DL_03_EX-1

March 17, 2021

Deep Learning

Rogério de Oliveira

MLP com TensorFlow

1 IMPORTANTE: Antes de começar

Execute a célula final desse Lab. Ela irá **inicializar** o seu ambiente com rotinas que são empregadas aqui.

2 Código completo

Aqui o código completo em uma única célula.

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
import os
warnings.filterwarnings("ignore")

from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report

from tensorflow import keras
from tensorflow.keras import layers
from keras import Sequential, layers
import tensorflow as tf
```

[2]:
```
def mlp_plot(hot=1, norm=1, layers_qty=3, n=10, act='sigmoid', get_date=0):
    fraud = pd.read_csv("http://meusite.mackenzie.br/rogerio/ML/
↪qconlondon2016_sample_data.csv")
    if (get_date):
        fraud['day'] = fraud['charge_time'].str.slice(8,10).astype(int)
```

```python
        fraud['month'] = fraud['charge_time'].str.slice(5,7).astype(int)

    fraud.drop(columns=['charge_time'],inplace=True)

    X = fraud.drop(columns=['fraudulent'])

    if (hot):
        ## Hot Encode
        X_number = X.select_dtypes(include='number')
        X_categorical = X.select_dtypes(exclude='number')

        dummies = [pd.get_dummies(X[c],prefix=c, prefix_sep='_') for c in␣
↪X_categorical.columns]
        X_dummies = pd.concat(dummies, axis=1)

        X = pd.concat([X_number,X_dummies], axis=1)
        X.head()
    else:
        ## Label Encode
        from sklearn.preprocessing import LabelEncoder
        labelencoder = LabelEncoder()
        X['card_country_label'] = labelencoder.fit_transform(X['card_country'])
        X = X.drop(columns=['card_country'])
    if (norm):
        ## Normalize
        from sklearn.preprocessing import scale
        X_norm = scale(X)
        X_norm
    else:
        ## Without normalization
        X_norm = X
        X_norm

    ## Preparando a saída `y`

    fraud.fraudulent = fraud.fraudulent.replace(True,1)
    fraud.fraudulent = fraud.fraudulent.replace(False,0)

    y_num = fraud.fraudulent
    y_num

    ## Separando os dados de Treinamento e Teste

    seed = 1234
    X_train, X_test, y_train, y_test = train_test_split(X_norm, y_num,␣
↪test_size=0.3, stratify=y_num, random_state=seed)
```

```python
    ## Adequando categorical(y_train) para o `Keras`

    from keras.utils import to_categorical

    y_train = to_categorical(y_train)
    y_train

    ## Configuração da Rede DeepLearning

    model = Sequential([layers.Dense(X.shape[1], activation='sigmoid',␣
 ↪input_shape=[X.shape[1],])])
    for i in range(layers_qty):
        model.add(layers.Dense(n, activation=act))
#   model.add(layers.Dense(8, activation='sigmoid'))

    model.add(layers.Dense(2, activation='sigmoid'))
    model.compile(loss='categorical_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])

    ## Treinamento da Rede DeepLearning

    history = model.fit(X_train, y_train, validation_split=0.2, epochs=20)

    ## Avaliação do Treinamento

    loss, val_loss, acc, val_acc = plot_loss_acc(history,'Two Hidden Layer␣
 ↪Neural Network 5,8,8,2 (sigmoid)')

    ## Predição, aplicando e avaliando o modelo

    y_pred = np.argmax(model.predict(X_test), axis=-1)

    print(y_pred)
    print(confusion_matrix(y_pred,y_test))

    print(classification_report(y_pred,y_test))

