```
import pandas as pd
```

```
data = pd.read_csv('/content/Churn_Modelling.csv')
data
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Ten
0	1	15634602	Hargrave	619	France	Female	42	
1	2	15647311	Hill	608	Spain	Female	41	
2	3	15619304	Onio	502	France	Female	42	
3	4	15701354	Boni	699	France	Female	39	
4	5	15737888	Mitchell	850	Spain	Female	43	
...	...	...	...	...	...	...	...	
9995	9996	15606229	Obijiaku	771	France	Male	39	
9996	9997	15569892	Johnstone	516	France	Male	35	
9997	9998	15584532	Liu	709	France	Female	36	
9998	9999	15682355	Sabbatini	772	Germany	Male	42	
9999	10000	15628319	Walker	792	France	Female	28	

10000 rows × 14 columns

```
data.head
```

```
<bound method NDFrame.head of       RowNumber  CustomerId    Surname  
CreditScore Geography  Gender  Age  \
0             1    15634602   Hargrave          619    France  Female   42
1             2    15647311       Hill          608     Spain  Female   41
2             3    15619304       Onio          502    France  Female   42
3             4    15701354       Boni          699    France  Female   39
4             5    15737888   Mitchell          850     Spain  Female   43
...         ...         ...        ...          ...       ...     ...  ...
9995       9996    15606229   Obijiaku          771    France    Male   39
9996       9997    15569892  Johnstone          516    France    Male   35
9997       9998    15584532        Liu          709    France  Female   36
9998       9999    15682355  Sabbatini          772   Germany    Male   42
9999      10000    15628319     Walker          792    France  Female   28

      Tenure    Balance  NumOfProducts  HasCrCard  IsActiveMember  \
0          2       0.00              1          1               1
1          1   83807.86              1          0               1
2          8  159660.80              3          1               0
3          1       0.00              2          0               0
4          2  125510.82              1          1               1
...      ...        ...            ...        ...             ...
9995       5       0.00              2          1               0
```

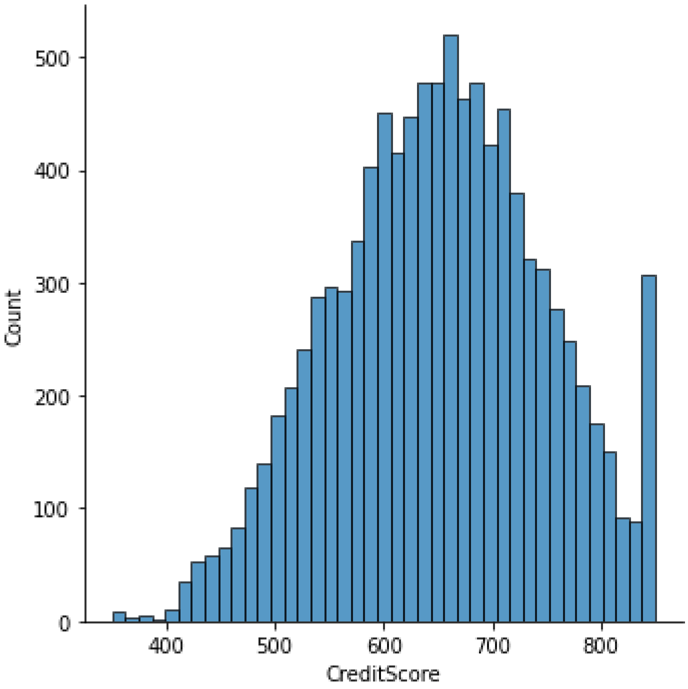
```
9996      10   57369.61              1           1                1
9997       7       0.00              1           0                1
9998       3   75075.31              2           1                0
9999       4  130142.79              1           1                0

      EstimatedSalary  Exited
0           101348.88       1
1           112542.58       0
2           113931.57       1
3            93826.63       0
4            79084.10       0
...               ...     ...
9995         96270.64       0
9996        101699.77       0
9997         42085.58       1
9998         92888.52       1
9999         38190.78       0

[10000 rows x 14 columns]>
```

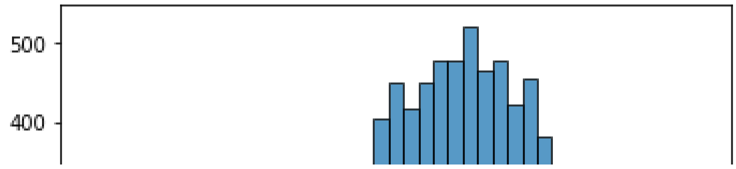
```
import seaborn as sns
sns.displot(data['CreditScore'])
```

```
<seaborn.axisgrid.FacetGrid at 0x7feb9295a050>
```



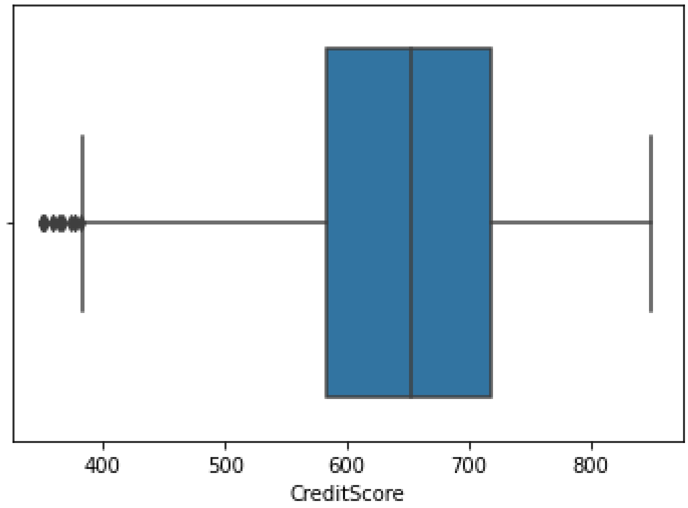
```
sns.histplot(data['CreditScore'])
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb83d0aed0>
```



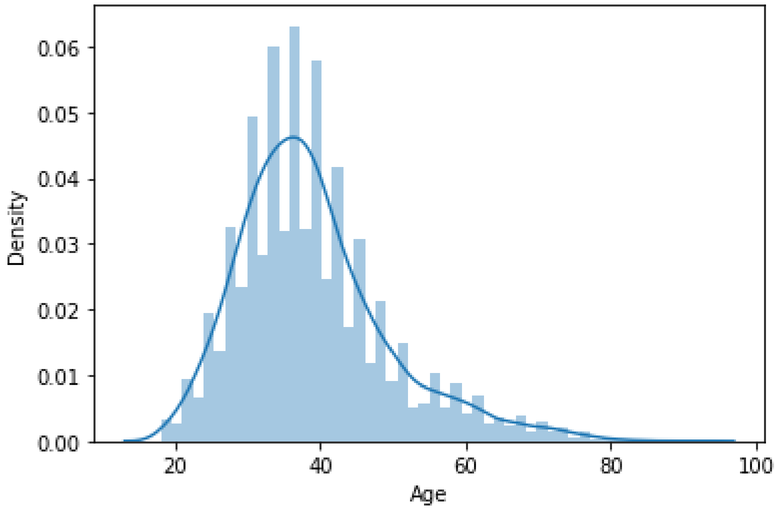
```
sns.boxplot(x = data['CreditScore'])
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb83733790>
```



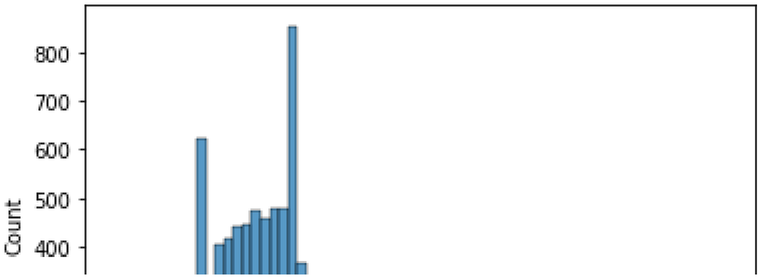
```
sns.distplot(data['Age'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/distributions.py:2619: FutureWa
  warnings.warn(msg, FutureWarning)
<matplotlib.axes._subplots.AxesSubplot at 0x7feb836d7c10>
```



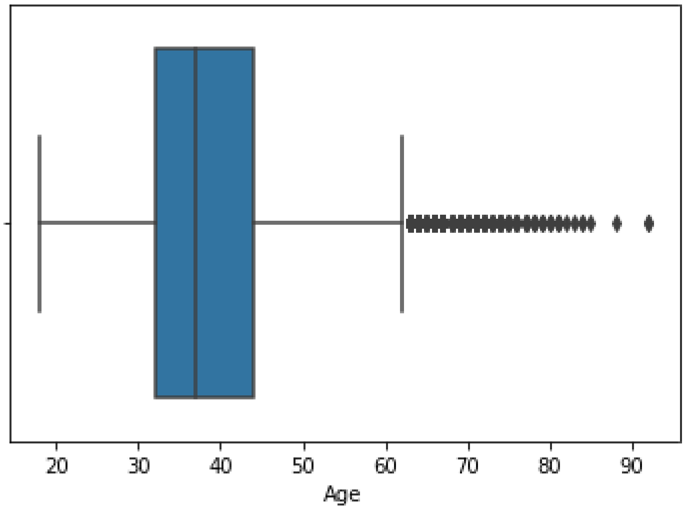
```
sns.histplot(data['Age'])
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb8369ed10>
```



```
sns.boxplot(data['Age'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb8342f3d0>
```

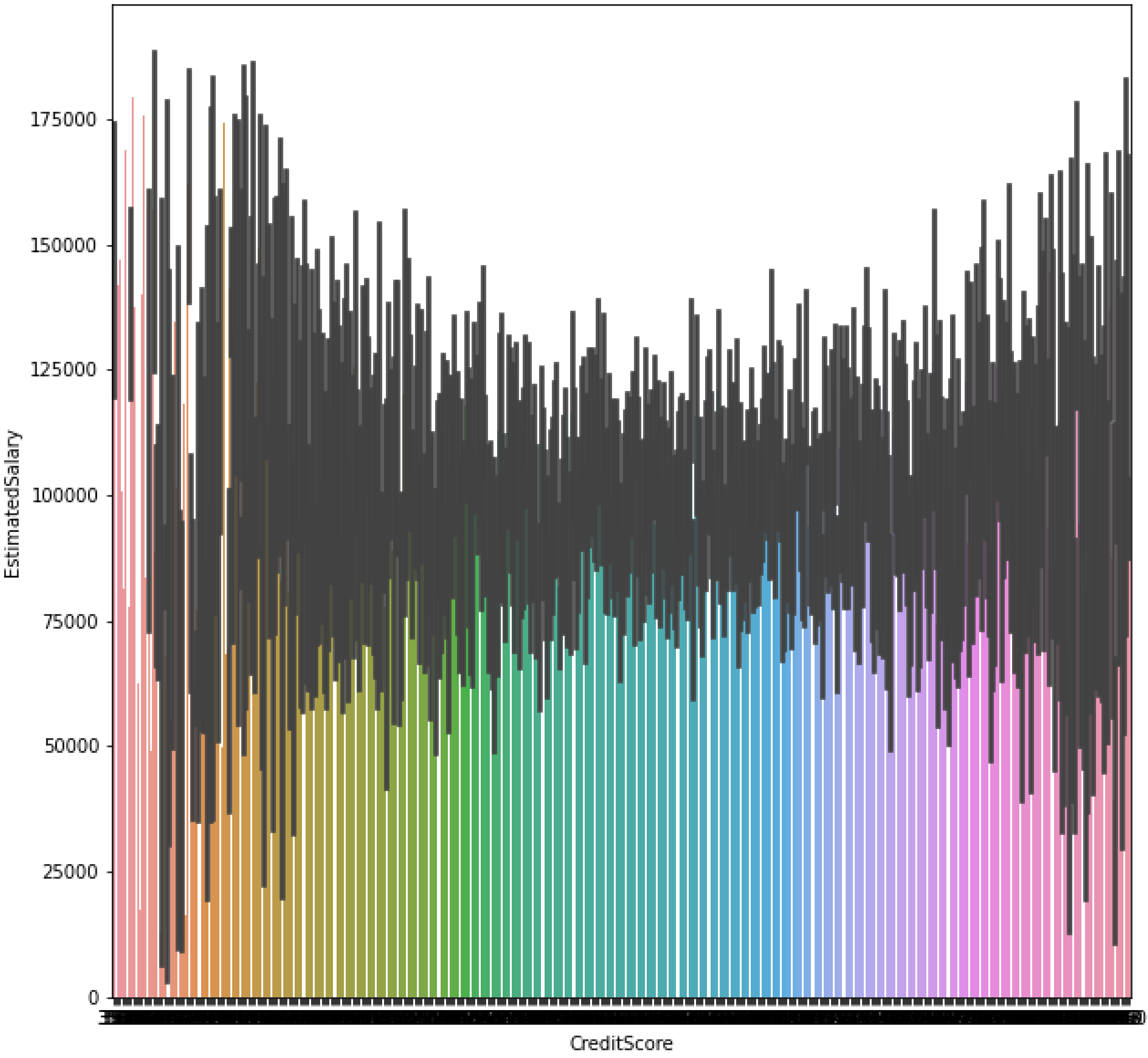


```
import matplotlib.pyplot as plt
plt.figure(figsize=(7,7))
sns.lineplot(data = data, x = 'Tenure', y = 'CreditScore')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb83414790>
```

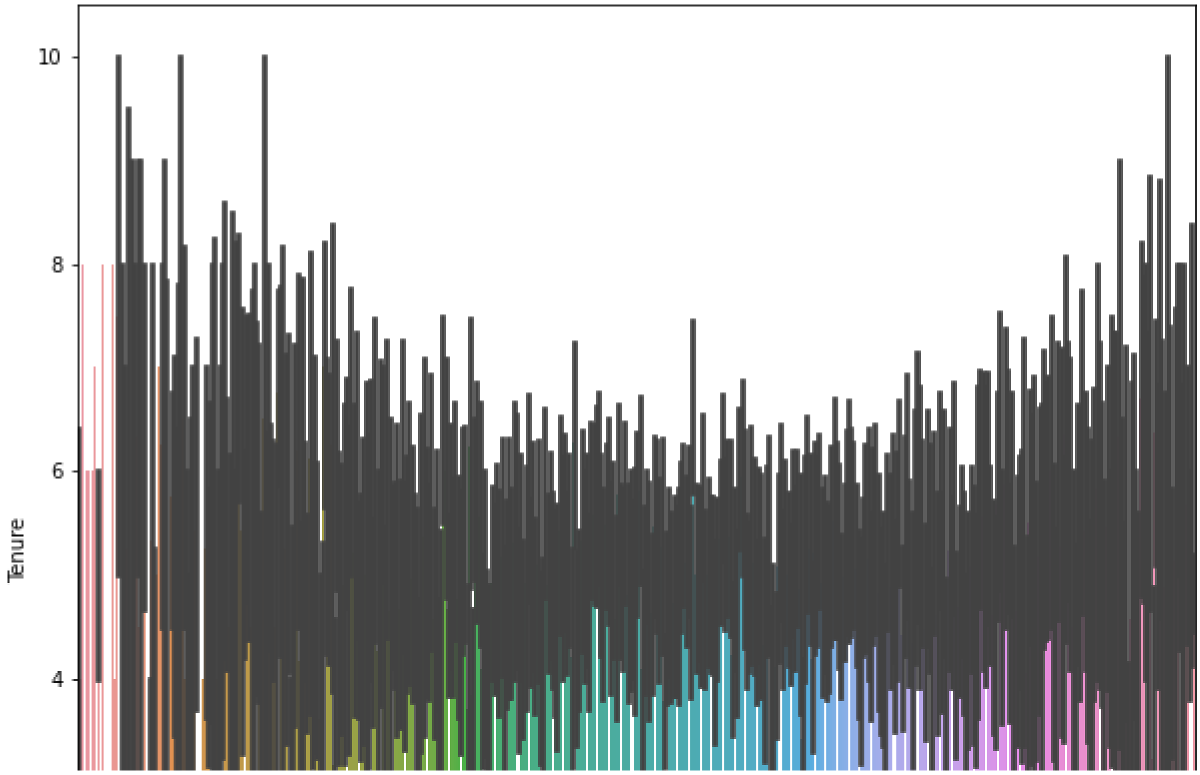
```
plt.figure(figsize=(10,10))
sns.barplot(data = data, x = 'CreditScore', y ='EstimatedSalary')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb833858d0>
```



```
plt.figure(figsize=(10,10))
sns.barplot(data = data, x = 'CreditScore', y = 'Tenure')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb86e6ac90>
```



```
plt.figure(figsize=(10,10))
sns.lineplot(data['Age'], data['EstimatedSalary'])
```

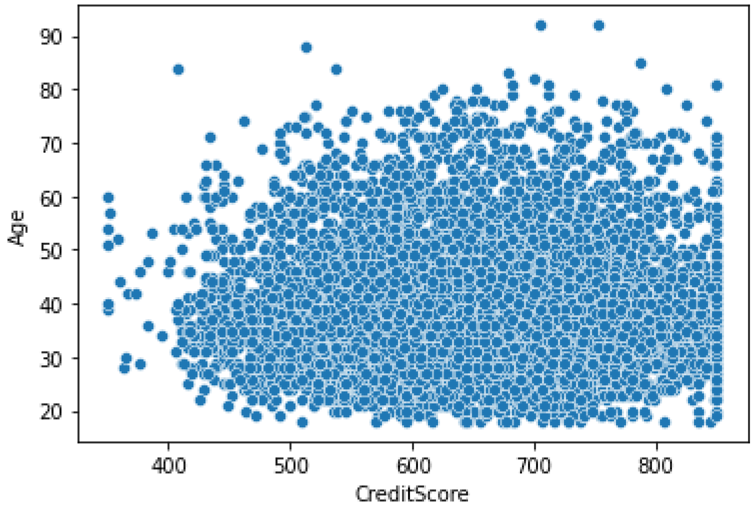
```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnin
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb81145210>
```

