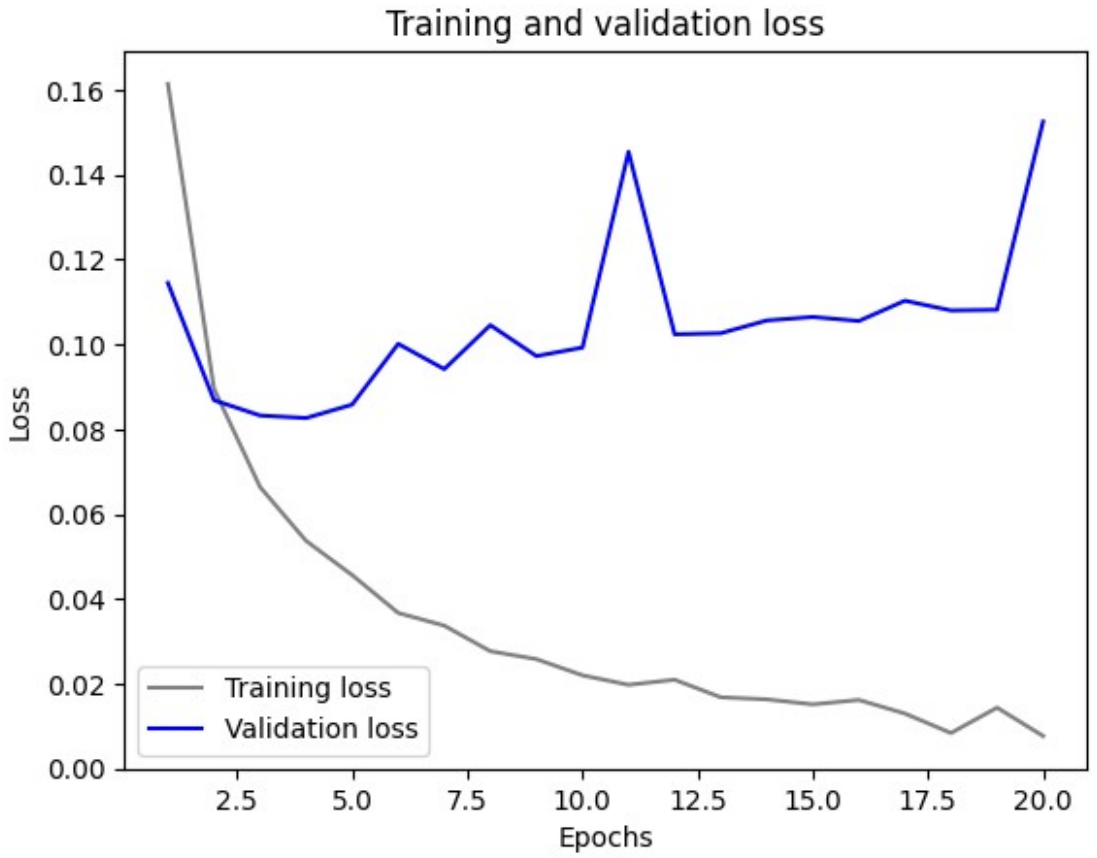
```
accuracy: 0.8874 - val_loss: 0.1013 - val_accuracy: 0.8623
Epoch 3/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0644 -
accuracy: 0.9188 - val_loss: 0.0930 - val_accuracy: 0.8749
Epoch 4/20
30/30 [==============================] - 1s 22ms/step - loss: 0.0549 -
accuracy: 0.9310 - val_loss: 0.0886 - val_accuracy: 0.8793
Epoch 5/20
30/30 [==============================] - 1s 22ms/step - loss: 0.0450 -
accuracy: 0.9446 - val_loss: 0.0992 - val_accuracy: 0.8681
Epoch 6/20
30/30 [==============================] - 1s 22ms/step - loss: 0.0398 -
accuracy: 0.9501 - val_loss: 0.0911 - val_accuracy: 0.8778
Epoch 7/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0349 -
accuracy: 0.9581 - val_loss: 0.0912 - val_accuracy: 0.8790
Epoch 8/20
30/30 [==============================] - 1s 22ms/step - loss: 0.0288 -
accuracy: 0.9664 - val_loss: 0.0936 - val_accuracy: 0.8784
Epoch 9/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0241 -
accuracy: 0.9733 - val_loss: 0.0971 - val_accuracy: 0.8752
Epoch 10/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0266 -
accuracy: 0.9687 - val_loss: 0.0989 - val_accuracy: 0.8756
Epoch 11/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0197 -
accuracy: 0.9783 - val_loss: 0.1209 - val_accuracy: 0.8559
Epoch 12/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0186 -
accuracy: 0.9801 - val_loss: 0.1032 - val_accuracy: 0.8742
Epoch 13/20
30/30 [==============================] - 1s 27ms/step - loss: 0.0179 -
accuracy: 0.9800 - val_loss: 0.1035 - val_accuracy: 0.8748
Epoch 14/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0147 -
accuracy: 0.9850 - val_loss: 0.1061 - val_accuracy: 0.8726
Epoch 15/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0150 -
accuracy: 0.9838 - val_loss: 0.1077 - val_accuracy: 0.8714
Epoch 16/20
30/30 [==============================] - 1s 23ms/step - loss: 0.0162 -
accuracy: 0.9817 - val_loss: 0.1071 - val_accuracy: 0.8732
Epoch 17/20
30/30 [==============================] - 1s 28ms/step - loss: 0.0091 -
accuracy: 0.9915 - val_loss: 0.1079 - val_accuracy: 0.8729
Epoch 18/20
30/30 [==============================] - 1s 31ms/step - loss: 0.0141 -
accuracy: 0.9849 - val_loss: 0.1081 - val_accuracy: 0.8734
```

```
Epoch 19/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0136 -
accuracy: 0.9853 - val_loss: 0.1090 - val_accuracy: 0.8732