    print(y_test)
```

3 Exercício.

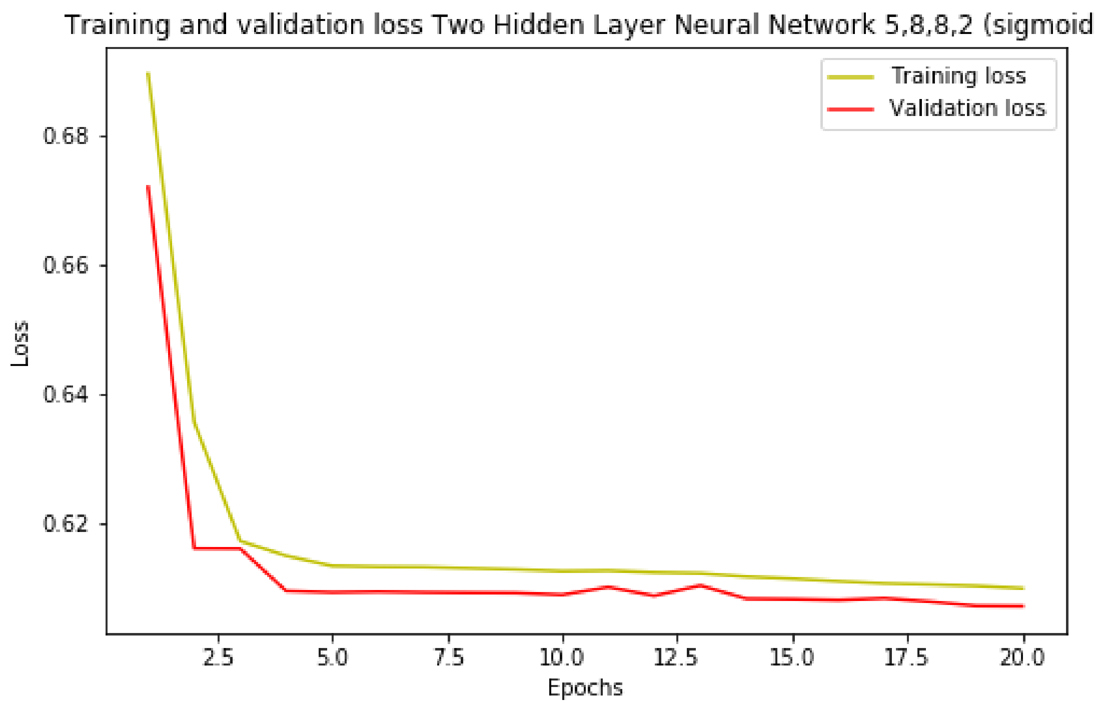
Execute o modelo acima sem normalização dos dados. O modelo é sensível a normalização?

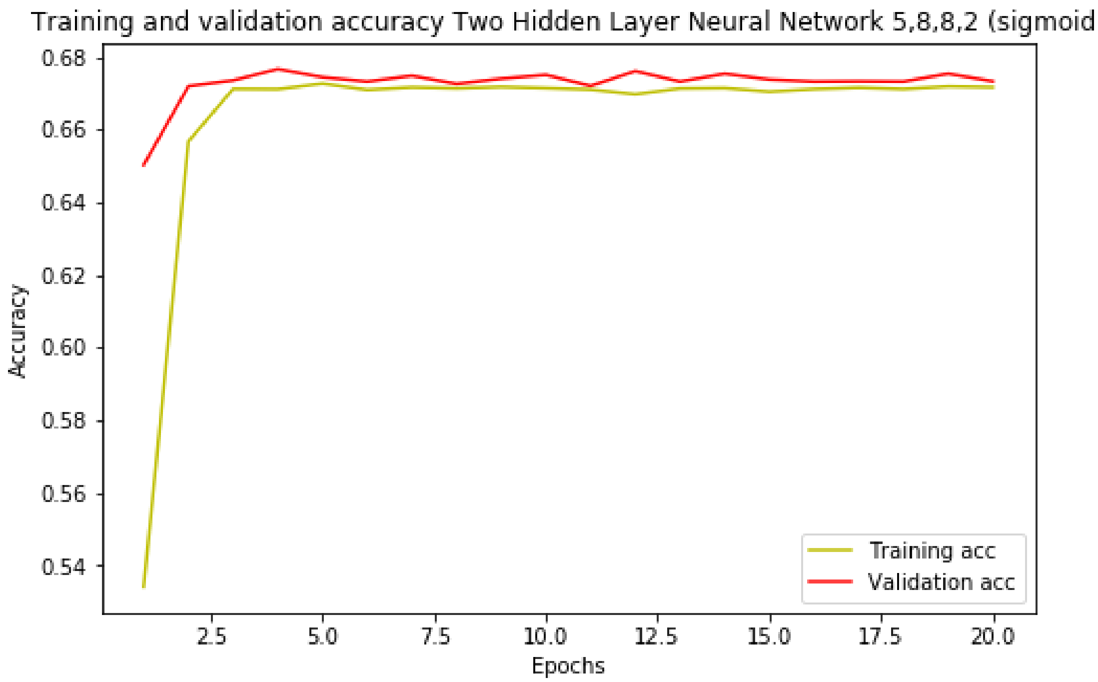
[5]:
```python
mlp_plot()
```

```
Epoch 1/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6929 -
```

```
accuracy: 0.5098 - val_loss: 0.6721 - val_accuracy: 0.6503
Epoch 2/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6489 -
accuracy: 0.6456 - val_loss: 0.6160 - val_accuracy: 0.6719
Epoch 3/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6165 -
accuracy: 0.6715 - val_loss: 0.6159 - val_accuracy: 0.6735
Epoch 4/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6179 -
accuracy: 0.6691 - val_loss: 0.6094 - val_accuracy: 0.6766
Epoch 5/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6143 -
accuracy: 0.6701 - val_loss: 0.6092 - val_accuracy: 0.6744
Epoch 6/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6143 -
accuracy: 0.6711 - val_loss: 0.6093 - val_accuracy: 0.6732
Epoch 7/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6110 -
accuracy: 0.6724 - val_loss: 0.6092 - val_accuracy: 0.6748
Epoch 8/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6153 -
accuracy: 0.6696 - val_loss: 0.6091 - val_accuracy: 0.6726
Epoch 9/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6144 -
accuracy: 0.6702 - val_loss: 0.6091 - val_accuracy: 0.6740
Epoch 10/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6120 -
accuracy: 0.6735 - val_loss: 0.6088 - val_accuracy: 0.6750
Epoch 11/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6117 -
accuracy: 0.6721 - val_loss: 0.6100 - val_accuracy: 0.6720
Epoch 12/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6121 -
accuracy: 0.6709 - val_loss: 0.6086 - val_accuracy: 0.6761
Epoch 13/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6086 -
accuracy: 0.6749 - val_loss: 0.6102 - val_accuracy: 0.6732
Epoch 14/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6144 -
accuracy: 0.6672 - val_loss: 0.6082 - val_accuracy: 0.6753
Epoch 15/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6113 -
accuracy: 0.6702 - val_loss: 0.6081 - val_accuracy: 0.6738
Epoch 16/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6090 -
accuracy: 0.6729 - val_loss: 0.6080 - val_accuracy: 0.6732
Epoch 17/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6080 -
```

