D4_Logistic Regression

August 10, 2018

1 Telecom Dataset

Understand the Telecom data provided by analysing and visualising the data.Build the model using Logistic Regression with the train data. Predict the customers churning for the test data provided based on the built and validate

```
In [35]: import pandas as pd
         import numpy as np
         import matplotlib.pyplot as plt
         from sklearn import linear_model
         import seaborn as sns
         from sklearn import preprocessing
         from sklearn import linear_model
         from sklearn.model_selection import train_test_split
         from sklearn.metrics import confusion_matrix
```

```
In [2]: df=pd.read_excel('train_telecom.xlsx')
```

1.0.1 Data Exploration

```
In [3]: df.shape
```

```
Out[3]: (3333, 20)
```

```
In [4]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3333 entries, 1 to 3333
Data columns (total 20 columns):
state                          3333 non-null object
account_length                 3333 non-null int64
area_code                      3333 non-null object
international_plan             3333 non-null object
voice_mail_plan                3333 non-null object
number_vmail_messages          3333 non-null int64
total_day_minutes              3333 non-null float64
total_day_calls                3333 non-null int64
total_day_charge               3333 non-null float64
```

```
total_eve_minutes                3333 non-null float64
total_eve_calls                  3333 non-null int64
total_eve_charge                 3333 non-null float64
total_night_minutes              3333 non-null float64
total_night_calls                3333 non-null int64
total_night_charge               3333 non-null float64
total_intl_minutes               3333 non-null float64
total_intl_calls                 3333 non-null int64
total_intl_charge                3333 non-null float64
number_customer_service_calls    3333 non-null int64
churn                            3333 non-null object
dtypes: float64(8), int64(7), object(5)
memory usage: 546.8+ KB
```

In [5]: df.describe()

```
Out[5]:        account_length  number_vmail_messages  total_day_minutes  \
        count     3333.000000            3333.000000        3333.000000
        mean       101.064806               8.099010         179.775098
        std         39.822106              13.688365          54.467389
        min          1.000000               0.000000           0.000000
        25%         74.000000               0.000000         143.700000
        50%        101.000000               0.000000         179.400000
        75%        127.000000              20.000000         216.400000
        max        243.000000              51.000000         350.800000

               total_day_calls  total_day_charge  total_eve_minutes  total_eve_calls  \
        count      3333.000000       3333.000000        3333.000000      3333.000000
        mean        100.435644         30.562307         200.980348       100.114311
        std          20.069084          9.259435          50.713844        19.922625
        min           0.000000          0.000000           0.000000         0.000000
        25%          87.000000         24.430000         166.600000        87.000000
        50%         101.000000         30.500000         201.400000       100.000000
        75%         114.000000         36.790000         235.300000       114.000000
        max         165.000000         59.640000         363.700000       170.000000

               total_eve_charge  total_night_minutes  total_night_calls  \
        count       3333.000000          3333.000000        3333.000000
        mean          17.083540           200.872037         100.107711
        std            4.310668            50.573847          19.568609
        min            0.000000            23.200000          33.000000
        25%           14.160000           167.000000          87.000000
        50%           17.120000           201.200000         100.000000
        75%           20.000000           235.300000         113.000000
        max           30.910000           395.000000         175.000000

               total_night_charge  total_intl_minutes  total_intl_calls  \
```

```
count         3333.000000          3333.000000        3333.000000
mean             9.039325            10.237294           4.479448
std              2.275873             2.791840           2.461214
min              1.040000             0.000000           0.000000
25%              7.520000             8.500000           3.000000
50%              9.050000            10.300000           4.000000
75%             10.590000            12.100000           6.000000
max             17.770000            20.000000          20.000000

       total_intl_charge  number_customer_service_calls
count        3333.000000                    3333.000000
mean            2.764581                       1.562856
std             0.753773                       1.315491
min             0.000000                       0.000000
25%             2.300000                       1.000000
50%             2.780000                       1.000000
75%             3.270000                       2.000000
max             5.400000                       9.000000
```

In [6]:
```python
def rstr(df): return df.apply(lambda x: [x.unique()])
rstr(df)
```

Out[6]:
```
state                            [[KS, OH, NJ, OK, AL, MA, MO, LA, WV, IN, RI, ...
account_length                   [[128, 107, 137, 84, 75, 118, 121, 147, 117, 1...
area_code                          [[area_code_415, area_code_408, area_code_510]]
international_plan                                                   [[no, yes]]
voice_mail_plan                                                      [[yes, no]]
number_vmail_messages            [[25, 26, 0, 24, 37, 27, 33, 39, 30, 41, 28, 3...
total_day_minutes                [[265.1, 161.6, 243.4, 299.4, 166.7, 223.4, 21...
total_day_calls                  [[110, 123, 114, 71, 113, 98, 88, 79, 97, 84, ...
total_day_charge                 [[45.07, 27.47, 41.38, 50.9, 28.34, 37.98, 37...
total_eve_minutes                [[197.4, 195.5, 121.2, 61.9, 148.3, 220.6, 348...
total_eve_calls                  [[99, 103, 110, 88, 122, 101, 108, 94, 80, 111...
total_eve_charge                 [[16.78, 16.62, 10.3, 5.26, 12.61, 18.75, 29.6...
total_night_minutes              [[244.7, 254.4, 162.6, 196.9, 186.9, 203.9, 21...
total_night_calls                [[91, 103, 104, 89, 121, 118, 96, 90, 97, 111,...
total_night_charge               [[11.01, 11.45, 7.32, 8.86, 8.41, 9.18, 9.57, ...
total_intl_minutes               [[10.0, 13.7, 12.2, 6.6, 10.1, 6.3, 7.5, 7.1, ...
total_intl_calls                 [[3, 5, 7, 6, 4, 2, 9, 19, 1, 10, 15, 8, 11, 0...
total_intl_charge                [[2.7, 3.7, 3.29, 1.78, 2.73, 1.7, 2.03, 1.92,...
number_customer_service_calls                   [[1, 0, 2, 3, 4, 5, 7, 9, 6, 8]]
churn                                                                [[no, yes]]
dtype: object
```

In [7]:
```python
df.shape
```

Out[7]:
```
(3333, 20)
```

In [8]:
```
df_temp=pd.pivot_table(df,index=['state'],columns='churn',values='account_length',margin
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp.sort_values('Percent',ascending=False).head(10)
```

Out[8]:
```
churn  no  yes  All  Percent
state
NJ     50   18   68     26.0
CA     25    9   34     26.0
TX     54   18   72     25.0
MD     53   17   70     24.0
SC     46   14   60     23.0
MI     57   16   73     22.0
MS     51   14   65     22.0
WA     52   14   66     21.0
ME     49   13   62     21.0
NV     52   14   66     21.0
```

In [9]:
```
df_temp=pd.pivot_table(df,index=['area_code'],columns='churn',values='state',margins=Tru
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp.sort_values('Percent',ascending=False)
```

Out[9]:
```
churn            no  yes   All  Percent
area_code
area_code_408   716  122   838     15.0
area_code_510   715  125   840     15.0
area_code_415  1419  236  1655     14.0
All            2850  483  3333     14.0
```

In [10]:
```
df_temp=pd.pivot_table(df,index=['international_plan'],columns='churn',values='state',m
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp
```

Out[10]:
```
churn                 no  yes   All  Percent
international_plan
no                  2664  346  3010     11.0
yes                  186  137   323     42.0
All                 2850  483  3333     14.0
```

In [11]:
```
df_temp=pd.pivot_table(df,index=['voice_mail_plan'],columns='churn',values='state',marg
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp
```

Out[11]:
```
churn              no  yes   All  Percent
voice_mail_plan
no               2008  403  2411     17.0
yes               842   80   922      9.0
All              2850  483  3333     14.0
```

In [12]:
```
df_temp=pd.pivot_table(df,index=['number_customer_service_calls'],columns='churn',value
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp
```

Out[12]:
```
churn                             no    yes   All  Percent
number_customer_service_calls
0                              605.0   92.0   697     13.0
1                             1059.0  122.0  1181     10.0
2                              672.0   87.0   759     11.0
3                              385.0   44.0   429     10.0
4                               90.0   76.0   166     46.0
5                               26.0   40.0    66     61.0
6                                8.0   14.0    22     64.0
7                                4.0    5.0     9     56.0
8                                1.0    1.0     2     50.0
9                                NaN    2.0     2    100.0
All                           2850.0  483.0  3333     14.0
```

In [13]:
```
df_temp=pd.pivot_table(df,index=['number_customer_service_calls'],columns='churn',value
df_temp['Percent']=round(df_temp[df_temp.columns[1]]/df_temp[df_temp.columns[2]],2)*100
df_temp.sort_values('Percent',ascending=False)
```

Out[13]:
```
churn                             no    yes   All  Percent
number_customer_service_calls
9                                NaN    2.0     2    100.0
6                                8.0   14.0    22     64.0
5                               26.0   40.0    66     61.0
7                                4.0    5.0     9     56.0
8                                1.0    1.0     2     50.0
4                               90.0   76.0   166     46.0
All                           2850.0  483.0  3333     14.0
0                              605.0   92.0   697     13.0
2                              672.0   87.0   759     11.0
1                             1059.0  122.0  1181     10.0
3                              385.0   44.0   429     10.0
```

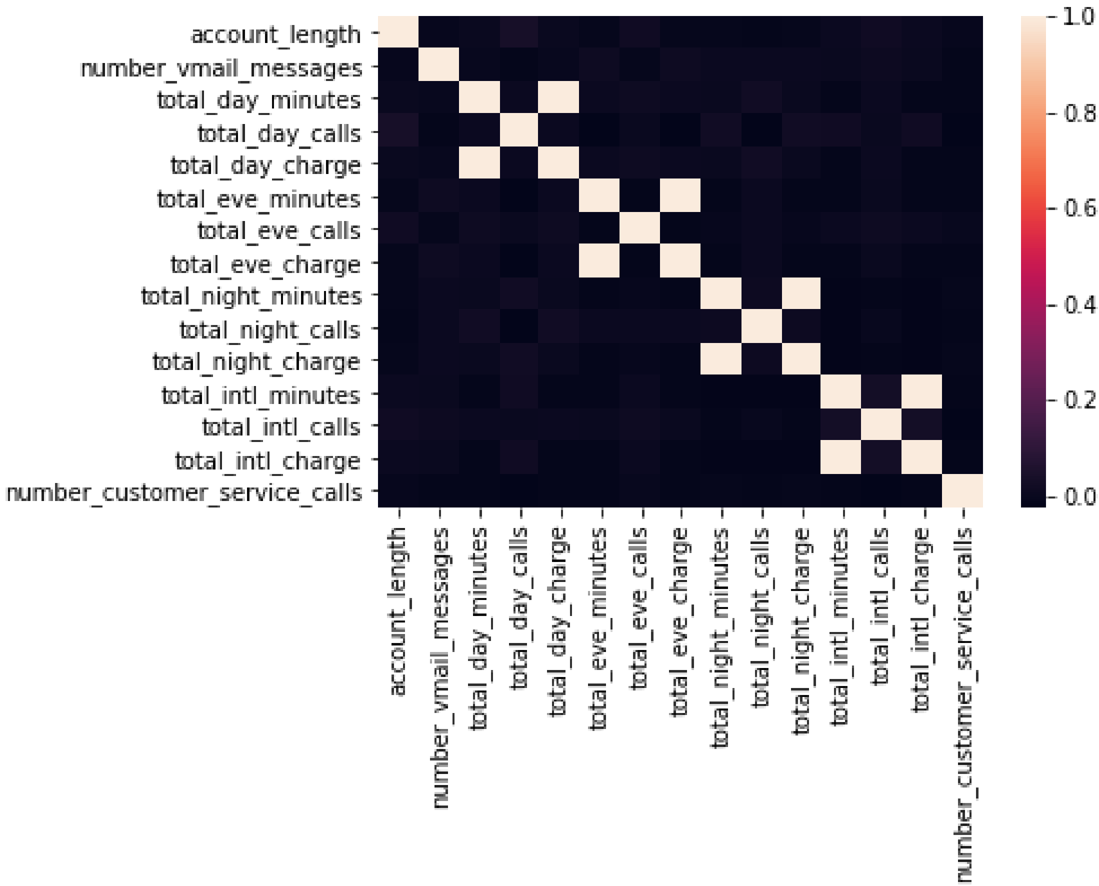
In [14]:
```
df.describe()
```

Out[14]:
```
       account_length  number_vmail_messages  total_day_minutes  \
count     3333.000000            3333.000000        3333.000000
mean       101.064806               8.099010         179.775098
std         39.822106              13.688365          54.467389
min          1.000000               0.000000           0.000000
25%         74.000000               0.000000         143.700000
50%        101.000000               0.000000         179.400000
75%        127.000000              20.000000         216.400000
max        243.000000              51.000000         350.800000

       total_day_calls  total_day_charge  total_eve_minutes  total_eve_calls  \
count      3333.000000       3333.000000        3333.000000      3333.000000
mean        100.435644         30.562307         200.980348       100.114311
std          20.069084          9.259435          50.713844        19.922625
min           0.000000          0.000000           0.000000         0.000000
```

```
25%          87.000000          24.430000          166.600000          87.000000
50%         101.000000          30.500000          201.400000         100.000000
75%         114.000000          36.790000          235.300000         114.000000
max         165.000000          59.640000          363.700000         170.000000

       total_eve_charge  total_night_minutes  total_night_calls  \
count       3333.000000          3333.000000        3333.000000
mean          17.083540           200.872037         100.107711
std            4.310668            50.573847          19.568609
min            0.000000            23.200000          33.000000
25%           14.160000           167.000000          87.000000
50%           17.120000           201.200000         100.000000
75%           20.000000           235.300000         113.000000
max           30.910000           395.000000         175.000000

       total_night_charge  total_intl_minutes  total_intl_calls  \
count         3333.000000         3333.000000       3333.000000
mean             9.039325           10.237294          4.479448
std              2.275873            2.791840          2.461214
min              1.040000            0.000000          0.000000
25%              7.520000            8.500000          3.000000
50%              9.050000           10.300000          4.000000
75%             10.590000           12.100000          6.000000
max             17.770000           20.000000         20.000000

       total_intl_charge  number_customer_service_calls
count        3333.000000                    3333.000000
mean            2.764581                       1.562856
std             0.753773                       1.315491
min             0.000000                       0.000000
25%             2.300000                       1.000000
50%             2.780000                       1.000000
75%             3.270000                       2.000000
max             5.400000                       9.000000
```

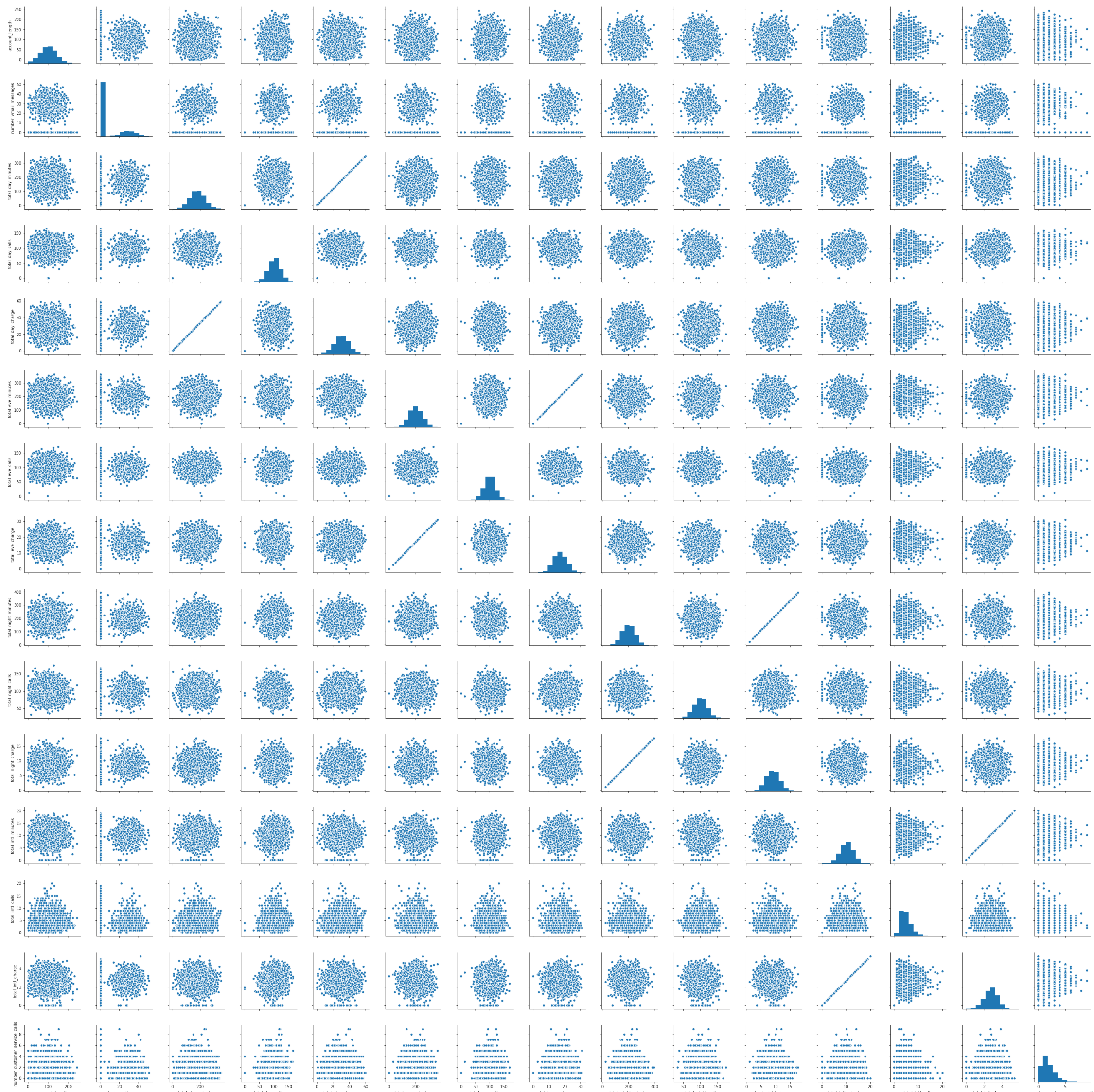
In [15]:
```
corr =df.corr()
sns.heatmap(corr,xticklabels=corr.columns.values,yticklabels=corr.columns.values)
```

Out[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd884fd0e10>
```




```
In [16]: sns.pairplot(df)
```

```
Out[16]: <seaborn.axisgrid.PairGrid at 0x7fd884fcb6a0>
```



2 Model Preparation

```
In [17]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3333 entries, 1 to 3333
Data columns (total 20 columns):
state                           3333 non-null object
account_length                  3333 non-null int64
area_code                       3333 non-null object
international_plan              3333 non-null object
voice_mail_plan                 3333 non-null object
```

```
number_vmail_messages           3333 non-null int64
total_day_minutes               3333 non-null float64
total_day_calls                 3333 non-null int64
total_day_charge                3333 non-null float64
total_eve_minutes               3333 non-null float64
total_eve_calls                 3333 non-null int64
total_eve_charge                3333 non-null float64
total_night_minutes             3333 non-null float64
total_night_calls               3333 non-null int64
total_night_charge              3333 non-null float64
total_intl_minutes              3333 non-null float64
total_intl_calls                3333 non-null int64
total_intl_charge               3333 non-null float64
number_customer_service_calls   3333 non-null int64
churn                           3333 non-null object
dtypes: float64(8), int64(7), object(5)
memory usage: 706.8+ KB
```

```
In [18]: def encode_df(df):
             df_encoded=pd.get_dummies(df, columns=["state", "area_code","international_plan","v
             df_encoded=df_encoded.drop(['international_plan_no','voice_mail_plan_no','churn_no'
             return (df_encoded)

In [20]: df_encoded=encode_df(df)
         y=df_encoded['churn_yes']
         x=df_encoded.drop('churn_yes',axis=1)

In [29]: def testmodel(x,y):
             x_split,x_test,y_split,y_test = train_test_split(x,y,test_size = 0.3,random_state=2
             x_train,x_valid,y_train,y_valid = train_test_split(x_split,y_split,test_size = 0.3,

             eqn=linear_model.LogisticRegression()
             eqn.fit(x_train,y_train)
             y_pred = eqn.predict(x_valid)
             confuse = confusion_matrix(y_valid,y_pred)
             accuracy = round((confuse[0][0] + confuse[1][1])/ len(y_valid),4)
             precision =  round(confuse[1][1]/(confuse[1][1]+confuse[0][1]),4)
             recall = round(confuse[1][1]/(confuse[1][1]+confuse[1][0]),4)
             print("***Training Data***")
             print("accuracy :",accuracy)
             print("precision :",precision)
             print("recall :",recall)
             print()
             print()

             y_pred = eqn.predict(x_test)
             confuse = confusion_matrix(y_test,y_pred)
```

```
            accuracy = round((confuse[0][0] + confuse[1][1])/ len(y_test),4)
            precision =  round(confuse[1][1]/(confuse[1][1]+confuse[0][1]),4)
            recall = round(confuse[1][1]/(confuse[1][1]+confuse[1][0]),4)
            print("***Validation Data***")
            print("accuracy :",accuracy)
            print("precision :",precision)
            print("recall :",recall)
            return eqn
```

In [48]:
```
model=testmodel(x,y)
```

```
***Training Data***
accuracy : 0.86
precision : 0.5
recall : 0.2449


***Validation Data***
accuracy : 0.8623
precision : 0.4545
recall : 0.1493
```

In [31]:
```
df_encoded.columns
x=df_encoded[['number_customer_service_calls','international_plan_yes','voice_mail_plan
y=df_encoded['churn_yes']
model=testmodel(x,y)
# x=["No_CS_Calls","International_Plan","Voice_Mail_Plan","Total_Day_charge","Total_Eve
```

```
***Training Data***
accuracy : 0.8686
precision : 0.6154
recall : 0.1633


***Validation Data***
accuracy : 0.8663
precision : 0.5
recall : 0.1045
```

In [43]:
```
x=df_encoded[['number_customer_service_calls','international_plan_yes','voice_mail_plan
y=df_encoded['churn_yes']
model=testmodel(x,y)
```

```
***Training Data***
accuracy : 0.8686
precision : 0.6154
recall : 0.1633
```

```
***Validation Data***
accuracy : 0.8683
precision : 0.5385
recall : 0.1045
```

2.0.2 So this appears to be the best model, Lets now test this with our test data.

```
In [49]: df=pd.read_excel('test_telecom.xlsx')
         df_encoded=encode_df(df)
         # x=df_encoded[['number_customer_service_calls','international_plan_yes','voice_mail_pl
         x=df_encoded.drop('churn_yes',axis=1)
         y=df_encoded['churn_yes']

         y_pred = model.predict(x)
         confuse = confusion_matrix(y,y_pred)

         accuracy = round((confuse[0][0] + confuse[1][1])/ len(y),4)
         precision =  round(confuse[1][1]/(confuse[1][1]+confuse[0][1]),4)
         recall = round(confuse[1][1]/(confuse[1][1]+confuse[1][0]),4)
         print("***Test Data***")
         print("accuracy :",accuracy)
         print("precision :",precision)
         print("recall :",recall)
```

```
***Test Data***
accuracy : 0.8758
precision : 0.6
recall : 0.2277
```