Importing libraries

```
import sys
import pandas as pd
import numpy as np
import sklearn
import matplotlib
import keras

print('Python: {}'.format(sys.version))
print('Pandas: {}'.format(pd.__version__))
print('Numpy: {}'.format(np.__version__))
print('sklearn: {}'.format(sklearn.__version__))
print('Matplotlib'.format(matplotlib.__version__))
print('Keras: {}'.format(keras.__version__))
```

```
Python: 3.6.9 (default, Oct  8 2020, 12:12:24)
[GCC 8.4.0]
Pandas: 1.1.4
Numpy: 1.18.5
sklearn: 0.22.2.post1
Matplotlib
Keras: 2.4.3
```

```
from pandas.plotting import scatter_matrix
import seaborn as sns
from matplotlib import pyplot as plt


# Read the dataset
cleveland = pd.read_csv("heart.csv")


# printing the shape of dataframe
print('Shape of the dataframe: {}'.format(cleveland.shape))
print(cleveland.loc[1])
```

```
Shape of the dataframe: (303, 14)
age          37.0
sex           1.0
cp            2.0
trestbps    130.0
chol        250.0
fbs           0.0
restecg       1.0
thalach     187.0
exang         0.0
oldpeak       3.5
slope         0.0
ca            0.0
```

```
thal          2.0
target        1.0
Name: 1, dtype: float64
```

```
# print some of the data points in the end
cleveland.loc[280:]
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	tha
280	42	1	0	136	315	0	1	125	1	1.8	1	0	
281	52	1	0	128	204	1	1	156	1	1.0	1	0	
282	59	1	2	126	218	1	1	134	0	2.2	1	1	
283	40	1	0	152	223	0	1	181	0	0.0	2	0	
284	61	1	0	140	207	0	0	138	1	1.9	2	1	
285	46	1	0	140	311	0	1	120	1	1.8	1	2	
286	59	1	3	134	204	0	1	162	0	0.8	2	2	
287	57	1	1	154	232	0	0	164	0	0.0	2	1	
288	57	1	0	110	335	0	1	143	1	3.0	1	1	
289	55	0	0	128	205	0	2	130	1	2.0	1	1	
290	61	1	0	148	203	0	1	161	0	0.0	2	1	
291	58	1	0	114	318	0	2	140	0	4.4	0	3	
292	58	0	0	170	225	1	0	146	1	2.8	1	2	
293	67	1	2	152	212	0	0	150	0	0.8	1	0	
294	44	1	0	120	169	0	1	144	1	2.8	0	0	
295	63	1	0	140	187	0	0	144	1	4.0	2	2	
296	63	0	0	124	197	0	1	136	1	0.0	1	0	
297	59	1	0	164	176	1	0	90	0	1.0	1	2	
298	57	0	0	140	241	0	1	123	1	0.2	1	0	
299	45	1	3	110	264	0	1	132	0	1.2	1	0	
300	68	1	0	144	193	1	1	141	0	3.4	1	2	
301	57	1	0	130	131	0	1	115	1	1.2	1	1	

```
# Removing missing data
data = cleveland[~cleveland.isin(['?'])]
data.loc[280:]
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	tha
280	42	1	0	136	315	0	1	125	1	1.8	1	0	
281	52	1	0	128	204	1	1	156	1	1.0	1	0	
282	59	1	2	126	218	1	1	134	0	2.2	1	1	
283	40	1	0	152	223	0	1	181	0	0.0	2	0	
284	61	1	0	140	207	0	0	138	1	1.9	2	1	
285	46	1	0	140	311	0	1	120	1	1.8	1	2	
286	59	1	3	134	204	0	1	162	0	0.8	2	2	
287	57	1	1	154	232	0	0	164	0	0.0	2	1	
288	57	1	0	110	335	0	1	143	1	3.0	1	1	
289	55	0	0	128	205	0	2	130	1	2.0	1	1	
290	61	1	0	148	203	0	1	161	0	0.0	2	1	
291	58	1	0	114	318	0	2	140	0	4.4	0	3	
292	58	0	0	170	225	1	0	146	1	2.8	1	2	
293	67	1	2	152	212	0	0	150	0	0.8	1	0	
294	44	1	0	120	169	0	1	144	1	2.8	0	0	
295	63	1	0	140	187	0	0	144	1	4.0	2	2	
296	63	0	0	124	197	0	1	136	1	0.0	1	0	
297	59	1	0	164	176	1	0	90	0	1.0	1	2	
298	57	0	0	140	241	0	1	123	1	0.2	1	0	
299	45	1	3	110	264	0	1	132	0	1.2	1	0	
300	68	1	0	144	193	1	1	141	0	3.4	1	2	
301	57	1	0	130	131	0	1	115	1	1.2	1	1	

```
data = data.dropna(axis = 0)
data.loc[280:]
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	tha
280	42	1	0	136	315	0	1	125	1	1.8	1	0	
281	52	1	0	128	204	1	1	156	1	1.0	1	0	
282	59	1	2	126	218	1	1	134	0	2.2	1	1	
283	40	1	0	152	223	0	1	181	0	0.0	2	0	
284	61	1	0	140	207	0	0	138	1	1.9	2	1	
285	46	1	0	140	311	0	1	120	1	1.8	1	2	
286	59	1	3	134	204	0	1	162	0	0.8	2	2	
287	57	1	1	154	232	0	0	164	0	0.0	2	1	
288	57	1	0	110	335	0	1	143	1	3.0	1	1	
289	55	0	0	128	205	0	2	130	1	2.0	1	1	
290	61	1	0	148	203	0	1	161	0	0.0	2	1	
291	58	1	0	114	318	0	2	140	0	4.4	0	3	
292	58	0	0	170	225	1	0	146	1	2.8	1	2	
293	67	1	2	152	212	0	0	150	0	0.8	1	0	
294	44	1	0	120	169	0	1	144	1	2.8	0	0	
295	63	1	0	140	187	0	0	144	1	4.0	2	2	

```
# Now print the shape and data type of the dataframe
print(data.shape)
print(data.dtypes)

# Convert all the data to numeric values
data = data.apply(pd.to_numeric)
data.dtypes
```

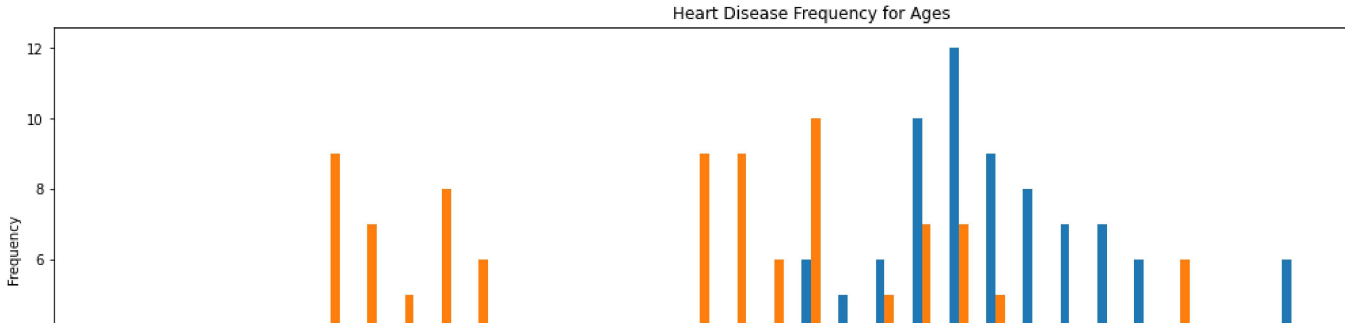
```
(303, 14)
age           int64
sex           int64
cp            int64
trestbps      int64
chol          int64
fbs           int64
restecg       int64
thalach       int64
exang         int64
oldpeak     float64
slope         int64
ca            int64
thal          int64
target        int64
dtype: object
age           int64
```