```
accuracy: 0.6747 - val_loss: 0.6083 - val_accuracy: 0.6733
Epoch 18/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6113 -
accuracy: 0.6679 - val_loss: 0.6077 - val_accuracy: 0.6732
Epoch 19/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6103 -
accuracy: 0.6723 - val_loss: 0.6071 - val_accuracy: 0.6753
Epoch 20/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6078 -
accuracy: 0.6737 - val_loss: 0.6070 - val_accuracy: 0.6733
```





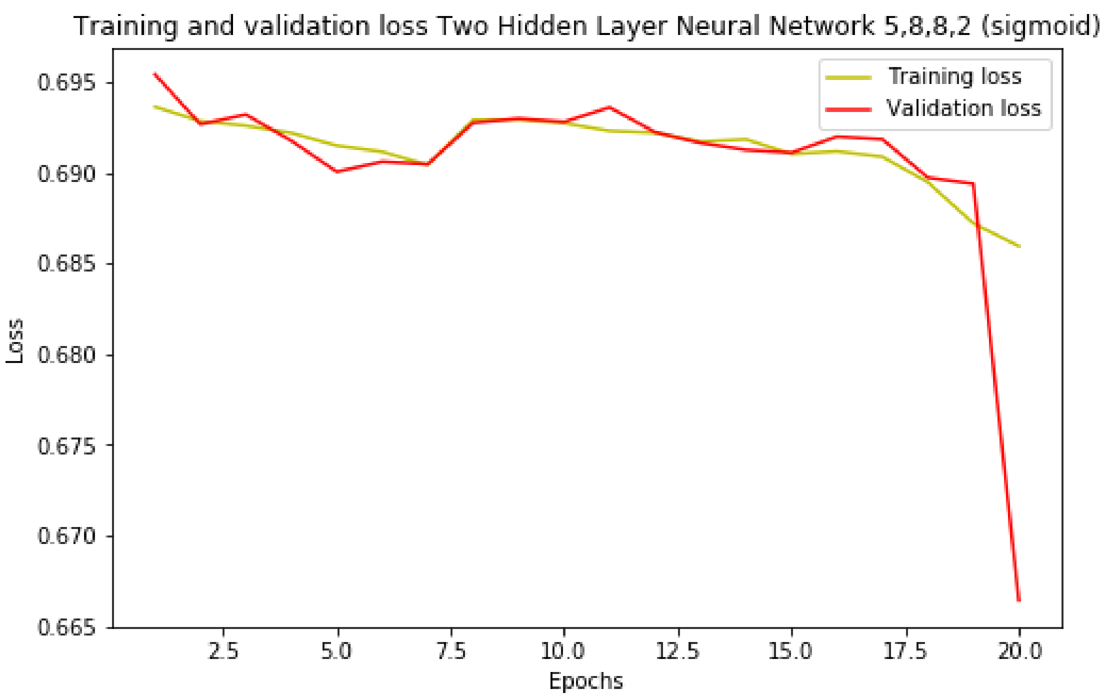

```
Two Hidden Layer Neural Network 5,8,8,2 (sigmoid)Accuracy Train: 67.16 %,
Accuracy Test: 67.33 %
[0 0 0 ... 0 0 0]
[[10544  5823]
 [ 3008  7443]]
              precision    recall  f1-score   support

           0       0.78      0.64      0.70     16367
           1       0.56      0.71      0.63     10451

    accuracy                           0.67     26818
   macro avg       0.67      0.68      0.67     26818
weighted avg       0.69      0.67      0.67     26818

9484     0.0
74480    1.0
9602     0.0
956      0.0
52324    1.0
        ...
47854    1.0
30665    0.0
24197    0.0
5977     0.0
3248     0.0
```

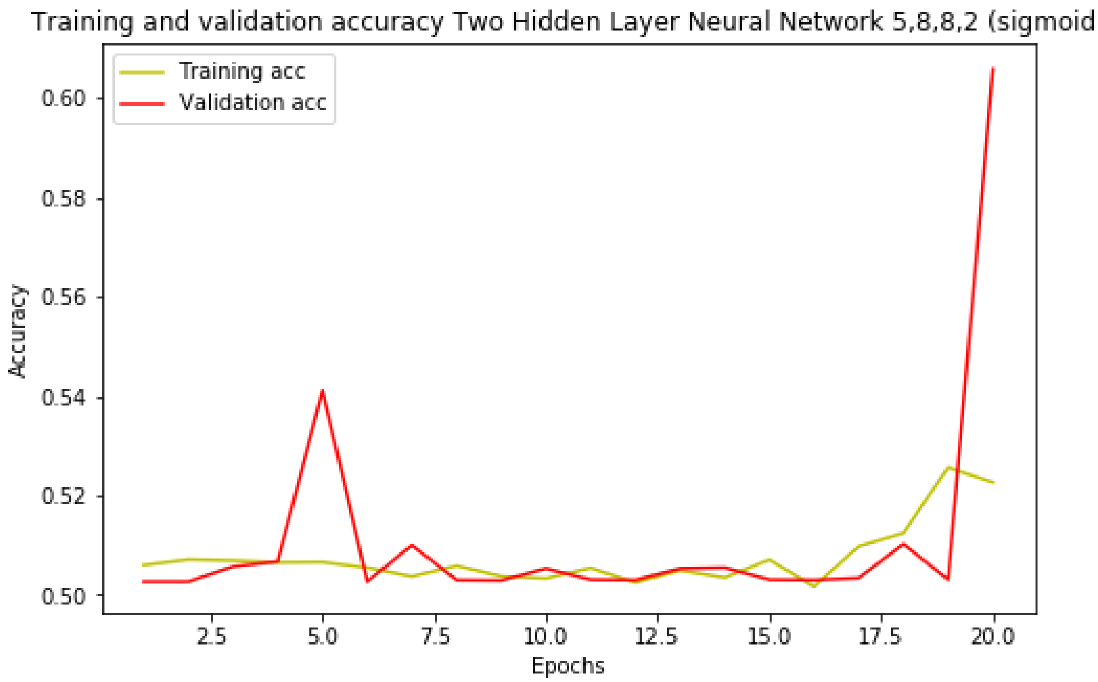
```
Name: fraudulent, Length: 26818, dtype: float64
```

[65]:
```
mlp_plot(norm=0)
```

```
Epoch 1/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6960 -
accuracy: 0.5010 - val_loss: 0.6954 - val_accuracy: 0.5027
Epoch 2/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6931 -
accuracy: 0.5041 - val_loss: 0.6927 - val_accuracy: 0.5027
Epoch 3/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6927 -
accuracy: 0.5063 - val_loss: 0.6932 - val_accuracy: 0.5057
Epoch 4/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6925 -
accuracy: 0.5059 - val_loss: 0.6918 - val_accuracy: 0.5068
Epoch 5/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6918 -
accuracy: 0.5060 - val_loss: 0.6901 - val_accuracy: 0.5412
Epoch 6/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6913 -
accuracy: 0.5082 - val_loss: 0.6906 - val_accuracy: 0.5027
Epoch 7/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6899 -
accuracy: 0.5015 - val_loss: 0.6905 - val_accuracy: 0.5100
Epoch 8/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6920 -
accuracy: 0.5135 - val_loss: 0.6927 - val_accuracy: 0.5030
Epoch 9/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6930 -
accuracy: 0.5021 - val_loss: 0.6930 - val_accuracy: 0.5029
Epoch 10/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6925 -
accuracy: 0.5091 - val_loss: 0.6928 - val_accuracy: 0.5053
Epoch 11/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6924 -
accuracy: 0.5075 - val_loss: 0.6936 - val_accuracy: 0.5031
Epoch 12/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6930 -
accuracy: 0.5013 - val_loss: 0.6922 - val_accuracy: 0.5030
Epoch 13/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6916 -
accuracy: 0.5082 - val_loss: 0.6916 - val_accuracy: 0.5053
Epoch 14/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6921 -
accuracy: 0.5027 - val_loss: 0.6913 - val_accuracy: 0.5055
Epoch 15/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6912 -
```

```
accuracy: 0.5088 - val_loss: 0.6911 - val_accuracy: 0.5031
Epoch 16/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6914 -
accuracy: 0.5003 - val_loss: 0.6920 - val_accuracy: 0.5030
Epoch 17/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6912 -
accuracy: 0.5077 - val_loss: 0.6918 - val_accuracy: 0.5034
Epoch 18/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6899 -
accuracy: 0.5074 - val_loss: 0.6897 - val_accuracy: 0.5103
Epoch 19/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6885 -
accuracy: 0.5164 - val_loss: 0.6894 - val_accuracy: 0.5031
Epoch 20/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6885 -
accuracy: 0.5121 - val_loss: 0.6664 - val_accuracy: 0.6058
```






```
Two Hidden Layer Neural Network 5,8,8,2 (sigmoid)Accuracy Train: 52.27 %,
Accuracy Test: 60.58 %
[0 0 0 … 0 0 0]
[[12168  9030]
 [ 1384  4236]]
              precision    recall  f1-score   support

           0       0.90      0.57      0.70     21198
           1       0.32      0.75      0.45      5620

    accuracy                           0.61     26818
   macro avg       0.61      0.66      0.57     26818
weighted avg       0.78      0.61      0.65     26818
```

O modelo fica pior:

C/ Normalização: Accuracy = +- 67%

S/ Normalização: Accuracy +- 51%

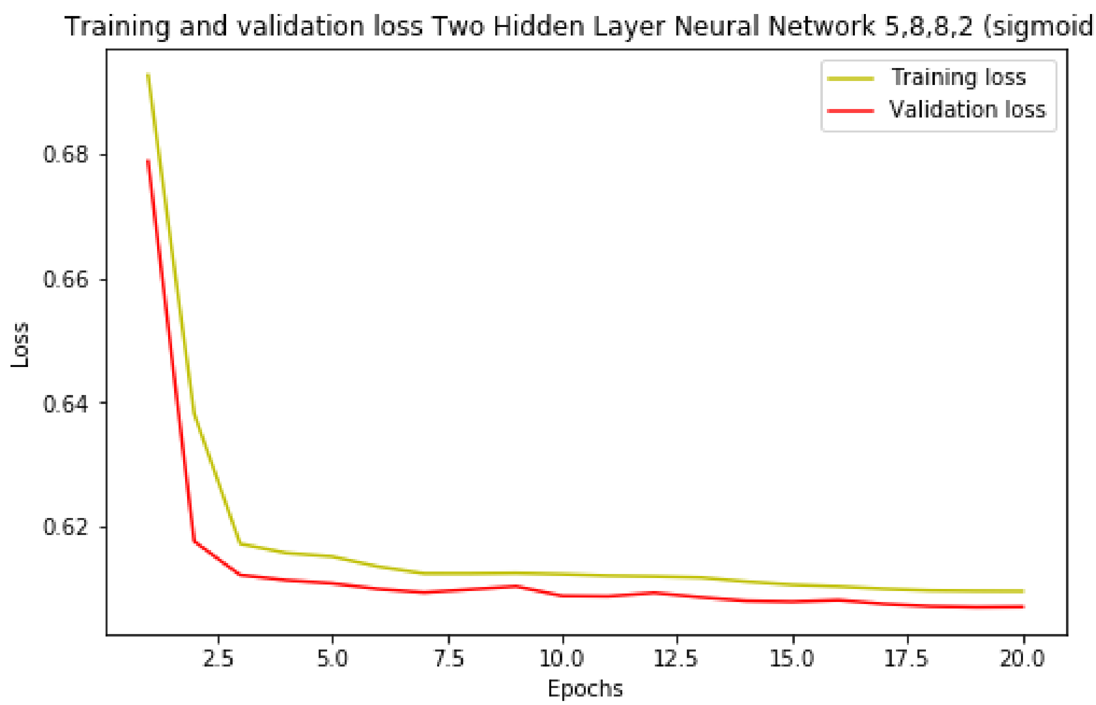
4 Exercício.

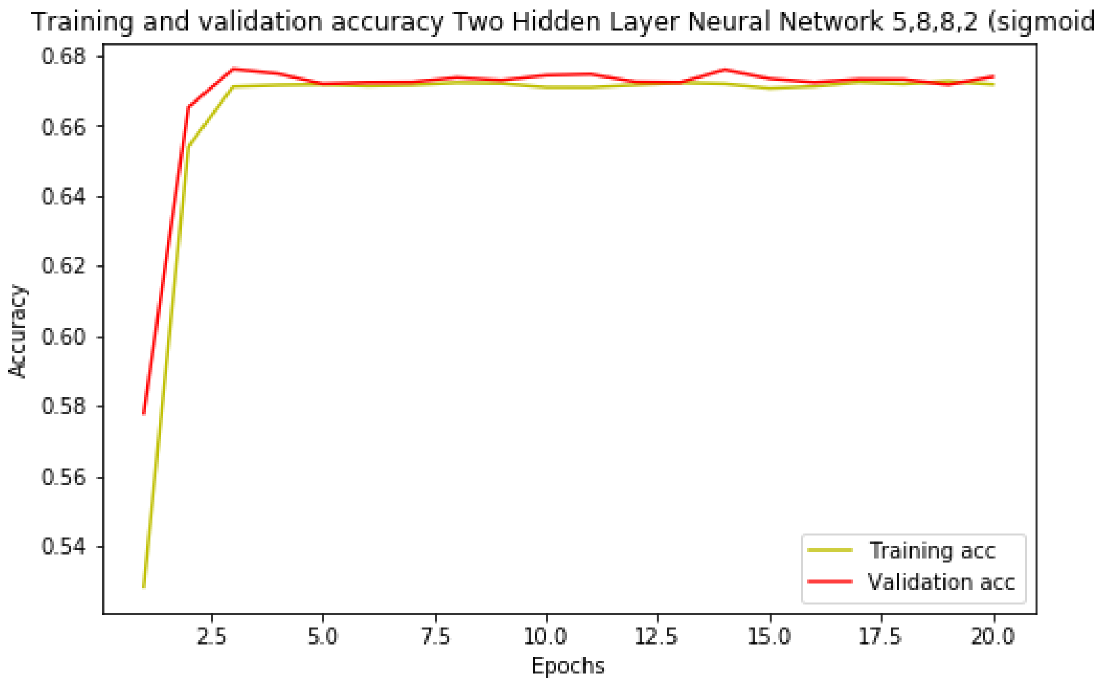
Execute o modelo agora empregando *label encode* do atributo `card_country`.

[68]:
```python
# Com o hot encoding desativado (hot=0), a função faz o label encoding
mlp_plot(hot=0)
```

```
Epoch 1/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.7022 -
accuracy: 0.5087 - val_loss: 0.6789 - val_accuracy: 0.5779
Epoch 2/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6546 -
accuracy: 0.6375 - val_loss: 0.6177 - val_accuracy: 0.6653
Epoch 3/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6203 -
accuracy: 0.6674 - val_loss: 0.6122 - val_accuracy: 0.6761
Epoch 4/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6151 -
accuracy: 0.6720 - val_loss: 0.6114 - val_accuracy: 0.6749
Epoch 5/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6147 -
accuracy: 0.6719 - val_loss: 0.6109 - val_accuracy: 0.6719
Epoch 6/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6140 -
accuracy: 0.6726 - val_loss: 0.6100 - val_accuracy: 0.6723
Epoch 7/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6154 -
accuracy: 0.6700 - val_loss: 0.6094 - val_accuracy: 0.6724
Epoch 8/20
1565/1565 [==============================] - 2s 1ms/step - loss: 0.6116 -
accuracy: 0.6736 - val_loss: 0.6099 - val_accuracy: 0.6738
Epoch 9/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6144 -
accuracy: 0.6692 - val_loss: 0.6104 - val_accuracy: 0.6730
Epoch 10/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6120 -
accuracy: 0.6710 - val_loss: 0.6089 - val_accuracy: 0.6744
Epoch 11/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6121 -
accuracy: 0.6733 - val_loss: 0.6088 - val_accuracy: 0.6747
Epoch 12/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6144 -
accuracy: 0.6697 - val_loss: 0.6094 - val_accuracy: 0.6725
Epoch 13/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6146 -
accuracy: 0.6688 - val_loss: 0.6087 - val_accuracy: 0.6723
Epoch 14/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6141 -
accuracy: 0.6692 - val_loss: 0.6081 - val_accuracy: 0.6760
Epoch 15/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6108 -
```

```
accuracy: 0.6703 - val_loss: 0.6079 - val_accuracy: 0.6734
Epoch 16/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6100 -
accuracy: 0.6720 - val_loss: 0.6082 - val_accuracy: 0.6723
Epoch 17/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6077 -
accuracy: 0.6740 - val_loss: 0.6076 - val_accuracy: 0.6733
Epoch 18/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.6089 -
accuracy: 0.6748 - val_loss: 0.6072 - val_accuracy: 0.6732
Epoch 19/20
1565/1565 [==============================] - 2s 1ms/step - loss: 0.6092 -
accuracy: 0.6739 - val_loss: 0.6071 - val_accuracy: 0.6717
Epoch 20/20
1565/1565 [==============================] - 2s 1ms/step - loss: 0.6116 -
accuracy: 0.6713 - val_loss: 0.6071 - val_accuracy: 0.6740
```






```
Two Hidden Layer Neural Network 5,8,8,2 (sigmoid)Accuracy Train: 67.18 %,
Accuracy Test: 67.40 %
[0 0 0 … 0 0 0]
[[10714  5973]
 [ 2838  7293]]
              precision    recall  f1-score   support

           0       0.79      0.64      0.71     16687
           1       0.55      0.72      0.62     10131

    accuracy                           0.67     26818
   macro avg       0.67      0.68      0.67     26818
weighted avg       0.70      0.67      0.68     26818
```

5 Exercício.

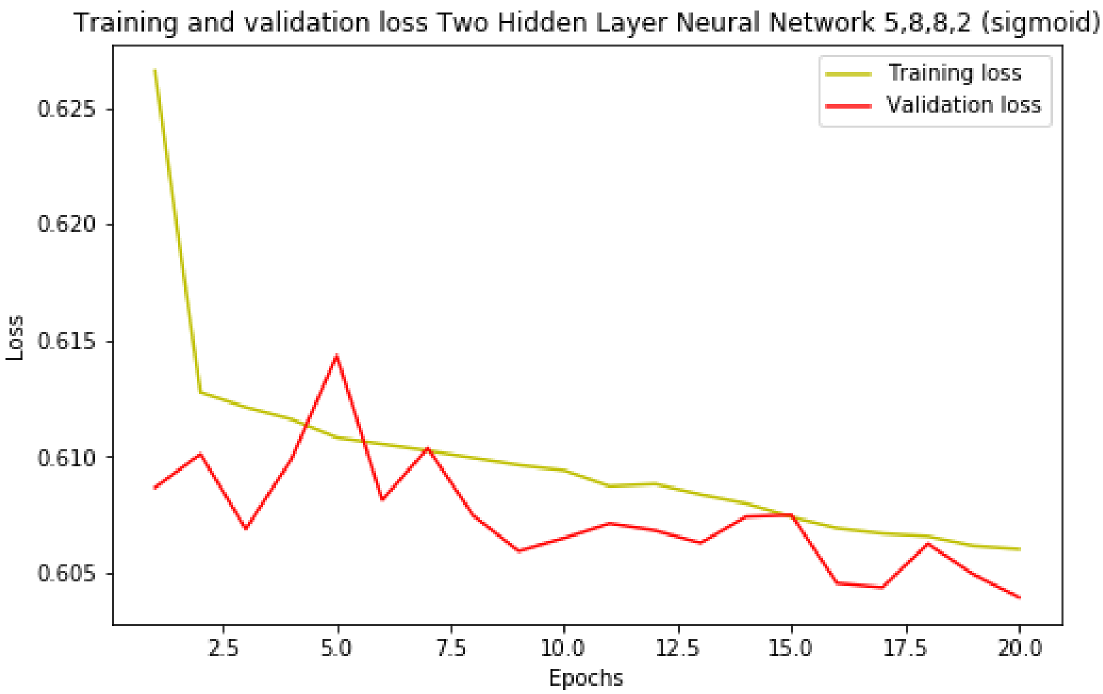
Agora varie parâmetros da rede neural, como número de camadas, número de neurônios e função de ativação. Veja se consegue obter um resultado significativamente melhor que os anteriores.

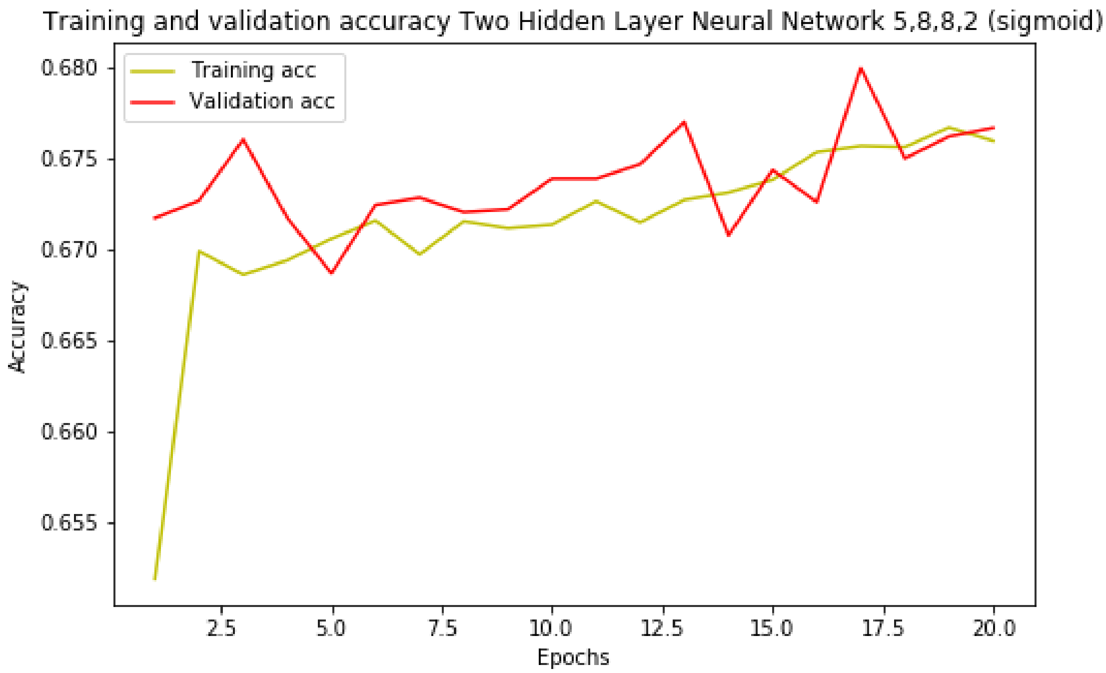
[70]:
```
mlp_plot(layers_qty=5, n=20, act='relu')
```

```
Epoch 1/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6465 -
accuracy: 0.6171 - val_loss: 0.6087 - val_accuracy: 0.6717
```

```
Epoch 2/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6110 -
accuracy: 0.6729 - val_loss: 0.6101 - val_accuracy: 0.6726
Epoch 3/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6110 -
accuracy: 0.6684 - val_loss: 0.6069 - val_accuracy: 0.6760
Epoch 4/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6109 -
accuracy: 0.6720 - val_loss: 0.6099 - val_accuracy: 0.6717
Epoch 5/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6105 -
accuracy: 0.6711 - val_loss: 0.6143 - val_accuracy: 0.6686
Epoch 6/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6088 -
accuracy: 0.6744 - val_loss: 0.6081 - val_accuracy: 0.6724
Epoch 7/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6117 -
accuracy: 0.6660 - val_loss: 0.6104 - val_accuracy: 0.6728
Epoch 8/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6113 -
accuracy: 0.6684 - val_loss: 0.6075 - val_accuracy: 0.6720
Epoch 9/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6088 -
accuracy: 0.6710 - val_loss: 0.6059 - val_accuracy: 0.6722
Epoch 10/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6098 -
accuracy: 0.6703 - val_loss: 0.6065 - val_accuracy: 0.6738
Epoch 11/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6077 -
accuracy: 0.6741 - val_loss: 0.6071 - val_accuracy: 0.6738
Epoch 12/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6095 -
accuracy: 0.6718 - val_loss: 0.6068 - val_accuracy: 0.6746
Epoch 13/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6093 -
accuracy: 0.6702 - val_loss: 0.6063 - val_accuracy: 0.6769
Epoch 14/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6056 -
accuracy: 0.6742 - val_loss: 0.6074 - val_accuracy: 0.6707
Epoch 15/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6062 -
accuracy: 0.6739 - val_loss: 0.6075 - val_accuracy: 0.6743
Epoch 16/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6040 -
accuracy: 0.6796 - val_loss: 0.6046 - val_accuracy: 0.6726
Epoch 17/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6052 -
accuracy: 0.6767 - val_loss: 0.6044 - val_accuracy: 0.6799
```

```
Epoch 18/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6054 -
accuracy: 0.6762 - val_loss: 0.6063 - val_accuracy: 0.6750
Epoch 19/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6090 -
accuracy: 0.6737 - val_loss: 0.6049 - val_accuracy: 0.6761
Epoch 20/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.6048 -
accuracy: 0.6787 - val_loss: 0.6040 - val_accuracy: 0.6766
```






```
Two Hidden Layer Neural Network 5,8,8,2 (sigmoid)Accuracy Train: 67.59 %,
Accuracy Test: 67.66 %
[0 0 0 … 0 0 0]
[[10578  5694]
 [ 2974  7572]]
              precision    recall  f1-score   support

           0       0.78      0.65      0.71     16272
           1       0.57      0.72      0.64     10546

    accuracy                           0.68     26818
   macro avg       0.68      0.68      0.67     26818
weighted avg       0.70      0.68      0.68     26818
```

6 Exercício.

Empregue os modelos acima e refaça o treinamento dos dados de fraude incluindo agora o dia e o mês das operações.

[3]:
```
fraud = pd.read_csv("http://meusite.mackenzie.br/rogerio/ML/
↪qconlondon2016_sample_data.csv")
```

[46]:
```
fraud.shape
print(fraud.charge_time[80000][8:10])
```

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[58]:
```
fraud['day'] = fraud['charge_time'].str.slice(8,10).astype(int)
fraud['month'] = fraud['charge_time'].str.slice(5,7).astype(int)
```

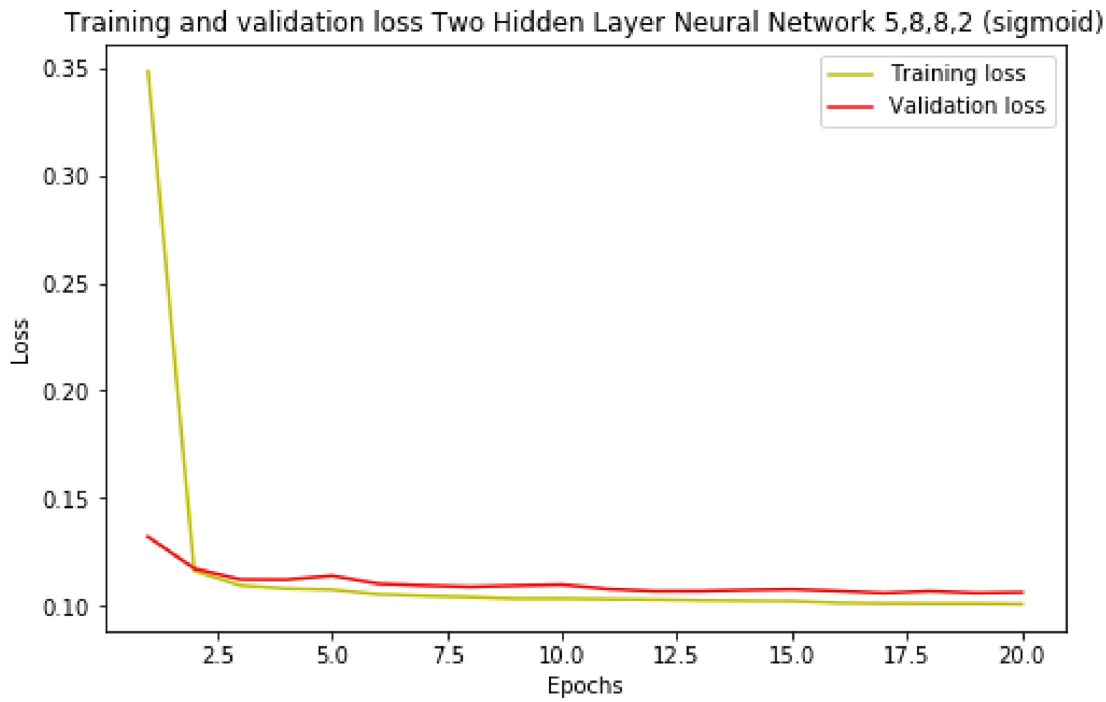
[59]:
```
fraud.dtypes
```

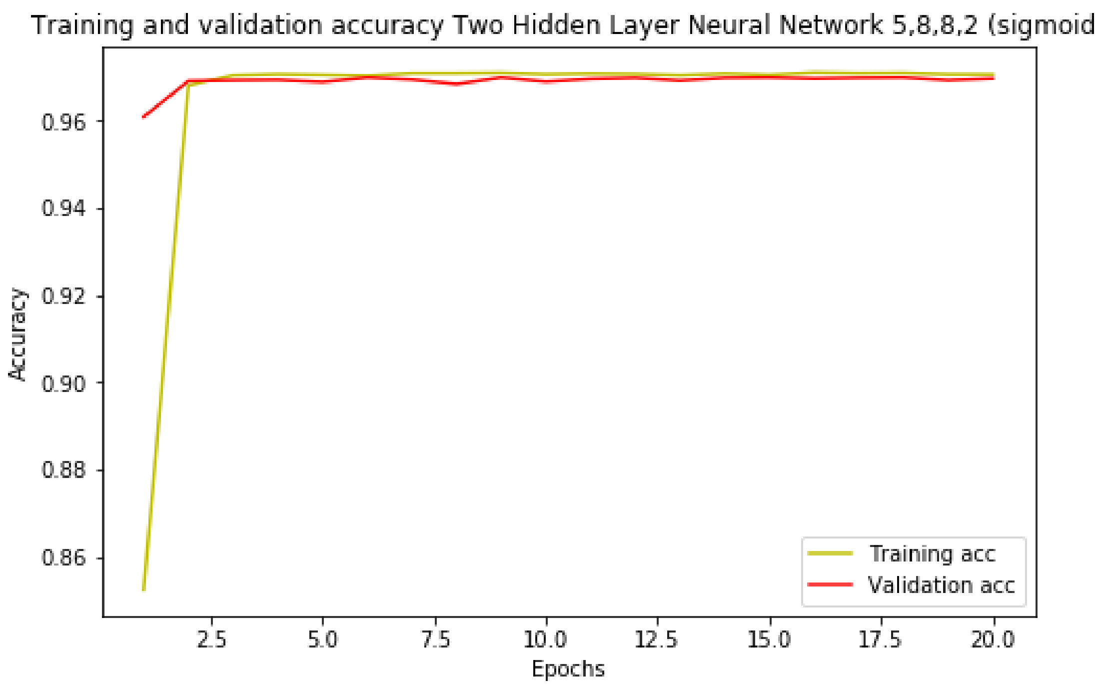
[59]:
```
fraudulent          bool
charge_time       object
amount             int64
card_country      object
card_use_24h       int64
day                int64
month              int64
dtype: object
```

[7]:
```
mlp_plot(get_date=1)
```

```
Epoch 1/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.5428 -
accuracy: 0.7113 - val_loss: 0.1321 - val_accuracy: 0.9609
Epoch 2/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1230 -
accuracy: 0.9642 - val_loss: 0.1174 - val_accuracy: 0.9692
Epoch 3/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1082 -
accuracy: 0.9714 - val_loss: 0.1123 - val_accuracy: 0.9693
Epoch 4/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1094 -
accuracy: 0.9700 - val_loss: 0.1122 - val_accuracy: 0.9694
Epoch 5/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1106 -
accuracy: 0.9695 - val_loss: 0.1140 - val_accuracy: 0.9689
Epoch 6/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1055 -
accuracy: 0.9704 - val_loss: 0.1103 - val_accuracy: 0.9700
Epoch 7/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1046 -
accuracy: 0.9712 - val_loss: 0.1095 - val_accuracy: 0.9695
Epoch 8/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1058 -
accuracy: 0.9705 - val_loss: 0.1089 - val_accuracy: 0.9684
Epoch 9/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1017 -
accuracy: 0.9713 - val_loss: 0.1094 - val_accuracy: 0.9700
Epoch 10/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1043 -
accuracy: 0.9701 - val_loss: 0.1099 - val_accuracy: 0.9690
```

```
Epoch 11/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1041 -
accuracy: 0.9712 - val_loss: 0.1079 - val_accuracy: 0.9696
Epoch 12/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1081 -
accuracy: 0.9686 - val_loss: 0.1069 - val_accuracy: 0.9699
Epoch 13/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.0992 -
accuracy: 0.9713 - val_loss: 0.1069 - val_accuracy: 0.9692
Epoch 14/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1044 -
accuracy: 0.9702 - val_loss: 0.1074 - val_accuracy: 0.9699
Epoch 15/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1038 -
accuracy: 0.9702 - val_loss: 0.1077 - val_accuracy: 0.9700
Epoch 16/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.0992 -
accuracy: 0.9722 - val_loss: 0.1069 - val_accuracy: 0.9697
Epoch 17/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1049 -
accuracy: 0.9697 - val_loss: 0.1060 - val_accuracy: 0.9699
Epoch 18/20
1565/1565 [==============================] - 3s 2ms/step - loss: 0.1020 -
accuracy: 0.9707 - val_loss: 0.1069 - val_accuracy: 0.9700
Epoch 19/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.1027 -
accuracy: 0.9706 - val_loss: 0.1060 - val_accuracy: 0.9693
Epoch 20/20
1565/1565 [==============================] - 2s 2ms/step - loss: 0.0996 -
accuracy: 0.9709 - val_loss: 0.1063 - val_accuracy: 0.9697
```






```
Two Hidden Layer Neural Network 5,8,8,2 (sigmoid)Accuracy Train: 97.07 %,
Accuracy Test: 96.97 %
```

```
[0 1 0 … 0 0 0]
[[13432   596]
 [  120 12670]]
              precision    recall  f1-score   support

           0       0.99      0.96      0.97     14028
           1       0.96      0.99      0.97     12790

    accuracy                           0.97     26818
   macro avg       0.97      0.97      0.97     26818
weighted avg       0.97      0.97      0.97     26818
```

6.1 LAB SET UP

Execute antes de iniciar o Lab.

[4]:
```python
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
import os
warnings.filterwarnings("ignore")

from tensorflow import keras
from tensorflow.keras import layers
from keras import Sequential, layers
import tensorflow as tf

from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report


def plot_loss_acc(history,more_title=''):

    loss = history.history['loss']
    val_loss = history.history['val_loss']
    epochs = range(1, len(loss) + 1)
    plt.figure(figsize=(8,5))
    plt.plot(epochs, loss, 'y', label='Training loss')
    plt.plot(epochs, val_loss, 'r', label='Validation loss')
    plt.title('Training and validation loss' + ' ' + more_title)
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()
    plt.show()
```

```
    acc = history.history['accuracy']
    val_acc = history.history['val_accuracy']
    plt.figure(figsize=(8,5))
    plt.plot(epochs, acc, 'y', label='Training acc')
    plt.plot(epochs, val_acc, 'r', label='Validation acc')
    plt.title('Training and validation accuracy' + ' ' + more_title)
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()
    plt.show()

    print(more_title + 'Accuracy Train: {:.2f} %, Accuracy Test: {:.2f} %'.
 ↪format(acc[len(acc)-1] *100, val_acc[len(val_acc)-1]*100))

    return loss, val_loss, acc, val_acc

print('Set Up completed!')
```

```
Set Up completed!
```

[ ]: