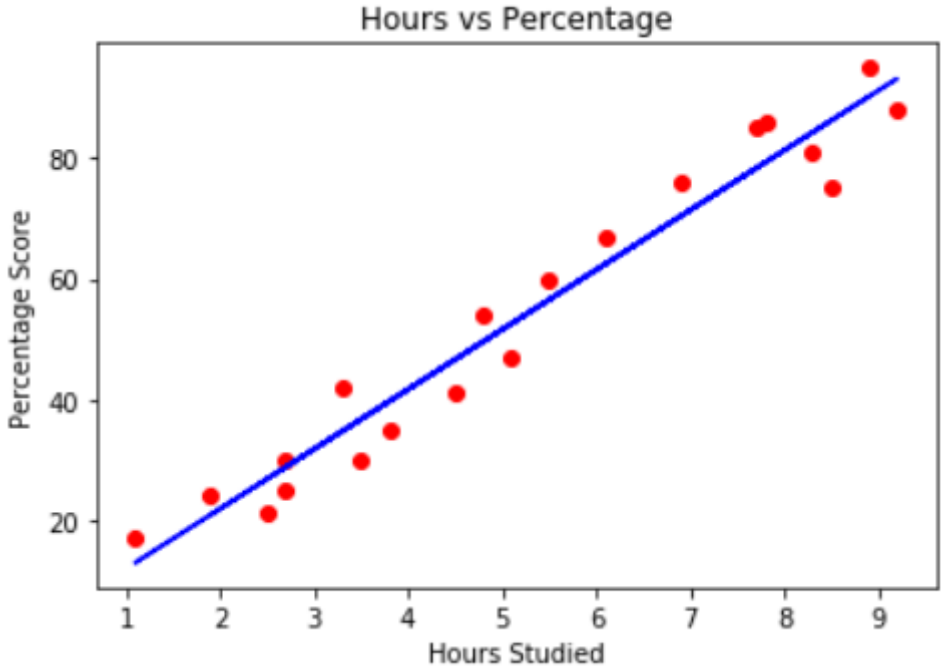
Linear Regression

Example Problem

Determine the linear relationship between the numbers of hours a student studies and the percentage of marks that student scores in an exam?

We want to find out that given the number of hours a student prepares for a test, about how high of a score can the student achieve? If we plot the independent variable (hours) on the x-axis and dependent variable (percentage) on the y-axis, linear regression gives us a straight line that best fits the data points, as shown in the figure below.



We know that the equation of a straight line is basically:

y = mx + b Where b is the intercept and m is the slope of the line. So basically, the linear regression algorithm gives us the most optimal value for the intercept and the slope (in two dimensions). The y and x variables remain the same, since they are the data features and cannot be changed. The values that we can control are the intercept and slope. There can be multiple straight lines depending upon the values of intercept and slope. Basically what the linear regression algorithm does is it fits multiple lines on the data points and returns the line that results in the least error.

This same concept can be extended to the cases where there are more than two variables. This is called **multiple linear regression**. For instance, consider a scenario where you have to predict the price of house based upon its area, number of bedrooms, average income of the people in the area, the age of the house, and so on. In this case the dependent variable is dependent upon several independent variables. A regression model involving multiple variables can be represented as:

y = b0 + m1b1 + m2b2 + m3b3 + ... mnbn

This is the equation of a hyper plane. Remember, a linear regression model in two dimensions is a straight line; in three dimensions it is a plane, and in more than three dimensions, a hyper plane.

Linear Regression with Python Scikit Learn

Simple Linear Regression

In this regression task we will predict the percentage of marks that a student is expected to score based upon the number of hours they studied. This is a simple linear regression task as it involves just two variables.

Importing Libraries

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

Reading Dataset

In [2]:

```
dataset = pd.read_csv('student_scores.csv')
dataset
```

Out[2]:

	Hours	Scores
0	2.5	21
1	5.1	47
2	3.2	27
3	8.5	75
4	3.5	30
5	1.5	20
6	9.2	88
7	5.5	60
8	8.3	81
9	2.7	25
10	7.7	85
11	5.9	62
12	4.5	41
13	3.3	42
14	1.1	17
15	8.9	95
16	2.5	30
17	1.9	24
18	6.1	67
19	7.4	69
20	2.7	30
21	4.8	54
22	3.8	35
23	6.9	76
24	7.8	86

In [3]:

```
dataset.shape
```

Out[3]:

```
(25, 2)
```

In [4]:

```
dataset.head()
```

Out[4]:

	Hours	Scores
0	2.5	21
1	5.1	47
2	3.2	27
3	8.5	75
4	3.5	30

In [5]:

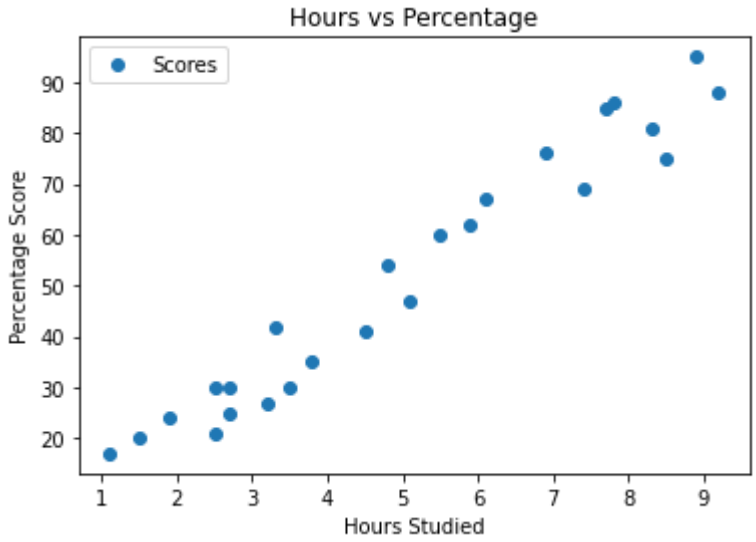
```
dataset.describe()
```

Out[5]:

	Hours	Scores
count	25.000000	25.000000
mean	5.012000	51.480000
std	2.525094	25.286887
min	1.100000	17.000000
25%	2.700000	30.000000
50%	4.800000	47.000000
75%	7.400000	75.000000
max	9.200000	95.000000

In [6]:

```
dataset.plot(x='Hours', y='Scores', style='o')
plt.title('Hours vs Percentage')
plt.xlabel('Hours Studied')
plt.ylabel('Percentage Score')
plt.show()
```



Preparing the Data

In [7]:

```
X = dataset.iloc[:, :-1].values
y = dataset.iloc[:, 1].values
```

In [8]:

```
!pip install sklearn
```

```
...
```

Splitting the Dataset

In [9]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)
```

Training the Algorithm

With Scikit-Learn it is extremely straight forward to implement linear regression models, as all you really need to do is import the LinearRegression class, instantiate it, and call the fit() method along with our training data.

In [10]:

```
from sklearn.linear_model import LinearRegression
regressor = LinearRegression()
regressor.fit(X_train, y_train)
```

Out[10]:

```
LinearRegression()
```

Linear regression model basically finds the best value for the intercept and slope, which results in a line that best fits the data.

In [11]:

```
print(regressor.intercept_)
print(regressor.coef_)
```

```
2.018160041434683
[9.91065648]
```

Making Predictions

Now that we have trained our algorithm, it's time to make some predictions. To do so, we will use our test data and see how accurately our algorithm predicts the percentage score.

In [12]:

```
y_pred = regressor.predict(X_test)
```

Compare the actual output values for X_test with the predicted values as below,

In [13]:

```
df = pd.DataFrame({'Actual': y_test, 'Predicted': y_pred})
df
```

Out[13]:

	Actual	Predicted
0	20	16.884145
1	27	33.732261
2	69	75.357018
3	30	26.794801
4	62	60.491033

Evaluating the Algorithm

The final step is to evaluate the performance of algorithm. This step is particularly important to compare how well different algorithms perform on a particular dataset. For regression algorithms, three evaluation metrics are commonly used:

Mean Absolute Error (MAE) is the mean of the absolute value of the errors. It is calculated as:

$$\frac{1}{n}\sum_{i=1}^{n}|Actual - Predicted|$$

Mean Squared Error (MSE) is the mean of the squared errors and is calculated as:

$$\frac{1}{n}\sum_{i=1}^{n}|Actual - Predicted|^2$$

Root Mean Squared Error (RMSE) is the square root of the mean of the squared errors:

$$\sqrt{\frac{1}{n}\sum_{i=1}^{n}|Actual - Predicted|^2}$$

we don't have to perform these calculations manually. The Scikit-Learn library comes with pre-built functions that can be used to find out these values for us.

In [14]:

```
from sklearn import metrics
print('Mean Absolute Error:', metrics.mean_absolute_error(y_test, y_pred))
print('Mean Squared Error:', metrics.mean_squared_error(y_test, y_pred))
print('Root Mean Squared Error:', np.sqrt(metrics.mean_squared_error(y_test, y_pred)))
```

```
Mean Absolute Error: 4.183859899002975
Mean Squared Error: 21.5987693072174
Root Mean Squared Error: 4.6474476121003665
```

In [ ]:

```

```