Overfitting

(better with training data, worst with testing data)

Sourcing the data

In [2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

In [3]:
```
ad = pd.read_csv('Advertising.csv')
```

In [4]:
```
ad
```

Out[4]:

	Unnamed: 0	TV	Radio	Newspaper	Sales
0	1	230.1	37.8	69.2	22.1
1	2	44.5	39.3	45.1	10.4
2	3	17.2	45.9	69.3	9.3
3	4	151.5	41.3	58.5	18.5
4	5	180.8	10.8	58.4	12.9
...	...	...	...	...	...
195	196	38.2	3.7	13.8	7.6
196	197	94.2	4.9	8.1	9.7
197	198	177.0	9.3	6.4	12.8
198	199	283.6	42.0	66.2	25.5
199	200	232.1	8.6	8.7	13.4

200 rows × 5 columns

Preprocessing

In [6]:
```
ad = ad.drop(['Unnamed: 0'], axis = 1)
ad
```

Out[6]:

	TV	Radio	Newspaper	Sales
0	230.1	37.8	69.2	22.1
1	44.5	39.3	45.1	10.4
2	17.2	45.9	69.3	9.3
3	151.5	41.3	58.5	18.5
4	180.8	10.8	58.4	12.9
...	...	...	...	...
195	38.2	3.7	13.8	7.6
196	94.2	4.9	8.1	9.7
197	177.0	9.3	6.4	12.8
198	283.6	42.0	66.2	25.5
199	232.1	8.6	8.7	13.4

200 rows × 4 columns

In [7]:
```
# Target

y = ad['Sales']
y
```

Out[7]:
```
0      22.1
1      10.4
2       9.3
3      18.5
4      12.9
       ...
195     7.6
196     9.7
197    12.8
198    25.5
199    13.4
Name: Sales, Length: 200, dtype: float64
```

In [11]:
```
X = ad.drop(['Sales'], axis = 1)
X
```

Out[11]:

	TV	Radio	Newspaper
0	230.1	37.8	69.2
1	44.5	39.3	45.1
2	17.2	45.9	69.3
3	151.5	41.3	58.5
4	180.8	10.8	58.4
...	...	...	...
195	38.2	3.7	13.8
196	94.2	4.9	8.1
197	177.0	9.3	6.4
198	283.6	42.0	66.2
199	232.1	8.6	8.7

200 rows × 3 columns

Standardization of features

In [14]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X) # conversion into standard scaler
```

In [15]:
```
X_scaled
```

Out[15]:
```
array([[ 9.69852266e-01,  9.81522472e-01,  1.77894547e+00],
       [-1.19737623e+00,  1.08280781e+00,  6.69578760e-01],
       [-1.51615499e+00,  1.52846331e+00,  1.78354865e+00],
       [ 5.20496822e-02,  1.21785493e+00,  1.28640506e+00],
       [ 3.94182198e-01, -8.41613655e-01,  1.28180188e+00],
       [-1.61540845e+00,  1.73103399e+00,  2.04592999e+00],
       [-1.04557682e+00,  6.43904671e-01, -3.24708413e-01],
       [-3.13436589e-01, -2.47406325e-01, -8.72486994e-01],
       [-1.61657614e+00, -1.42906863e+00, -1.36042422e+00],
       [ 6.16042873e-01, -1.39530685e+00, -4.30581584e-01],
       [-9.45155670e-01, -1.17923146e+00, -2.92486143e-01],
       [ 7.90028350e-01,  4.96973404e-02, -1.22232878e+00],
       [-1.43908760e+00,  7.99208859e-01,  1.62704048e+00],
       [-5.78501712e-01, -1.05768905e+00, -1.07502697e+00],
       [ 6.66253447e-01,  6.50657027e-01,  7.11007392e-01],
       [ 5.64664612e-01,  1.65000572e+00,  1.02862691e+00],
       [-9.25304978e-01,  9.00494200e-01,  3.84117072e+00],
       [ 1.56887609e+00,  1.10306488e+00,  1.16211917e+00],
       [-9.08957349e-01, -1.86635121e-01, -5.64073843e-01],
```

Splitting to train and test

In [16]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X_scaled, y, test_size = 0.2, random_state = 10)
```

In [20]:
```
X_train.shape, X_test.shape, y_test.shape, y_train.shape
```

Out[20]:
```
((160, 3), (40, 3), (40,), (160,))
```

Model building - LR

In [21]:
```
from sklearn.linear_model import LinearRegression

lr = LinearRegression()

lr.fit(X_train, y_train)
```

Out[21]:
```
LinearRegression()
```

Model Performance

In [25]:
```
from sklearn.metrics import r2_score, mean_squared_error

r2_train = r2_score(y_train, lr.predict(X_train))
r2_test = r2_score(y_test, lr.predict(X_test))

mse_train = mean_squared_error(y_train, lr.predict(X_train))
mse_test = mean_squared_error(y_test, lr.predict(X_test))

print('R2 score - training:', r2_train)
print('R2 score - testing:', r2_test)
print()
print('MSE - training:', mse_train)
print('MSE - testing:', mse_test)
```

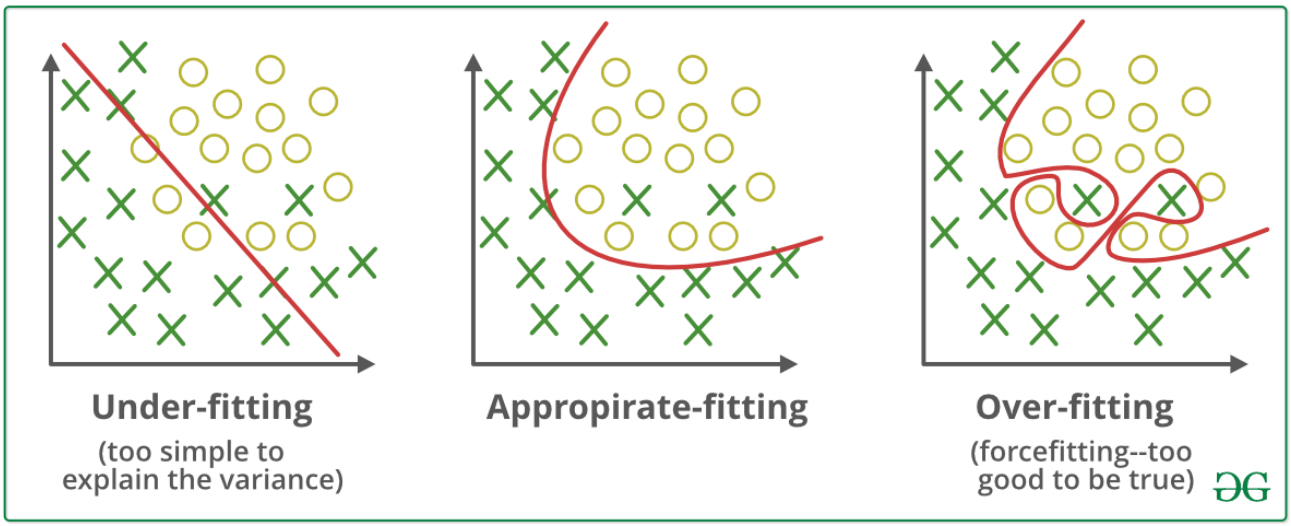
```
R2 score - training: 0.9209087553499528
R2 score - testing: 0.8353672324670594

MSE - training: 1.8585966709492503
MSE - testing: 6.700486756528875
```

Remark This shows there is substantial a difference in the performance of the training and training data(not huge overfitting, but it exists)

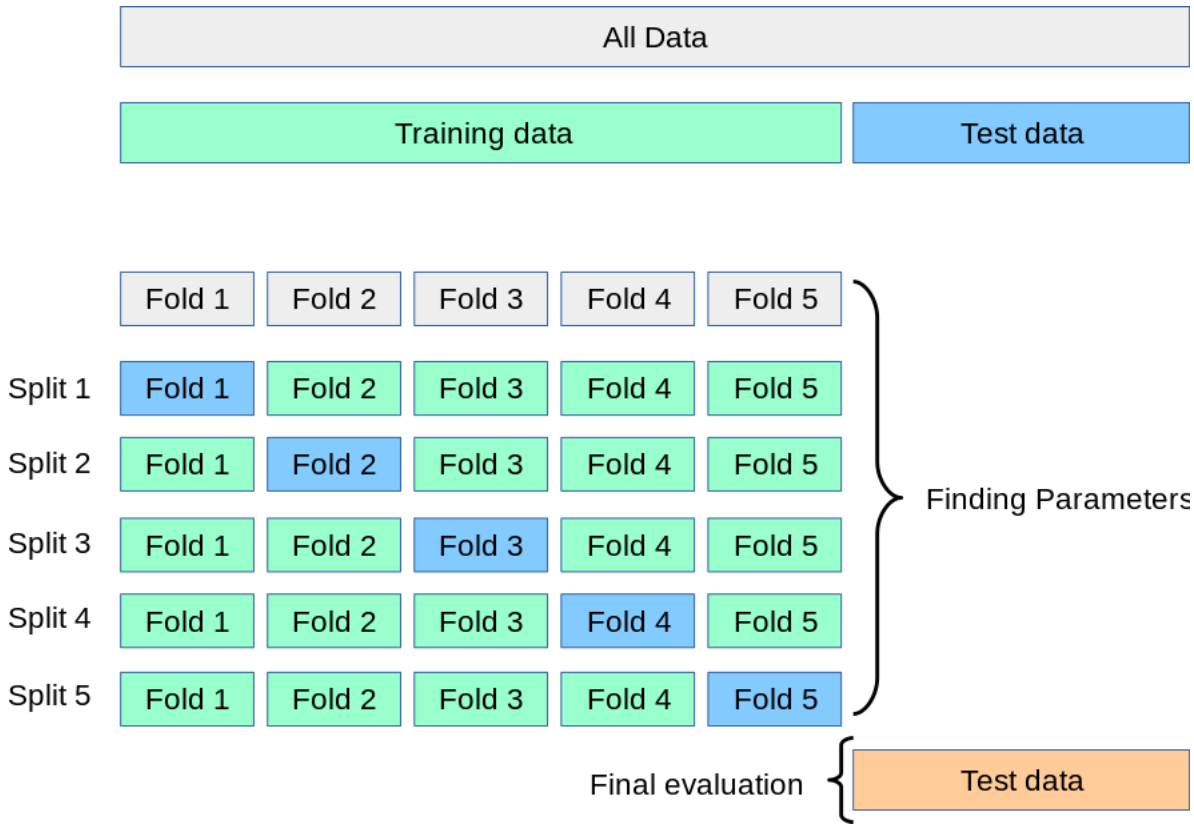
Resolving Overfitting

Cross validation

####



Cross Validation



LR using K-fold cross validation

In [26]:
```
from sklearn.model_selection import cross_val_score, cross_val_predict

lr = LinearRegression()
cv_score = cross_val_score(lr, X_train, y_train, cv = 5) # (model, datax, datay, cv (no. of folds))
print('CV Score:', cv_score)
```

```
CV Score: [0.92009437 0.90119987 0.90916145 0.92654738 0.92166077]
```

In [27]:
```
print('CV Score mean:', cv_score.mean())
```

```
CV Score mean: 0.9157327701186169
```

In [28]:
```
# cv = 10
lr = LinearRegression()
cv_score = cross_val_score(lr, X_train, y_train, cv = 10) # (model, datax, datay, cv (no. of folds))
print('CV Score:', cv_score)
print('CV Score mean:', cv_score.mean())
```

```
CV Score: [0.89460976 0.93950986 0.80333388 0.94414693 0.8591572  0.92865633
 0.93605667 0.91725888 0.89502386 0.94632849]
CV Score mean: 0.9064081863045436
```

k fold validation n = total no. of data points (# of training size)

k = 1-> usual training

k = n -> Leave One Out Cross Validation

k = 2, 3, 4, n-1 -> K-fold Cross Validation

In [29]:
```
# k = 3 is the chosen value of cv

y_pred = cross_val_predict(lr, X_test, y_test, cv = 3)
y_pred
```

Out[29]:
```
array([16.69812691, 13.77294838, 18.68652929, 24.70832629, 20.41825367,
       13.26993187, 14.4217984 , 21.86149324, 20.27040927, 13.38669332,
       24.37495037,  6.65045497, 13.87964762, 19.05256276, 17.9246288 ,
       14.32047367, 20.48140766, 10.11716933, 21.63438514, 21.72363756,
       16.1253366 , 12.0547364 , 22.31567978, 14.98667724, 17.2923942 ,
        7.35500235, 12.98380294,  9.99191968, 22.40667304,  4.87314157,
       11.70341491, 21.0898296 ,  2.14747765,  2.28387402, 18.95228016,
       17.86677142,  5.08108469, 19.67787454,  7.59493555, 14.59240111])
```

In [30]:
```
y_test
```

Out[30]:
```
59     18.4
5       7.2
20     18.0
198    25.5
52     22.6
19     14.6
162    14.9
55     23.7
69     22.3
2       9.3
98     25.4
10      8.6
75      8.7
142    20.1
124    19.7
63     14.0
109    19.8
78      5.3
111    21.8
185    22.6
154    15.6
130     1.6
61     24.2
87     16.0
102    14.8
121     7.0
136     9.5
1      10.4
47     23.2
172     7.6
159    12.9
39     21.5
76      6.9
91      7.3
35     12.8
178    11.8
127     8.8
169    15.0
46     10.6
174    11.5
Name: Sales, dtype: float64
```

Cross validation is a general tool, which can be applied to any ML technique

Regularisation - LR

Lasso

Ridge

Elastic Net

Lasso

In [39]:
```
from sklearn.linear_model import Lasso

lasso = Lasso(alpha = 0.1)
lasso.fit(X_train, y_train)

r2_lasso_train = r2_score(y_train, lasso.predict(X_train))
r2_lasso_test = r2_score(y_test, lasso.predict(X_test))

print('R2 Score: Lasso_train', r2_lasso_train)
print('R2 Score: Lasso_test', r2_lasso_test)

mse_lasso_train = mean_squared_error(y_train, lasso.predict(X_train))
mse_lasso_test = mean_squared_error(y_test, lasso.predict(X_test))

print('MSE: Lasso_train', mse_lasso_train)
print('MSE: Lasso_test', mse_lasso_test)
```

```
R2 Score: Lasso_train 0.9199573974585257
R2 Score: Lasso_test 0.8319851097741227
MSE: Lasso_train 1.8809530090965556
MSE: Lasso_test 6.8381377761440545
```

Ridge

In [40]:
```
from sklearn.linear_model import Ridge

ridge = Ridge(alpha = 0.1)
ridge.fit(X_train, y_train)

r2_ridge_train = r2_score(y_train, ridge.predict(X_train))
r2_ridge_test = r2_score(y_test, ridge.predict(X_test))

print('R2 Score: Ridge_train', r2_ridge_train)
print('R2 Score: Ridge_test', r2_ridge_test)

mse_ridge_train = mean_squared_error(y_train, ridge.predict(X_train))
mse_ridge_test = mean_squared_error(y_test, ridge.predict(X_test))

print('MSE: Ridge_train', mse_ridge_train)
print('MSE: Ridge_test', mse_ridge_test)
```

```
R2 Score: Ridge_train 0.9209083458884119
R2 Score: Ridge_test 0.8352944314323737
MSE: Ridge_train 1.8586062930491445
MSE: Ridge_test 6.70344972906516
```

Elastic Net

In [43]:
```
from sklearn.linear_model import ElasticNet

enet = ElasticNet()
enet.fit(X_train, y_train)

r2_enet_train = r2_score(y_train, enet.predict(X_train))
r2_enet_test = r2_score(y_test, enet.predict(X_test))

print('R2 Score: Enet_train', r2_enet_train)
print('R2 Score: Enet_test', r2_enet_test)

mse_enet_train = mean_squared_error(y_train, enet.predict(X_train))
mse_enet_test = mean_squared_error(y_test, enet.predict(X_test))

print('MSE: Enet_train', mse_enet_train)
print('MSE: Enet_test', mse_enet_test)
```

```
R2 Score: Enet_train 0.7431344504513608
R2 Score: Enet_test 0.643247265959083
MSE: Enet_train 6.036185893710871
MSE: Enet_test 14.519691344667118
```

In [ ]: