In [3]:

```
pip install keras
```

```
Collecting keras
  Downloading keras-2.9.0-py2.py3-none-any.whl (1.6 MB)
Installing collected packages: keras
Successfully installed keras-2.9.0
Note: you may need to restart the kernel to use updated packages.
```

In [5]:

```
pip install Tensorflow
```

```
Requirement already satisfied: Tensorflow in c:\anaconda3\lib\site-packages
(2.9.1)
Requirement already satisfied: flatbuffers<2,>=1.12 in c:\anaconda3\lib\site
-packages (from Tensorflow) (1.12)
Requirement already satisfied: h5py>=2.9.0 in c:\anaconda3\lib\site-packages
(from Tensorflow) (3.2.1)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\anaconda3\lib\site-pa
ckages (from Tensorflow) (3.3.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\anaconda3\lib\site-pa
ckages (from Tensorflow) (1.6.3)
Requirement already satisfied: libclang>=13.0.0 in c:\anaconda3\lib\site-pac
kages (from Tensorflow) (14.0.1)
Requirement already satisfied: keras-preprocessing>=1.1.1 in c:\anaconda3\li
b\site-packages (from Tensorflow) (1.1.2)
Requirement already satisfied: tensorboard<2.10,>=2.9 in c:\anaconda3\lib\si
te-packages (from Tensorflow) (2.9.0)
Requirement already satisfied: tensorflow-estimator<2.10.0,>=2.9.0rc0 in
c:\anaconda3\lib\site-packages (from Tensorflow) (2.9.0)
Requirement already satisfied: six>=1.12.0 in c:\anaconda3\lib\site-packages
(from Tensorflow) (1.16.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\anaconda3\lib\site-packa
ges (from Tensorflow) (1.0.0)
Requirement already satisfied: wrapt>=1.11.0 in c:\anaconda3\lib\site-packag
es (from Tensorflow) (1.12.1)
Requirement already satisfied: protobuf<3.20,>=3.9.2 in c:\anaconda3\lib\sit
e-packages (from Tensorflow) (3.19.4)
Requirement already satisfied: google-pasta>=0.1.1 in c:\anaconda3\lib\site-
packages (from Tensorflow) (0.2.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\an
aconda3\lib\site-packages (from Tensorflow) (0.26.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\anaconda3\lib\site-
packages (from Tensorflow) (1.46.3)
Requirement already satisfied: keras<2.10.0,>=2.9.0rc0 in c:\anaconda3\lib\s
ite-packages (from Tensorflow) (2.9.0)
Requirement already satisfied: setuptools in c:\anaconda3\lib\site-packages
(from Tensorflow) (58.0.4)
Requirement already satisfied: termcolor>=1.1.0 in c:\anaconda3\lib\site-pac
kages (from Tensorflow) (1.1.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\anaconda3\lib\site-
packages (from Tensorflow) (0.4.0)
Requirement already satisfied: numpy>=1.20 in c:\anaconda3\lib\site-packages
(from Tensorflow) (1.20.3)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\anaconda3\lib
\site-packages (from Tensorflow) (3.10.0.2)
Requirement already satisfied: packaging in c:\anaconda3\lib\site-packages
(from Tensorflow) (21.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\anaconda3\lib\site-p
ackages (from astunparse>=1.6.0->Tensorflow) (0.37.0)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in c:\anacon
da3\lib\site-packages (from tensorboard<2.10,>=2.9->Tensorflow) (0.4.6)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\anaconda3\lib\sit
e-packages (from tensorboard<2.10,>=2.9->Tensorflow) (2.6.6)
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in c:\a
naconda3\lib\site-packages (from tensorboard<2.10,>=2.9->Tensorflow) (0.6.1)
Requirement already satisfied: requests<3,>=2.21.0 in c:\anaconda3\lib\site-
packages (from tensorboard<2.10,>=2.9->Tensorflow) (2.26.0)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in c:\anaconda3
```

```
\lib\site-packages (from tensorboard<2.10,>=2.9->Tensorflow) (1.8.1)
Requirement already satisfied: werkzeug>=1.0.1 in c:\anaconda3\lib\site-pack
ages (from tensorboard<2.10,>=2.9->Tensorflow) (2.0.2)
Requirement already satisfied: markdown>=2.6.8 in c:\anaconda3\lib\site-pack
ages (from tensorboard<2.10,>=2.9->Tensorflow) (3.3.7)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\anaconda3\lib\site-packag
es (from google-auth<3,>=1.6.3->tensorboard<2.10,>=2.9->Tensorflow) (4.8)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\anaconda3\lib\sit
e-packages (from google-auth<3,>=1.6.3->tensorboard<2.10,>=2.9->Tensorflow)
(0.2.8)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\anaconda3\lib\si
te-packages (from google-auth<3,>=1.6.3->tensorboard<2.10,>=2.9->Tensorflow)
(5.1.0)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\anaconda3\lib
\site-packages (from google-auth-oauthlib<0.5,>=0.4.1->tensorboard<2.10,>=2.
9->Tensorflow) (1.3.1)
Requirement already satisfied: importlib-metadata>=4.4 in c:\anaconda3\lib\s
ite-packages (from markdown>=2.6.8->tensorboard<2.10,>=2.9->Tensorflow) (4.
8.1)
Requirement already satisfied: zipp>=0.5 in c:\anaconda3\lib\site-packages
(from importlib-metadata>=4.4->markdown>=2.6.8->tensorboard<2.10,>=2.9->Tens
orflow) (3.6.0)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\anaconda3\lib\site
-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.
10,>=2.9->Tensorflow) (0.4.8)
Requirement already satisfied: idna<4,>=2.5 in c:\anaconda3\lib\site-package
s (from requests<3,>=2.21.0->tensorboard<2.10,>=2.9->Tensorflow) (3.2)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in c:\anaconda3\lib\sit
e-packages (from requests<3,>=2.21.0->tensorboard<2.10,>=2.9->Tensorflow)
(1.26.7)
Requirement already satisfied: charset-normalizer~=2.0.0 in c:\anaconda3\lib
\site-packages (from requests<3,>=2.21.0->tensorboard<2.10,>=2.9->Tensorflo
w) (2.0.4)
Requirement already satisfied: certifi>=2017.4.17 in c:\anaconda3\lib\site-p
ackages (from requests<3,>=2.21.0->tensorboard<2.10,>=2.9->Tensorflow) (202
1.10.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\anaconda3\lib\site-pack
ages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<0.5,>=0.4.1->tenso
rboard<2.10,>=2.9->Tensorflow) (3.2.0)
Requirement already satisfied: pyparsing>=2.0.2 in c:\anaconda3\lib\site-pac
kages (from packaging->Tensorflow) (3.0.4)
Note: you may need to restart the kernel to use updated packages.
```

In [6]:

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler
from keras.models import Sequential
from keras.layers import Dense
import matplotlib.pyplot as plt
```

In [8]:

```
dataframe=pd.read_csv("/creditcard.csv")
```

In [9]:

```
dataframe.head()
```

Out[9]:

	Time	V1	V2	V3	V4	V5	V6	V7	V8
0	0.0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	0.239599	0.098698
1	0.0	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	-0.078803	0.085102
2	1.0	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	0.791461	0.247676
3	1.0	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	0.237609	0.377436
4	2.0	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	0.592941	-0.270533

5 rows × 31 columns

In [10]:

```
dataframe.tail()
```

Out[10]:

	Time	V1	V2	V3	V4	V5	V6	V7
284802	172786.0	-11.881118	10.071785	-9.834783	-2.066656	-5.364473	-2.606837	-4.918215
284803	172787.0	-0.732789	-0.055080	2.035030	-0.738589	0.868229	1.058415	0.024330
284804	172788.0	1.919565	-0.301254	-3.249640	-0.557828	2.630515	3.031260	-0.296827
284805	172788.0	-0.240440	0.530483	0.702510	0.689799	-0.377961	0.623708	-0.686180
284806	172792.0	-0.533413	-0.189733	0.703337	-0.506271	-0.012546	-0.649617	1.577006

5 rows × 31 columns

In [11]:

```
dataframe.isnull().sum()
```

Out[11]:

```
Time      0
V1        0
V2        0
V3        0
V4        0
V5        0
V6        0
V7        0
V8        0
V9        0
V10       0
V11       0
V12       0
V13       0
V14       0
V15       0
V16       0
V17       0
V18       0
V19       0
V20       0
V21       0
V22       0
V23       0
V24       0
V25       0
V26       0
V27       0
V28       0
Amount    0
Class     0
dtype: int64
```

In [12]:

```
dataframe.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 284807 entries, 0 to 284806
Data columns (total 31 columns):
 #   Column  Non-Null Count   Dtype  
---  ------  --------------   -----  
 0   Time    284807 non-null  float64
 1   V1      284807 non-null  float64
 2   V2      284807 non-null  float64
 3   V3      284807 non-null  float64
 4   V4      284807 non-null  float64
 5   V5      284807 non-null  float64
 6   V6      284807 non-null  float64
 7   V7      284807 non-null  float64
 8   V8      284807 non-null  float64
 9   V9      284807 non-null  float64
 10  V10     284807 non-null  float64
 11  V11     284807 non-null  float64
 12  V12     284807 non-null  float64
 13  V13     284807 non-null  float64
 14  V14     284807 non-null  float64
 15  V15     284807 non-null  float64
 16  V16     284807 non-null  float64
 17  V17     284807 non-null  float64
 18  V18     284807 non-null  float64
 19  V19     284807 non-null  float64
 20  V20     284807 non-null  float64
 21  V21     284807 non-null  float64
 22  V22     284807 non-null  float64
 23  V23     284807 non-null  float64
 24  V24     284807 non-null  float64
 25  V25     284807 non-null  float64
 26  V26     284807 non-null  float64
 27  V27     284807 non-null  float64
 28  V28     284807 non-null  float64
 29  Amount  284807 non-null  float64
 30  Class   284807 non-null  int64  
dtypes: float64(30), int64(1)
memory usage: 67.4 MB
```

In [13]:

```
dataframe['Class'].value_counts()
```

Out[13]:

```
0    284315
1       492
Name: Class, dtype: int64
```

In [14]:

```
non_default = dataframe[dataframe.Class == 0]
default = dataframe[dataframe.Class == 1]
print(non_default.shape)
print(default.shape)
```

```
(284315, 31)
(492, 31)
```

In [15]:

```
dataframe.groupby('Class').mean()
```

Out[15]:

Class	Time	V1	V2	V3	V4	V5	V6	V7
0	94838.202258	0.008258	-0.006271	0.012171	-0.007860	0.005453	0.002419	0.009637
1	80746.806911	-4.771948	3.623778	-7.033281	4.542029	-3.151225	-1.397737	-5.568731

2 rows × 30 columns

In [16]:

```
non_default_sample = non_default.sample(n=492)
```

In [17]:

```
updated_dataframe = pd.concat([non_default_sample, default], axis=0)
```

In [18]:

```
updated_dataframe.head()
```

Out[18]:

	Time	V1	V2	V3	V4	V5	V6	V7	
29619	35552.0	-1.157265	-0.399137	0.831705	1.496427	-0.829262	1.032040	2.015676	(
173064	121347.0	-0.542615	-1.138015	-3.160786	-0.185688	-4.394256	3.154825	6.710087	-
76437	56569.0	-0.467958	0.389235	0.458680	-2.173947	0.040808	-1.041474	1.195709	-(
93457	64428.0	-2.728952	-3.103041	2.200832	1.002404	2.812762	-1.745798	-1.608264	(
96344	65732.0	-0.791644	0.254513	1.825866	1.243562	0.404067	0.282735	0.212899	(

5 rows × 31 columns

In [19]:

```
updated_dataframe.tail()
```

Out[19]:

	Time	V1	V2	V3	V4	V5	V6	V7	
279863	169142.0	-1.927883	1.125653	-4.518331	1.749293	-1.566487	-2.010494	-0.882850	0.
280143	169347.0	1.378559	1.289381	-5.004247	1.411850	0.442581	-1.326536	-1.413170	0.
280149	169351.0	-0.676143	1.126366	-2.213700	0.468308	-1.120541	-0.003346	-2.234739	1.
281144	169966.0	-3.113832	0.585864	-5.399730	1.817092	-0.840618	-2.943548	-2.208002	1.
281674	170348.0	1.991976	0.158476	-2.583441	0.408670	1.151147	-0.096695	0.223050	-0.

5 rows × 31 columns

In [20]:

```
updated_dataframe['Class'].value_counts()
```

Out[20]:

```
0    492
1    492
Name: Class, dtype: int64
```

In [21]:

```
updated_dataframe.groupby('Class').mean()
```

Out[21]:

	Time	V1	V2	V3	V4	V5	V6	V7
Class								
0	94912.105691	0.097671	0.036639	0.019749	0.058980	0.026047	0.059391	0.031678
1	80746.806911	-4.771948	3.623778	-7.033281	4.542029	-3.151225	-1.397737	-5.568731

2 rows × 30 columns

In [22]:

```
X = updated_dataframe.drop(columns='Class', axis=1)
Y = updated_dataframe['Class']
print(X)
```

```
            Time        V1        V2        V3        V4        V5        V6
\
29619    35552.0 -1.157265 -0.399137  0.831705  1.496427 -0.829262  1.032040
173064  121347.0 -0.542615 -1.138015 -3.160786 -0.185688 -4.394256  3.154825
76437    56569.0 -0.467958  0.389235  0.458680 -2.173947  0.040808 -1.041474
93457    64428.0 -2.728952 -3.103041  2.200832  1.002404  2.812762 -1.745798
96344    65732.0 -0.791644  0.254513  1.825866  1.243562  0.404067  0.282735
...          ...       ...       ...       ...       ...       ...       ...
279863  169142.0 -1.927883  1.125653 -4.518331  1.749293 -1.566487 -2.010494
280143  169347.0  1.378559  1.289381 -5.004247  1.411850  0.442581 -1.326536
280149  169351.0 -0.676143  1.126366 -2.213700  0.468308 -1.120541 -0.003346
281144  169966.0 -3.113832  0.585864 -5.399730  1.817092 -0.840618 -2.943548
281674  170348.0  1.991976  0.158476 -2.583441  0.408670  1.151147 -0.096695

              V7        V8        V9  ...       V20       V21       V22  \
29619   2.015676  0.037130 -0.431519  ...  0.930647  0.206630 -0.025299
173064  6.710087 -1.510140 -2.526369  ...  0.689625  0.488443  1.871167
76437   1.195709 -0.266412  0.169296  ... -0.049925 -0.237547 -0.674008
93457  -1.608264  0.092993  0.987192  ...  0.328986  0.324029  0.729087
96344   0.212899  0.298448 -0.573935  ...  0.246361 -0.020224 -0.099508
...          ...       ...       ...  ...       ...       ...       ...
279863 -0.882850  0.697211 -2.064945  ...  1.252967  0.778584 -0.319189
280143 -1.413170  0.248525 -1.127396  ...  0.226138  0.370612  0.028234
280149 -2.234739  1.210158 -0.652250  ...  0.247968  0.751826  0.834108
281144 -2.208002  1.058733 -1.632333  ...  0.306271  0.583276 -0.269209
281674  0.223050 -0.068384  0.577829  ... -0.017652 -0.164350 -0.295135

              V23       V24       V25       V26       V27       V28    Amount
29619   0.767132 -0.497995  0.329988 -0.169624 -0.015019  0.136485    449.00
173064  0.465990  0.242498  0.208226  0.623293  0.411023 -0.392755   1367.30
76437   0.085752  0.005914  0.096774 -0.332324 -0.089310 -0.037425     75.00
93457   0.304399 -0.035045 -0.528884 -0.582084 -0.541161  0.385130      1.00
96344  -0.041325  0.020561  0.408418 -0.261293  0.012647 -0.009095     51.99
...          ...       ...       ...       ...       ...       ...       ...
279863  0.639419 -0.294885  0.537503  0.788395  0.292680  0.147968    390.00
280143 -0.145640 -0.081049  0.521875  0.739467  0.389152  0.186637      0.76
280149  0.190944  0.032070 -0.739695  0.471111  0.385107  0.194361     77.89
281144 -0.456108 -0.183659 -0.328168  0.606116  0.884876 -0.253700    245.00
281674 -0.072173 -0.450261  0.313267 -0.289617  0.002988 -0.015309     42.53

[984 rows x 30 columns]
```

In [23]:

```
print(Y)
```

```
29619     0
173064    0
76437     0
93457     0
96344     0
         ..
279863    1
280143    1
280149    1
281144    1
281674    1
Name: Class, Length: 984, dtype: int64
```

In [24]:

```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, stratify=Y, random
```

In [25]:

```
print(X.shape, X_train.shape, X_test.shape)
```

```
(984, 30) (787, 30) (197, 30)
```

In [26]:

```
print(Y.shape, Y_train.shape, Y_test.shape)
```

```
(984,) (787,) (197,)
```

In [27]:

```
m1 = LogisticRegression()
```

In [28]:

```
m1.fit(X_train, Y_train)
```

Out[28]:

▸ LogisticRegression

In [29]:

```
training_of_x_prediction = m1.predict(X_train)
accuracy_on_training_data = accuracy_score(training_of_x_prediction, Y_train)
```

In [30]:

```
print("the accuracy on the trainset is : ")
print(accuracy_on_training_data)
```

```
the accuracy on the trainset is :
0.9428208386277002
```

In [31]:

```
testing_of_x_prediction = m1.predict(X_test)
accuracy_on_testing_data = accuracy_score(testing_of_x_prediction, Y_test)
```

In [32]:

```
print("the accuracy on the testset is : ")
print(accuracy_on_testing_data)
```

```
the accuracy on the testset is :
0.9238578680203046
```

In [33]:

```
#normalization
scalar = StandardScaler()
x=X
X=scalar.fit_transform(x)
X
```

Out[33]:

```
array([[-1.09463459,  0.21440378, -0.61167094, ..., -0.09478914,
         0.23857877,  1.4352119 ],
       [ 0.70182188,  0.32609652, -0.81439867, ...,  0.33212079,
        -1.02245324,  5.28142265],
       [-0.65456086,  0.33966293, -0.39536343, ..., -0.16923199,
        -0.17579961, -0.13125094],
       ...,
       [ 1.70697482,  0.3018322 , -0.19311504, ...,  0.30615274,
         0.37648315, -0.11914645],
       [ 1.71985227, -0.14113874, -0.34141386, ...,  0.80693938,
        -0.69112459,  0.58077762],
       [ 1.72785095,  0.78667629, -0.45867743, ..., -0.0767459 ,
        -0.12310335, -0.26724839]])
```

In [34]:

```
#spliting the training and test & validation set
X_train, X_val_and_test, Y_train, Y_val_and_test = train_test_split(X, Y, test_size=0.3)

