Simple Linear Regression

In this example we will consider sales based on 'TV' marketing budget.

In this notebook, we'll build a linear regression model to predict 'Sales' using 'TV' as the predictor variable.

Understanding the Data

Let's start with the following steps:

1. Importing data using the pandas library
2. Understanding the structure of the data

In [2]:
```
import pandas as pd
```

In [3]:
```
!pip install matplotlib
```

```
Requirement already satisfied: matplotlib in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (3.9.1)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (1.2.1)
Requirement already satisfied: cycler>=0.10 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (4.53.1)
Requirement already satisfied: kiwisolver>=1.3.1 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (1.4.5)
Requirement already satisfied: numpy>=1.23 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (2.0.0)
Requirement already satisfied: packaging>=20.0 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (24.1)
Requirement already satisfied: pillow>=8 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (3.1.2)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
[notice] A new release of pip is available: 23.2.1 -> 24.1.2
[notice] To update, run: C:\Users\PC-Udaya\AppData\Local\Programs\Python\Python312\python.exe -m pip install --upgrade pip
```

In [4]:
```
import matplotlib.pyplot as plt
```

In [5]:
```
pip install scikit-learn
```

```
Requirement already satisfied: scikit-learn in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-p
ackages (1.5.1)
Requirement already satisfied: numpy>=1.19.5 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-
packages (from scikit-learn) (2.0.0)
Requirement already satisfied: scipy>=1.6.0 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-p
ackages (from scikit-learn) (1.14.0)
Requirement already satisfied: joblib>=1.2.0 in c:\users\pc-udaya\appdata\local\programs\python\python312\lib\site-
packages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in c:\users\pc-udaya\appdata\local\programs\python\python312\li
b\site-packages (from scikit-learn) (3.5.0)
Note: you may need to restart the kernel to use updated packages.
[notice] A new release of pip is available: 23.2.1 -> 24.1.2
[notice] To update, run: C:\Users\PC-Udaya\AppData\Local\Programs\Python\Python312\python.exe -m pip install --upgr
ade pip
```

Now, let's check the structure of the advertising dataset.

In [6]:
```
advertising = pd.read_csv('E:\\python project\\New folder\\tvmarketing.csv', encoding='utf-8')
```

In [7]:
```
# Display the first 5 rows
#print(advertising.to_string())
advertising.head()
```

Out[7]:

	TV	Sales
0	230.1	22.1
1	44.5	10.4
2	17.2	9.3
3	151.5	18.5
4	180.8	12.9

In [8]:
```
# Display the last 5 rows
advertising.tail()
```

Out[8]:

	TV	Sales
195	38.2	7.6
196	94.2	9.7
197	177.0	12.8
198	283.6	25.5
199	232.1	13.4

In [9]:
```
# Let's check the columns
advertising.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   TV      200 non-null    float64
 1   Sales   200 non-null    float64
dtypes: float64(2)
memory usage: 3.3 KB
```

In [10]:
```
# Check the shape of the DataFrame (rows, columns)
advertising.shape
```

Out[10]:
```
(200, 2)
```

In [11]:
```
# Let's look at some statistical information about the dataframe.
advertising.describe()
```

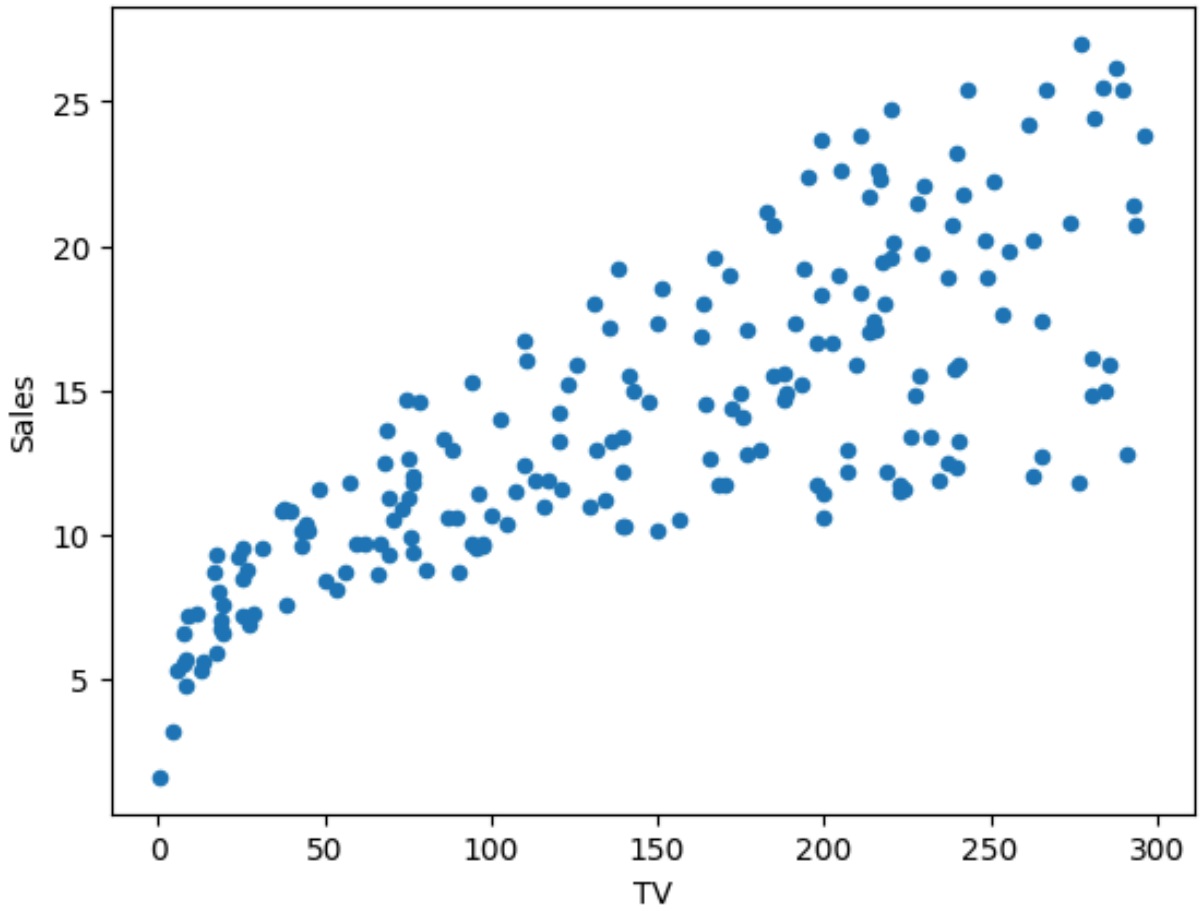
Out[11]:

