Adithya Nair

Roll No: AM.EN.U4CSE19103

Trying Different Regression Models on the Life Expectancy dataset

In [410]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import preprocessing, linear_model, model_selection, metrics
import warnings
warnings.filterwarnings('ignore')
import seaborn as sns
```

Reading the Life Expectancy dataset, using pandas.

In [411]:

```
df = pd.read_csv("life-expectancy.csv")
df
```

Out[411]:

	Entity	Code	Year	Life expectancy (years)
0	Afghanistan	AFG	1950	27.638
1	Afghanistan	AFG	1951	27.878
2	Afghanistan	AFG	1952	28.361
3	Afghanistan	AFG	1953	28.852
4	Afghanistan	AFG	1954	29.350
...	...	...	...	...
19023	Zimbabwe	ZWE	2015	59.534
19024	Zimbabwe	ZWE	2016	60.294
19025	Zimbabwe	ZWE	2017	60.812
19026	Zimbabwe	ZWE	2018	61.195
19027	Zimbabwe	ZWE	2019	61.490

19028 rows × 4 columns

Checking the types of the features and the number of non-null examples. There are missing values on every feature, before feeding the dataset to the model, they need to be dealt.

In [412]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19028 entries, 0 to 19027
Data columns (total 4 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   Entity                    19028 non-null  object 
 1   Code                      18445 non-null  object 
 2   Year                      19028 non-null  int64  
 3   Life expectancy (years)  19028 non-null  float64
dtypes: float64(1), int64(1), object(2)
memory usage: 594.8+ KB
```

Describing the dataset. The dataset consists of examples from 193 different countries from different years. It is shown that minimum value for year is 1881 and maximum is 2019. Also the status column is binary, can be converted to 1 and 0s. The population column has huge values in it, which is expected. The values can be showed as millions.

In [413]:

```
df.describe(include='all')
```

Out[413]:

	Entity	Code	Year	Life expectancy (years)
count	19028	18445	19028.000000	19028.000000
unique	243	235	NaN	NaN
top	Sweden	SWE	NaN	NaN
freq	269	269	NaN	NaN
mean	NaN	NaN	1974.955171	61.751767
std	NaN	NaN	38.157409	13.091632
min	NaN	NaN	1543.000000	17.760000
25%	NaN	NaN	1961.000000	52.314750
50%	NaN	NaN	1980.000000	64.713000
75%	NaN	NaN	2000.000000	71.984250
max	NaN	NaN	2019.000000	86.751000

In [ ]:

```

```

Droping the feature with missing values

In [414]:

```
df = df.drop('Code',axis=1)
```

In [415]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19028 entries, 0 to 19027
Data columns (total 3 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   Entity                   19028 non-null  object 
 1   Year                     19028 non-null  int64  
 2   Life expectancy (years)  19028 non-null  float64
dtypes: float64(1), int64(1), object(1)
memory usage: 446.1+ KB
```

In [416]:

```
df['Life expectancy (years)']
```

Out[416]:

```
0        27.638
1        27.878
2        28.361
3        28.852
4        29.350
          ...  
19023    59.534
19024    60.294
19025    60.812
19026    61.195
19027    61.490
Name: Life expectancy (years), Length: 19028, dtype: float64
```

Life Expectancy Of India (1881 - 2019)

In [417]:

```
India = df[df['Entity'] == 'India']
India
```

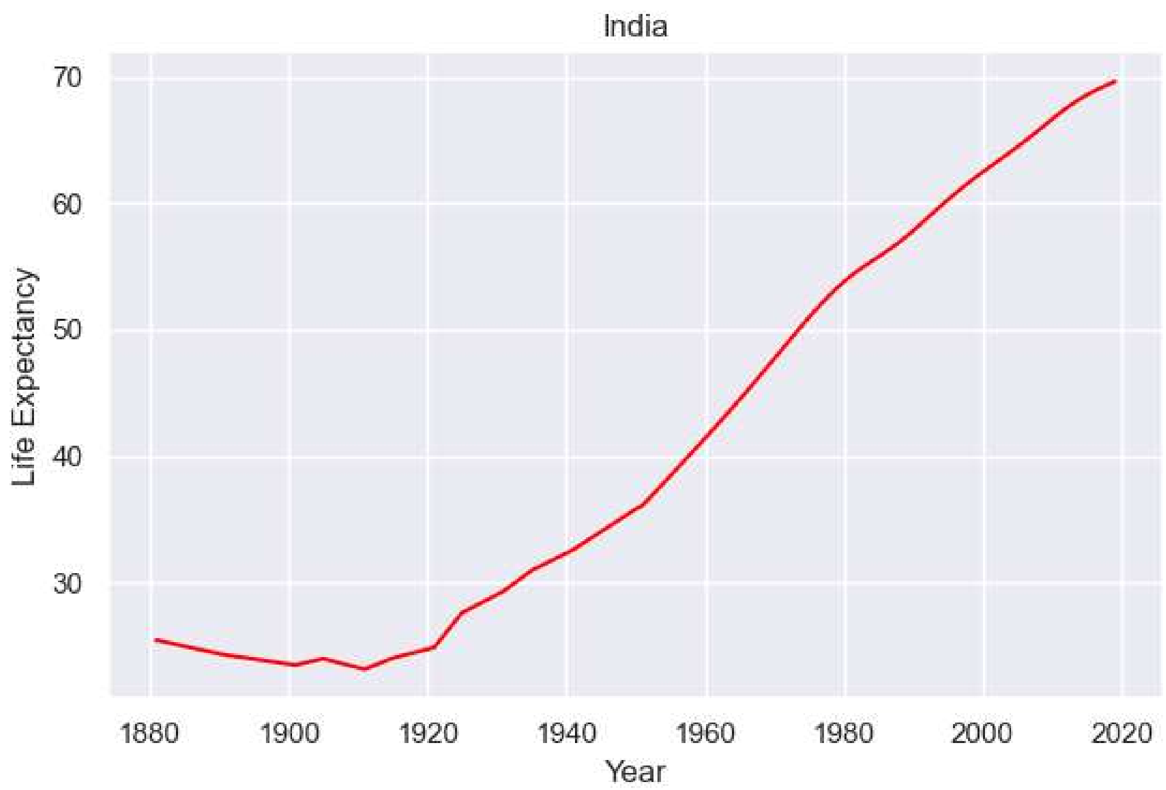
Out[417]:

	Entity	Year	Life expectancy (years)
7691	India	1881	25.442400
7692	India	1891	24.266399
7693	India	1901	23.485600
7694	India	1905	23.980000
7695	India	1911	23.146400
...	...	...	...
7767	India	2015	68.607000
7768	India	2016	68.897000
7769	India	2017	69.165000
7770	India	2018	69.416000
7771	India	2019	69.656000

81 rows × 3 columns

In [418]:

```
plt.plot(India['Year'], India['Life expectancy (years)'], color='red')
plt.xlabel('Year')
plt.ylabel('Life Expectancy')
plt.title("India")
plt.show()
```

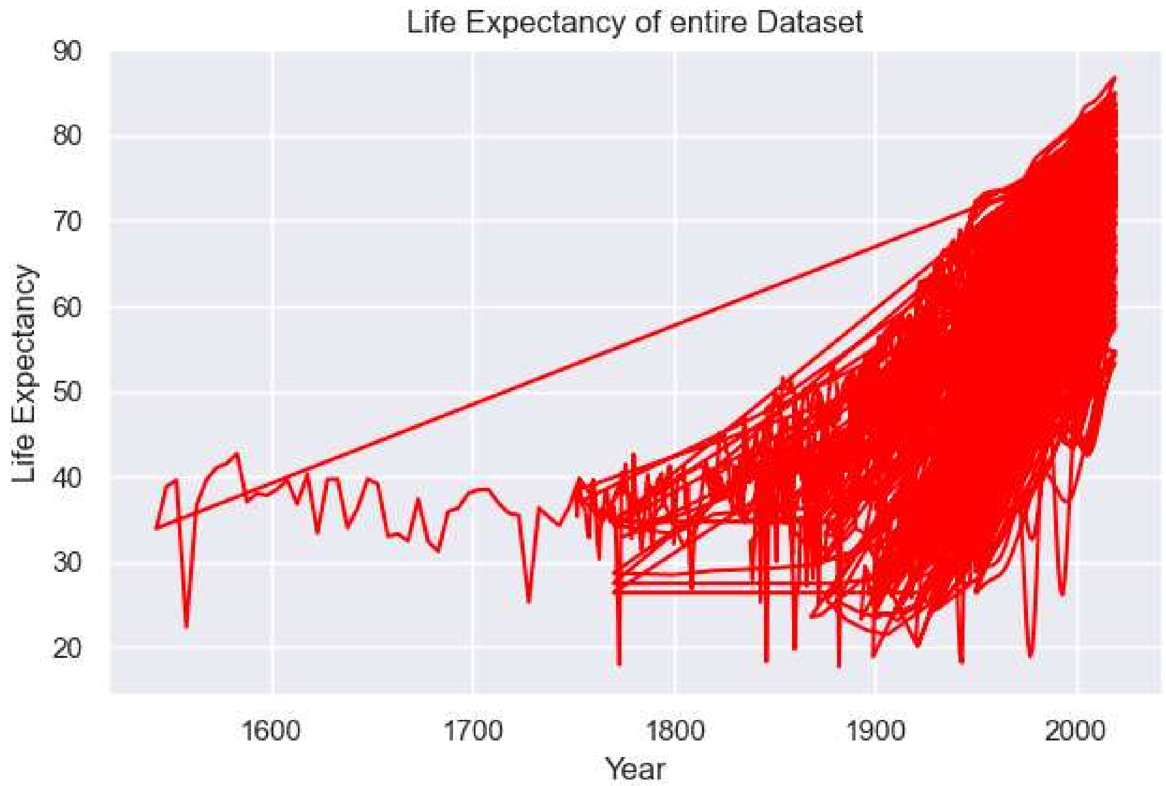


This plot shows that India's life expectancy was below 30 at year 1881 and hit the top with 70 at 2019. Then it increases lineary.

This dataframe shows the countries with lowest and highest life expectancy. We can see African countries generally have the lowest life expectancy and the European ones have the highest.

In [419]:

```
plt.plot(df['Year'], df['Life expectancy (years)'], color='red')
plt.xlabel('Year')
plt.ylabel('Life Expectancy')
plt.title("Life Expectancy of entire Dataset")
plt.show()
```



In [420]:

```
df.sort_values('Life expectancy (years)')
```

Out[420]:

	Entity	Year	Life expectancy (years)
7553	Iceland	1882	17.760000
16062	Sweden	1773	17.959999
17595	Ukraine	1943	18.200001
7517	Iceland	1846	18.320000
4059	Cuba	1899	18.900000
...	...	...	...
11001	Monaco	2015	85.739000
11002	Monaco	2016	86.049000
11003	Monaco	2017	86.325000
11004	Monaco	2018	86.560000
11005	Monaco	2019	86.751000

19028 rows × 3 columns

Label Encoding Countries

In [421]:

```
l_encoder= preprocessing.LabelEncoder()
df['labels'] = l_encoder.fit_transform(df.loc[:, 'Entity'])
df
```

Out[421]:

	Entity	Year	Life expectancy (years)	labels
0	Afghanistan	1950	27.638	0
1	Afghanistan	1951	27.878	0
2	Afghanistan	1952	28.361	0
3	Afghanistan	1953	28.852	0
4	Afghanistan	1954	29.350	0
...	...	...	...	...
19023	Zimbabwe	2015	59.534	242
19024	Zimbabwe	2016	60.294	242
19025	Zimbabwe	2017	60.812	242
19026	Zimbabwe	2018	61.195	242
19027	Zimbabwe	2019	61.490	242

19028 rows × 4 columns

In [422]:

```
df[df['Entity'] == 'United States']
```

Out[422]:

	Entity	Year	Life expectancy (years)	labels
17980	United States	1880	39.410000	229
17981	United States	1890	45.209999	229
17982	United States	1901	49.299999	229
17983	United States	1902	50.500000	229
17984	United States	1903	50.599998	229
...	...	...	...	...
18096	United States	2015	78.910000	229
18097	United States	2016	78.885000	229
18098	United States	2017	78.861000	229
18099	United States	2018	78.851000	229
18100	United States	2019	78.862000	229

121 rows × 4 columns

In [423]:

```
df['Life expectancy (years)']
```

Out[423]:

```
0        27.638
1        27.878
2        28.361
3        28.852
4        29.350
          ...
19023    59.534
19024    60.294
19025    60.812
19026    61.195
19027    61.490
Name: Life expectancy (years), Length: 19028, dtype: float64
```

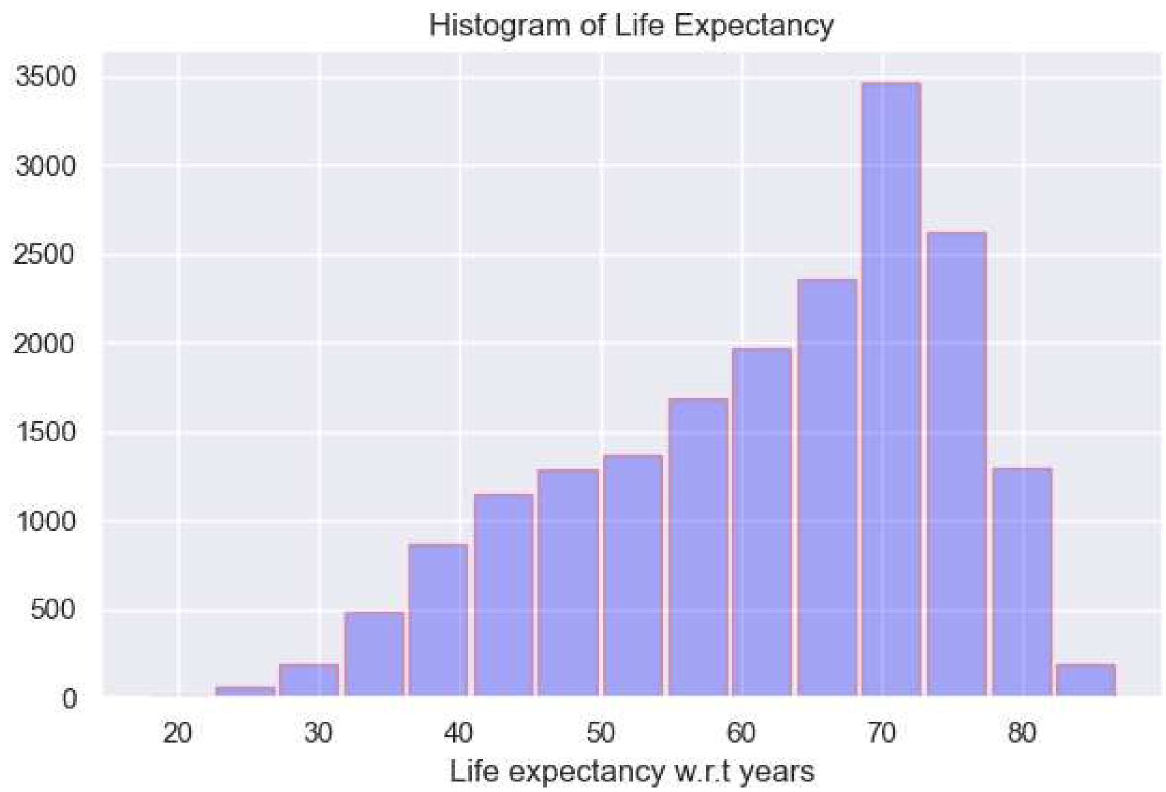
Data Visualization

In [424]:

```
fig, ax = plt.subplots(figsize=(7, 5))
sns.regplot(y="labels", x="Life expectancy (years)", data=df, scatter_kws={"color": "gray"}
plt.title("Life Expectancy w.r.t Country in labels")
plt.show()
```

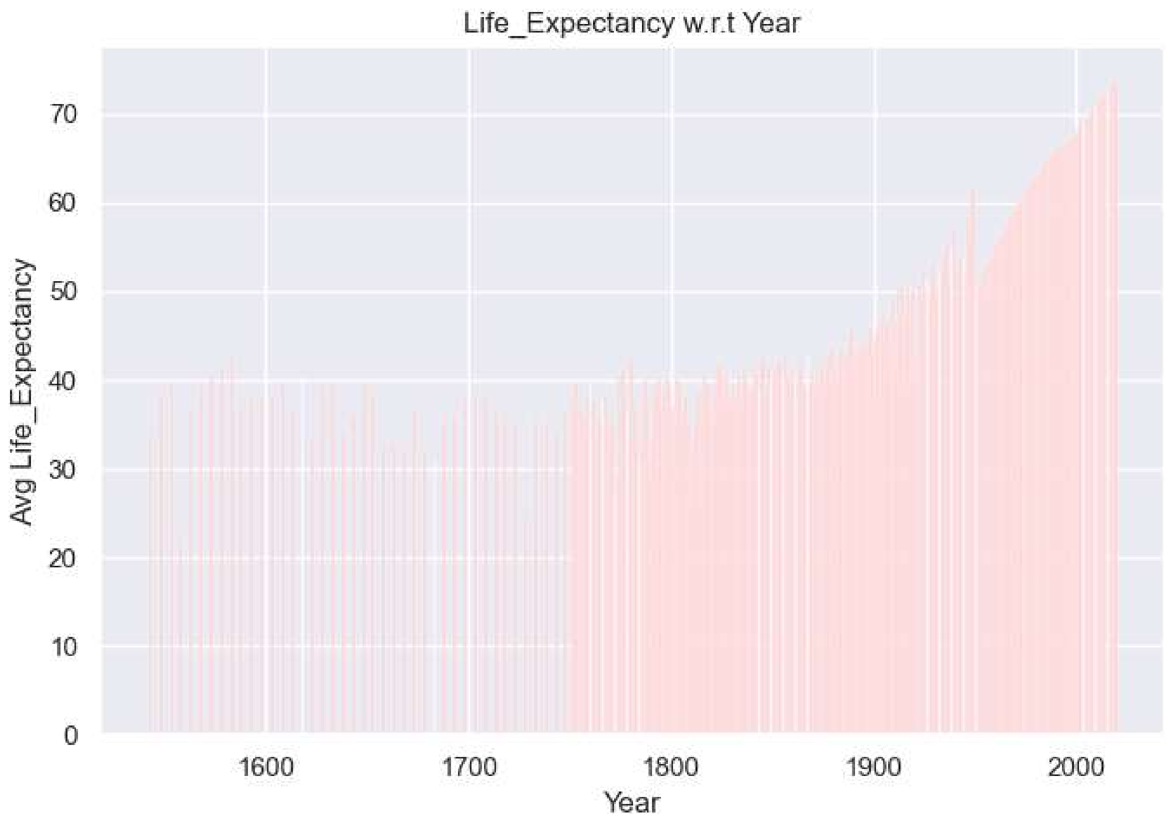
In [425]:

```
plt.hist(df['Life expectancy (years)'],rwidth=0.9,alpha=0.3,color='blue',bins=15,edgecolor=

#x and y-axis labels
plt.xlabel('Life expectancy w.r.t years')
#plt.ylabel('Year')

#plot title
plt.title('Histogram of Life Expectancy')
plt.show();
```



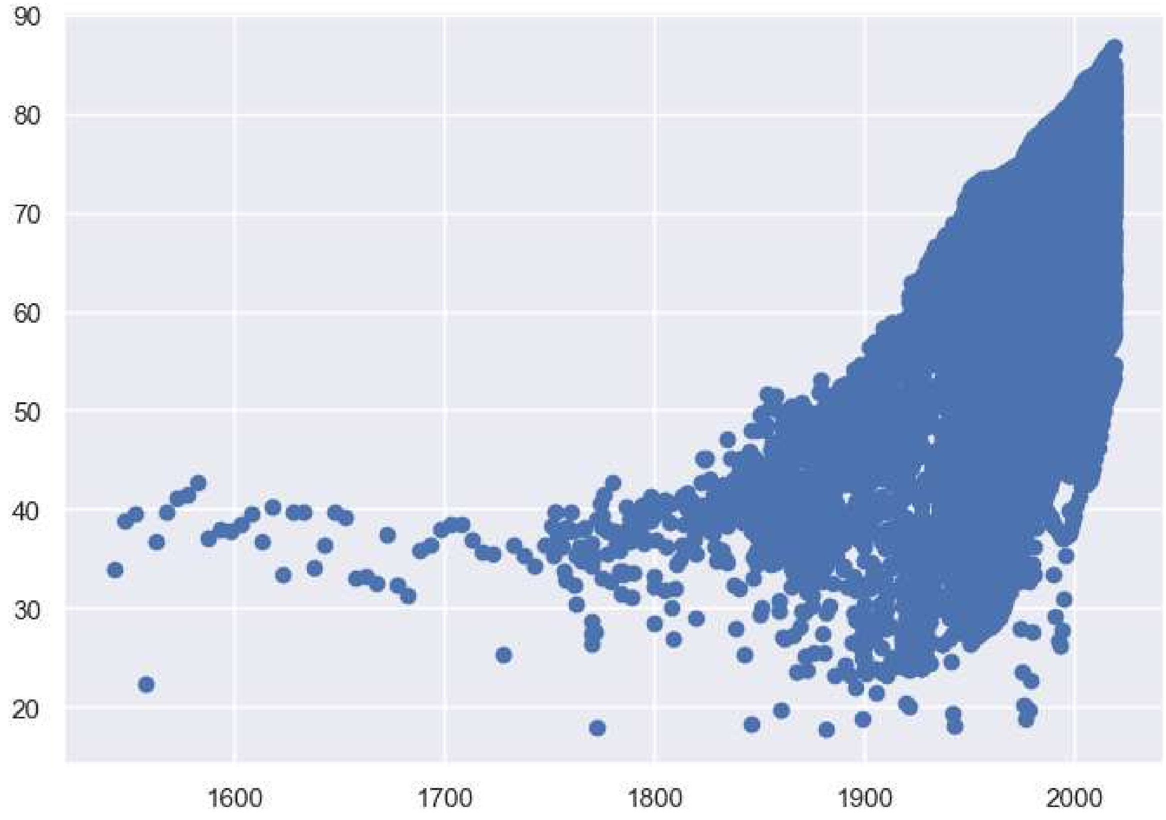
In [426]:

```
plt.figure(figsize=(7,5))
plt.bar(df.groupby('Year')['Year'].count().index, df.groupby('Year')['Life expectancy (year
plt.xlabel("Year",fontsize=12)
plt.ylabel("Avg Life_Expectancy",fontsize=12)
plt.title("Life_Expectancy w.r.t Year")
plt.show()
```



In [427]:

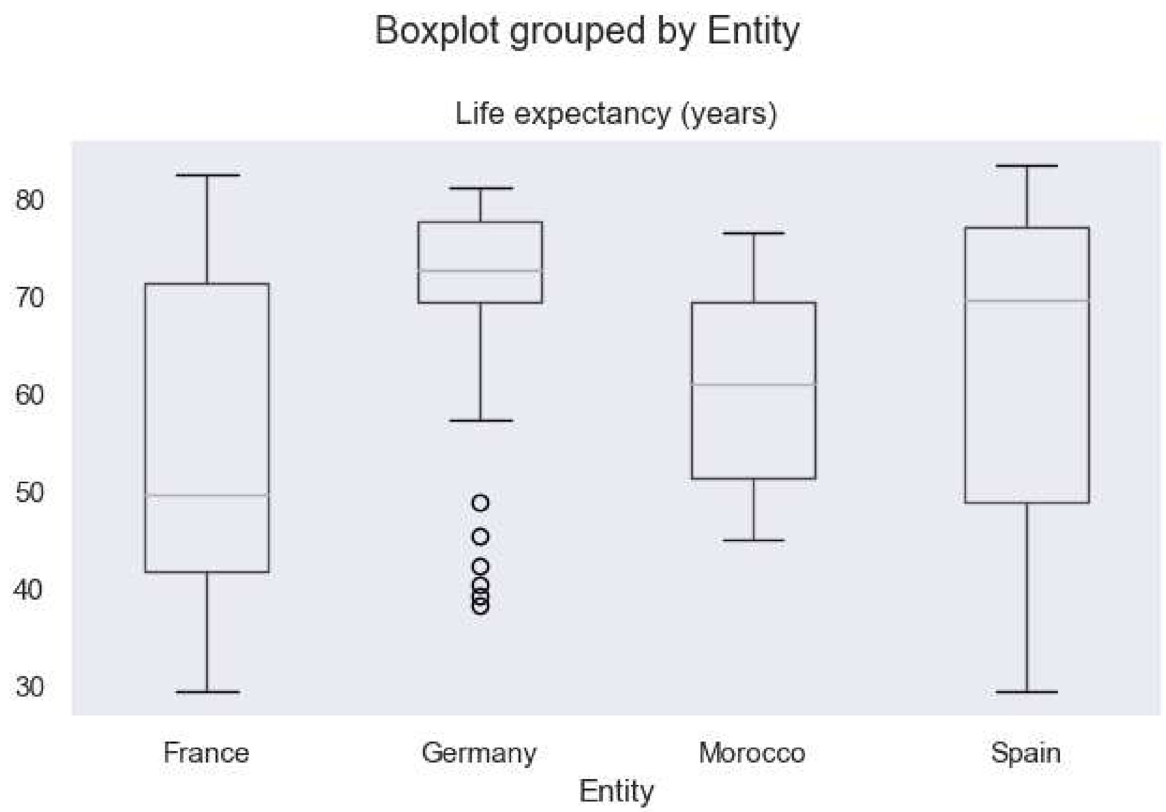
```
plt.figure(figsize=(7,5))
plt.scatter(x='Year', y='Life expectancy (years)', data=df)
plt.show()
```



In [428]:

```
plt.figure(figsize=(7,5))
df[df.Entity.isin(['Morocco','Germany','Spain','France'])].boxplot(by='Entity',
                       column=['Life expectancy (years)'],
                       grid=False)
plt.show()
```

```
<Figure size 700x500 with 0 Axes>
```



Data Normalization

In [429]:

```
y = df['Life expectancy (years)']
df = df.drop(labels='Life expectancy (years)', axis=1)
df
```

Out[429]:

	Entity	Year	labels
0	Afghanistan	1950	0
1	Afghanistan	1951	0
2	Afghanistan	1952	0
3	Afghanistan	1953	0
4	Afghanistan	1954	0
...	...	...	...
19023	Zimbabwe	2015	242
19024	Zimbabwe	2016	242
19025	Zimbabwe	2017	242
19026	Zimbabwe	2018	242
19027	Zimbabwe	2019	242

19028 rows × 3 columns

In [430]:

```
y
```

Out[430]:

```
0        27.638
1        27.878
2        28.361
3        28.852
4        29.350
          ...
19023    59.534
19024    60.294
19025    60.812
19026    61.195
19027    61.490
Name: Life expectancy (years), Length: 19028, dtype: float64
```

In [431]:

```
y = y.to_numpy(dtype='float64')
y
```

Out[431]:

```
array([27.638, 27.878, 28.361, ..., 60.812, 61.195, 61.49 ])
```

In [432]:

```
X = df
X
```

Out[432]:

	Entity	Year	labels
0	Afghanistan	1950	0
1	Afghanistan	1951	0
2	Afghanistan	1952	0
3	Afghanistan	1953	0
4	Afghanistan	1954	0
...	...	...	...
19023	Zimbabwe	2015	242
19024	Zimbabwe	2016	242
19025	Zimbabwe	2017	242
19026	Zimbabwe	2018	242
19027	Zimbabwe	2019	242

19028 rows × 3 columns

In [433]:

```
X = X.drop(labels=['Entity'],axis=1)
```

In [434]:

```
X
```

Out[434]:

	Year	labels
0	1950	0
1	1951	0
2	1952	0
3	1953	0
4	1954	0
...	...	...
19023	2015	242
19024	2016	242
19025	2017	242
19026	2018	242
19027	2019	242

19028 rows × 2 columns

Splitting dataset into Train - Test

In [482]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X, y, test_size=0.67, random_state=42)
```

In [483]:

```
X_train
```

	Year	labels
11389	1982	146
18488	1977	235
17483	1987	224
2476	1991	32
4248	1982	56
...	...	...
11284	2018	144
11964	1962	153
5390	1983	70
860	2013	11
15795	1985	204

In [484]:

```
Y_train
```

Out[484]:

```
array([53.726, 67.723, 60.868, ..., 71.844, 74.056, 69.079])
```

Preprocessing - Standardization

In [485]:

```
from sklearn import preprocessing, linear_model, model_selection, metrics

scaler = preprocessing.StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

In [486]:

```
X_train
```

Out[486]:

```
array([[ 0.16898081,  0.33729351],
       [ 0.03817349,  1.60510994],
       [ 0.29978814,  1.44841353],
       ...,
       [ 0.19514228, -0.74533624],
       [ 0.97998622, -1.58579882],
       [ 0.24746521,  1.16351096]])
```

In [ ]:

```

```

Mean Absolute Error Function

In [468]:

```
import numpy as np
def MAPE(Y_actual,Y_Predicted):
    mape = np.mean(np.abs((Y_actual - Y_Predicted)/Y_actual))*100
    return mape
```

Models

1. KNN Regressor from Scratch

In [441]:

```
def euclid_distance(a,b):
        dist = (a-b)**2
        return np.sqrt(np.sum(dist))
```

In [442]:

```
class KNeighbourRegressor():

    def __init__(self,k):
        self.k = k

    def fit(self,X,y):

        self.X_train = X
        self.y_train = y

    def predictions(self,x):

        distances = [euclid_distance(x,x_train) for x_train in self.X_train]

        k_indices = np.argsort(distances)[:self.k]
        k_nearest_labels = [self.y_train[i] for i in k_indices]

        y_pred = np.mean(k_nearest_labels)

        return y_pred


    def predict(self,X):

        predicted_labels = [self.predictions(x) for x in X]

        return np.array(predicted_labels)
```

2. Linear Regression from Scratch

In [469]:

```
class LinearRegression:
    def __init__(self,X,Y):
        self.X_train = X
        self.y_train = Y

    def gradient_descent(self,x, y, iter = 100, lr = 0.08):
        m, n, b = np.zeros(x.shape[1]), (-2*lr)/x.shape[0], 0
        for _ in range(iter):
            yd = [j-(sum(m*i)+b) for i, j in zip(x, y)]
            m -= n*sum([i*j for i,j in zip(x, yd)])
            b -= n*sum(yd)
        return m, b

    def fit(self,x, y):
        coef,intercept = self.gradient_descent(x, y)
        return coef,intercept

    def predict(self,x):
        m,b = self.fit(self.X_train,self.y_train)

        return np.dot(x,m) + b
```

3. SVR - Inbuilt

In [470]:

```
from sklearn.svm import SVR
svrRegressor= SVR()
```

Cross Validation Using KFold

In [471]:

```
from sklearn.model_selection import KFold
```

In [472]:

```
def kfold(x,y,model):

    res = []

    model_accuracies = []

    kf = KFold(n_splits = 5)

    for train_index, test_index in kf.split(x):

        X_train, X_valid = x[train_index], x[test_index]
        Y_train, Y_valid = y[train_index], y[test_index]

        model.fit(X_train, Y_train)
        Y_pred = model.predict(X_valid)

        score = metrics.r2_score(Y_valid, Y_pred)
        model_accuracies.append(score)
        res.append(score)

    return res,(sorted(model_accuracies)[-1])
```

In [317]:

```

```

KNN - Highest Validation Accuracy

In [451]:

```
KNN = KNeighbourRegressor(7)
best_KNN, best_out = kfold(X_train,Y_train,KNN)
print("KNN:",best_out)
```

```
KNN: 0.5142345395284846
```

Linear Regression - Highest Validation Accuracy

In [473]:

```
LR = LinearRegression(X_train,Y_train)
best_LR, best_out = kfold(X_train,Y_train,LR)
print("LR:",best_out)
```

```
LR: 0.3723386358958235
```

Support Vector Regression - Highest Validation Accuracy

In [474]:

```
best_SVR, best_out = kfold(X_train,Y_train,svrRegressor)
print("SVR:",best_out)
```

```
SVR: 0.40340959133565946
```

TESTING SECTION

Finding The Best Model Using Test Data

Linear Regression - Testing

Using Mean Absolute Error we find the error and accuracy of the respective regressor

In [475]:

```
y_pred_LR = LR.predict(X_test)
```

In [476]:

```
metrics.r2_score(Y_test, y_pred_LR)
```

Out[476]:

```
0.3378395132388059
```

In [477]:

```
LR_MAE = MAPE(Y_test,y_pred_LR)
Accuracy_LR = 100 - LR_MAE
print("MAE: ",LR_MAE)
print('Accuracy of LR model: {:0.2f}%.'.format(Accuracy_LR))
```

```
MAE:  16.440178993153303
Accuracy of LR model: 83.56%.
```

KNN - Testing

In [ ]:

```
y_pred_KNN = KNN.predict(X_test)
```

In [457]:

```
metrics.r2_score(Y_test, y_pred_KNN)
```

Out[457]:

```
0.4720208842940671
```

In [458]:

```
KNN_MAE = MAPE(Y_test,y_pred_KNN)
Accuracy_KNN = 100 - KNN_MAE
print("Mean Absolute Error: ",KNN_MAE)
print('Accuracy of KNN model: {:0.2f}%.'.format(Accuracy_KNN))
```

```
Mean Absolute Error:  13.934746811371479
Accuracy of KNN model: 86.07%.
```

SVR - Testing

In [478]:

```
y_pred_svr= svrRegressor.predict(X_test)
```

In [479]:

```
metrics.r2_score(Y_test, y_pred_svr)
```

Out[479]:

```
0.3593466749746298
```

In [480]:

```
SVR_MAE = MAPE(Y_test,y_pred_svr)
Accuracy_SVR = 100 - SVR_MAE
print("MAE: ",SVR_MAE)
print('Accuracy of SVR model: {:0.2f}%.'.format(Accuracy_SVR))
```

```
MAE:  15.611417698168639
Accuracy of SVR model: 84.39%.
```

KNN Model has the highest accuracy of 86 %

Box Plot Comparison

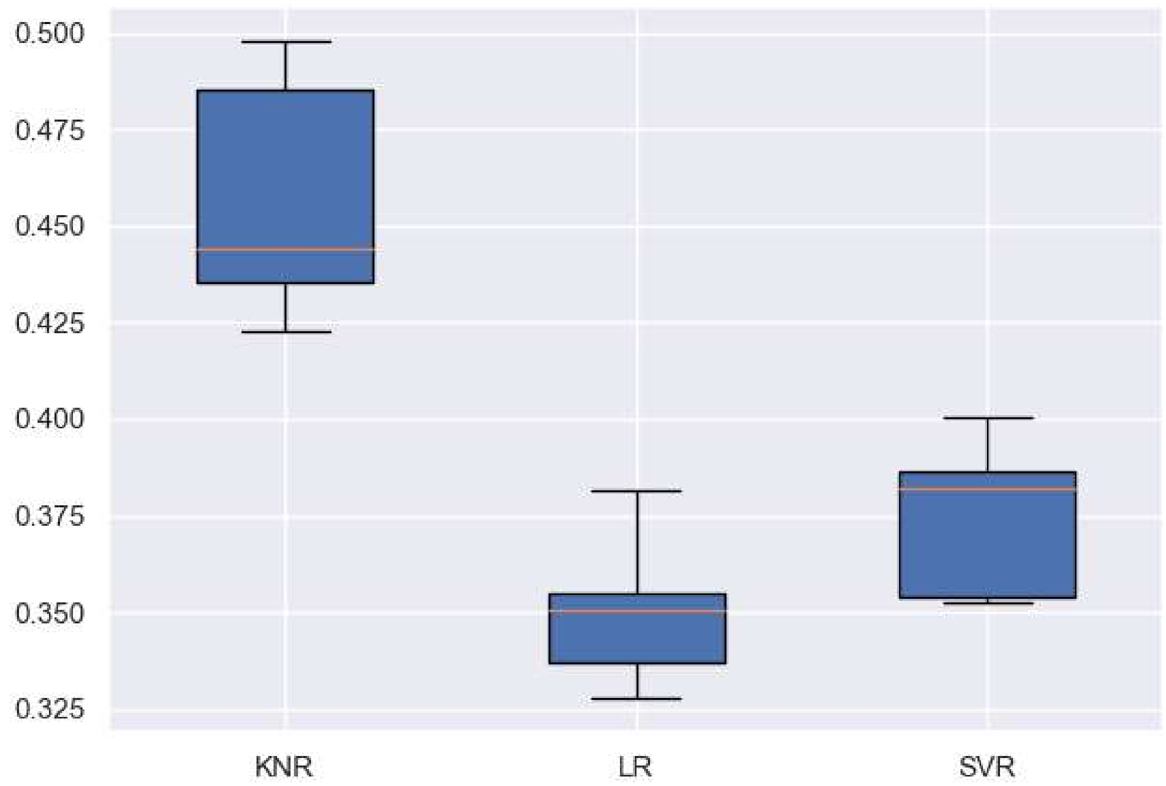
In [375]:

```
print(best_KNN)
print(best_LR)
print(best_SVR)
```

```
[0.4355629784140892, 0.49813443172974026, 0.4853452146308609, 0.422552018110
6218, 0.4439978831405893]
[0.3505367563673656, 0.381399158980658, 0.35501731251480384, 0.3367917685179
9686, 0.32762423555719977]
[0.3864928007034887, 0.4003893046163828, 0.38223262341234376, 0.352462601571
24476, 0.3538477475511208]
```

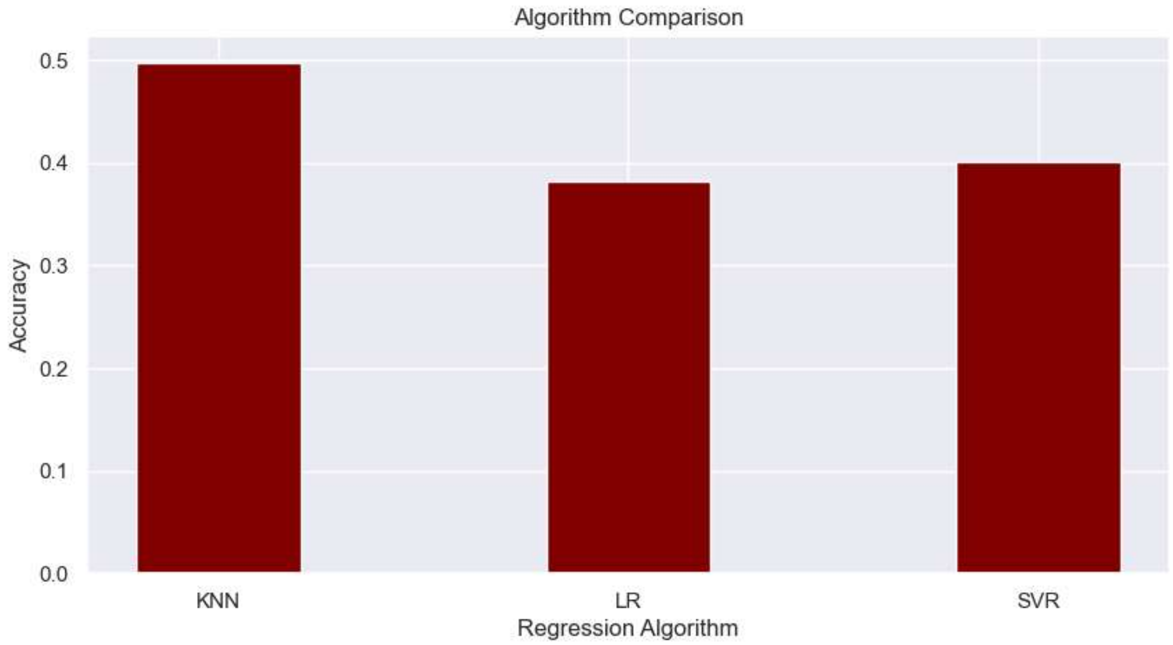
In [378]:

```
plt.rcParams["figure.figsize"] = [6.50, 4.50]
plt.rcParams["figure.autolayout"] = True

box_plot_data=[best_KNN,best_LR,best_SVR]
plt.boxplot(box_plot_data,patch_artist=True,labels=['KNR','LR','SVR'],widths=(0.5, 0.5, 0.5
plt.show()
```



In [366]:

```
fig = plt.figure(figsize = (10, 5))

# creating the bar plot
plt.bar(courses, values, color ='maroon',width = 0.4 )

plt.xlabel("Regression Algorithm")
plt.ylabel("Accuracy")
plt.title("Algorithm Comparison")
plt.show()
```



Plot accuracy for different values of k.

In [487]:

```
acc_score = []
k_values = []

for k in range(1,20,2):

    KNN = KNeighbourRegressor(k)
    _,best_out = kfold(X_train,Y_train,KNN)
    acc_score.append(best_out)
    k_values.append(k)
```

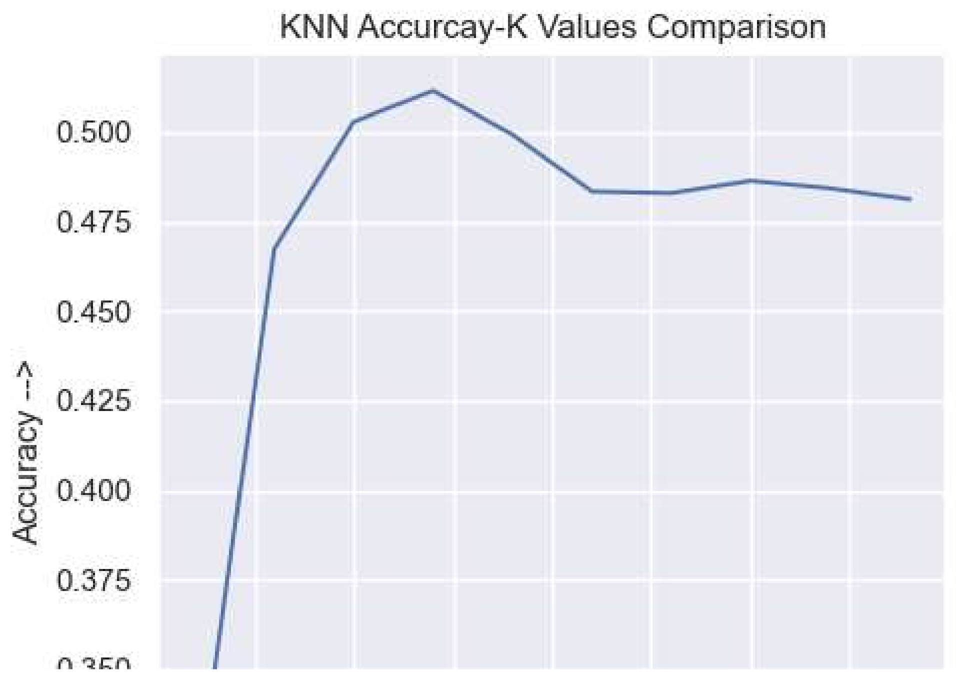
In [488]:

```
print(acc_score,' - ', k_values)
```

```
[0.31010311992839035, 0.4673598562521022, 0.5028770926833546, 0.511507929374
5468, 0.49936600128899755, 0.48342673317656115, 0.48298006450601827, 0.48642
285473190217, 0.48431858871988875, 0.4812671214848221]  -  [1, 3, 5, 7, 9, 1
1, 13, 15, 17, 19]
```

In [492]:

```
fig = plt.figure(figsize = (5, 5))
plt.plot(k_values,acc_score)

plt.xlabel('K-Values -->')
plt.ylabel('Accuracy -->')
plt.title('KNN Accurcay-K Values Comparison')
plt.show()
```



from the above model, we can see that the accuracy increases for KNN regressor till 7 neighbours and then it decreases as the number of neighbours increases.

Predicting new data with the best model - KNN

In [460]:

```
tester = np.array([[2019,229]])
tester
```

Out[460]:

```
array([[2019,  229]])
```

In [461]:

```
tester = scaler.transform(tester)
tester
```

Out[461]:

```
array([[1.13077776, 1.51866747]])
```

Life Expectancy - United States - 2019

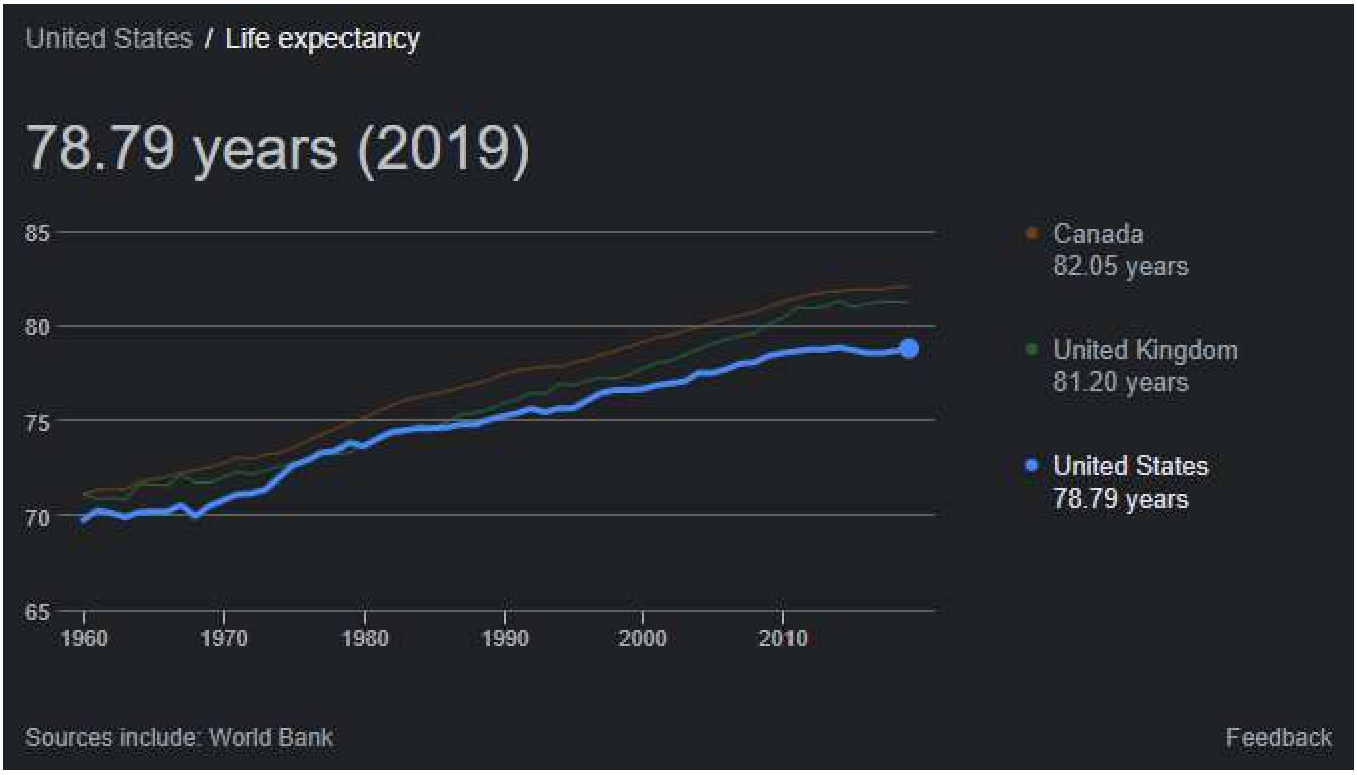
In [462]:

```
out = KNN.predict(tester)
out
```

Out[462]:

```
array([77.344])
```

Actual Life Expectancy



Life Expectancy of United States is 78.79 in 2019 while the KNN regressor predicted the life expectancy as 77.34. The slight change in value is because of the reduced accuracy of the KNN model.