```
plt.figure(figsize=(17,17))
sns.barplot(data['Age'], data['EstimatedSalary'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb812da890>
```

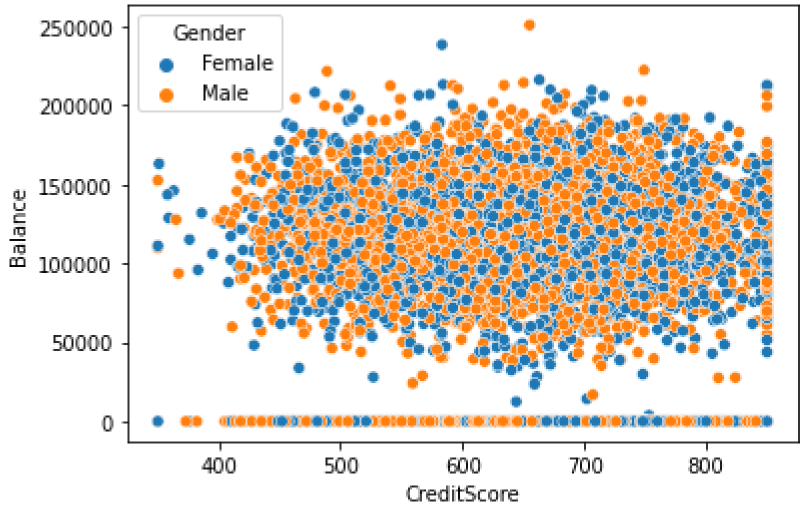
```
sns.scatterplot(data = data, x = 'CreditScore', y = 'Age')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb810490d0>
```



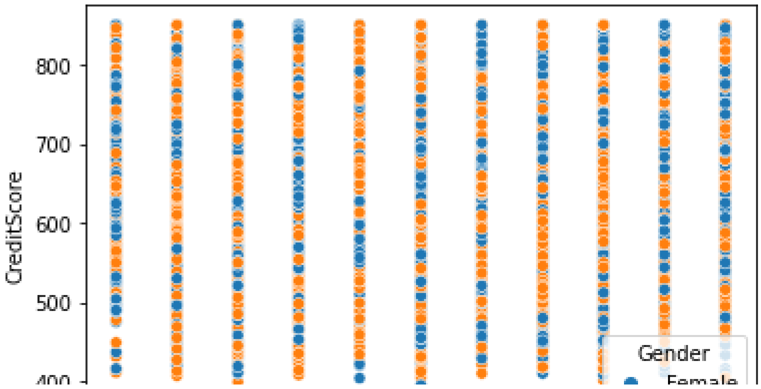
```
sns.scatterplot(data = data, x = 'CreditScore', y = 'Balance', hue = 'Gender')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7feb7f54f990>
```



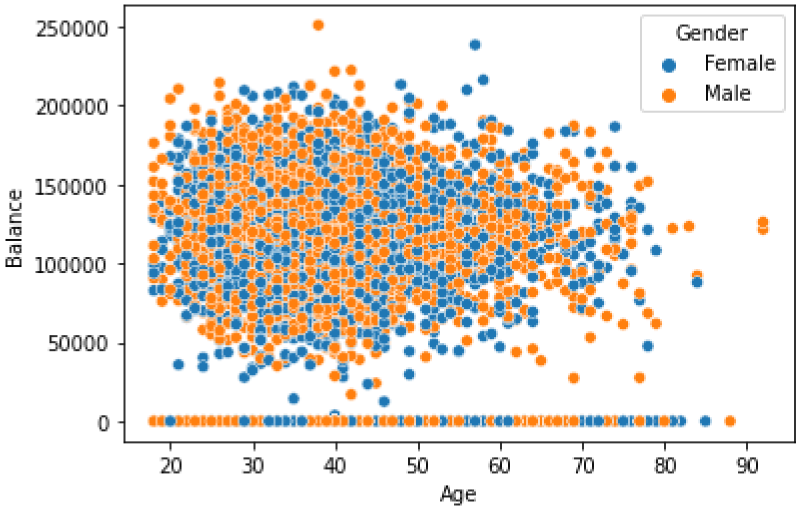
```
sns.scatterplot(data['Tenure'], data['CreditScore'], hue = data['Gender'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb7f4ceb50>
```



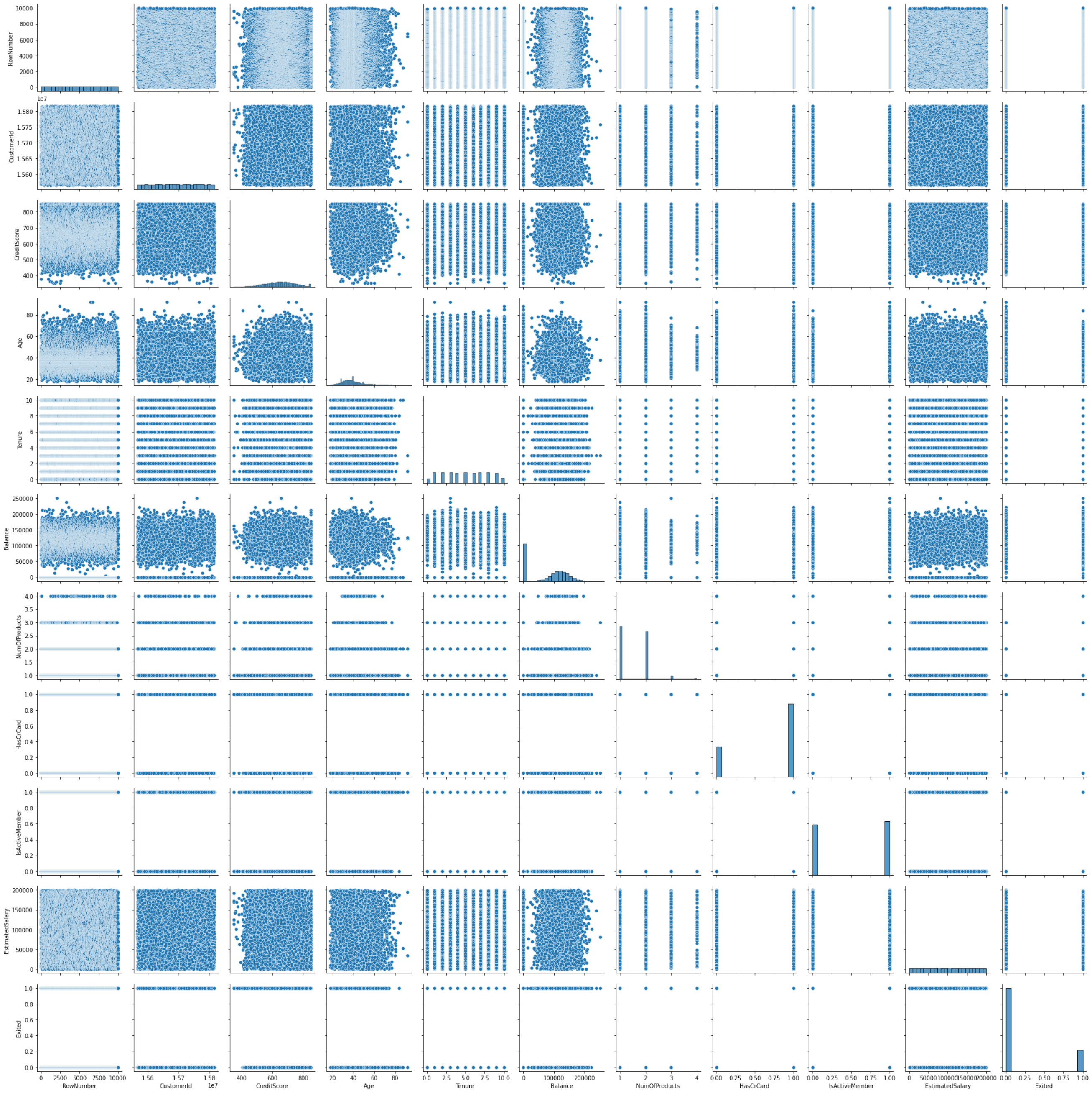
```
sns.scatterplot(data['Age'], data['Balance'], hue = data['Gender'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb7f48bc90>
```



```
sns.pairplot(data)
```

```
<seaborn.axisgrid.PairGrid at 0x7feb7f3503d0>
```



```
data.mean(numeric_only = True)
```

```
RowNumber          5.000500e+03
CustomerId         1.569094e+07
CreditScore        6.505288e+02
Age                3.892180e+01
Tenure             5.012800e+00
Balance            7.648589e+04
NumOfProducts      1.530200e+00
HasCrCard          7.055000e-01
IsActiveMember     5.151000e-01
EstimatedSalary    1.000902e+05
Exited             2.037000e-01
dtype: float64
```

```
data.median(numeric_only = True)
```

```
RowNumber          5.000500e+03
CustomerId         1.569074e+07
CreditScore        6.520000e+02
Age                3.700000e+01
Tenure             5.000000e+00
Balance            9.719854e+04
NumOfProducts      1.000000e+00
HasCrCard          1.000000e+00
IsActiveMember     1.000000e+00
EstimatedSalary    1.001939e+05
Exited             0.000000e+00
dtype: float64
```

```
data['CreditScore'].mode()
```

```
0    850
dtype: int64
```

```
data['EstimatedSalary'].mode()
```

```
0    24924.92
dtype: float64
```

```
data['HasCrCard'].unique()
```

```
array([1, 0])
```

```
data['Tenure'].unique()
```

```
array([ 2,  1,  8,  7,  4,  6,  3, 10,  5,  9,  0])
```

```
data.std(numeric_only=True)
```

```
RowNumber           2886.895680
CustomerId         71936.186123
CreditScore           96.653299
Age                   10.487806
```

```
    Tenure                2.892174
    Balance           62397.405202
    NumOfProducts         0.581654
    HasCrCard             0.455840
    IsActiveMember        0.499797
    EstimatedSalary   57510.492818
    Exited                0.402769
    dtype: float64
```

```
data.describe()
```

	RowNumber	CustomerId	CreditScore	Age	Tenure	Balar
count	10000.00000	1.000000e+04	10000.000000	10000.000000	10000.000000	10000.000(
mean	5000.50000	1.569094e+07	650.528800	38.921800	5.012800	76485.8892
std	2886.89568	7.193619e+04	96.653299	10.487806	2.892174	62397.4052
min	1.00000	1.556570e+07	350.000000	18.000000	0.000000	0.000(
25%	2500.75000	1.562853e+07	584.000000	32.000000	3.000000	0.000(
50%	5000.50000	1.569074e+07	652.000000	37.000000	5.000000	97198.540(
75%	7500.25000	1.575323e+07	718.000000	44.000000	7.000000	127644.240(
max	10000.00000	1.581569e+07	850.000000	92.000000	10.000000	250898.090(

```
data.isnull().any()
```

```
    RowNumber          False
    CustomerId         False
    Surname            False
    CreditScore        False
    Geography          False
    Gender             False
    Age                False
    Tenure             False
    Balance            False
    NumOfProducts      False
    HasCrCard          False
    IsActiveMember     False
    EstimatedSalary    False
    Exited             False
    dtype: bool
```

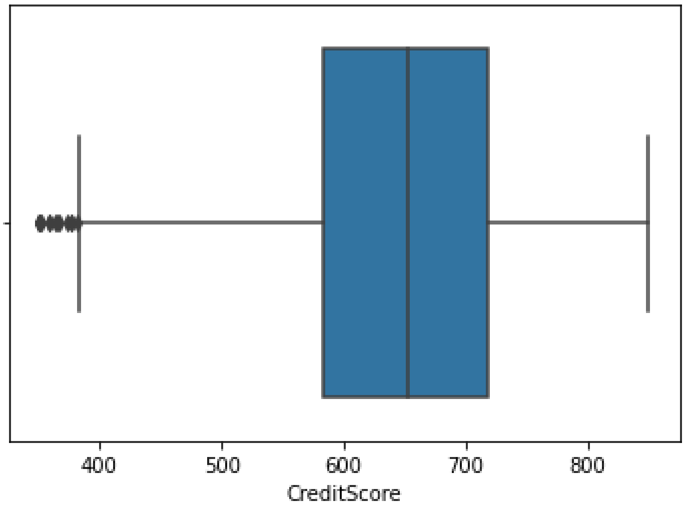
```
data.isnull().sum()
```

```
    RowNumber          0
    CustomerId         0
    Surname            0
    CreditScore        0
    Geography          0
    Gender             0
    Age                0
    Tenure             0
    Balance            0
```

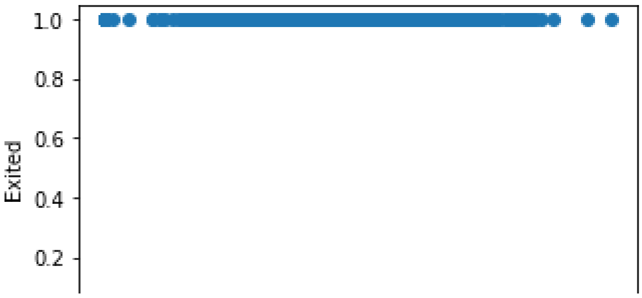
```
NumOfProducts      0
HasCrCard          0
IsActiveMember     0
EstimatedSalary    0
Exited             0
dtype: int64
```

```
sns.boxplot(data['CreditScore']) #Outlier detection - box plot
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb7d935310>
```



```
fig, ax = plt.subplots(figsize = (5,3)) #Outlier detection - Scatter plot
ax.scatter(data['Balance'], data['Exited'])
# x-axis label
ax.set_xlabel('Balance')
# y-axis label
ax.set_ylabel('Exited')
plt.show()
sns.boxplot(x=data['Balance'])
```



```
from scipy import stats #Outlier detection – zscore
import numpy as np
zscore = np.abs(stats.zscore(data['CreditScore']))
print(zscore)
print('No. of Outliers : ', np.shape(np.where(zscore>3)))
```

```
0       0.326221
1       0.440036
2       1.536794
3       0.501521
4       2.063884
          ...
9995    1.246488
9996    1.391939
9997    0.604988
9998    1.256835
9999    1.463771
Name: CreditScore, Length: 10000, dtype: float64
No. of Outliers :  (1, 8)
```

```
q = data.quantile([0.75,0.25])
q
```

	RowNumber	CustomerId	CreditScore	Age	Tenure	Balance	NumOfProducts
0.75	7500.25	15753233.75	718.0	44.0	7.0	127644.24	2.0
0.25	2500.75	15628528.25	584.0	32.0	3.0	0.00	1.0

```
iqr = q.iloc[0] - q.iloc[1]
iqr
```

```
RowNumber            4999.5000
CustomerId         124705.5000
CreditScore           134.0000
Age                    12.0000
Tenure                  4.0000
Balance            127644.2400
NumOfProducts           1.0000
HasCrCard               1.0000
IsActiveMember          1.0000
EstimatedSalary     98386.1375
Exited                  0.0000
dtype: float64
```

```
u = q.iloc[0] + (1.5*iqr)
```

```
u
```

```
    RowNumber          1.499950e+04
    CustomerId         1.594029e+07
    CreditScore        9.190000e+02
    Age                6.200000e+01
    Tenure             1.300000e+01
    Balance            3.191106e+05
    NumOfProducts      3.500000e+00
    HasCrCard          2.500000e+00
    IsActiveMember     2.500000e+00
    EstimatedSalary    2.969675e+05
    Exited             0.000000e+00
    dtype: float64
```

```
l = q.iloc[1] - (1.5*iqr)
l
```

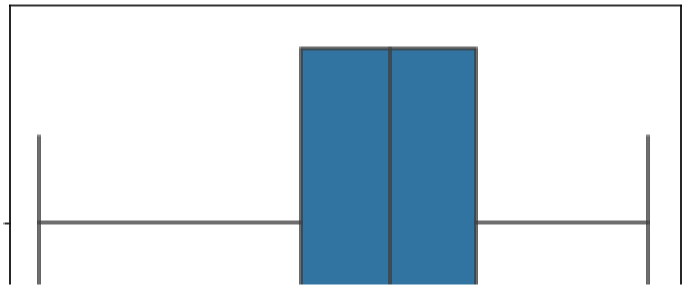
```
    RowNumber         -4.998500e+03
    CustomerId         1.544147e+07
    CreditScore        3.830000e+02
    Age                1.400000e+01
    Tenure            -3.000000e+00
    Balance           -1.914664e+05
    NumOfProducts     -5.000000e-01
    HasCrCard         -1.500000e+00
    IsActiveMember    -1.500000e+00
    EstimatedSalary   -9.657710e+04
    Exited             0.000000e+00
    dtype: float64
```

```
Q1 = data['EstimatedSalary'].quantile(0.25) #Outlier detection - IQR
Q3 = data['EstimatedSalary'].quantile(0.75)
iqr = Q3 - Q1
print(iqr)
upper=Q3 + 1.5 * iqr
lower=Q1 - 1.5 * iqr
count = np.size(np.where(data['EstimatedSalary'] >upper))
count = count + np.size(np.where(data['EstimatedSalary'] <lower))
print('No. of outliers : ', count)
```

```
    98386.1375
    No. of outliers :  0
```

```
data['CreditScore'] = np.where(np.logical_or(data['CreditScore']>900, data['CreditS
sns.boxplot(data['CreditScore'])
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarnir
  FutureWarning
<matplotlib.axes._subplots.AxesSubplot at 0x7feb81064cd0>
```



```
upper = data.Age.mean() + (3 * data.Age.std()) #Outlier detection - 3 sigma
lower = data.Age.mean() - (3 * data.Age.std())
columns = data[ ( data['Age'] > upper ) | ( data['Age']<lower ) ]
print('Upper range : ', upper)
print('Lower range : ', lower)
print('No. of Outliers : ', len(columns))
```

```
Upper range :  70.38521935511383
Lower range :  7.458380644886169
No. of Outliers :  133
```

```
columns = ['EstimatedSalary', 'Age', 'Balance', 'NumOfProducts', 'Tenure', 'CreditS
#After outlier removal
for i in columns:
 Q1 = data[i].quantile(0.25)
 Q3 = data[i].quantile(0.75)
 iqr = Q3 - Q1
 upper=Q3 + 1.5 * iqr
 lower=Q1 - 1.5 * iqr
 count = np.size(np.where(data[i] >upper))
 count = count + np.size(np.where(data[i] <lower))
 print('No. of outliers in ', i, ' : ', count)
```

```
No. of outliers in  EstimatedSalary  :  0
No. of outliers in  Age  :  359
No. of outliers in  Balance  :  0
No. of outliers in  NumOfProducts  :  60
No. of outliers in  Tenure  :  0
No. of outliers in  CreditScore  :  0
```

```
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
le = LabelEncoder()
oneh = OneHotEncoder()
data['Surname'] = le.fit_transform(data['Surname'])
data['Gender'] = le.fit_transform(data['Gender'])
data['Geography'] = le.fit_transform(data['Geography'])
data.head()
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure
0	1	15634602	1115	619	0	0	42	2
1	2	15647311	1177	608	2	0	41	1
2	3	15619304	2040	502	0	0	42	8
3	4	15701354	289	699	0	0	39	1

```
x = data.iloc[:, 0:13]
x # independent values ( inputs)
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenu
0	1	15634602	1115	619	0	0	42	
1	2	15647311	1177	608	2	0	41	
2	3	15619304	2040	502	0	0	42	
3	4	15701354	289	699	0	0	39	
4	5	15737888	1822	850	2	0	43	
...	...	...	...	...	...	...	...	
9995	9996	15606229	1999	771	0	1	39	
9996	9997	15569892	1336	516	0	1	35	
9997	9998	15584532	1570	709	0	0	36	
9998	9999	15682355	2345	772	1	1	42	
9999	10000	15628319	2751	792	0	0	28	

10000 rows × 13 columns

```
y = data['Exited']
y # dependent values (output)
```

```
0       1
1       0
2       1
3       0
4       0
       ..
9995    0
9996    0
9997    1
9998    1
9999    0
Name: Exited, Length: 10000, dtype: int64
```

```
from sklearn.preprocessing import StandardScaler, MinMaxScaler
sc = StandardScaler()
x_scaled = sc.fit_transform(x)
x_scaled
```

```
    array([[-1.73187761, -0.78321342, -0.46418322, ...,  0.64609167,
             0.97024255,  0.02188649],
           [-1.7315312 , -0.60653412, -0.3909112 , ..., -1.54776799,
             0.97024255,  0.21653375],
           [-1.73118479, -0.99588476,  0.62898807, ...,  0.64609167,
            -1.03067011,  0.2406869 ],
           ...,
           [ 1.73118479, -1.47928179,  0.07353887, ..., -1.54776799,
             0.97024255, -1.00864308],
           [ 1.7315312 , -0.11935577,  0.98943914, ...,  0.64609167,
            -1.03067011, -0.12523071],
           [ 1.73187761, -0.87055909,  1.4692527 , ...,  0.64609167,
            -1.03067011, -1.07636976]])
```

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x_scaled, y, test_size = 0.3, r
```

```
x_train
```

```
    array([[ 0.92889885, -0.79703192, -1.47580983, ...,  0.64609167,
             0.97024255, -0.77021814],
           [ 1.39655257,  0.71431365, -1.58808148, ...,  0.64609167,
            -1.03067011, -1.39576675],
           [-0.4532777 ,  0.96344969, -0.24082173, ..., -1.54776799,
             0.97024255, -1.49965629],
           ...,
           [-0.60119484, -1.62052514, -0.36136603, ...,  0.64609167,
            -1.03067011,  1.41441489],
           [ 1.67853045, -0.37403866,  0.72589622, ...,  0.64609167,
             0.97024255,  0.84614739],
           [-0.78548505, -1.36411841,  1.3829808 , ...,  0.64609167,
            -1.03067011,  0.32630495]])
```

```
x_train.shape
```

```
    (7000, 13)
```

```
x_test
```

```
    array([[ 1.52229946, -1.04525042,  1.39834429, ...,  0.64609167,
             0.97024255,  1.61304597],
           [-1.42080128, -0.50381294, -0.78208925, ...,  0.64609167,
            -1.03067011,  0.49753166],
           [-0.90118604, -0.7932923 ,  0.41271742, ...,  0.64609167,
             0.97024255, -0.4235611 ],
           ...,
           [ 1.49216178, -0.14646448,  0.6868966 , ...,  0.64609167,
             0.97024255,  1.17045451],
           [ 1.1758893 , -1.29228727, -1.38481071, ...,  0.64609167,
             0.97024255, -0.50846777],
           [ 0.08088677, -1.38538833,  1.11707427, ...,  0.64609167,
             0.97024255, -1.15342685]])
```

```
x_test.shape
```

```
(3000, 13)
```

```
y_train
```

```
7681    1
9031    0
3691    0
202     1
5625    0
       ..
9225    0
4859    0
3264    0
9845    0
2732    1
Name: Exited, Length: 7000, dtype: int64
```

```
y_test
```

```
9394    0
898     1
2398    0
5906    0
2343    0
       ..
4004    0
7375    0
9307    0
8394    0
5233    1
Name: Exited, Length: 3000, dtype: int64
```