	TV	Sales
count	200.000000	200.000000
mean	147.042500	14.022500
std	85.854236	5.217457
min	0.700000	1.600000
25%	74.375000	10.375000
50%	149.750000	12.900000
75%	218.825000	17.400000
max	296.400000	27.000000

Visualising Data Using Plot

In [12]:
```
# Visualise the relationship between the features and the response using scatterplots
advertising.plot(x='TV',y='Sales',kind='scatter')
```

Out[12]:
```
<Axes: xlabel='TV', ylabel='Sales'>
```



Perfroming Simple Linear Regression

Equation of linear regression

$y = c + m_1x_1 + m_2x_2 + ... + m_nx_n$

- y is the response
- c is the intercept
- m_1 is the coefficient for the first feature

- m_n is the coefficient for the nth feature

In our case:

$y = c + m_1 \times TV$

The m values are called the model **coefficients** or **model parameters**.

Generic Steps in Model Building using `sklearn`

Before you read further, it is good to understand the generic structure of modeling using the scikit-learn library. Broadly, the steps to build any model can be divided as follows:

Preparing X and y

- The scikit-learn library expects X (feature variable) and y (response variable) to be NumPy arrays.
- However, X can be a dataframe as Pandas is built over NumPy.

In [23]:
```
# Putting feature variable to X
X= advertising[['TV']]

# Print the first 5 rows
X.head()
```

Out[23]:

	TV
0	230.1
1	44.5
2	17.2
3	151.5
4	180.8

In [14]:
```
# Putting response variable to y
y = advertising['Sales']

# Print the first 5 rows
y.head()
```

Out[14]:
```
0    22.1
1    10.4
2     9.3
3    18.5
4    12.9
Name: Sales, dtype: float64
```

Splitting Data into Training and Testing Sets

In [24]:
```
#random_state is the seed used by the random number generator, it can be any integer.

from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size=0.7 , random_state=42)
```

In [25]:
```
print(X_train.shape)
print(y_train.shape)
```

```
print(X_test.shape)
print(y_test.shape)
```

```
(140, 1)
(140,)
(60, 1)
(60,)
```

Performing Linear Regression

In [26]:
```
# import LinearRegression from sklearn
from sklearn.linear_model import LinearRegression

# Representing LinearRegression as lr(Creating LinearRegression Object)
lr = LinearRegression()

# Fit the model using lr.fit()
lr.fit(X_train,y_train)
```

Out[26]:
```
LinearRegression()
```

Coefficients Calculation

In [27]:
```
# Print the intercept and coefficients
print(lr.intercept_)
print(lr.coef_)
```

```
7.239459830751138
[0.0464078]
```

Predictions

In [44]:
```
# Making predictions on the set
y_pred = lr.predict(X_test)
```

In [45]:
```
print(lr.intercept_)
print(lr.coef_)
```

```
7.239459830751138
[0.0464078]
```

In [46]:
```
type(y_pred)
```

Out[46]: numpy.ndarray

In [47]:
```
y_pred.shape
```

Out[47]: (60,)

Computing RMSE and R^2 Values

RMSE is the standard deviation of the errors which occur when a prediction is made on a dataset. This is the same as MSE (Mean Squared Error) but the root of the value is considered while determining the accuracy of the model

In [34]:
```
y_test.shape
```

Out[34]: (60,)

In [49]:
```
assert len(y_test) == len(y_pred), "y_test and y_pred must be the same length"
```

In [48]:
```
# Actual vs Predicted
import matplotlib.pyplot as plt
c = [i for i in range(1,61,1)]         # generating index
fig = plt.figure()
plt.plot(c,y_test, color="blue", linewidth=2, linestyle="-")
plt.plot(c,y_pred, color="red",  linewidth=2, linestyle="-")
```

```
fig.suptitle('Actual and Predicted', fontsize=20)              # Plot heading
plt.xlabel('Index', fontsize=18)                               # X-label
plt.ylabel('Sales', fontsize=16)                           # Y-label
```

Out[48]: Text(0, 0.5, 'Sales')