```
sex           int64
cp            int64
trestbps      int64
chol          int64
fbs           int64
restecg       int64
thalach       int64
exang         int64
oldpeak     float64
slope         int64
ca            int64
thal          int64
target        int64
dtype: object
```

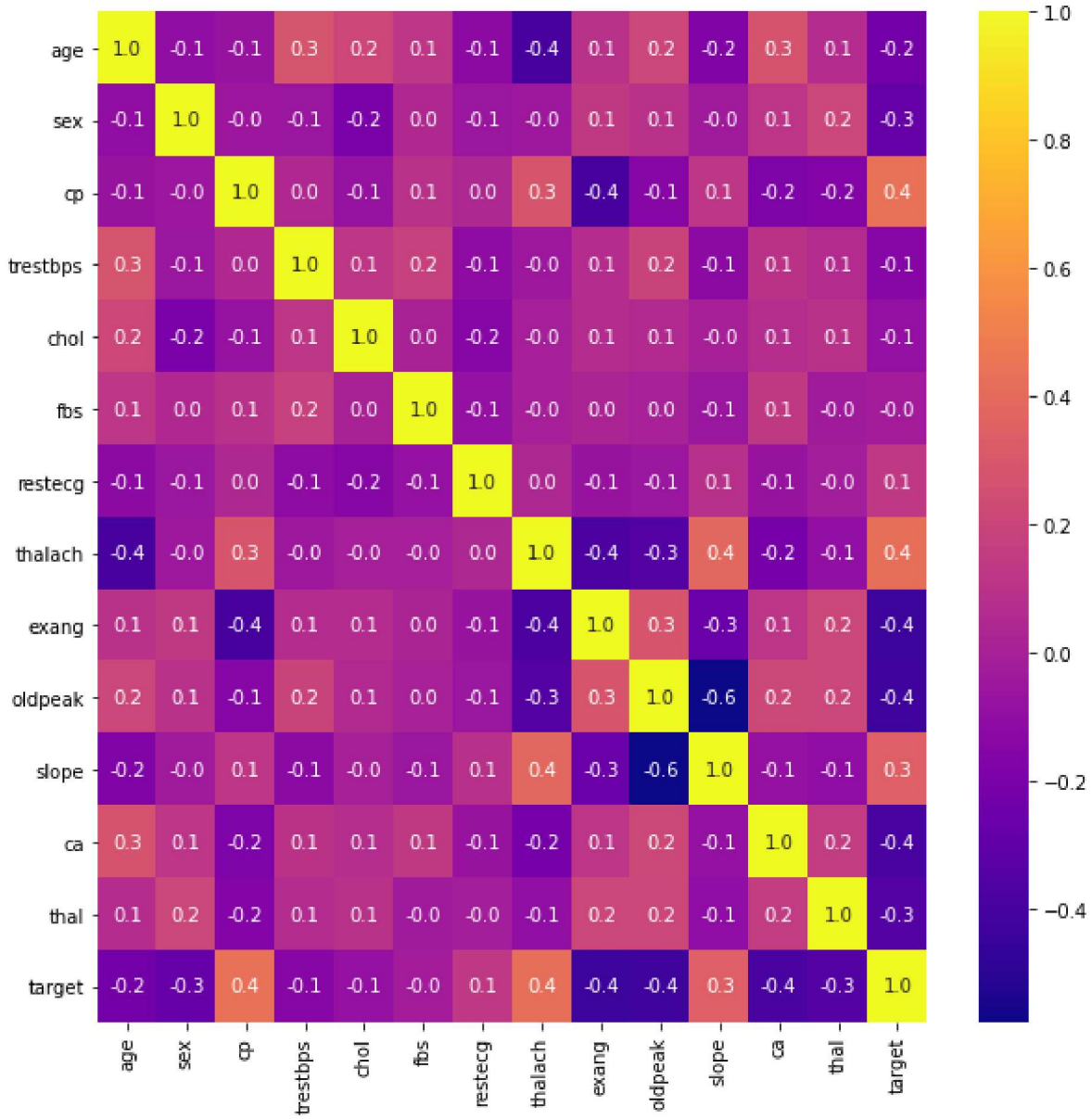
```
# print data characteristics, usings pandas built-in describe() function
data.describe()
```

	age	sex	cp	trestbps	chol	fbs	restecg
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000

```
pd.crosstab(data.age,data.target).plot(kind="bar",figsize=(20,6))
plt.title('Heart Disease Frequency for Ages')
plt.xlabel('Age')
plt.ylabel('Frequency')
plt.show()
```



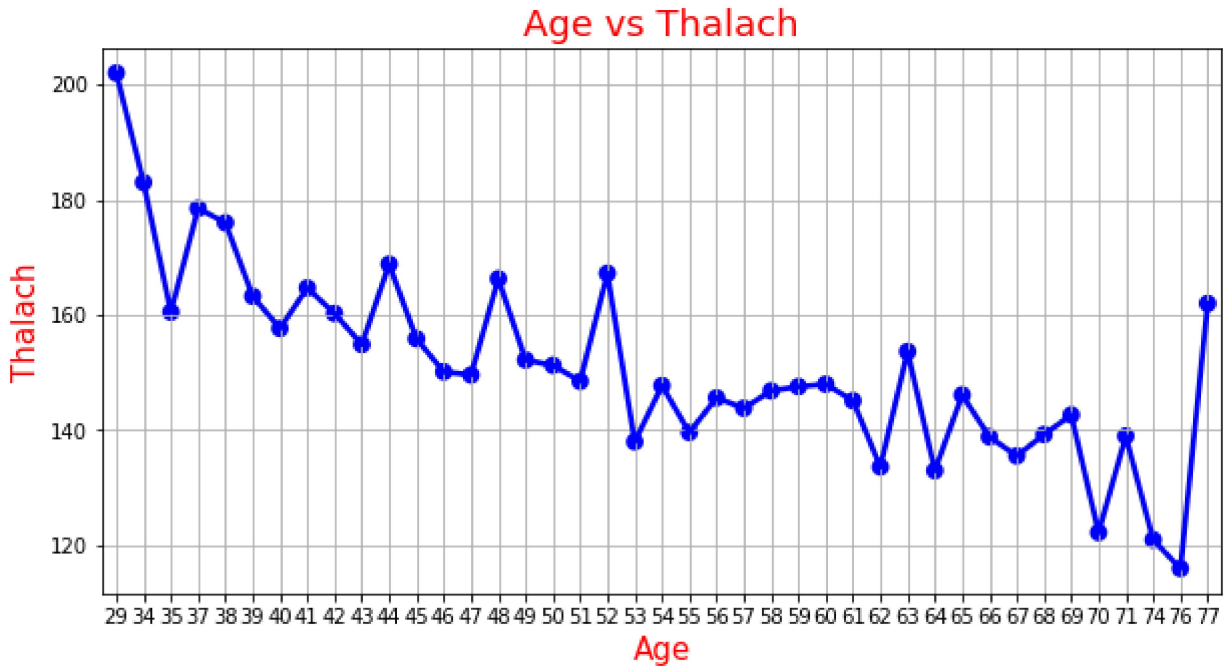

```
# Drawing heatmap for the correlation between attributes
plt.figure(figsize=(10,10))
sns.heatmap(data.corr(),annot=True,fmt='.1f', cmap = 'plasma')
plt.show()
```



Plotting age vs Thalach

```
age_unique = sorted(data.age.unique())
age_thalach_values = data.groupby('age')['thalach'].count().values
mean_thalach = []
for i, age in enumerate(age_unique):
  mean_thalach.append(sum(data[data['age'] == age].thalach)/age_thalach_values[i])

plt.figure(figsize=(10,5))
sns.pointplot(x = age_unique, y = mean_thalach, color = 'blue', alpha = 0.8)
plt.xlabel('Age', fontsize = 15, color = 'red')
plt.ylabel('Thalach', fontsize = 15, color = 'red')
plt.title('Age vs Thalach', fontsize = 18, color = 'red')
plt.grid()
plt.show()
```



Creation of Training and testing datasets

Dividing the dataset in 70% for training and 30% for testing

```
X = np.array(data.drop(['target'], 1))
y = np.array(data['target'])
```

```
X[0]
```

```
array([ 63. ,   1. ,   3. , 145. , 233. ,   1. ,   0. , 150. ,   0. ,
        2.3,   0. ,   0. ,   1. ])
```

```
# Normalizing the database
mean = X.mean(axis = 0)
```

```
X -= mean
std = X.std(axis = 0)
X /= std
```

```
X[0]
```

```
array([ 0.9521966 ,  0.68100522,  1.97312292,  0.76395577, -0.25633371,
        2.394438  , -1.00583187,  0.01544279, -0.69663055,  1.08733806,
       -2.27457861, -0.71442887, -2.14887271])
```

```
from sklearn import model_selection
X_train, X_test, y_train, y_test = model_selection.train_test_split(X, y, stratify = y,
                                                                    random_state = 42, test_s
```

```
# Conversion of data into categorical labels
from keras.utils.np_utils import to_categorical
Y_train = to_categorical(y_train, num_classes = None)
Y_test = to_categorical(y_test, num_classes = None)
print(Y_train.shape)
print(Y_train[:10])
```

```
(212, 2)
[[0. 1.]
 [1. 0.]
 [1. 0.]
 [0. 1.]
 [1. 0.]
 [0. 1.]
 [0. 1.]
 [1. 0.]
 [0. 1.]
 [1. 0.]]
```

```
X_train[0]
```

```
array([ 2.38595135, -1.46841752,  1.00257707,  0.47839125, -0.95205107,
       -0.41763453,  2.80375634, -1.47139438, -0.69663055,  0.05210339,
       -0.64911323, -0.71442887, -0.51292188])
```

```
from keras.models import Sequential
from keras.layers import Dense
from keras.optimizers import Adam
from keras.layers import Dropout
from keras import regularizers

# define a function to build the keras model
def create_model():
    # create model
    model = Sequential()
    model.add(Dense(16, input_dim=13, kernel_initializer='normal', kernel_regularizer=regular
    model.add(Dropout(0.25))
```

```
    model.add(Dropout(0.25))
    model.add(Dense(8, kernel_initializer='normal', kernel_regularizer=regularizers.l2(0.001)
    model.add(Dropout(0.25))
    model.add(Dense(2, activation='softmax'))

    # compile model
    adam = Adam(lr=0.001)
    model.compile(loss='categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])
    return model

model = create_model()

print(model.summary())
```

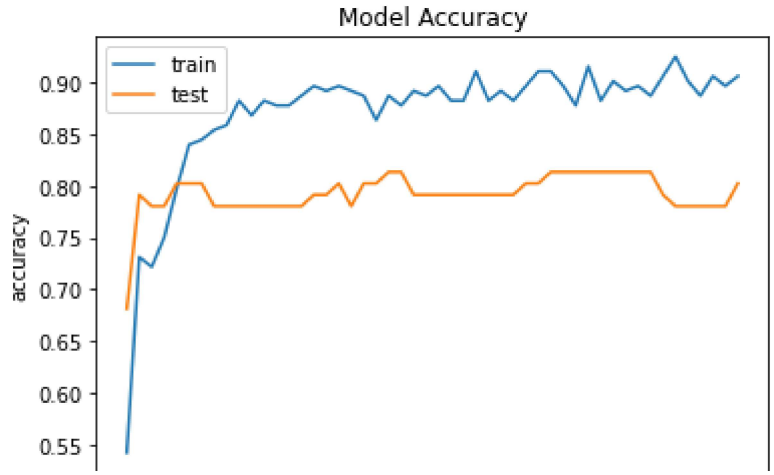
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 16)                224
_________________________________________________________________
dropout (Dropout)            (None, 16)                0
_________________________________________________________________
dense_1 (Dense)              (None, 8)                 136
_________________________________________________________________
dropout_1 (Dropout)          (None, 8)                 0
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 18
=================================================================
Total params: 378
Trainable params: 378
Non-trainable params: 0
_________________________________________________________________
None
```

```
# fit the model to the training data
history = model.fit(X_train, Y_train, validation_data=(X_test, Y_test), epochs=50, batch_size
```

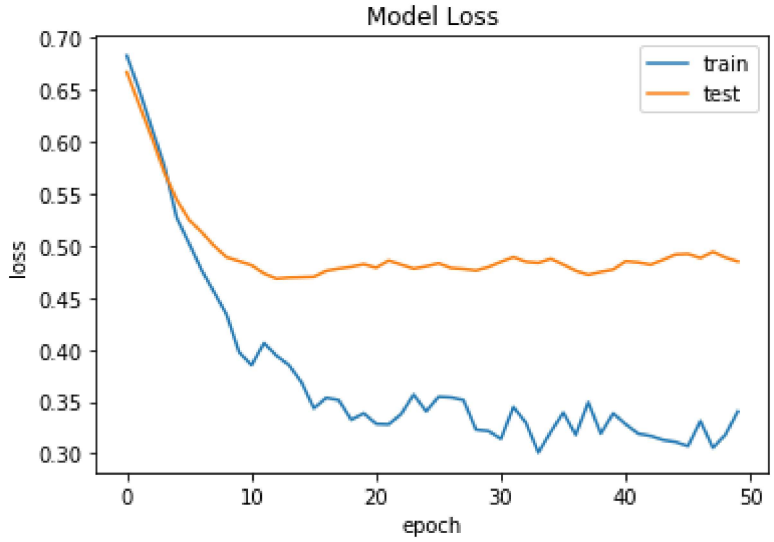
```
Epoch 22/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3282 - accuracy: 0.886
Epoch 23/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3381 - accuracy: 0.877
Epoch 24/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3568 - accuracy: 0.891
Epoch 25/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3407 - accuracy: 0.886
Epoch 26/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3547 - accuracy: 0.896
Epoch 27/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3541 - accuracy: 0.882
Epoch 28/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3515 - accuracy: 0.882
Epoch 29/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3230 - accuracy: 0.910
Epoch 30/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3218 - accuracy: 0.882
Epoch 31/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3142 - accuracy: 0.891
```

```
22/22 [==============================] - 0s 2ms/step - loss: 0.3142 - accuracy: 0.891
Epoch 32/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3448 - accuracy: 0.882
Epoch 33/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3298 - accuracy: 0.896
Epoch 34/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3011 - accuracy: 0.910
Epoch 35/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3209 - accuracy: 0.910
Epoch 36/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3394 - accuracy: 0.896
Epoch 37/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3180 - accuracy: 0.877
Epoch 38/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3494 - accuracy: 0.915
Epoch 39/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3193 - accuracy: 0.882
Epoch 40/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3388 - accuracy: 0.900
Epoch 41/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3283 - accuracy: 0.891
Epoch 42/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3193 - accuracy: 0.896
Epoch 43/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3171 - accuracy: 0.886
Epoch 44/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3131 - accuracy: 0.905
Epoch 45/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3113 - accuracy: 0.924
Epoch 46/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3072 - accuracy: 0.900
Epoch 47/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3313 - accuracy: 0.886
Epoch 48/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3056 - accuracy: 0.905
Epoch 49/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3182 - accuracy: 0.896
Epoch 50/50
22/22 [==============================] - 0s 2ms/step - loss: 0.3406 - accuracy: 0.905
```

```
import matplotlib.pyplot as plt
%matplotlib inline
# Model accuracy
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'])
plt.show()
```




```
# Model Losss
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'])
plt.show()
```




```
_, accuracy = model.evaluate(X_test, Y_test)
print('Accuracy: %.2f' % (accuracy*100))
```

```
3/3 [==============================] - 0s 1ms/step - loss: 0.4847 - accuracy: 0.8022
Accuracy: 80.22
```

```
predictions = model.predict_classes(X_test)
```

```
WARNING:tensorflow:From <ipython-input-25-bc83193b8b59>:1: Sequential.predict_classes (f
Instructions for updating:
Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if your model does multi-
```

```
for i in range(0,15):
  print("{}. Prediction => {}, Actual => [{}]".format(i,predictions[i],y[i]))
```

```
0. Prediction => 1, Actual => [1]
1. Prediction => 1, Actual => [1]
2. Prediction => 0, Actual => [1]
3. Prediction => 0, Actual => [1]
4. Prediction => 0, Actual => [1]
5. Prediction => 0, Actual => [1]
6. Prediction => 1, Actual => [1]
7. Prediction => 1, Actual => [1]
8. Prediction => 1, Actual => [1]
9. Prediction => 0, Actual => [1]
10. Prediction => 0, Actual => [1]
11. Prediction => 1, Actual => [1]
12. Prediction => 1, Actual => [1]
13. Prediction => 1, Actual => [1]
14. Prediction => 1, Actual => [1]
```