#now spliting the test and validation set
X_val, X_test, Y_val, Y_test = train_test_split(X_val_and_test, Y_val_and_test, test_size=0

print(X_train.shape, X_val.shape, X_test.shape, Y_train.shape, Y_val.shape, Y_test.shape)
```

```
(688, 30) (148, 30) (148, 30) (688,) (148,) (148,)
```

In [35]:

```
m2 = Sequential([
    Dense(64, activation='relu', input_shape=(30,)),
    Dense(64, activation='relu'),
    Dense(1, activation='sigmoid'),
])
```

In [36]:

```
m2.compile(optimizer='sgd',
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

In [37]:

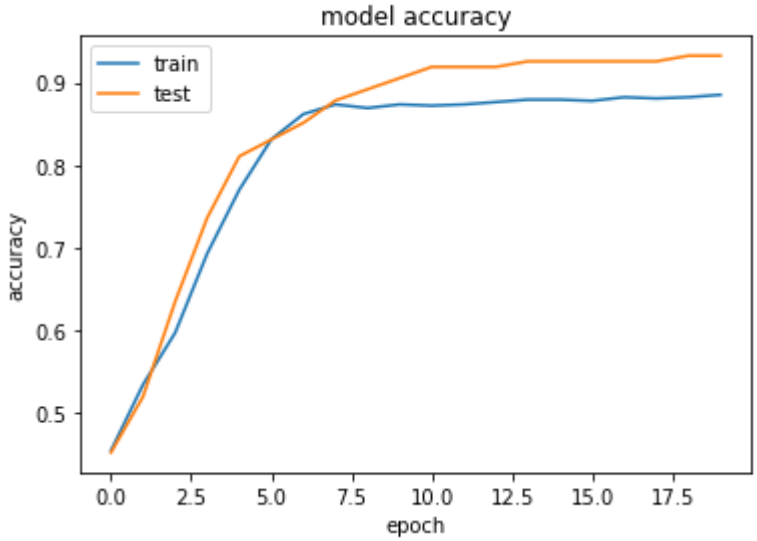
```
history = m2.fit(X_train, Y_train,
          batch_size=64, epochs=20,
          validation_data=(X_val, Y_val))
```

```
Epoch 1/20
11/11 [==============================] - 1s 53ms/step - loss: 0.7125 - acc
uracy: 0.4549 - val_loss: 0.6925 - val_accuracy: 0.4527
Epoch 2/20
11/11 [==============================] - 0s 6ms/step - loss: 0.6574 - accu
racy: 0.5349 - val_loss: 0.6414 - val_accuracy: 0.5203
Epoch 3/20
11/11 [==============================] - 0s 6ms/step - loss: 0.6155 - accu
racy: 0.5974 - val_loss: 0.6018 - val_accuracy: 0.6351
Epoch 4/20
11/11 [==============================] - 0s 10ms/step - loss: 0.5821 - acc
uracy: 0.6933 - val_loss: 0.5690 - val_accuracy: 0.7365
Epoch 5/20
11/11 [==============================] - 0s 14ms/step - loss: 0.5545 - acc
uracy: 0.7703 - val_loss: 0.5413 - val_accuracy: 0.8108
Epoch 6/20
11/11 [==============================] - 0s 9ms/step - loss: 0.5310 - accu
racy: 0.8314 - val_loss: 0.5172 - val_accuracy: 0.8311
Epoch 7/20
11/11 [==============================] - 0s 18ms/step - loss: 0.5106 - acc
uracy: 0.8619 - val_loss: 0.4957 - val_accuracy: 0.8514
Epoch 8/20
11/11 [==============================] - 0s 11ms/step - loss: 0.4923 - acc
uracy: 0.8735 - val_loss: 0.4761 - val_accuracy: 0.8784
Epoch 9/20
11/11 [==============================] - 0s 19ms/step - loss: 0.4757 - acc
uracy: 0.8692 - val_loss: 0.4585 - val_accuracy: 0.8919
Epoch 10/20
11/11 [==============================] - 0s 15ms/step - loss: 0.4605 - acc
uracy: 0.8735 - val_loss: 0.4421 - val_accuracy: 0.9054
Epoch 11/20
11/11 [==============================] - 0s 14ms/step - loss: 0.4465 - acc
uracy: 0.8721 - val_loss: 0.4267 - val_accuracy: 0.9189
Epoch 12/20
11/11 [==============================] - 0s 10ms/step - loss: 0.4333 - acc
uracy: 0.8735 - val_loss: 0.4123 - val_accuracy: 0.9189
Epoch 13/20
11/11 [==============================] - 0s 11ms/step - loss: 0.4209 - acc
uracy: 0.8765 - val_loss: 0.3986 - val_accuracy: 0.9189
Epoch 14/20
11/11 [==============================] - 0s 11ms/step - loss: 0.4094 - acc
uracy: 0.8794 - val_loss: 0.3859 - val_accuracy: 0.9257
Epoch 15/20
11/11 [==============================] - 0s 15ms/step - loss: 0.3986 - acc
uracy: 0.8794 - val_loss: 0.3738 - val_accuracy: 0.9257
Epoch 16/20
11/11 [==============================] - 0s 13ms/step - loss: 0.3883 - acc
uracy: 0.8779 - val_loss: 0.3626 - val_accuracy: 0.9257
Epoch 17/20
11/11 [==============================] - 0s 14ms/step - loss: 0.3787 - acc
uracy: 0.8823 - val_loss: 0.3519 - val_accuracy: 0.9257
Epoch 18/20
11/11 [==============================] - 0s 10ms/step - loss: 0.3696 - acc
uracy: 0.8808 - val_loss: 0.3419 - val_accuracy: 0.9257
Epoch 19/20
```

```
11/11 [==============================] - 0s 6ms/step - loss: 0.3611 - accu
racy: 0.8823 - val_loss: 0.3324 - val_accuracy: 0.9324
Epoch 20/20
11/11 [==============================] - 0s 9ms/step - loss: 0.3530 - accu
racy: 0.8852 - val_loss: 0.3237 - val_accuracy: 0.9324
```

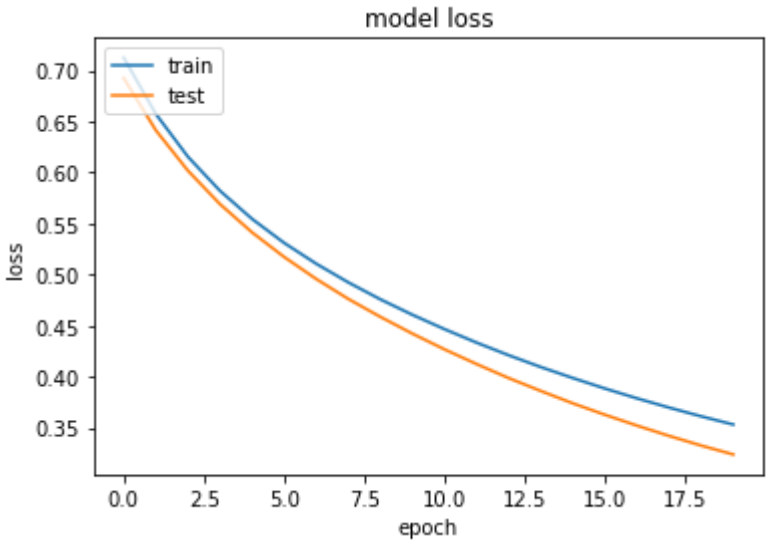
In [38]:

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```



In [39]:

```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```



In [40]:

```
m2.evaluate(X_test, Y_test)[1]
```

```
5/5 [==============================] - 0s 8ms/step - loss: 0.3240 - accurac
y: 0.9392
```

Out[40]:

```
0.9391891956329346
```

In [ ]: