```python
import seaborn as sns
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

2502041956 - Nicholas Javier - LA05 (SOAL UTS NOMOR 1)
Link Youtube(ada di 1f): https://youtu.be/GTk_jg8N2PM

```python
df = pd.read_csv('dataset_spine.csv')
df
```

```
     Unnamed: 0        Col1        Col2        Col3        Col4
Col5  \
0             0   63.027817   22.552586   39.609117   40.475232
98.672917
1             1   39.056951   10.060991   25.015378   28.995960
114.405425
2             2   68.832021   22.218482   50.092194   46.613539
105.985135
3             3   69.297008   24.652878   44.311238   44.644130
101.868495
4             4   49.712859    9.652075   28.317406   40.060784
108.168725
..          ...         ...         ...         ...         ...         ..
.
305         305   47.903565   13.616688   36.000000   34.286877
117.449062
306         306   53.936748   20.721496   29.220534   33.215251
114.365845
307         307   61.446597   22.694968   46.170347   38.751628
125.670725
308         308   45.252792    8.693157   41.583126   36.559635
118.545842
309         309   33.841641    5.073991   36.641233   28.767649
123.945244

          Col6       Col7      Col8      Col9     Col10      Col11
Col12  \
0    -0.254400   0.744503   12.5661   14.5386   15.30468 -28.658501
43.5123
1     4.564259   0.415186   12.8874   17.5323   16.78486 -25.530607
16.1102
2    -3.530317   0.474889   26.8343   17.4861   16.65897 -29.031888
19.2221
3    11.211523   0.369345   23.5603   12.7074   11.42447 -30.470246
18.8329
4     7.918501   0.543360   35.4940   15.9546    8.87237 -16.378376
24.9171
..         ...        ...       ...       ...        ...        ...       .
```

```
..
305  -4.245395  0.129744   7.8433  14.7484   8.51707 -15.728927
11.5472
306  -0.421010  0.047913  19.1986  18.1972   7.08745   6.013843
43.8693
307  -2.707880  0.081070  16.2059  13.5565   8.89572   3.564463
18.4151
308   0.214750  0.159251  14.7334  16.0928   9.75922   5.767308
33.7192
309  -0.199249  0.674504  19.3825  17.6963  13.72929   1.783007
40.6049

    Class_att
0    Abnormal
1    Abnormal
2    Abnormal
3    Abnormal
4    Abnormal
..        ...
305    Normal
306    Normal
307    Normal
308    Normal
309    Normal

[310 rows x 14 columns]
```

#1a

```
df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 310 entries, 0 to 309
Data columns (total 14 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   Unnamed: 0  310 non-null    int64
 1   Col1        310 non-null    float64
 2   Col2        310 non-null    float64
 3   Col3        310 non-null    float64
 4   Col4        310 non-null    float64
 5   Col5        310 non-null    float64
 6   Col6        310 non-null    float64
 7   Col7        310 non-null    float64
 8   Col8        310 non-null    float64
 9   Col9        310 non-null    float64
 10  Col10       310 non-null    float64
 11  Col11       310 non-null    float64
 12  Col12       310 non-null    float64
```

```
 13  Class_att   310 non-null    object
dtypes: float64(12), int64(1), object(1)
memory usage: 34.0+ KB
```

```
df.describe()
```

```
       Unnamed: 0        Col1        Col2        Col3        Col4
Col5  \
count  310.000000  310.000000  310.000000  310.000000  310.000000
310.000000
mean   154.500000   60.496653   17.542822   51.930930   42.953831
117.920655
std     89.633513   17.236520   10.008330   18.554064   13.423102
13.317377
min      0.000000   26.147921   -6.554948   14.000000   13.366931
70.082575
25%     77.250000   46.430294   10.667069   37.000000   33.347122
110.709196
50%    154.500000   58.691038   16.357689   49.562398   42.404912
118.268178
75%    231.750000   72.877696   22.120395   63.000000   52.695888
125.467674
max    309.000000  129.834041   49.431864  125.742385  121.429566
163.071041

             Col6        Col7        Col8        Col9       Col10
Col11  \
count  310.000000  310.000000  310.000000  310.000000  310.000000
310.000000
mean    26.296694    0.472979   21.321526   13.064511   11.933317  -
14.053139
std     37.559027    0.285787    8.639423    3.399713    2.893265
12.225582
min    -11.058179    0.003220    7.027000    7.037800    7.030600  -
35.287375
25%      1.603727    0.224367   13.054400   10.417800    9.541140  -
24.289522
50%     11.767934    0.475989   21.907150   12.938450   11.953835  -
14.622856
75%     41.287352    0.704846   28.954075   15.889525   14.371810   -
3.497094
max    418.543082    0.998827   36.743900   19.324000   16.821080
6.972071

            Col12
count  310.000000
mean    25.645981
std     10.450558
min      7.007900
25%     17.189075
```

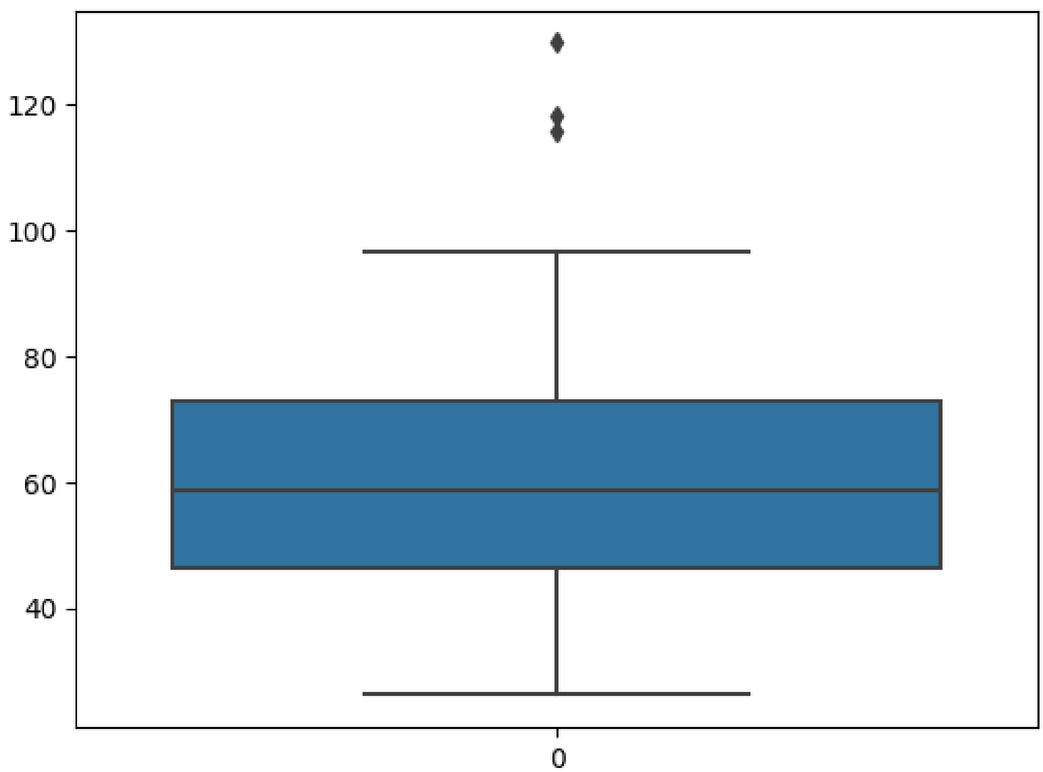
```
50%      24.931950
75%      33.979600
max      44.341200
```

```
df.isna().sum()
```

```
Unnamed: 0    0
Col1          0
Col2          0
Col3          0
Col4          0
Col5          0
Col6          0
Col7          0
Col8          0
Col9          0
Col10         0
Col11         0
Col12         0
Class_att     0
dtype: int64
```

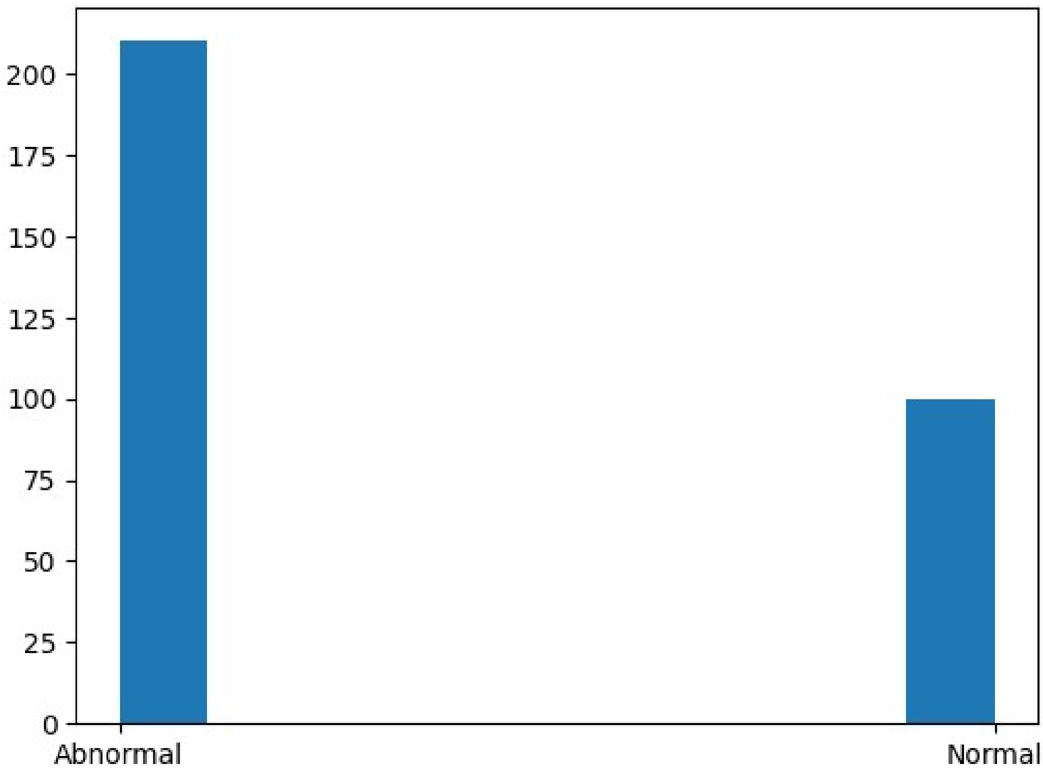
```
sns.boxplot(df['Col1'])
```

```
<Axes: >
```



```
plt.hist(df['Class_att'])
```

```
(array([210.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0., 100.]),
 array([0. , 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1. ]),
 <BarContainer object of 10 artists>)
```




```
duplicates = df[df.duplicated()]
if not duplicates.empty:
    print("Duplicate rows found:")
    print(duplicates)
else:
    print("No duplicate rows found.")
```

```
No duplicate rows found.
```

```
df.drop(columns=['Unnamed: 0'],inplace = True)
df
```

```
          Col1       Col2       Col3       Col4        Col5      Col6  \
0    63.027817  22.552586  39.609117  40.475232   98.672917  -0.254400

1    39.056951  10.060991  25.015378  28.995960  114.405425   4.564259

2    68.832021  22.218482  50.092194  46.613539  105.985135  -3.530317
```

```
3    69.297008  24.652878  44.311238  44.644130  101.868495  11.211523

4    49.712859   9.652075  28.317406  40.060784  108.168725   7.918501

..         ...        ...        ...        ...         ...        ...

305  47.903565  13.616688  36.000000  34.286877  117.449062  -4.245395

306  53.936748  20.721496  29.220534  33.215251  114.365845  -0.421010

307  61.446597  22.694968  46.170347  38.751628  125.670725  -2.707880

308  45.252792   8.693157  41.583126  36.559635  118.545842   0.214750

309  33.841641   5.073991  36.641233  28.767649  123.945244  -0.199249


         Col7     Col8     Col9     Col10      Col11    Col12
Class_att
0    0.744503  12.5661  14.5386  15.30468 -28.658501  43.5123
Abnormal
1    0.415186  12.8874  17.5323  16.78486 -25.530607  16.1102
Abnormal
2    0.474889  26.8343  17.4861  16.65897 -29.031888  19.2221
Abnormal
3    0.369345  23.5603  12.7074  11.42447 -30.470246  18.8329
Abnormal
4    0.543360  35.4940  15.9546   8.87237 -16.378376  24.9171
Abnormal
..        ...      ...      ...       ...        ...      ...        ..
.
305  0.129744   7.8433  14.7484   8.51707 -15.728927  11.5472
Normal
306  0.047913  19.1986  18.1972   7.08745   6.013843  43.8693
Normal
307  0.081070  16.2059  13.5565   8.89572   3.564463  18.4151
Normal
308  0.159251  14.7334  16.0928   9.75922   5.767308  33.7192
Normal
309  0.674504  19.3825  17.6963  13.72929   1.783007  40.6049
Normal

[310 rows x 13 columns]
```

```
# from sklearn.preprocessing import OneHotEncoder
# encoder = OneHotEncoder()

# # df["Class_att"] = encoder.fit_transform(df["Class_att"])
# encoded_data = encoder.fit_transform(df[["Class_att"]])
# print(encoded_data)
# column_names = encoder.get_feature_names_out(["Class_att"])
```

```
# column_names
# encoded_df = pd.DataFrame(encoded_data, columns=column_names)
# a = encoded_df[0]
# b = encoded_df[1]

# # # Update the original DataFrame by dropping the "Class_att" column
and concatenating the one-hot encoded DataFrame
# df = df.drop("Class_att", axis=1)
# df = pd.concat([df, a], axis=1)
# df = pd.concat([df, b], axis=1)

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 310 entries, 0 to 309
Data columns (total 13 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Col1       310 non-null    float64
 1   Col2       310 non-null    float64
 2   Col3       310 non-null    float64
 3   Col4       310 non-null    float64
 4   Col5       310 non-null    float64
 5   Col6       310 non-null    float64
 6   Col7       310 non-null    float64
 7   Col8       310 non-null    float64
 8   Col9       310 non-null    float64
 9   Col10      310 non-null    float64
 10  Col11      310 non-null    float64
 11  Col12      310 non-null    float64
 12  Class_att  310 non-null    object 
dtypes: float64(12), object(1)
memory usage: 31.6+ KB
```

Pada dataset_spine.csv, masalah yang saya temukan adalah adanya kolom 'Unnamed: 0' yang tidak memiliki arti apa2 sehingga saya drop columns tersebut. Selebihnya sudah dapat digunakan

#1b

```
from sklearn.model_selection import train_test_split


df_drop = df.drop(['Class_att'],axis=1)
df_spl = df['Class_att']

x_train,x_temp,y_train,y_temp = train_test_split(df_drop,
                                                 df_spl,
                                                 test_size = 0.2,
                                                 random_state = 99)
```

```
x_val,x_test,y_val,y_test = train_test_split(x_temp,
                                             y_temp,
                                             test_size = 0.5,
                                             random_state = 99)

y_train = pd.get_dummies(y_train)
y_val = pd.get_dummies(y_val)
y_test = pd.get_dummies(y_test)


print("Xtrain: ",len(x_train))
print("Ytrain: ",len(y_train))
print("Xtest: ",len(x_test))
print("Ytest: ",len(y_test))
# print(x_train)
print(y_train)
```

```
Xtrain:  248
Ytrain:  248
Xtest:  31
Ytest:  31
     Abnormal  Normal
118         1       0
207         1       0
96          1       0
90          1       0
175         1       0
..        ...     ...
201         1       0
168         1       0
185         1       0
35          1       0
129         1       0

[248 rows x 2 columns]
```

1c

```
import tensorflow as tf
from tensorflow import keras

ft = x_train.shape[1]
# category 2 karena abnormal dan normal
cate = 2
neuron1 = 512
#neuron2 : 512 / 2
neuron2 = 256
```

```
#neuron3 : 216 / 2
neuron3 = 128

model_neuron = keras.models.Sequential([
    tf.keras.layers.Dense(neuron1,activation = 'sigmoid',
input_shape=(ft,)),
    tf.keras.layers.Dense(neuron2,activation = 'sigmoid'),
    tf.keras.layers.Dense(neuron3,activation = 'sigmoid'),
    tf.keras.layers.Dense(cate,activation = 'softmax'),
])

model_neuron.compile(optimizer = "adam",
                     loss = "categorical_crossentropy",
                     metrics =["accuracy"] )

sum_model_neur = model_neuron.summary()
sum_model_neur
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 512)               6656

 dense_1 (Dense)             (None, 256)               131328

 dense_2 (Dense)             (None, 128)               32896

 dense_3 (Dense)             (None, 2)                 258

=================================================================
Total params: 171138 (668.51 KB)
Trainable params: 171138 (668.51 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
model_neuron_result = model_neuron.fit(x_train,
                                       y_train,
                                       epochs = 148,
                                       batch_size = 20,
                                       validation_data=(x_val,y_val))
```

```
Epoch 1/148
13/13 [==============================] - 2s 42ms/step - loss: 0.6415 -
accuracy: 0.6492 - val_loss: 0.6710 - val_accuracy: 0.6452
Epoch 2/148
13/13 [==============================] - 0s 7ms/step - loss: 0.5242 -
accuracy: 0.6734 - val_loss: 0.5117 - val_accuracy: 0.7097
Epoch 3/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4491 -
```

```
accuracy: 0.7661 - val_loss: 0.4241 - val_accuracy: 0.7419
Epoch 4/148
13/13 [==============================] - 0s 7ms/step - loss: 0.4032 -
accuracy: 0.7782 - val_loss: 0.4112 - val_accuracy: 0.7419
Epoch 5/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4031 -
accuracy: 0.7581 - val_loss: 0.4579 - val_accuracy: 0.7097
Epoch 6/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3596 -
accuracy: 0.8185 - val_loss: 0.5021 - val_accuracy: 0.7097
Epoch 7/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3327 -
accuracy: 0.8427 - val_loss: 0.4687 - val_accuracy: 0.7097
Epoch 8/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3441 -
accuracy: 0.8185 - val_loss: 0.4292 - val_accuracy: 0.7742
Epoch 9/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3774 -
accuracy: 0.7863 - val_loss: 0.3957 - val_accuracy: 0.8065
Epoch 10/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3663 -
accuracy: 0.8145 - val_loss: 0.3871 - val_accuracy: 0.8065
Epoch 11/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3396 -
accuracy: 0.8387 - val_loss: 0.6190 - val_accuracy: 0.7097
Epoch 12/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3219 -
accuracy: 0.8306 - val_loss: 0.4023 - val_accuracy: 0.7419
Epoch 13/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3189 -
accuracy: 0.8306 - val_loss: 0.4616 - val_accuracy: 0.7097
Epoch 14/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3004 -
accuracy: 0.8589 - val_loss: 0.6483 - val_accuracy: 0.7097
Epoch 15/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3210 -
accuracy: 0.8226 - val_loss: 0.4173 - val_accuracy: 0.7742
Epoch 16/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3182 -
accuracy: 0.8468 - val_loss: 0.3742 - val_accuracy: 0.7742
Epoch 17/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3101 -
accuracy: 0.8266 - val_loss: 0.4235 - val_accuracy: 0.7742
Epoch 18/148
13/13 [==============================] - 0s 11ms/step - loss: 0.2892 -
accuracy: 0.8468 - val_loss: 0.4734 - val_accuracy: 0.7419
Epoch 19/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2827 -
accuracy: 0.8669 - val_loss: 0.5535 - val_accuracy: 0.7419
```

```
Epoch 20/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2813 -
accuracy: 0.8548 - val_loss: 0.4695 - val_accuracy: 0.7419
Epoch 21/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2841 -
accuracy: 0.8468 - val_loss: 0.5325 - val_accuracy: 0.7419
Epoch 22/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2875 -
accuracy: 0.8629 - val_loss: 0.6518 - val_accuracy: 0.7097
Epoch 23/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2976 -
accuracy: 0.8589 - val_loss: 0.4623 - val_accuracy: 0.7419
Epoch 24/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2858 -
accuracy: 0.8669 - val_loss: 0.3731 - val_accuracy: 0.7419
Epoch 25/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2757 -
accuracy: 0.8468 - val_loss: 0.3559 - val_accuracy: 0.7742
Epoch 26/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2661 -
accuracy: 0.8831 - val_loss: 0.4313 - val_accuracy: 0.7419
Epoch 27/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2665 -
accuracy: 0.8710 - val_loss: 0.4812 - val_accuracy: 0.7419
Epoch 28/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2397 -
accuracy: 0.8831 - val_loss: 0.3732 - val_accuracy: 0.7419
Epoch 29/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2956 -
accuracy: 0.8750 - val_loss: 0.3178 - val_accuracy: 0.8065
Epoch 30/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3068 -
accuracy: 0.8589 - val_loss: 0.4641 - val_accuracy: 0.7097
Epoch 31/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2481 -
accuracy: 0.8750 - val_loss: 0.7134 - val_accuracy: 0.7097
Epoch 32/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2662 -
accuracy: 0.8710 - val_loss: 0.3112 - val_accuracy: 0.8387
Epoch 33/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2441 -
accuracy: 0.8629 - val_loss: 0.4120 - val_accuracy: 0.7742
Epoch 34/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2373 -
accuracy: 0.8710 - val_loss: 0.3965 - val_accuracy: 0.7742
Epoch 35/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2232 -
accuracy: 0.8871 - val_loss: 0.4438 - val_accuracy: 0.7742
Epoch 36/148
```

```
13/13 [==============================] - 0s 8ms/step - loss: 0.2443 -
accuracy: 0.8831 - val_loss: 0.5932 - val_accuracy: 0.7419
Epoch 37/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2447 -
accuracy: 0.8750 - val_loss: 0.3945 - val_accuracy: 0.7419
Epoch 38/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2198 -
accuracy: 0.8911 - val_loss: 0.4639 - val_accuracy: 0.7742
Epoch 39/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2536 -
accuracy: 0.8871 - val_loss: 0.4363 - val_accuracy: 0.7419
Epoch 40/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2212 -
accuracy: 0.8952 - val_loss: 0.6306 - val_accuracy: 0.7419
Epoch 41/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2391 -
accuracy: 0.8831 - val_loss: 0.7578 - val_accuracy: 0.7097
Epoch 42/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2217 -
accuracy: 0.8992 - val_loss: 0.4772 - val_accuracy: 0.7742
Epoch 43/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2023 -
accuracy: 0.8992 - val_loss: 0.4127 - val_accuracy: 0.8065
Epoch 44/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1859 -
accuracy: 0.9194 - val_loss: 0.3774 - val_accuracy: 0.8387
Epoch 45/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1867 -
accuracy: 0.9073 - val_loss: 0.4582 - val_accuracy: 0.7742
Epoch 46/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3375 -
accuracy: 0.8548 - val_loss: 0.5928 - val_accuracy: 0.7419
Epoch 47/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2564 -
accuracy: 0.8952 - val_loss: 0.7454 - val_accuracy: 0.7097
Epoch 48/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2494 -
accuracy: 0.8871 - val_loss: 0.5647 - val_accuracy: 0.7419
Epoch 49/148
13/13 [==============================] - 0s 8ms/step - loss: 0.2143 -
accuracy: 0.8911 - val_loss: 0.4384 - val_accuracy: 0.7742
Epoch 50/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1876 -
accuracy: 0.9113 - val_loss: 0.4458 - val_accuracy: 0.7742
Epoch 51/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1882 -
accuracy: 0.8992 - val_loss: 0.3743 - val_accuracy: 0.7742
Epoch 52/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1873 -
```

```
accuracy: 0.9113 - val_loss: 0.4114 - val_accuracy: 0.7742
Epoch 53/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1775 -
accuracy: 0.9355 - val_loss: 0.4136 - val_accuracy: 0.7742
Epoch 54/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1916 -
accuracy: 0.9274 - val_loss: 0.3687 - val_accuracy: 0.7742
Epoch 55/148
13/13 [==============================] - 0s 9ms/step - loss: 0.1982 -
accuracy: 0.9073 - val_loss: 0.3968 - val_accuracy: 0.7742
Epoch 56/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2401 -
accuracy: 0.8790 - val_loss: 0.4366 - val_accuracy: 0.8065
Epoch 57/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3532 -
accuracy: 0.8145 - val_loss: 0.3973 - val_accuracy: 0.7742
Epoch 58/148
13/13 [==============================] - 0s 7ms/step - loss: 0.2496 -
accuracy: 0.8629 - val_loss: 0.6048 - val_accuracy: 0.7097
Epoch 59/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1914 -
accuracy: 0.8992 - val_loss: 0.4820 - val_accuracy: 0.7097
Epoch 60/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1712 -
accuracy: 0.9355 - val_loss: 0.5061 - val_accuracy: 0.7742
Epoch 61/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1672 -
accuracy: 0.9194 - val_loss: 0.6202 - val_accuracy: 0.7742
Epoch 62/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1520 -
accuracy: 0.9315 - val_loss: 0.6398 - val_accuracy: 0.7742
Epoch 63/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1538 -
accuracy: 0.9315 - val_loss: 0.4723 - val_accuracy: 0.8065
Epoch 64/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1442 -
accuracy: 0.9395 - val_loss: 0.5061 - val_accuracy: 0.8065
Epoch 65/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1501 -
accuracy: 0.9315 - val_loss: 0.4680 - val_accuracy: 0.7419
Epoch 66/148
13/13 [==============================] - 0s 9ms/step - loss: 0.2401 -
accuracy: 0.8911 - val_loss: 0.4870 - val_accuracy: 0.8065
Epoch 67/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1469 -
accuracy: 0.9435 - val_loss: 0.4682 - val_accuracy: 0.8065
Epoch 68/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1406 -
accuracy: 0.9395 - val_loss: 0.5513 - val_accuracy: 0.8065
```

```
Epoch 69/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1248 -
accuracy: 0.9435 - val_loss: 0.4145 - val_accuracy: 0.7742
Epoch 70/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1468 -
accuracy: 0.9355 - val_loss: 0.4527 - val_accuracy: 0.7742
Epoch 71/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1326 -
accuracy: 0.9435 - val_loss: 0.4633 - val_accuracy: 0.8065
Epoch 72/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1252 -
accuracy: 0.9556 - val_loss: 0.5080 - val_accuracy: 0.7742
Epoch 73/148
13/13 [==============================] - 0s 10ms/step - loss: 0.1124 -
accuracy: 0.9516 - val_loss: 0.5144 - val_accuracy: 0.8065
Epoch 74/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1042 -
accuracy: 0.9597 - val_loss: 0.6623 - val_accuracy: 0.8387
Epoch 75/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1145 -
accuracy: 0.9435 - val_loss: 0.5071 - val_accuracy: 0.7742
Epoch 76/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1450 -
accuracy: 0.9355 - val_loss: 0.4543 - val_accuracy: 0.7742
Epoch 77/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1098 -
accuracy: 0.9476 - val_loss: 0.4708 - val_accuracy: 0.8065
Epoch 78/148
13/13 [==============================] - 0s 9ms/step - loss: 0.1014 -
accuracy: 0.9597 - val_loss: 0.8601 - val_accuracy: 0.7742
Epoch 79/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1965 -
accuracy: 0.9153 - val_loss: 0.7771 - val_accuracy: 0.8065
Epoch 80/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1267 -
accuracy: 0.9476 - val_loss: 0.4837 - val_accuracy: 0.8065
Epoch 81/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1292 -
accuracy: 0.9395 - val_loss: 0.7171 - val_accuracy: 0.8065
Epoch 82/148
13/13 [==============================] - 0s 10ms/step - loss: 0.1221 -
accuracy: 0.9556 - val_loss: 0.5125 - val_accuracy: 0.8387
Epoch 83/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1155 -
accuracy: 0.9556 - val_loss: 0.6077 - val_accuracy: 0.7742
Epoch 84/148
13/13 [==============================] - 0s 9ms/step - loss: 0.1431 -
accuracy: 0.9274 - val_loss: 0.6472 - val_accuracy: 0.8065
Epoch 85/148
```

```
13/13 [==============================] - 0s 9ms/step - loss: 0.1055 -
accuracy: 0.9597 - val_loss: 0.4495 - val_accuracy: 0.8710
Epoch 86/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0899 -
accuracy: 0.9637 - val_loss: 0.5899 - val_accuracy: 0.8387
Epoch 87/148
13/13 [==============================] - 0s 9ms/step - loss: 0.1022 -
accuracy: 0.9637 - val_loss: 0.6064 - val_accuracy: 0.7742
Epoch 88/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0934 -
accuracy: 0.9556 - val_loss: 0.5583 - val_accuracy: 0.8387
Epoch 89/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0799 -
accuracy: 0.9758 - val_loss: 0.6676 - val_accuracy: 0.8065
Epoch 90/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0845 -
accuracy: 0.9677 - val_loss: 0.5713 - val_accuracy: 0.8065
Epoch 91/148
13/13 [==============================] - 0s 13ms/step - loss: 0.0990 -
accuracy: 0.9677 - val_loss: 0.6670 - val_accuracy: 0.8065
Epoch 92/148
13/13 [==============================] - 0s 13ms/step - loss: 0.0622 -
accuracy: 0.9798 - val_loss: 0.6108 - val_accuracy: 0.8065
Epoch 93/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0783 -
accuracy: 0.9758 - val_loss: 0.5782 - val_accuracy: 0.8387
Epoch 94/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0633 -
accuracy: 0.9879 - val_loss: 0.5459 - val_accuracy: 0.8065
Epoch 95/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0650 -
accuracy: 0.9798 - val_loss: 0.8041 - val_accuracy: 0.8387
Epoch 96/148
13/13 [==============================] - 0s 12ms/step - loss: 0.0571 -
accuracy: 0.9839 - val_loss: 0.7348 - val_accuracy: 0.8065
Epoch 97/148
13/13 [==============================] - 0s 13ms/step - loss: 0.0568 -
accuracy: 0.9758 - val_loss: 0.5777 - val_accuracy: 0.8387
Epoch 98/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0440 -
accuracy: 0.9919 - val_loss: 0.7052 - val_accuracy: 0.8387
Epoch 99/148
13/13 [==============================] - 0s 12ms/step - loss: 0.0560 -
accuracy: 0.9758 - val_loss: 0.5589 - val_accuracy: 0.8065
Epoch 100/148
13/13 [==============================] - 0s 13ms/step - loss: 0.0916 -
accuracy: 0.9435 - val_loss: 0.7565 - val_accuracy: 0.8065
Epoch 101/148
13/13 [==============================] - 0s 12ms/step - loss: 0.1005 -
```

```
accuracy: 0.9516 - val_loss: 0.9518 - val_accuracy: 0.8065
Epoch 102/148
13/13 [==============================] - 0s 12ms/step - loss: 0.1375 -
accuracy: 0.9315 - val_loss: 0.6765 - val_accuracy: 0.8065
Epoch 103/148
13/13 [==============================] - 0s 11ms/step - loss: 0.1186 -
accuracy: 0.9516 - val_loss: 0.7764 - val_accuracy: 0.7419
Epoch 104/148
13/13 [==============================] - 0s 12ms/step - loss: 0.1871 -
accuracy: 0.9194 - val_loss: 0.4895 - val_accuracy: 0.8065
Epoch 105/148
13/13 [==============================] - 0s 11ms/step - loss: 0.1287 -
accuracy: 0.9677 - val_loss: 0.7054 - val_accuracy: 0.7742
Epoch 106/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0682 -
accuracy: 0.9758 - val_loss: 0.7661 - val_accuracy: 0.8065
Epoch 107/148
13/13 [==============================] - 0s 12ms/step - loss: 0.0551 -
accuracy: 0.9879 - val_loss: 0.7216 - val_accuracy: 0.8065
Epoch 108/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0420 -
accuracy: 0.9919 - val_loss: 0.5746 - val_accuracy: 0.8065
Epoch 109/148
13/13 [==============================] - 0s 11ms/step - loss: 0.0487 -
accuracy: 0.9798 - val_loss: 0.5672 - val_accuracy: 0.8710
Epoch 110/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0998 -
accuracy: 0.9597 - val_loss: 0.4764 - val_accuracy: 0.8387
Epoch 111/148
13/13 [==============================] - 0s 7ms/step - loss: 0.1003 -
accuracy: 0.9597 - val_loss: 0.8651 - val_accuracy: 0.8065
Epoch 112/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1125 -
accuracy: 0.9395 - val_loss: 1.3006 - val_accuracy: 0.7742
Epoch 113/148
13/13 [==============================] - 0s 8ms/step - loss: 0.1559 -
accuracy: 0.9315 - val_loss: 0.6749 - val_accuracy: 0.8387
Epoch 114/148
13/13 [==============================] - 0s 9ms/step - loss: 0.1302 -
accuracy: 0.9597 - val_loss: 0.6706 - val_accuracy: 0.7742
Epoch 115/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0947 -
accuracy: 0.9556 - val_loss: 0.5164 - val_accuracy: 0.8387
Epoch 116/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0658 -
accuracy: 0.9718 - val_loss: 0.5456 - val_accuracy: 0.8065
Epoch 117/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0585 -
accuracy: 0.9798 - val_loss: 0.7557 - val_accuracy: 0.8065
```

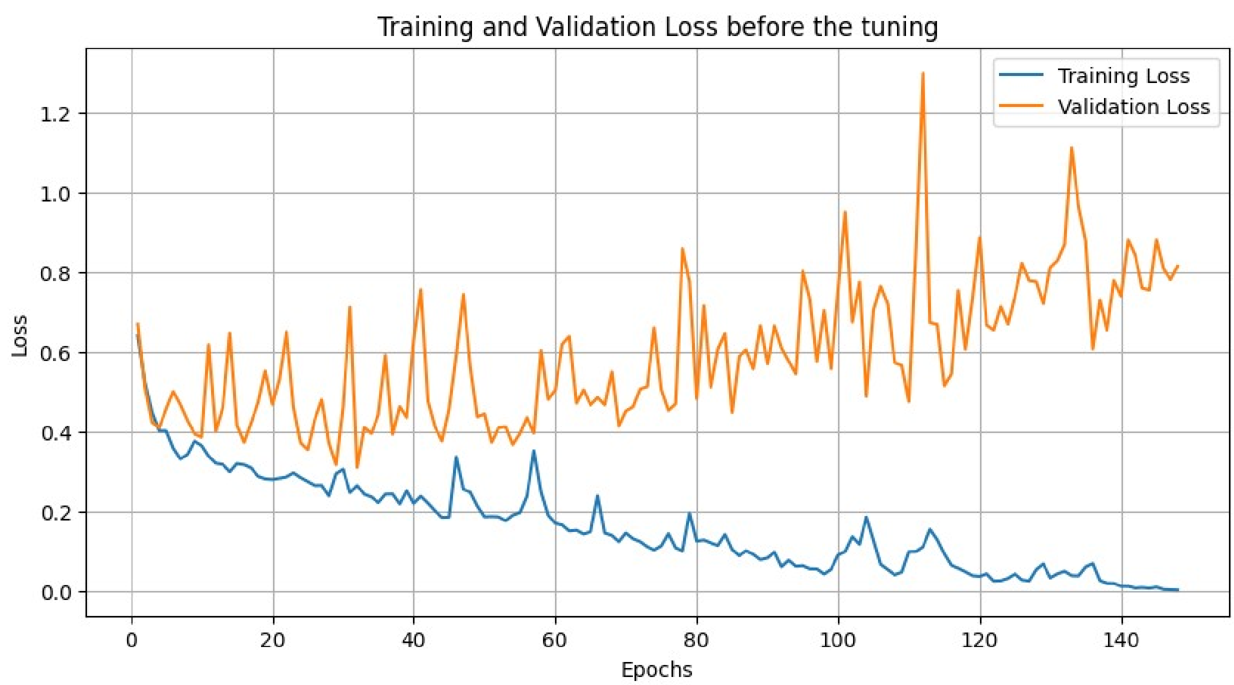
```
Epoch 118/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0497 -
accuracy: 0.9798 - val_loss: 0.6080 - val_accuracy: 0.8387
Epoch 119/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0399 -
accuracy: 0.9839 - val_loss: 0.7362 - val_accuracy: 0.8387
Epoch 120/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0382 -
accuracy: 0.9879 - val_loss: 0.8885 - val_accuracy: 0.8065
Epoch 121/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0446 -
accuracy: 0.9758 - val_loss: 0.6691 - val_accuracy: 0.8387
Epoch 122/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0263 -
accuracy: 0.9919 - val_loss: 0.6562 - val_accuracy: 0.8065
Epoch 123/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0271 -
accuracy: 0.9919 - val_loss: 0.7149 - val_accuracy: 0.8065
Epoch 124/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0331 -
accuracy: 0.9960 - val_loss: 0.6712 - val_accuracy: 0.7742
Epoch 125/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0441 -
accuracy: 0.9798 - val_loss: 0.7412 - val_accuracy: 0.8387
Epoch 126/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0291 -
accuracy: 0.9879 - val_loss: 0.8239 - val_accuracy: 0.8387
Epoch 127/148
13/13 [==============================] - 0s 7ms/step - loss: 0.0264 -
accuracy: 0.9879 - val_loss: 0.7801 - val_accuracy: 0.8065
Epoch 128/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0550 -
accuracy: 0.9798 - val_loss: 0.7776 - val_accuracy: 0.8387
Epoch 129/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0694 -
accuracy: 0.9677 - val_loss: 0.7221 - val_accuracy: 0.8065
Epoch 130/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0343 -
accuracy: 0.9839 - val_loss: 0.8132 - val_accuracy: 0.8387
Epoch 131/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0445 -
accuracy: 0.9798 - val_loss: 0.8302 - val_accuracy: 0.8065
Epoch 132/148
13/13 [==============================] - 0s 7ms/step - loss: 0.0510 -
accuracy: 0.9718 - val_loss: 0.8700 - val_accuracy: 0.8065
Epoch 133/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0400 -
accuracy: 0.9879 - val_loss: 1.1130 - val_accuracy: 0.7742
Epoch 134/148
```

```
13/13 [==============================] - 0s 9ms/step - loss: 0.0394 -
accuracy: 0.9798 - val_loss: 0.9659 - val_accuracy: 0.7742
Epoch 135/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0616 -
accuracy: 0.9758 - val_loss: 0.8799 - val_accuracy: 0.8387
Epoch 136/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0702 -
accuracy: 0.9798 - val_loss: 0.6087 - val_accuracy: 0.8710
Epoch 137/148
13/13 [==============================] - 0s 7ms/step - loss: 0.0274 -
accuracy: 0.9879 - val_loss: 0.7318 - val_accuracy: 0.8387
Epoch 138/148
13/13 [==============================] - 0s 10ms/step - loss: 0.0206 -
accuracy: 0.9960 - val_loss: 0.6554 - val_accuracy: 0.7742
Epoch 139/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0203 -
accuracy: 0.9960 - val_loss: 0.7804 - val_accuracy: 0.8387
Epoch 140/148
13/13 [==============================] - 0s 7ms/step - loss: 0.0134 -
accuracy: 0.9960 - val_loss: 0.7410 - val_accuracy: 0.8065
Epoch 141/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0134 -
accuracy: 1.0000 - val_loss: 0.8817 - val_accuracy: 0.8065
Epoch 142/148
13/13 [==============================] - 0s 8ms/step - loss: 0.0087 -
accuracy: 1.0000 - val_loss: 0.8435 - val_accuracy: 0.8065
Epoch 143/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0100 -
accuracy: 0.9960 - val_loss: 0.7616 - val_accuracy: 0.8065
Epoch 144/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0083 -
accuracy: 1.0000 - val_loss: 0.7565 - val_accuracy: 0.8065
Epoch 145/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0112 -
accuracy: 0.9960 - val_loss: 0.8822 - val_accuracy: 0.8387
Epoch 146/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0054 -
accuracy: 1.0000 - val_loss: 0.8093 - val_accuracy: 0.8387
Epoch 147/148
13/13 [==============================] - 0s 10ms/step - loss: 0.0048 -
accuracy: 1.0000 - val_loss: 0.7826 - val_accuracy: 0.8065
Epoch 148/148
13/13 [==============================] - 0s 9ms/step - loss: 0.0039 -
accuracy: 1.0000 - val_loss: 0.8163 - val_accuracy: 0.8387
```

```python
def plot_training_history(history):
    train_loss = history.history['loss']
    val_loss = history.history['val_loss']
    epochs = range(1, len(train_loss) + 1)
```

```
    plt.figure(figsize=(10, 5))
    plt.plot(epochs, train_loss, label='Training Loss')
    plt.plot(epochs, val_loss, label='Validation Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.title('Training and Validation Loss before the tuning')
    plt.legend()
    plt.grid(True)
    plt.show()

plot_training_history(model_neuron_result)
```



1d

```
model_neuron1 = keras.models.Sequential([
    tf.keras.layers.Dense(neuron1,activation = 'sigmoid',
input_shape=(ft,)),
    tf.keras.layers.Dropout(0.75),
    tf.keras.layers.Dense(neuron2,activation = 'sigmoid'),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(neuron3,activation = 'sigmoid'),
    tf.keras.layers.Dropout(0.75),
    tf.keras.layers.Dense(cate,activation = 'softmax'),
])

model_neuron1.compile(optimizer = tf.optimizers.Adam(0.00023),
                     loss = "categorical_crossentropy",
```

```
                     metrics =["accuracy"] )

sum_model_neur = model_neuron1.summary()
sum_model_neur

Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_4 (Dense)             (None, 512)               6656

 dropout (Dropout)           (None, 512)               0

 dense_5 (Dense)             (None, 256)               131328

 dropout_1 (Dropout)         (None, 256)               0

 dense_6 (Dense)             (None, 128)               32896

 dropout_2 (Dropout)         (None, 128)               0

 dense_7 (Dense)             (None, 2)                 258

=================================================================
Total params: 171138 (668.51 KB)
Trainable params: 171138 (668.51 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

model_neuron1_result = model_neuron1.fit(x_train,
                                       y_train,
                                       epochs = 148,
                                       batch_size = 20,
                                       validation_data=(x_val,y_val))

Epoch 1/148
13/13 [==============================] - 1s 23ms/step - loss: 1.0210 -
accuracy: 0.5363 - val_loss: 0.5977 - val_accuracy: 0.7097
Epoch 2/148
13/13 [==============================] - 0s 9ms/step - loss: 0.8825 -
accuracy: 0.5968 - val_loss: 0.6108 - val_accuracy: 0.7097
Epoch 3/148
13/13 [==============================] - 0s 9ms/step - loss: 0.9334 -
accuracy: 0.6008 - val_loss: 0.6012 - val_accuracy: 0.7097
Epoch 4/148
13/13 [==============================] - 0s 9ms/step - loss: 0.9043 -
accuracy: 0.6048 - val_loss: 0.5864 - val_accuracy: 0.7097
Epoch 5/148
13/13 [==============================] - 0s 8ms/step - loss: 0.8508 -
accuracy: 0.5726 - val_loss: 0.5754 - val_accuracy: 0.7097
```

```
Epoch 6/148
13/13 [==============================] - 0s 9ms/step - loss: 0.8022 -
accuracy: 0.6048 - val_loss: 0.5684 - val_accuracy: 0.7097
Epoch 7/148
13/13 [==============================] - 0s 9ms/step - loss: 0.8053 -
accuracy: 0.5968 - val_loss: 0.5601 - val_accuracy: 0.7097
Epoch 8/148
13/13 [==============================] - 0s 10ms/step - loss: 0.8030 -
accuracy: 0.5806 - val_loss: 0.5516 - val_accuracy: 0.7097
Epoch 9/148
13/13 [==============================] - 0s 9ms/step - loss: 0.8081 -
accuracy: 0.6129 - val_loss: 0.5415 - val_accuracy: 0.7097
Epoch 10/148
13/13 [==============================] - 0s 9ms/step - loss: 0.7627 -
accuracy: 0.6250 - val_loss: 0.5350 - val_accuracy: 0.7097
Epoch 11/148
13/13 [==============================] - 0s 9ms/step - loss: 0.7132 -
accuracy: 0.6694 - val_loss: 0.5295 - val_accuracy: 0.7097
Epoch 12/148
13/13 [==============================] - 0s 8ms/step - loss: 0.7347 -
accuracy: 0.6210 - val_loss: 0.5197 - val_accuracy: 0.7097
Epoch 13/148
13/13 [==============================] - 0s 8ms/step - loss: 0.7594 -
accuracy: 0.6008 - val_loss: 0.5125 - val_accuracy: 0.7097
Epoch 14/148
13/13 [==============================] - 0s 9ms/step - loss: 0.7207 -
accuracy: 0.6008 - val_loss: 0.5045 - val_accuracy: 0.7097
Epoch 15/148
13/13 [==============================] - 0s 8ms/step - loss: 0.7197 -
accuracy: 0.6129 - val_loss: 0.4972 - val_accuracy: 0.7097
Epoch 16/148
13/13 [==============================] - 0s 8ms/step - loss: 0.6920 -
accuracy: 0.6290 - val_loss: 0.4893 - val_accuracy: 0.7097
Epoch 17/148
13/13 [==============================] - 0s 9ms/step - loss: 0.6371 -
accuracy: 0.6976 - val_loss: 0.4845 - val_accuracy: 0.7097
Epoch 18/148
13/13 [==============================] - 0s 8ms/step - loss: 0.6587 -
accuracy: 0.6452 - val_loss: 0.4793 - val_accuracy: 0.7097
Epoch 19/148
13/13 [==============================] - 0s 9ms/step - loss: 0.6126 -
accuracy: 0.6976 - val_loss: 0.4726 - val_accuracy: 0.7419
Epoch 20/148
13/13 [==============================] - 0s 9ms/step - loss: 0.6448 -
accuracy: 0.6532 - val_loss: 0.4690 - val_accuracy: 0.7097
Epoch 21/148
13/13 [==============================] - 0s 9ms/step - loss: 0.6594 -
accuracy: 0.6089 - val_loss: 0.4650 - val_accuracy: 0.7097
Epoch 22/148
```

```
13/13 [==============================] - 0s 9ms/step - loss: 0.5625 -
accuracy: 0.7339 - val_loss: 0.4596 - val_accuracy: 0.6774
Epoch 23/148
13/13 [==============================] - 0s 10ms/step - loss: 0.5315 -
accuracy: 0.7298 - val_loss: 0.4609 - val_accuracy: 0.7742
Epoch 24/148
13/13 [==============================] - 0s 9ms/step - loss: 0.5790 -
accuracy: 0.7097 - val_loss: 0.4496 - val_accuracy: 0.6774
Epoch 25/148
13/13 [==============================] - 0s 8ms/step - loss: 0.5575 -
accuracy: 0.6694 - val_loss: 0.4441 - val_accuracy: 0.7097
Epoch 26/148
13/13 [==============================] - 0s 8ms/step - loss: 0.5612 -
accuracy: 0.6895 - val_loss: 0.4445 - val_accuracy: 0.7742
Epoch 27/148
13/13 [==============================] - 0s 9ms/step - loss: 0.5244 -
accuracy: 0.7258 - val_loss: 0.4466 - val_accuracy: 0.8065
Epoch 28/148
13/13 [==============================] - 0s 8ms/step - loss: 0.5308 -
accuracy: 0.7177 - val_loss: 0.4463 - val_accuracy: 0.8065
Epoch 29/148
13/13 [==============================] - 0s 9ms/step - loss: 0.5400 -
accuracy: 0.6976 - val_loss: 0.4514 - val_accuracy: 0.6774
Epoch 30/148
13/13 [==============================] - 0s 8ms/step - loss: 0.5440 -
accuracy: 0.6895 - val_loss: 0.4496 - val_accuracy: 0.6774
Epoch 31/148
13/13 [==============================] - 0s 8ms/step - loss: 0.5560 -
accuracy: 0.7056 - val_loss: 0.4481 - val_accuracy: 0.6774
Epoch 32/148
13/13 [==============================] - 0s 13ms/step - loss: 0.5094 -
accuracy: 0.7298 - val_loss: 0.4422 - val_accuracy: 0.7097
Epoch 33/148
13/13 [==============================] - 0s 14ms/step - loss: 0.5563 -
accuracy: 0.7177 - val_loss: 0.4467 - val_accuracy: 0.6774
Epoch 34/148
13/13 [==============================] - 0s 12ms/step - loss: 0.4691 -
accuracy: 0.7782 - val_loss: 0.4569 - val_accuracy: 0.7097
Epoch 35/148
13/13 [==============================] - 0s 12ms/step - loss: 0.4864 -
accuracy: 0.7540 - val_loss: 0.4534 - val_accuracy: 0.7097
Epoch 36/148
13/13 [==============================] - 0s 14ms/step - loss: 0.5040 -
accuracy: 0.7419 - val_loss: 0.4491 - val_accuracy: 0.7097
Epoch 37/148
13/13 [==============================] - 0s 14ms/step - loss: 0.4870 -
accuracy: 0.7258 - val_loss: 0.4388 - val_accuracy: 0.7097
Epoch 38/148
13/13 [==============================] - 0s 14ms/step - loss: 0.4807 -
```

```
accuracy: 0.7460 - val_loss: 0.4396 - val_accuracy: 0.7097
Epoch 39/148
13/13 [==============================] - 0s 15ms/step - loss: 0.5178 -
accuracy: 0.7177 - val_loss: 0.4420 - val_accuracy: 0.7097
Epoch 40/148
13/13 [==============================] - 0s 15ms/step - loss: 0.5092 -
accuracy: 0.7500 - val_loss: 0.4271 - val_accuracy: 0.7419
Epoch 41/148
13/13 [==============================] - 0s 13ms/step - loss: 0.4779 -
accuracy: 0.7500 - val_loss: 0.4562 - val_accuracy: 0.7097
Epoch 42/148
13/13 [==============================] - 0s 12ms/step - loss: 0.4756 -
accuracy: 0.7540 - val_loss: 0.4480 - val_accuracy: 0.7097
Epoch 43/148
13/13 [==============================] - 0s 11ms/step - loss: 0.4430 -
accuracy: 0.7742 - val_loss: 0.4570 - val_accuracy: 0.7097
Epoch 44/148
13/13 [==============================] - 0s 13ms/step - loss: 0.4625 -
accuracy: 0.7782 - val_loss: 0.4491 - val_accuracy: 0.7097
Epoch 45/148
13/13 [==============================] - 0s 14ms/step - loss: 0.4691 -
accuracy: 0.7823 - val_loss: 0.4481 - val_accuracy: 0.7097
Epoch 46/148
13/13 [==============================] - 0s 15ms/step - loss: 0.4024 -
accuracy: 0.7782 - val_loss: 0.4343 - val_accuracy: 0.7419
Epoch 47/148
13/13 [==============================] - 0s 12ms/step - loss: 0.4602 -
accuracy: 0.7863 - val_loss: 0.4450 - val_accuracy: 0.7097
Epoch 48/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4498 -
accuracy: 0.7702 - val_loss: 0.4412 - val_accuracy: 0.7097
Epoch 49/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4236 -
accuracy: 0.7702 - val_loss: 0.4294 - val_accuracy: 0.7097
Epoch 50/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4481 -
accuracy: 0.7500 - val_loss: 0.4425 - val_accuracy: 0.7097
Epoch 51/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4648 -
accuracy: 0.7540 - val_loss: 0.4544 - val_accuracy: 0.7097
Epoch 52/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4098 -
accuracy: 0.7903 - val_loss: 0.4665 - val_accuracy: 0.7097
Epoch 53/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4210 -
accuracy: 0.7742 - val_loss: 0.4554 - val_accuracy: 0.7097
Epoch 54/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4293 -
accuracy: 0.7863 - val_loss: 0.4504 - val_accuracy: 0.7097
```

```
Epoch 55/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4081 -
accuracy: 0.7782 - val_loss: 0.4417 - val_accuracy: 0.7097
Epoch 56/148
13/13 [==============================] - 0s 10ms/step - loss: 0.4637 -
accuracy: 0.7419 - val_loss: 0.4401 - val_accuracy: 0.7097
Epoch 57/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4413 -
accuracy: 0.7581 - val_loss: 0.4471 - val_accuracy: 0.7097
Epoch 58/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4445 -
accuracy: 0.7540 - val_loss: 0.4650 - val_accuracy: 0.7097
Epoch 59/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4288 -
accuracy: 0.7540 - val_loss: 0.4545 - val_accuracy: 0.7097
Epoch 60/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3893 -
accuracy: 0.8024 - val_loss: 0.4545 - val_accuracy: 0.7097
Epoch 61/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4175 -
accuracy: 0.7782 - val_loss: 0.4492 - val_accuracy: 0.7097
Epoch 62/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3716 -
accuracy: 0.8065 - val_loss: 0.4397 - val_accuracy: 0.7419
Epoch 63/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4420 -
accuracy: 0.7782 - val_loss: 0.4475 - val_accuracy: 0.7097
Epoch 64/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4271 -
accuracy: 0.7903 - val_loss: 0.4645 - val_accuracy: 0.7097
Epoch 65/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3799 -
accuracy: 0.8065 - val_loss: 0.4545 - val_accuracy: 0.7097
Epoch 66/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4619 -
accuracy: 0.7581 - val_loss: 0.4358 - val_accuracy: 0.7097
Epoch 67/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4003 -
accuracy: 0.7944 - val_loss: 0.4503 - val_accuracy: 0.7097
Epoch 68/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4217 -
accuracy: 0.7661 - val_loss: 0.4573 - val_accuracy: 0.7097
Epoch 69/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3905 -
accuracy: 0.7944 - val_loss: 0.4383 - val_accuracy: 0.7097
Epoch 70/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3749 -
accuracy: 0.8226 - val_loss: 0.4436 - val_accuracy: 0.7419
Epoch 71/148
```

```
13/13 [==============================] - 0s 9ms/step - loss: 0.3947 -
accuracy: 0.7782 - val_loss: 0.4533 - val_accuracy: 0.7097
Epoch 72/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3933 -
accuracy: 0.7944 - val_loss: 0.4477 - val_accuracy: 0.7419
Epoch 73/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4060 -
accuracy: 0.7782 - val_loss: 0.4574 - val_accuracy: 0.7097
Epoch 74/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4056 -
accuracy: 0.7823 - val_loss: 0.4466 - val_accuracy: 0.7419
Epoch 75/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3719 -
accuracy: 0.8226 - val_loss: 0.4300 - val_accuracy: 0.7419
Epoch 76/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4042 -
accuracy: 0.7742 - val_loss: 0.4673 - val_accuracy: 0.7097
Epoch 77/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3772 -
accuracy: 0.7903 - val_loss: 0.4397 - val_accuracy: 0.7419
Epoch 78/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3507 -
accuracy: 0.8226 - val_loss: 0.4546 - val_accuracy: 0.7419
Epoch 79/148
13/13 [==============================] - 0s 9ms/step - loss: 0.4228 -
accuracy: 0.7782 - val_loss: 0.4489 - val_accuracy: 0.7419
Epoch 80/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3871 -
accuracy: 0.8024 - val_loss: 0.4586 - val_accuracy: 0.7419
Epoch 81/148
13/13 [==============================] - 0s 8ms/step - loss: 0.4038 -
accuracy: 0.7984 - val_loss: 0.4609 - val_accuracy: 0.7419
Epoch 82/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3878 -
accuracy: 0.7863 - val_loss: 0.4407 - val_accuracy: 0.7419
Epoch 83/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3698 -
accuracy: 0.8226 - val_loss: 0.4430 - val_accuracy: 0.7419
Epoch 84/148
13/13 [==============================] - 0s 7ms/step - loss: 0.4264 -
accuracy: 0.7621 - val_loss: 0.4473 - val_accuracy: 0.7419
Epoch 85/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3976 -
accuracy: 0.7782 - val_loss: 0.4509 - val_accuracy: 0.7419
Epoch 86/148
13/13 [==============================] - 0s 7ms/step - loss: 0.4041 -
accuracy: 0.7742 - val_loss: 0.4666 - val_accuracy: 0.7419
Epoch 87/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3767 -
```

```
accuracy: 0.8024 - val_loss: 0.4332 - val_accuracy: 0.7097
Epoch 88/148
13/13 [==============================] - 0s 7ms/step - loss: 0.3857 -
accuracy: 0.8024 - val_loss: 0.4454 - val_accuracy: 0.7419
Epoch 89/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3739 -
accuracy: 0.7863 - val_loss: 0.4439 - val_accuracy: 0.7419
Epoch 90/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3667 -
accuracy: 0.8105 - val_loss: 0.4554 - val_accuracy: 0.7419
Epoch 91/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3604 -
accuracy: 0.7984 - val_loss: 0.4539 - val_accuracy: 0.7419
Epoch 92/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3741 -
accuracy: 0.8145 - val_loss: 0.4917 - val_accuracy: 0.7097
Epoch 93/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3634 -
accuracy: 0.8226 - val_loss: 0.4443 - val_accuracy: 0.7097
Epoch 94/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3733 -
accuracy: 0.8024 - val_loss: 0.4353 - val_accuracy: 0.7419
Epoch 95/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3759 -
accuracy: 0.8065 - val_loss: 0.4421 - val_accuracy: 0.7097
Epoch 96/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3797 -
accuracy: 0.7984 - val_loss: 0.4714 - val_accuracy: 0.7419
Epoch 97/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3538 -
accuracy: 0.8185 - val_loss: 0.4641 - val_accuracy: 0.7419
Epoch 98/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3508 -
accuracy: 0.8427 - val_loss: 0.4600 - val_accuracy: 0.7419
Epoch 99/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3864 -
accuracy: 0.8145 - val_loss: 0.4411 - val_accuracy: 0.7097
Epoch 100/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3452 -
accuracy: 0.8508 - val_loss: 0.4582 - val_accuracy: 0.7419
Epoch 101/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3475 -
accuracy: 0.8226 - val_loss: 0.4557 - val_accuracy: 0.7419
Epoch 102/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3435 -
accuracy: 0.8105 - val_loss: 0.4456 - val_accuracy: 0.7419
Epoch 103/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3528 -
accuracy: 0.8266 - val_loss: 0.4295 - val_accuracy: 0.7097
```

```
Epoch 104/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3593 -
accuracy: 0.8226 - val_loss: 0.4308 - val_accuracy: 0.7097
Epoch 105/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3616 -
accuracy: 0.8105 - val_loss: 0.4294 - val_accuracy: 0.7097
Epoch 106/148
13/13 [==============================] - 0s 10ms/step - loss: 0.4099 -
accuracy: 0.7984 - val_loss: 0.4481 - val_accuracy: 0.7419
Epoch 107/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3630 -
accuracy: 0.8024 - val_loss: 0.4786 - val_accuracy: 0.7419
Epoch 108/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3284 -
accuracy: 0.8347 - val_loss: 0.4821 - val_accuracy: 0.7419
Epoch 109/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3637 -
accuracy: 0.8347 - val_loss: 0.4910 - val_accuracy: 0.7097
Epoch 110/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3949 -
accuracy: 0.8105 - val_loss: 0.4457 - val_accuracy: 0.7097
Epoch 111/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3314 -
accuracy: 0.8306 - val_loss: 0.4392 - val_accuracy: 0.7097
Epoch 112/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3758 -
accuracy: 0.8266 - val_loss: 0.4300 - val_accuracy: 0.7097
Epoch 113/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3464 -
accuracy: 0.7944 - val_loss: 0.4352 - val_accuracy: 0.7097
Epoch 114/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3829 -
accuracy: 0.8065 - val_loss: 0.4529 - val_accuracy: 0.7419
Epoch 115/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3810 -
accuracy: 0.7863 - val_loss: 0.4593 - val_accuracy: 0.7419
Epoch 116/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3203 -
accuracy: 0.8387 - val_loss: 0.4492 - val_accuracy: 0.7419
Epoch 117/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3464 -
accuracy: 0.8226 - val_loss: 0.4410 - val_accuracy: 0.7097
Epoch 118/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3539 -
accuracy: 0.8266 - val_loss: 0.4425 - val_accuracy: 0.7097
Epoch 119/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3590 -
accuracy: 0.7984 - val_loss: 0.4393 - val_accuracy: 0.7097
Epoch 120/148
```

```
13/13 [==============================] - 0s 9ms/step - loss: 0.3876 -
accuracy: 0.7944 - val_loss: 0.4464 - val_accuracy: 0.7097
Epoch 121/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3308 -
accuracy: 0.8548 - val_loss: 0.4667 - val_accuracy: 0.7419
Epoch 122/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3509 -
accuracy: 0.8306 - val_loss: 0.4496 - val_accuracy: 0.7097
Epoch 123/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3928 -
accuracy: 0.8266 - val_loss: 0.4474 - val_accuracy: 0.7097
Epoch 124/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3469 -
accuracy: 0.8145 - val_loss: 0.4436 - val_accuracy: 0.7097
Epoch 125/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3281 -
accuracy: 0.8347 - val_loss: 0.4398 - val_accuracy: 0.7097
Epoch 126/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3459 -
accuracy: 0.8065 - val_loss: 0.4474 - val_accuracy: 0.7419
Epoch 127/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3256 -
accuracy: 0.8427 - val_loss: 0.4296 - val_accuracy: 0.7097
Epoch 128/148
13/13 [==============================] - 0s 10ms/step - loss: 0.3153 -
accuracy: 0.8387 - val_loss: 0.4265 - val_accuracy: 0.7097
Epoch 129/148
13/13 [==============================] - 0s 9ms/step - loss: 0.3619 -
accuracy: 0.8145 - val_loss: 0.4347 - val_accuracy: 0.7097
Epoch 130/148
13/13 [==============================] - 0s 8ms/step - loss: 0.3607 -
accuracy: 0.8145 - val_loss: 0.4611 - val_accuracy: 0.7419
Epoch 131/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3424 -
accuracy: 0.8347 - val_loss: 0.4572 - val_accuracy: 0.7419
Epoch 132/148
13/13 [==============================] - 0s 15ms/step - loss: 0.3442 -
accuracy: 0.8266 - val_loss: 0.4631 - val_accuracy: 0.7419
Epoch 133/148
13/13 [==============================] - 0s 13ms/step - loss: 0.3607 -
accuracy: 0.8347 - val_loss: 0.4624 - val_accuracy: 0.7419
Epoch 134/148
13/13 [==============================] - 0s 12ms/step - loss: 0.3297 -
accuracy: 0.8468 - val_loss: 0.4376 - val_accuracy: 0.7097
Epoch 135/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3611 -
accuracy: 0.8347 - val_loss: 0.4268 - val_accuracy: 0.7097
Epoch 136/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3376 -
```

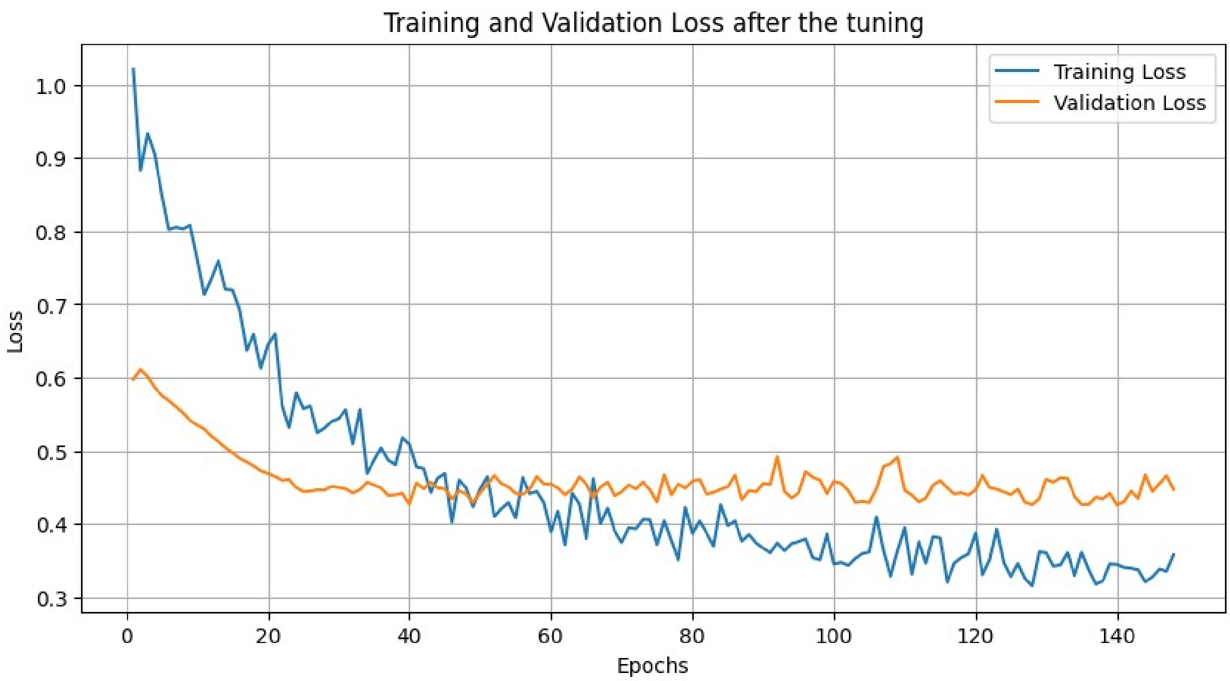
```
accuracy: 0.8306 - val_loss: 0.4268 - val_accuracy: 0.7097
Epoch 137/148
13/13 [==============================] - 0s 12ms/step - loss: 0.3177 -
accuracy: 0.8589 - val_loss: 0.4365 - val_accuracy: 0.7097
Epoch 138/148
13/13 [==============================] - 0s 13ms/step - loss: 0.3225 -
accuracy: 0.8629 - val_loss: 0.4342 - val_accuracy: 0.7097
Epoch 139/148
13/13 [==============================] - 0s 13ms/step - loss: 0.3455 -
accuracy: 0.8266 - val_loss: 0.4417 - val_accuracy: 0.7419
Epoch 140/148
13/13 [==============================] - 0s 13ms/step - loss: 0.3446 -
accuracy: 0.8589 - val_loss: 0.4260 - val_accuracy: 0.7097
Epoch 141/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3406 -
accuracy: 0.8508 - val_loss: 0.4307 - val_accuracy: 0.7097
Epoch 142/148
13/13 [==============================] - 0s 11ms/step - loss: 0.3396 -
accuracy: 0.8468 - val_loss: 0.4449 - val_accuracy: 0.7419
Epoch 143/148
13/13 [==============================] - 0s 12ms/step - loss: 0.3376 -
accuracy: 0.8508 - val_loss: 0.4348 - val_accuracy: 0.7097
Epoch 144/148
13/13 [==============================] - 0s 12ms/step - loss: 0.3209 -
accuracy: 0.8508 - val_loss: 0.4673 - val_accuracy: 0.7419
Epoch 145/148
13/13 [==============================] - 0s 14ms/step - loss: 0.3279 -
accuracy: 0.8266 - val_loss: 0.4440 - val_accuracy: 0.7419
Epoch 146/148
13/13 [==============================] - 0s 14ms/step - loss: 0.3385 -
accuracy: 0.8145 - val_loss: 0.4557 - val_accuracy: 0.7419
Epoch 147/148
13/13 [==============================] - 0s 12ms/step - loss: 0.3354 -
accuracy: 0.8306 - val_loss: 0.4661 - val_accuracy: 0.7419
Epoch 148/148
13/13 [==============================] - 0s 13ms/step - loss: 0.3579 -
accuracy: 0.8145 - val_loss: 0.4473 - val_accuracy: 0.7419
```

```python
def plot1_training_history(history):
    train_loss = history.history['loss']
    val_loss = history.history['val_loss']
    epochs = range(1, len(train_loss) + 1)

    plt.figure(figsize=(10, 5))
    plt.plot(epochs, train_loss, label='Training Loss')
    plt.plot(epochs, val_loss, label='Validation Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.title('Training and Validation Loss after the tuning')
    plt.legend()
```

```
    plt.grid(True)
    plt.show()

plot1_training_history(model_neuron1_result)
```



1e

```
from sklearn.metrics import classification_report

# before being trained

prediction_before = model_neuron.predict(x_test)

print(classification_report(y_test,np.round(prediction_before)))

1/1 [==============================] - 0s 97ms/step
              precision    recall  f1-score   support

           0       0.87      0.91      0.89        22
           1       0.75      0.67      0.71         9

   micro avg       0.84      0.84      0.84        31
   macro avg       0.81      0.79      0.80        31
weighted avg       0.83      0.84      0.84        31
 samples avg       0.84      0.84      0.84        31
```

```python
# after being trained
prediction_after = model_neuron1.predict(x_test)

print(classification_report(y_test,np.round(prediction_after)))
```

```
1/1 [==============================] - 0s 68ms/step
              precision    recall  f1-score   support

           0       1.00      0.86      0.93        22
           1       0.75      1.00      0.86         9

   micro avg       0.90      0.90      0.90        31
   macro avg       0.88      0.93      0.89        31
weighted avg       0.93      0.90      0.91        31
 samples avg       0.90      0.90      0.90        31
```

Setelah dilakukan tuning dengan perubahan acitvation dan dropping terhadap 1 layer, hasilnya menjadi lebih bagus

#1f

Link Youtube penjelasan: https://youtu.be/GTk_jg8N2PM