Epoch 20/20
30/30 [==============================] - 1s 25ms/step - loss: 0.0083 -
accuracy: 0.9921 - val_loss: 0.1108 - val_accuracy: 0.8696

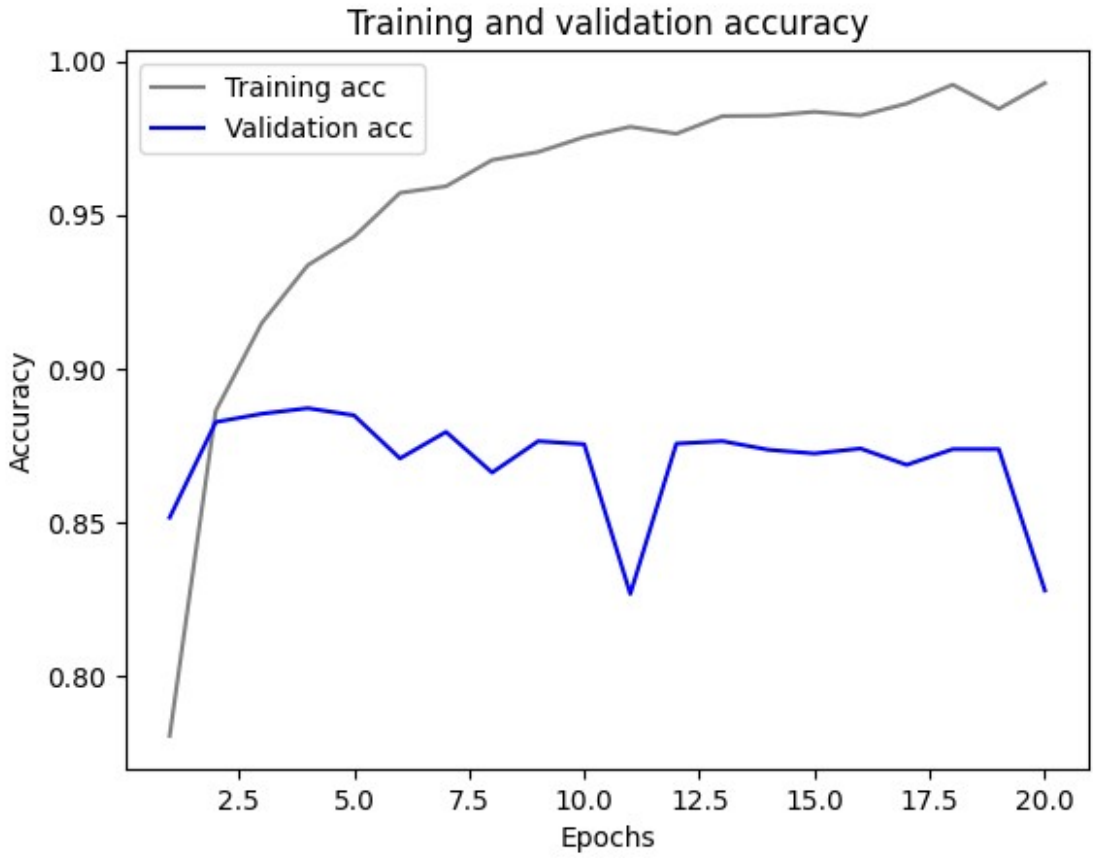
history_dict_32 = history_32.history
history_dict_32.keys()

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

loss_values = history_dict_32["loss"]
val_loss_values = history_dict_32["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "blue", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```



```
plt.clf()
acc = history_dict_32["accuracy"]
val_acc = history_dict_32["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
plt.plot(epochs, val_acc, "blue", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




```
history_32 = model_32.fit(x_train, y_train, epochs=3, batch_size=512)
results_32 = model_32.evaluate(x_test, y_test)
results_32

Epoch 1/3
49/49 [==============================] - 1s 16ms/step - loss: 0.0555 -
accuracy: 0.9359
Epoch 2/3
49/49 [==============================] - 1s 16ms/step - loss: 0.0438 -
accuracy: 0.9495
Epoch 3/3
```

```
49/49 [==============================] - 1s 19ms/step - loss: 0.0393 -
accuracy: 0.9550
782/782 [==============================] - 1s 2ms/step - loss: 0.1124
- accuracy: 0.8659

[0.11240310221910477, 0.865880012512207]

model_32.predict(x_test)

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

array([[7.6968636e-04],
       [9.9999607e-01],
       [3.2178441e-01],
       ...,
       [4.6674330e-02],
       [2.4356099e-03],
       [9.7670722e-01]], dtype=float32)

np.random.seed(555)
model_64 = keras.Sequential([
    layers.Dense(64, activation="tanh"),
    layers.Dense(64, activation="tanh"),
    layers.Dense(1, activation="sigmoid")
])
model_64.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])
# validation
x_val = x_train[:10000]
partial_x_train = x_train[10000:]

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

np.random.seed(123)
history_64 = model_64.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))

Epoch 1/20
30/30 [==============================] - 2s 61ms/step - loss: 0.1667 -
accuracy: 0.7558 - val_loss: 0.1031 - val_accuracy: 0.8699
Epoch 2/20
30/30 [==============================] - 1s 36ms/step - loss: 0.0909 -
accuracy: 0.8816 - val_loss: 0.0941 - val_accuracy: 0.8706
Epoch 3/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0693 -
accuracy: 0.9104 - val_loss: 0.0823 - val_accuracy: 0.8879
```

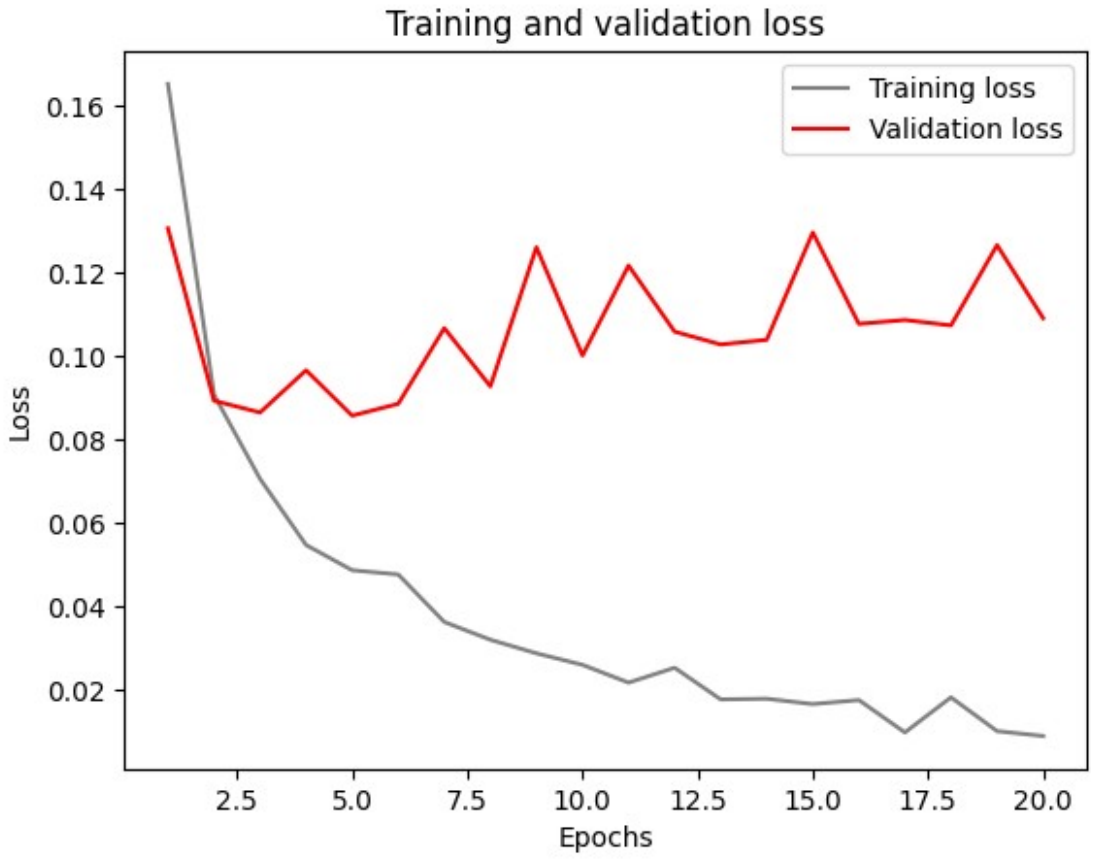
```
Epoch 4/20
30/30 [==============================] - 1s 36ms/step - loss: 0.0589 -
accuracy: 0.9235 - val_loss: 0.0840 - val_accuracy: 0.8852
Epoch 5/20
30/30 [==============================] - 1s 49ms/step - loss: 0.0525 -
accuracy: 0.9329 - val_loss: 0.0876 - val_accuracy: 0.8829
Epoch 6/20
30/30 [==============================] - 1s 44ms/step - loss: 0.0407 -
accuracy: 0.9511 - val_loss: 0.0901 - val_accuracy: 0.8803
Epoch 7/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0444 -
accuracy: 0.9425 - val_loss: 0.1033 - val_accuracy: 0.8638
Epoch 8/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0331 -
accuracy: 0.9605 - val_loss: 0.0942 - val_accuracy: 0.8799
Epoch 9/20
30/30 [==============================] - 1s 36ms/step - loss: 0.0281 -
accuracy: 0.9667 - val_loss: 0.1022 - val_accuracy: 0.8691
Epoch 10/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0293 -
accuracy: 0.9641 - val_loss: 0.1019 - val_accuracy: 0.8726
Epoch 11/20
30/30 [==============================] - 1s 34ms/step - loss: 0.0237 -
accuracy: 0.9726 - val_loss: 0.1002 - val_accuracy: 0.8763
Epoch 12/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0229 -
accuracy: 0.9744 - val_loss: 0.1012 - val_accuracy: 0.8748
Epoch 13/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0220 -
accuracy: 0.9751 - val_loss: 0.1039 - val_accuracy: 0.8733
Epoch 14/20
30/30 [==============================] - 1s 37ms/step - loss: 0.0215 -
accuracy: 0.9753 - val_loss: 0.1048 - val_accuracy: 0.8728
Epoch 15/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0180 -
accuracy: 0.9796 - val_loss: 0.1054 - val_accuracy: 0.8746
Epoch 16/20
30/30 [==============================] - 2s 56ms/step - loss: 0.0160 -
accuracy: 0.9821 - val_loss: 0.1089 - val_accuracy: 0.8713
Epoch 17/20
30/30 [==============================] - 1s 38ms/step - loss: 0.0183 -
accuracy: 0.9794 - val_loss: 0.1056 - val_accuracy: 0.8741
Epoch 18/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0175 -
accuracy: 0.9805 - val_loss: 0.1054 - val_accuracy: 0.8778
Epoch 19/20
30/30 [==============================] - 1s 34ms/step - loss: 0.0151 -
accuracy: 0.9839 - val_loss: 0.1120 - val_accuracy: 0.8695
Epoch 20/20
```

```
30/30 [==============================] - 1s 36ms/step - loss: 0.0114 -
accuracy: 0.9886 - val_loss: 0.1155 - val_accuracy: 0.8673

history_dict_64 = history_64.history
history_dict_64.keys()

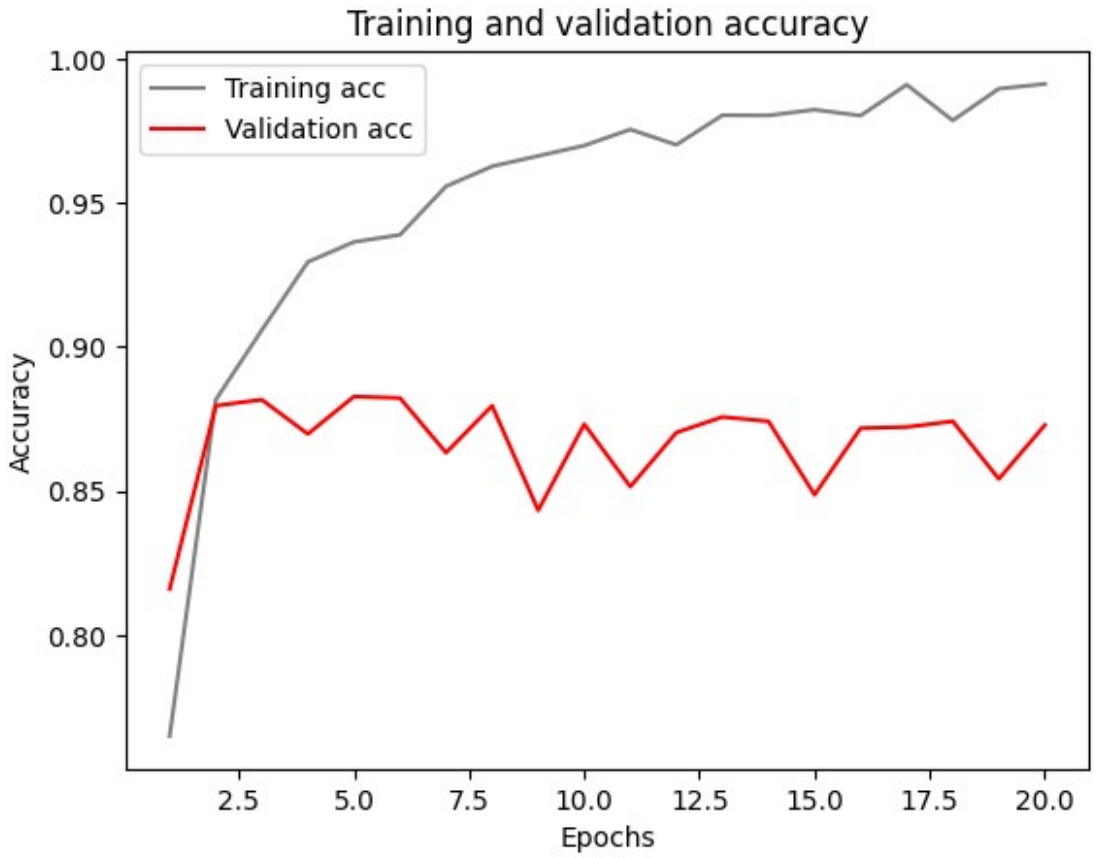
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])

loss_values = history_dict_64["loss"]
val_loss_values = history_dict_64["val_loss"]
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "red", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```




```
plt.clf()
acc = history_dict_64["accuracy"]
val_acc = history_dict_64["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
```

```
plt.plot(epochs, val_acc, "red", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




```
history_64 = model_64.fit(x_train, y_train, epochs=3, batch_size=512)
results_64 = model_64.evaluate(x_test, y_test)
results_64
```

```
Epoch 1/3
49/49 [==============================] - 1s 27ms/step - loss: 0.0536 -
accuracy: 0.9374
Epoch 2/3
49/49 [==============================] - 2s 32ms/step - loss: 0.0435 -
accuracy: 0.9502
Epoch 3/3
49/49 [==============================] - 2s 32ms/step - loss: 0.0384 -
accuracy: 0.9566
782/782 [==============================] - 2s 2ms/step - loss: 0.1271
- accuracy: 0.8500
```

```
[0.12711021304130554, 0.8499600291252136]
```

```
model_64.predict(x_test)
```

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

```
array([[0.01669381],
       [0.99999994],
       [0.99933356],
       ...,
       [0.04973997],
       [0.05992302],
       [0.99896365]], dtype=float32)
```

```
np.random.seed(666)
model_Dropout = keras.Sequential([
    layers.Dense(16, activation="tanh"),
    layers.Dropout(0.5),
    layers.Dense(16, activation="tanh"),
    layers.Dropout(0.5),
    layers.Dense(1, activation="sigmoid")
])
model_Dropout.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])
np.random.seed(666)
history_model_Dropout = model_Dropout.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))
history_dict_Dropout = history_model_Dropout.history
history_dict_Dropout.keys()
```

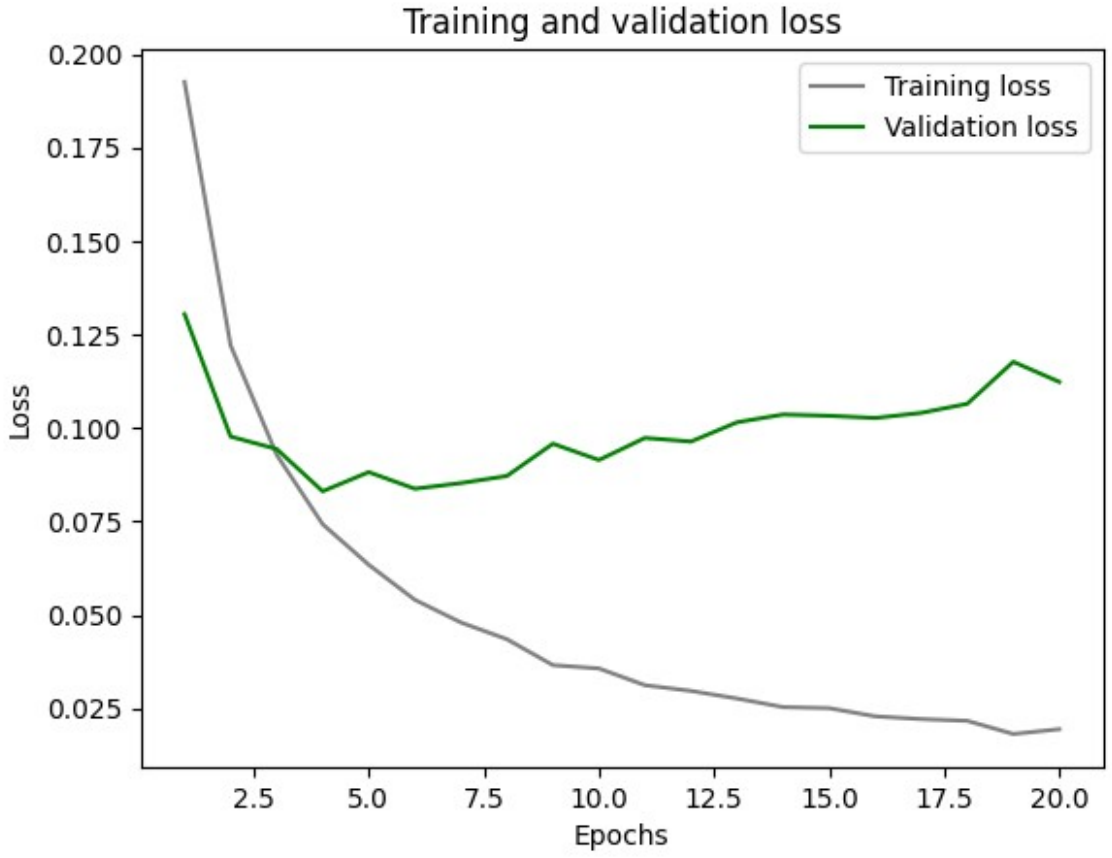
```
Epoch 1/20
30/30 [==============================] - 2s 43ms/step - loss: 0.1844 -
accuracy: 0.7446 - val_loss: 0.1288 - val_accuracy: 0.8548
Epoch 2/20
30/30 [==============================] - 1s 19ms/step - loss: 0.1186 -
accuracy: 0.8675 - val_loss: 0.0959 - val_accuracy: 0.8822
Epoch 3/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0894 -
accuracy: 0.8992 - val_loss: 0.0895 - val_accuracy: 0.8803
Epoch 4/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0739 -
accuracy: 0.9145 - val_loss: 0.0822 - val_accuracy: 0.8876
Epoch 5/20
30/30 [==============================] - 1s 31ms/step - loss: 0.0626 -
accuracy: 0.9274 - val_loss: 0.0871 - val_accuracy: 0.8811
Epoch 6/20
```

```
30/30 [==============================] - 1s 30ms/step - loss: 0.0545 -
accuracy: 0.9377 - val_loss: 0.0880 - val_accuracy: 0.8818
Epoch 7/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0469 -
accuracy: 0.9471 - val_loss: 0.0868 - val_accuracy: 0.8844
Epoch 8/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0431 -
accuracy: 0.9511 - val_loss: 0.0882 - val_accuracy: 0.8859
Epoch 9/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0380 -
accuracy: 0.9566 - val_loss: 0.0902 - val_accuracy: 0.8829
Epoch 10/20
30/30 [==============================] - 1s 19ms/step - loss: 0.0339 -
accuracy: 0.9625 - val_loss: 0.0924 - val_accuracy: 0.8827
Epoch 11/20
30/30 [==============================] - 1s 19ms/step - loss: 0.0312 -
accuracy: 0.9652 - val_loss: 0.0939 - val_accuracy: 0.8824
Epoch 12/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0302 -
accuracy: 0.9647 - val_loss: 0.0990 - val_accuracy: 0.8767
Epoch 13/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0266 -
accuracy: 0.9703 - val_loss: 0.1088 - val_accuracy: 0.8695
Epoch 14/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0240 -
accuracy: 0.9739 - val_loss: 0.1043 - val_accuracy: 0.8767
Epoch 15/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0231 -
accuracy: 0.9741 - val_loss: 0.1033 - val_accuracy: 0.8742
Epoch 16/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0246 -
accuracy: 0.9713 - val_loss: 0.1022 - val_accuracy: 0.8783
Epoch 17/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0192 -
accuracy: 0.9791 - val_loss: 0.1057 - val_accuracy: 0.8764
Epoch 18/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0186 -
accuracy: 0.9801 - val_loss: 0.1064 - val_accuracy: 0.8760
Epoch 19/20
30/30 [==============================] - 1s 17ms/step - loss: 0.0182 -
accuracy: 0.9804 - val_loss: 0.1066 - val_accuracy: 0.8750
Epoch 20/20
30/30 [==============================] - 1s 18ms/step - loss: 0.0176 -
accuracy: 0.9813 - val_loss: 0.1076 - val_accuracy: 0.8748

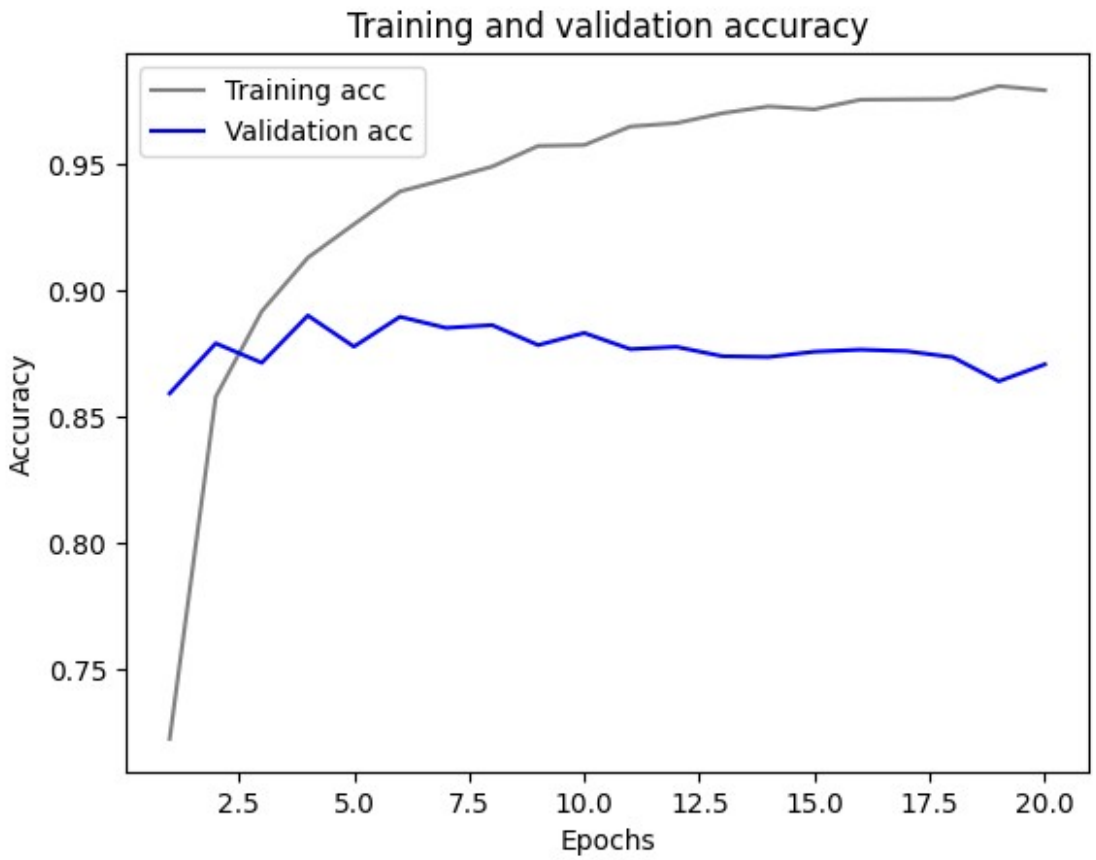
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

```python
loss_values = history_dict_Dropout["loss"]
val_loss_values = history_dict_Dropout["val_loss"]
epochs = range(1, len(loss_values) + 1)
```

```
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "green", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```




```
plt.clf()
acc = history_dict_Dropout["accuracy"]
val_acc = history_dict_Dropout["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
plt.plot(epochs, val_acc, "blue", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




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

Epoch 1/8
49/49 [==============================] - 1s 12ms/step - loss: 0.0553 -
accuracy: 0.9366
Epoch 2/8
49/49 [==============================] - 1s 13ms/step - loss: 0.0483 -
accuracy: 0.9438
Epoch 3/8
49/49 [==============================] - 1s 12ms/step - loss: 0.0433 -
accuracy: 0.9500
Epoch 4/8
49/49 [==============================] - 1s 13ms/step - loss: 0.0410 -
accuracy: 0.9528
Epoch 5/8
49/49 [==============================] - 1s 13ms/step - loss: 0.0386 -
accuracy: 0.9552
Epoch 6/8
49/49 [==============================] - 1s 13ms/step - loss: 0.0365 -
accuracy: 0.9585
Epoch 7/8
```

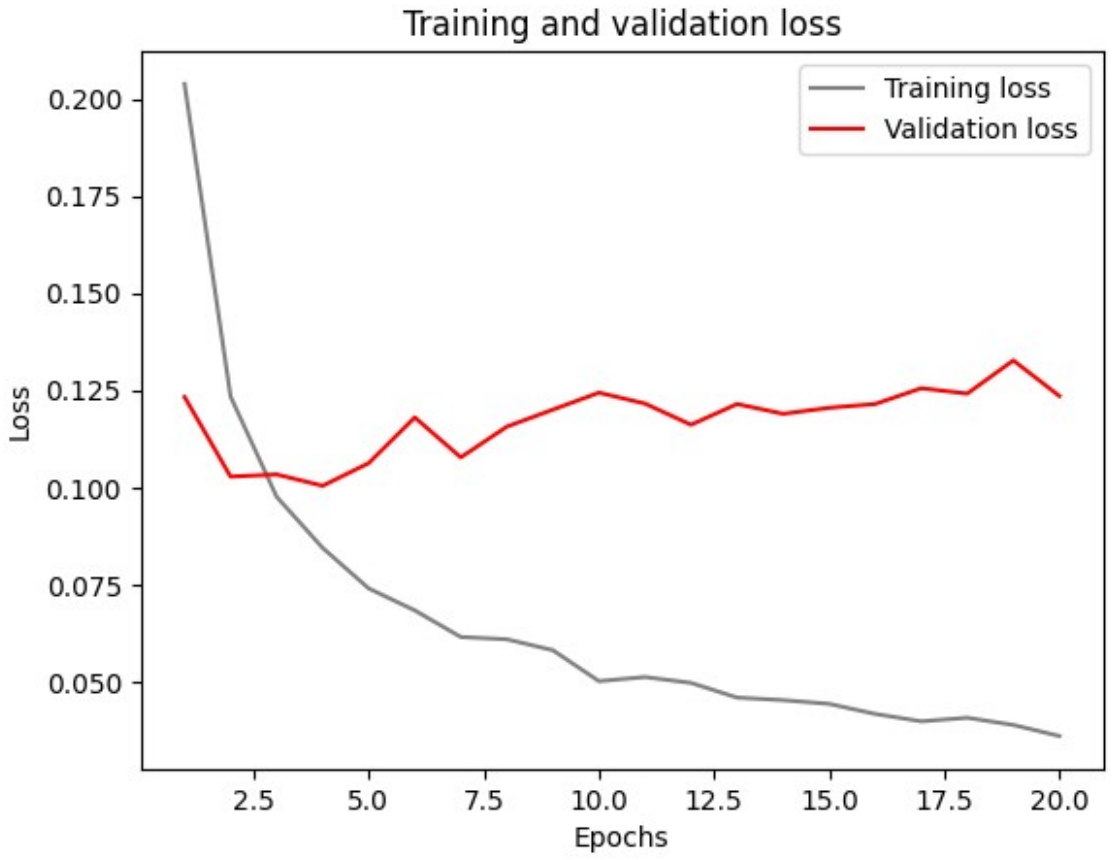
```
49/49 [==============================] - 1s 12ms/step - loss: 0.0344 -
accuracy: 0.9613
Epoch 8/8
49/49 [==============================] - 1s 11ms/step - loss: 0.0335 -
accuracy: 0.9619
782/782 [==============================] - 1s 1ms/step - loss: 0.1157
- accuracy: 0.8671

[0.1156952828168869, 0.8670799732208252]
```

```
np.random.seed(111)
model_Hyper = keras.Sequential([
    layers.Dense(32,
activation="tanh",kernel_regularizer=regularizers.l2(0.0001)),
    layers.Dropout(0.5),
    layers.Dense(32,
activation="tanh",kernel_regularizer=regularizers.l2(0.0001)),
    layers.Dropout(0.5),
    layers.Dense(16,
activation="tanh",kernel_regularizer=regularizers.l2(0.0001)),
    layers.Dropout(0.5),
    layers.Dense(1, activation="sigmoid")
])
model_Hyper.compile(optimizer="rmsprop",
              loss="mse",
              metrics=["accuracy"])
np.random.seed(123)
history_model_Hyper = model_Hyper.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))
history_dict_Hyper = history_model_Hyper.history
history_dict_Hyper.keys()
```

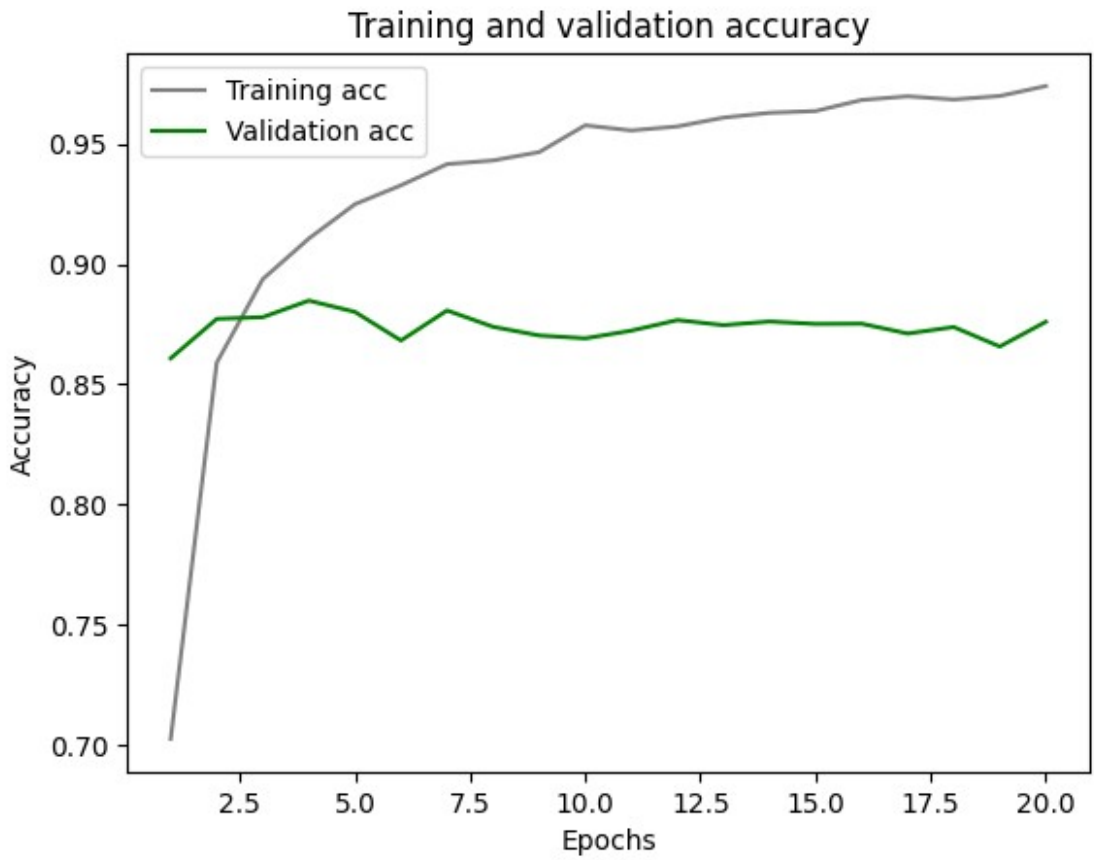
```
Epoch 1/20
30/30 [==============================] - 3s 52ms/step - loss: 0.2017 -
accuracy: 0.7171 - val_loss: 0.1227 - val_accuracy: 0.8634
Epoch 2/20
30/30 [==============================] - 1s 25ms/step - loss: 0.1246 -
accuracy: 0.8637 - val_loss: 0.1012 - val_accuracy: 0.8806
Epoch 3/20
30/30 [==============================] - 1s 25ms/step - loss: 0.0993 -
accuracy: 0.8938 - val_loss: 0.1114 - val_accuracy: 0.8682
Epoch 4/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0843 -
accuracy: 0.9144 - val_loss: 0.0990 - val_accuracy: 0.8859
Epoch 5/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0742 -
accuracy: 0.9251 - val_loss: 0.1096 - val_accuracy: 0.8761
```

```
Epoch 6/20
30/30 [==============================] - 1s 34ms/step - loss: 0.0658 -
accuracy: 0.9369 - val_loss: 0.1038 - val_accuracy: 0.8858
Epoch 7/20
30/30 [==============================] - 1s 33ms/step - loss: 0.0650 -
accuracy: 0.9363 - val_loss: 0.1063 - val_accuracy: 0.8833
Epoch 8/20
30/30 [==============================] - 1s 25ms/step - loss: 0.0571 -
accuracy: 0.9479 - val_loss: 0.1202 - val_accuracy: 0.8716
Epoch 9/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0548 -
accuracy: 0.9514 - val_loss: 0.1144 - val_accuracy: 0.8774
Epoch 10/20
30/30 [==============================] - 1s 39ms/step - loss: 0.0538 -
accuracy: 0.9525 - val_loss: 0.1129 - val_accuracy: 0.8801
Epoch 11/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0517 -
accuracy: 0.9543 - val_loss: 0.1156 - val_accuracy: 0.8773
Epoch 12/20
30/30 [==============================] - 2s 62ms/step - loss: 0.0462 -
accuracy: 0.9620 - val_loss: 0.1156 - val_accuracy: 0.8777
Epoch 13/20
30/30 [==============================] - 1s 36ms/step - loss: 0.0470 -
accuracy: 0.9606 - val_loss: 0.1168 - val_accuracy: 0.8786
Epoch 14/20
30/30 [==============================] - 1s 32ms/step - loss: 0.0439 -
accuracy: 0.9651 - val_loss: 0.1251 - val_accuracy: 0.8700
Epoch 15/20
30/30 [==============================] - 1s 30ms/step - loss: 0.0456 -
accuracy: 0.9633 - val_loss: 0.1200 - val_accuracy: 0.8771
Epoch 16/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0403 -
accuracy: 0.9699 - val_loss: 0.1241 - val_accuracy: 0.8742
Epoch 17/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0418 -
accuracy: 0.9677 - val_loss: 0.1269 - val_accuracy: 0.8696
Epoch 18/20
30/30 [==============================] - 1s 33ms/step - loss: 0.0388 -
accuracy: 0.9711 - val_loss: 0.1228 - val_accuracy: 0.8747
Epoch 19/20
30/30 [==============================] - 1s 35ms/step - loss: 0.0395 -
accuracy: 0.9703 - val_loss: 0.1308 - val_accuracy: 0.8674
Epoch 20/20
30/30 [==============================] - 1s 24ms/step - loss: 0.0379 -
accuracy: 0.9719 - val_loss: 0.1219 - val_accuracy: 0.8774

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

loss_values = history_dict_Hyper["loss"]
val_loss_values = history_dict_Hyper["val_loss"]
```

```
epochs = range(1, len(loss_values) + 1)
plt.plot(epochs, loss_values, "grey", label="Training loss")
plt.plot(epochs, val_loss_values, "red", label="Validation loss")
plt.title("Training and validation loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```




```
plt.clf()
acc = history_dict_Hyper["accuracy"]
val_acc = history_dict_Hyper["val_accuracy"]
plt.plot(epochs, acc, "grey", label="Training acc")
plt.plot(epochs, val_acc, "green", label="Validation acc")
plt.title("Training and validation accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend()
plt.show()
```




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

Epoch 1/8
49/49 [==============================] - 1s 23ms/step - loss: 0.0719 -
accuracy: 0.9318
Epoch 2/8
49/49 [==============================] - 1s 22ms/step - loss: 0.0640 -
accuracy: 0.9404
Epoch 3/8
49/49 [==============================] - 1s 18ms/step - loss: 0.0626 -
accuracy: 0.9414
Epoch 4/8
49/49 [==============================] - 1s 17ms/step - loss: 0.0599 -
accuracy: 0.9435
Epoch 5/8
49/49 [==============================] - 1s 18ms/step - loss: 0.0556 -
accuracy: 0.9501
Epoch 6/8
49/49 [==============================] - 1s 17ms/step - loss: 0.0532 -
accuracy: 0.9529
Epoch 7/8
```

```
49/49 [==============================] - 1s 17ms/step - loss: 0.0523 -
accuracy: 0.9538
Epoch 8/8
49/49 [==============================] - 1s 17ms/step - loss: 0.0517 -
accuracy: 0.9548
782/782 [==============================] - 1s 2ms/step - loss: 0.1273
- accuracy: 0.8660

[0.12725219130516052, 0.8659600019454956]
```

```
Models = ('Model1','Model2','Model3','Model4','Model5')
Loss = (0.8824,0.8821,0.8799,0.8632,0.8684)

plt.scatter(Models,Loss,color='blue')
plt.title('Performance Loss')
plt.ylabel('Loss (%)')

for (xi, yi) in zip(Models,Loss):
    plt.text(xi, yi, yi, va='bottom', ha='center')


plt.show()
```