logistic_regression

November 7, 2024

1 Logistic Regression

1.1 Importing the libraries

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

1.2 Importing the dataset

[ ]:
```
dataset = pd.read_csv('Social_Network_Ads.csv')
X = dataset.iloc[:, :-1].values
y = dataset.iloc[:, -1].values
```

1.3 Splitting the dataset into the Training set and Test set

[ ]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.25,␣
↪random_state = 0)
```

[ ]:
```
print(X_train)
```

```
[[     44   39000]
 [     32  120000]
 [     38   50000]
 [     32  135000]
 [     52   21000]
 [     53  104000]
 [     39   42000]
 [     38   61000]
 [     36   50000]
 [     36   63000]
 [     35   25000]
 [     35   50000]
 [     42   73000]
 [     47   49000]
 [     59   29000]
 [     49   65000]
```

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[     45 131000]
[     31  89000]
[     46  82000]
[     47  51000]
[     26  15000]
[     60 102000]
[     38 112000]
[     40 107000]
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[     35  59000]
[     48  41000]
[     48 134000]
[     38 113000]
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[     60 108000]
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[     57  74000]
[     42  65000]
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[     46 117000]
[     35  61000]
[     21  68000]
[     28  44000]
[     41  87000]
```

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[     58 101000]
[     45  45000]
[     23  82000]
[     46  23000]
```

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[     41  59000]
[     49  89000]
[     28  79000]
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[     37  57000]
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[     39 134000]
[     29  43000]
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[     41  45000]
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[     39 134000]
[     27 137000]
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 [     39  73000]
 [     41  79000]
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 [     48  30000]
 [     29  43000]
 [     36  52000]
 [     27  54000]
 [     26 118000]]
```

[ ]:
```
print(y_train)
```

```
[0 1 0 1 1 1 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 1 0 1 0 0 1 1 1 1 0 1 0 1 0 0 1
```

```
 0 0 1 0 0 0 0 0 1 1 1 1 0 0 0 1 0 1 0 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1 0 1
 1 1 0 0 1 1 0 0 1 1 0 1 0 0 1 1 0 1 1 1 0 0 0 0 0 1 0 0 1 1 1 1 1 0 1 1 0
 1 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 0 0 1 1 0 0
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 0 0 1 0 1 1 0 0 0 0 0 1 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1
 0 0 0 0]
```

[ ]:
```
print(X_test)
```

```
[[    30  87000]
 [    38  50000]
 [    35  75000]
 [    30  79000]
 [    35  50000]
 [    27  20000]
 [    31  15000]
 [    36 144000]
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 [    28  55000]
 [    37  55000]
 [    39  77000]
 [    20  86000]
 [    32 117000]
 [    37  77000]
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 [    24  58000]
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 [    22  81000]
```

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[     34  43000]
[     31  34000]
[     49  36000]
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[     27  84000]
[     35  20000]
[     43 112000]
[     27  58000]
[     37  80000]
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[     57 122000]
[     34  25000]
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[     19  26000]
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[     32 150000]
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[     25  33000]
[     24  84000]
[     27  96000]
[     23  63000]
[     48  33000]
[     48  90000]
[     42 104000]]
```

[ ]:
```
print(y_test)
```

```
[0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 0 0 0
 0 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 0 1 1 0 0 1 0 0 1 0 1 0 1 0 0 0 0 1 0 0 1
 0 0 0 0 1 1 1 0 0 0 1 1 0 1 1 0 0 1 0 0 0 1 0 1 1 1]
```

1.4 Feature Scaling

[ ]:
```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

[ ]:
```
print(X_train)
```

```
[[ 0.58164944 -0.88670699]
 [-0.60673761  1.46173768]
 [-0.01254409 -0.5677824 ]
 [-0.60673761  1.89663484]
 [ 1.37390747 -1.40858358]
 [ 1.47293972  0.99784738]
 [ 0.08648817 -0.79972756]
 [-0.01254409 -0.24885782]
 [-0.21060859 -0.5677824 ]
 [-0.21060859 -0.19087153]
 [-0.30964085 -1.29261101]
 [-0.30964085 -0.5677824 ]
 [ 0.38358493  0.09905991]
 [ 0.8787462  -0.59677555]
 [ 2.06713324 -1.17663843]
 [ 1.07681071 -0.13288524]
 [ 0.68068169  1.78066227]
 [-0.70576986  0.56295021]
```

```
[ 0.77971394  0.35999821]
[ 0.8787462  -0.53878926]
[-1.20093113 -1.58254245]
[ 2.1661655   0.93986109]
[-0.01254409  1.22979253]
[ 0.18552042  1.08482681]
[ 0.38358493 -0.48080297]
[-0.30964085 -0.30684411]
[ 0.97777845 -0.8287207 ]
[ 0.97777845  1.8676417 ]
[-0.01254409  1.25878567]
[-0.90383437  2.27354572]
[-1.20093113 -1.58254245]
[ 2.1661655  -0.79972756]
[-1.39899564 -1.46656987]
[ 0.38358493  2.30253886]
[ 0.77971394  0.76590222]
[-1.00286662 -0.30684411]
[ 0.08648817  0.76590222]
[-1.00286662  0.56295021]
[ 0.28455268  0.07006676]
[ 0.68068169 -1.26361786]
[-0.50770535 -0.01691267]
[-1.79512465  0.35999821]
[-0.70576986  0.12805305]
[ 0.38358493  0.30201192]
[-0.30964085  0.07006676]
[-0.50770535  2.30253886]
[ 0.18552042  0.04107362]
[ 1.27487521  2.21555943]
[ 0.77971394  0.27301877]
[-0.30964085  0.1570462 ]
[-0.01254409 -0.53878926]
[-0.21060859  0.1570462 ]
[-0.11157634  0.24402563]
[-0.01254409 -0.24885782]
[ 2.1661655   1.11381995]
[-1.79512465  0.35999821]
[ 1.86906873  0.12805305]
[ 0.38358493 -0.13288524]
[-1.20093113  0.30201192]
[ 0.77971394  1.37475825]
[-0.30964085 -0.24885782]
[-1.6960924  -0.04590581]
[-1.00286662 -0.74174127]
[ 0.28455268  0.50496393]
[-0.11157634 -1.06066585]
[-1.10189888  0.59194336]
```

```
[ 0.08648817 -0.79972756]
[-1.00286662  1.54871711]
[-0.70576986  1.40375139]
[-1.29996338  0.50496393]
[-0.30964085  0.04107362]
[-0.11157634  0.01208048]
[-0.30964085 -0.88670699]
[ 0.8787462  -1.3505973 ]
[-0.30964085  2.24455257]
[ 0.97777845  1.98361427]
[-1.20093113  0.47597078]
[-1.29996338  0.27301877]
[ 1.37390747  1.98361427]
[ 1.27487521 -1.3505973 ]
[-0.30964085 -0.27785096]
[-0.50770535  1.25878567]
[-0.80480212  1.08482681]
[ 0.97777845 -1.06066585]
[ 0.28455268  0.30201192]
[ 0.97777845  0.76590222]
[-0.70576986 -1.49556302]
[-0.70576986  0.04107362]
[ 0.48261718  1.72267598]
[ 2.06713324  0.18603934]
[-1.99318916 -0.74174127]
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[ 0.38358493  0.59194336]
[ 0.8787462  -1.14764529]
[-1.20093113 -0.77073441]
[ 0.18552042  0.24402563]
[ 0.77971394 -0.30684411]
[ 2.06713324 -0.79972756]
[ 0.77971394  0.12805305]
[-0.30964085  0.6209365 ]
[-1.00286662 -0.30684411]
[ 0.18552042 -0.3648304 ]
[ 2.06713324  2.12857999]
[ 1.86906873 -1.26361786]
[ 1.37390747 -0.91570013]
[ 0.8787462   1.25878567]
[ 1.47293972  2.12857999]
[-0.30964085 -1.23462472]
[ 1.96810099  0.91086794]
[ 0.68068169 -0.71274813]
[-1.49802789  0.35999821]
[ 0.77971394 -1.3505973 ]
[ 0.38358493 -0.13288524]
[-1.00286662  0.41798449]
```

```
[-0.01254409 -0.30684411]
[-1.20093113  0.41798449]
[-0.90383437 -1.20563157]
[-0.11157634  0.04107362]
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[ 0.97777845 -1.00267957]
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[-0.01254409 -0.13288524]
[-1.10189888 -1.52455616]
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[-1.39899564 -1.23462472]
[-0.60673761 -1.49556302]
[ 0.77971394  0.53395707]
[-0.30964085 -0.33583725]
[ 1.77003648 -0.27785096]
[ 0.8787462  -1.03167271]
[ 0.18552042  0.07006676]
[-0.60673761  0.8818748 ]
[-1.89415691 -1.40858358]
[-1.29996338  0.59194336]
[-0.30964085  0.53395707]
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[ 1.17584296 -0.74174127]
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[ 0.18552042  2.09958685]
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[-1.79512465  0.12805305]
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[-0.70576986  0.18603934]
[ 0.8787462  -1.29261101]
[ 0.18552042 -0.24885782]
[-0.4086731   1.22979253]
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[ 0.38358493  0.1570462 ]
[ 0.8787462  -0.65476184]
[ 0.08648817  0.1570462 ]
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[-0.11157634  0.30201192]
[-0.21060859 -0.27785096]
[ 0.28455268 -0.50979612]
[-0.21060859  1.6067034 ]
```

```
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[ 0.08648817 -0.24885782]
[-1.59706014 -1.23462472]
[-0.50770535 -0.27785096]
[ 0.97777845  0.12805305]
[ 1.96810099 -1.3505973 ]
[ 1.47293972  0.07006676]
[-0.60673761  1.37475825]
[ 1.57197197  0.01208048]
[-0.80480212  0.30201192]
[ 1.96810099  0.73690908]
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[ 0.68068169  0.27301877]
[-1.39899564 -0.42281668]
[ 0.18552042  0.1570462 ]
[-0.50770535 -1.20563157]
[ 0.58164944  2.01260742]
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[-0.50770535 -0.53878926]
[ 0.48261718  1.83864855]
[-1.39899564 -1.089659  ]
[ 0.77971394 -1.37959044]
[-0.30964085 -0.42281668]
[ 1.57197197  0.99784738]
[ 0.97777845  1.43274454]
[-0.30964085 -0.48080297]
[-0.11157634  2.15757314]
[-1.49802789 -0.1038921 ]
[-0.11157634  1.95462113]
[-0.70576986 -0.33583725]
[-0.50770535 -0.8287207 ]
[ 0.68068169 -1.37959044]
[-0.80480212 -1.58254245]
[-1.89415691 -1.46656987]
[ 1.07681071  0.12805305]
[ 0.08648817  1.51972397]
[-0.30964085  0.09905991]
[ 0.08648817  0.04107362]
[-1.39899564 -1.3505973 ]
[ 0.28455268  0.07006676]
[-0.90383437  0.38899135]
[ 1.57197197 -1.26361786]
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[-0.11157634  0.1570462 ]
```

```
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[ 1.77003648  1.83864855]
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[-0.80480212  0.56295021]
[-1.20093113 -1.5535493 ]
[-0.50770535 -1.11865214]
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[-0.21060859 -1.06066585]
[ 1.67100423  1.6067034 ]
[ 0.97777845  1.78066227]
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[-0.80480212 -0.21986468]
[-0.11157634  0.07006676]
[ 0.28455268 -0.19087153]
[ 1.96810099 -0.65476184]
[-0.80480212  1.3457651 ]
[-1.79512465 -0.59677555]
[-0.11157634  0.12805305]
[ 0.28455268 -0.30684411]
[ 1.07681071  0.56295021]
[-1.00286662  0.27301877]
[ 1.47293972  0.35999821]
[ 0.18552042 -0.3648304 ]
[ 2.1661655  -1.03167271]
[-0.30964085  1.11381995]
[-1.6960924   0.07006676]
[-0.01254409  0.04107362]
[ 0.08648817  1.05583366]
[-0.11157634 -0.3648304 ]
[-1.20093113  0.07006676]
[-0.30964085 -1.3505973 ]
[ 1.57197197  1.11381995]
[-0.80480212 -1.52455616]
[ 0.08648817  1.8676417 ]
[-0.90383437 -0.77073441]
[-0.50770535 -0.77073441]
[-0.30964085 -0.91570013]
[ 0.28455268 -0.71274813]
[ 0.28455268  0.07006676]
[ 0.08648817  1.8676417 ]
[-1.10189888  1.95462113]
[-1.6960924  -1.5535493 ]
[-1.20093113 -1.089659  ]
```

```
 [-0.70576986 -0.1038921 ]
 [ 0.08648817  0.09905991]
 [ 0.28455268  0.27301877]
 [ 0.8787462  -0.5677824 ]
 [ 0.28455268 -1.14764529]
 [-0.11157634  0.67892279]
 [ 2.1661655  -0.68375498]
 [-1.29996338 -1.37959044]
 [-1.00286662 -0.94469328]
 [-0.01254409 -0.42281668]
 [-0.21060859 -0.45180983]
 [-1.79512465 -0.97368642]
 [ 1.77003648  0.99784738]
 [ 0.18552042 -0.3648304 ]
 [ 0.38358493  1.11381995]
 [-1.79512465 -1.3505973 ]
 [ 0.18552042 -0.13288524]
 [ 0.8787462  -1.43757673]
 [-1.99318916  0.47597078]
 [-0.30964085  0.27301877]
 [ 1.86906873 -1.06066585]
 [-0.4086731   0.07006676]
 [ 1.07681071 -0.88670699]
 [-1.10189888 -1.11865214]
 [-1.89415691  0.01208048]
 [ 0.08648817  0.27301877]
 [-1.20093113  0.33100506]
 [-1.29996338  0.30201192]
 [-1.00286662  0.44697764]
 [ 1.67100423 -0.88670699]
 [ 1.17584296  0.53395707]
 [ 1.07681071  0.53395707]
 [ 1.37390747  2.331532  ]
 [-0.30964085 -0.13288524]
 [ 0.38358493 -0.45180983]
 [-0.4086731  -0.77073441]
 [-0.11157634 -0.50979612]
 [ 0.97777845 -1.14764529]
 [-0.90383437 -0.77073441]
 [-0.21060859 -0.50979612]
 [-1.10189888 -0.45180983]
 [-1.20093113  1.40375139]]
```

[ ]:

```
print(X_test)
```

```
[[-0.80480212  0.50496393]
 [-0.01254409 -0.5677824 ]
 [-0.30964085  0.1570462 ]
```

```
[-0.80480212  0.27301877]
[-0.30964085 -0.5677824 ]
[-1.10189888 -1.43757673]
[-0.70576986 -1.58254245]
[-0.21060859  2.15757314]
[-1.99318916 -0.04590581]
[ 0.8787462  -0.77073441]
[-0.80480212 -0.59677555]
[-1.00286662 -0.42281668]
[-0.11157634 -0.42281668]
[ 0.08648817  0.21503249]
[-1.79512465  0.47597078]
[-0.60673761  1.37475825]
[-0.11157634  0.21503249]
[-1.89415691  0.44697764]
[ 1.67100423  1.75166912]
[-0.30964085 -1.37959044]
[-0.30964085 -0.65476184]
[ 0.8787462   2.15757314]
[ 0.28455268 -0.53878926]
[ 0.8787462   1.02684052]
[-1.49802789 -1.20563157]
[ 1.07681071  2.07059371]
[-1.00286662  0.50496393]
[-0.90383437  0.30201192]
[-0.11157634 -0.21986468]
[-0.60673761  0.47597078]
[-1.6960924   0.53395707]
[-0.11157634  0.27301877]
[ 1.86906873 -0.27785096]
[-0.11157634 -0.48080297]
[-1.39899564 -0.33583725]
[-1.99318916 -0.50979612]
[-1.59706014  0.33100506]
[-0.4086731  -0.77073441]
[-0.70576986 -1.03167271]
[ 1.07681071 -0.97368642]
[-1.10189888  0.53395707]
[ 0.28455268 -0.50979612]
[-1.10189888  0.41798449]
[-0.30964085 -1.43757673]
[ 0.48261718  1.22979253]
[-1.10189888 -0.33583725]
[-0.11157634  0.30201192]
[ 1.37390747  0.59194336]
[-1.20093113 -1.14764529]
[ 1.07681071  0.47597078]
[ 1.86906873  1.51972397]
```

```
[-0.4086731  -1.29261101]
[-0.30964085 -0.3648304 ]
[-0.4086731   1.31677196]
[ 2.06713324  0.53395707]
[ 0.68068169 -1.089659  ]
[-0.90383437  0.38899135]
[-1.20093113  0.30201192]
[ 1.07681071 -1.20563157]
[-1.49802789 -1.43757673]
[-0.60673761 -1.49556302]
[ 2.1661655  -0.79972756]
[-1.89415691  0.18603934]
[-0.21060859  0.85288166]
[-1.89415691 -1.26361786]
[ 2.1661655   0.38899135]
[-1.39899564  0.56295021]
[-1.10189888 -0.33583725]
[ 0.18552042 -0.65476184]
[ 0.38358493  0.01208048]
[-0.60673761  2.331532  ]
[-0.30964085  0.21503249]
[-1.59706014 -0.19087153]
[ 0.68068169 -1.37959044]
[-1.10189888  0.56295021]
[-1.99318916  0.35999821]
[ 0.38358493  0.27301877]
[ 0.18552042 -0.27785096]
[ 1.47293972 -1.03167271]
[ 0.8787462   1.08482681]
[ 1.96810099  2.15757314]
[ 2.06713324  0.38899135]
[-1.39899564 -0.42281668]
[-1.20093113 -1.00267957]
[ 1.96810099 -0.91570013]
[ 0.38358493  0.30201192]
[ 0.18552042  0.1570462 ]
[ 2.06713324  1.75166912]
[ 0.77971394 -0.8287207 ]
[ 0.28455268 -0.27785096]
[ 0.38358493 -0.16187839]
[-0.11157634  2.21555943]
[-1.49802789 -0.62576869]
[-1.29996338 -1.06066585]
[-1.39899564  0.41798449]
[-1.10189888  0.76590222]
[-1.49802789 -0.19087153]
[ 0.97777845 -1.06066585]
[ 0.97777845  0.59194336]
```

```
[ 0.38358493  0.99784738]]
```

1.5 Training the Logistic Regression model on the Training set

```
[ ]: from sklearn.linear_model import LogisticRegression
     classifier = LogisticRegression(random_state = 0)
     classifier.fit(X_train, y_train)
```

```
[ ]: LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                        intercept_scaling=1, l1_ratio=None, max_iter=100,
                        multi_class='auto', n_jobs=None, penalty='l2',
                        random_state=0, solver='lbfgs', tol=0.0001, verbose=0,
                        warm_start=False)
```

1.6 Predicting a new result

```
[ ]: print(classifier.predict(sc.transform([[30,87000]])))
```

```
[0]
```

1.7 Predicting the Test set results

```
[ ]: y_pred = classifier.predict(X_test)
     print(np.concatenate((y_pred.reshape(len(y_pred),1), y_test.
      ↪reshape(len(y_test),1)),1))
```

```
[[0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [1 1]
 [0 0]
 [1 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [0 0]
 [1 1]
 [0 0]
 [0 0]
 [1 1]
```

```
[0 0]
[1 1]
[0 0]
[1 1]
[0 0]
[0 0]
[0 0]
[0 0]
[0 0]
[0 1]
[1 1]
[0 0]
[0 0]
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[0 0]
[0 0]
[0 0]
[0 0]
```

```
 [1 1]
 [0 0]
 [0 0]
 [0 1]
 [0 0]
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 [1 1]
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 [0 0]
 [0 0]
 [1 1]
 [0 0]
 [0 0]
 [0 0]
 [0 1]
 [0 0]
 [0 1]
 [1 1]
 [1 1]]
```

1.8 Making the Confusion Matrix

[ ]:
```
from sklearn.metrics import confusion_matrix, accuracy_score
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy_score(y_test, y_pred)
```

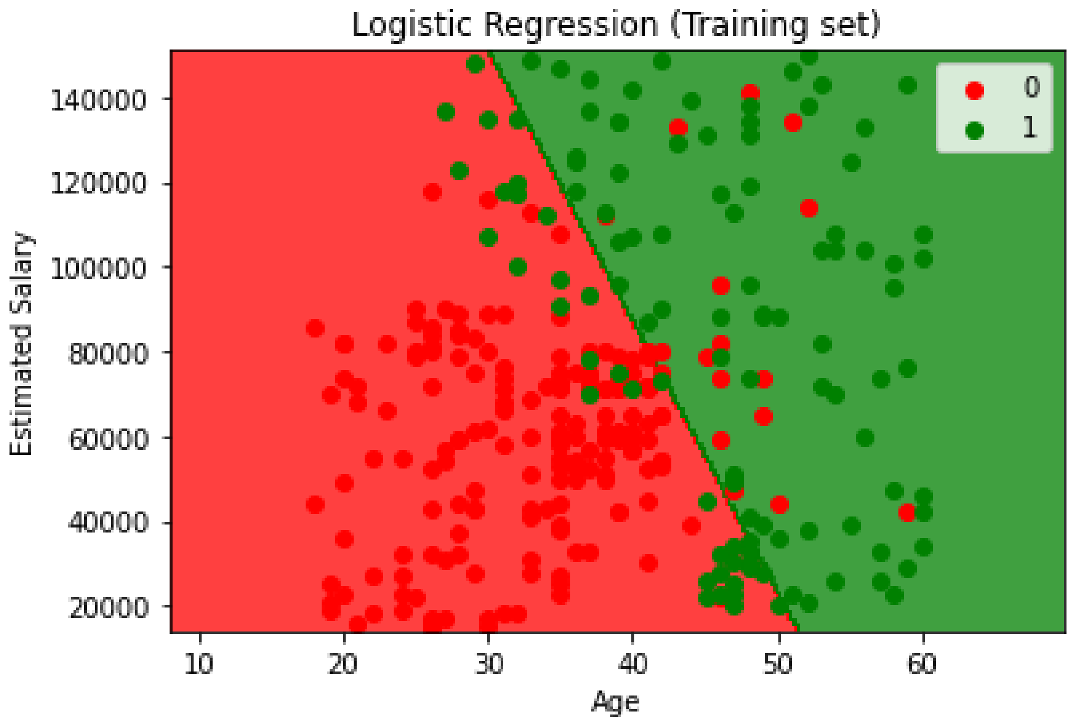
```
[[65  3]
 [ 8 24]]
```

[ ]:
```
0.89
```

1.9 Visualising the Training set results

[ ]:
```
from matplotlib.colors import ListedColormap
X_set, y_set = sc.inverse_transform(X_train), y_train
X1, X2 = np.meshgrid(np.arange(start = X_set[:, 0].min() - 10, stop = X_set[:,␣
↪0].max() + 10, step = 0.25),
                     np.arange(start = X_set[:, 1].min() - 1000, stop = X_set[:
↪, 1].max() + 1000, step = 0.25))
plt.contourf(X1, X2, classifier.predict(sc.transform(np.array([X1.ravel(), X2.
↪ravel()]).T)).reshape(X1.shape),
             alpha = 0.75, cmap = ListedColormap(('red', 'green')))
plt.xlim(X1.min(), X1.max())
plt.ylim(X2.min(), X2.max())
for i, j in enumerate(np.unique(y_set)):
    plt.scatter(X_set[y_set == j, 0], X_set[y_set == j, 1], c =␣
↪ListedColormap(('red', 'green'))(i), label = j)
plt.title('Logistic Regression (Training set)')
plt.xlabel('Age')
plt.ylabel('Estimated Salary')
plt.legend()
plt.show()
```

```
'c' argument looks like a single numeric RGB or RGBA sequence, which should be
avoided as value-mapping will have precedence in case its length matches with
'x' & 'y'.  Please use a 2-D array with a single row if you really want to
specify the same RGB or RGBA value for all points.
'c' argument looks like a single numeric RGB or RGBA sequence, which should be
avoided as value-mapping will have precedence in case its length matches with
'x' & 'y'.  Please use a 2-D array with a single row if you really want to
specify the same RGB or RGBA value for all points.
```



1.10 Visualising the Test set results

[ ]:
```
from matplotlib.colors import ListedColormap
X_set, y_set = sc.inverse_transform(X_test), y_test
X1, X2 = np.meshgrid(np.arange(start = X_set[:, 0].min() - 10, stop = X_set[:,␣
↪0].max() + 10, step = 0.25),
                     np.arange(start = X_set[:, 1].min() - 1000, stop = X_set[:
↪, 1].max() + 1000, step = 0.25))
plt.contourf(X1, X2, classifier.predict(sc.transform(np.array([X1.ravel(), X2.
↪ravel()]).T)).reshape(X1.shape),
             alpha = 0.75, cmap = ListedColormap(('red', 'green')))
plt.xlim(X1.min(), X1.max())
plt.ylim(X2.min(), X2.max())
for i, j in enumerate(np.unique(y_set)):
    plt.scatter(X_set[y_set == j, 0], X_set[y_set == j, 1], c =␣
↪ListedColormap(('red', 'green'))(i), label = j)
plt.title('Logistic Regression (Test set)')
plt.xlabel('Age')
plt.ylabel('Estimated Salary')
plt.legend()
plt.show()
```

```
'c' argument looks like a single numeric RGB or RGBA sequence, which should be
```

```
avoided as value-mapping will have precedence in case its length matches with
'x' & 'y'.  Please use a 2-D array with a single row if you really want to
specify the same RGB or RGBA value for all points.
'c' argument looks like a single numeric RGB or RGBA sequence, which should be
avoided as value-mapping will have precedence in case its length matches with
'x' & 'y'.  Please use a 2-D array with a single row if you really want to
specify the same RGB or RGBA value for all points.
```