Problem 1: Clustering

A leading bank wants to develop a customer segmentation to give promotional offers to its customers. They collected a sample that summarizes the activities of users during the past few months. You are given the task to identify the segments based on credit card usage.

1.1 Read the data and do exploratory data analysis. Describe the data briefly.

In [1]:

```
# importing libraries.

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib.inline
```

```
UsageError: Line magic function `%matplotlib.inline` not found.
```

In [9]:

```
# Lets read the Data and check the head of it to ensure the Data is being properly Load
ed.

df = pd.read_csv (r'E:\Great Learning\Projects\Data Mining- Clusters,CART,RF,ANN\Data s
ets\bank_marketing_part1_Data-1.csv')
df.head()
```

Out[9]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	mi
0	19.94	16.92	0.8752	6.675	3.763	
1	15.99	14.89	0.9064	5.363	3.582	
2	18.95	16.42	0.8829	6.248	3.755	
3	10.83	12.96	0.8099	5.278	2.641	
4	17.99	15.86	0.8992	5.890	3.694	

Describing the Data :

In [10]:

```
# Lets check few basic information.

df.shape
```

Out[10]:

```
(210, 7)
```

In [11]:

```
df.columns
```

Out[11]:

```
Index(['spending', 'advance_payments', 'probability_of_full_payment',
       'current_balance', 'credit_limit', 'min_payment_amt',
       'max_spent_in_single_shopping'],
      dtype='object')
```

In [12]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 210 entries, 0 to 209
Data columns (total 7 columns):
spending                        210 non-null float64
advance_payments                210 non-null float64
probability_of_full_payment     210 non-null float64
current_balance                 210 non-null float64
credit_limit                    210 non-null float64
min_payment_amt                 210 non-null float64
max_spent_in_single_shopping    210 non-null float64
dtypes: float64(7)
memory usage: 11.6 KB
```

In [13]:

```
df.duplicated().sum()
```

Out[13]:

```
0
```

In [14]:

```
df.isnull().sum()
```

Out[14]:

```
spending                        0
advance_payments                0
probability_of_full_payment     0
current_balance                 0
credit_limit                    0
min_payment_amt                 0
max_spent_in_single_shopping    0
dtype: int64
```

There are 7 columns: spending, advance_payments, probability_of_full_payment, current_balance, credit_limit, min_payment_amt, max_spent_in_single_shopping.

As we can see from the above Table, there are no Missing Values and also the Data Type is Float 64 for all the 7 variables.

In [18]:

```
df.describe()
```

Out[18]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_lim
count	210.000000	210.000000	210.000000	210.000000	210.00000
mean	14.847524	14.559286	0.870999	5.628533	3.25860
std	2.909699	1.305959	0.023629	0.443063	0.37771
min	10.590000	12.410000	0.808100	4.899000	2.63000
25%	12.270000	13.450000	0.856900	5.262250	2.94400
50%	14.355000	14.320000	0.873450	5.523500	3.23700
75%	17.305000	15.715000	0.887775	5.979750	3.56175
max	21.180000	17.250000	0.918300	6.675000	4.03300

Above table shows us that Variance is somehow close to each other,but the Magnitude's are different.

In [ ]:

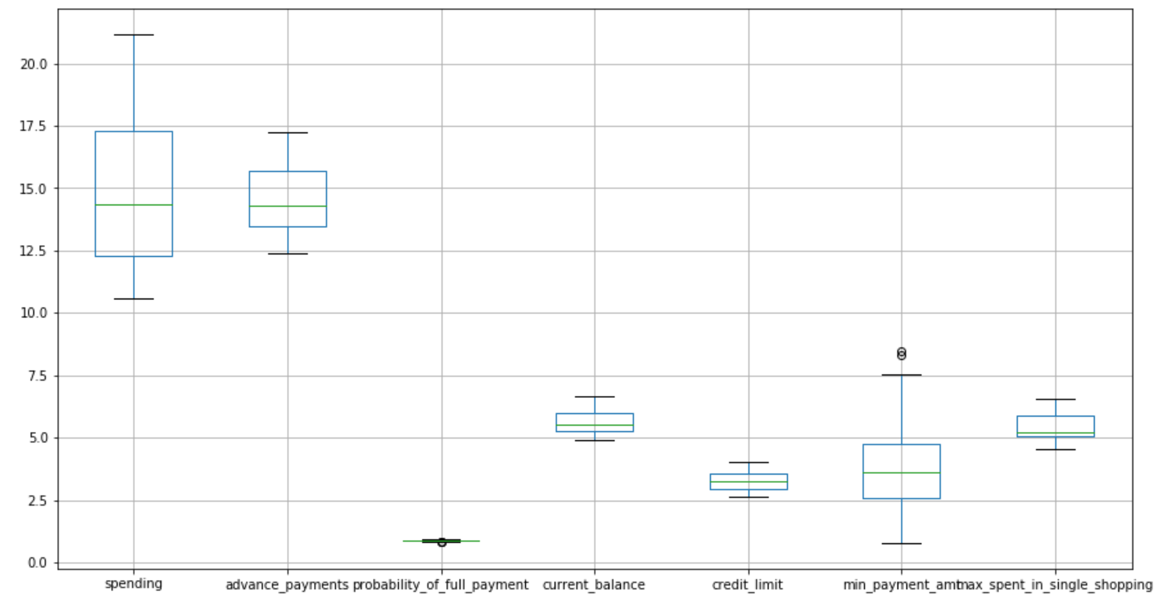
Exploratory Data Analysis (EDA).

In [ ]:

```
# Checing Outliers.
```

In [19]:

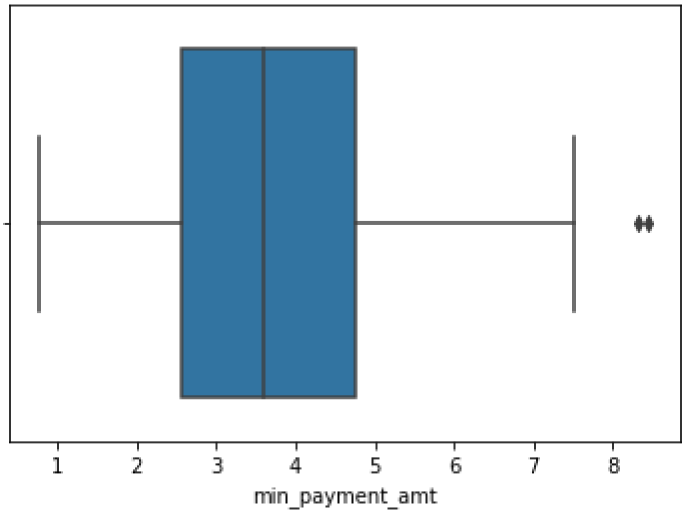
```
df.boxplot (figsize=(15,8));
```



In [ ]:

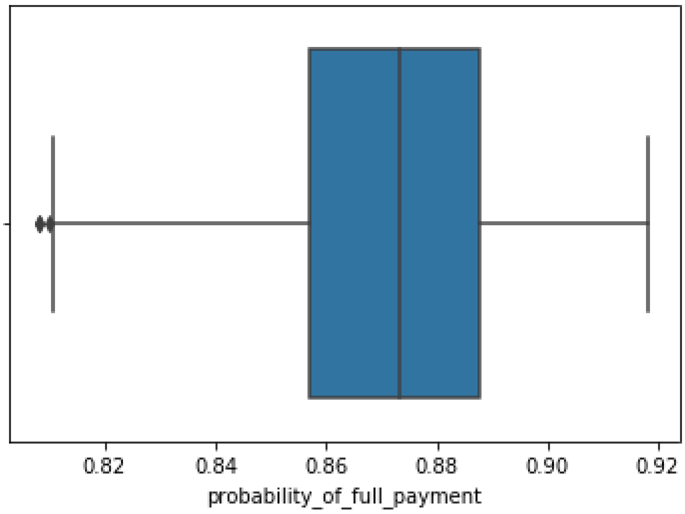
In [20]:

```
sns.boxplot (df ['min_payment_amt']);
```



In [21]:

```
sns.boxplot(df['probability_of_full_payment']);
```



Inferences : Above both the variables have outliers but this outliers cant change or harm the data as they are less and very close to the Minimim and Maximum value.So we will not treating the Outliers as if we will treat the outliers it can bring down all the values on single Digit as range for values are similar or close to each other for both the Variables.

In [39]:

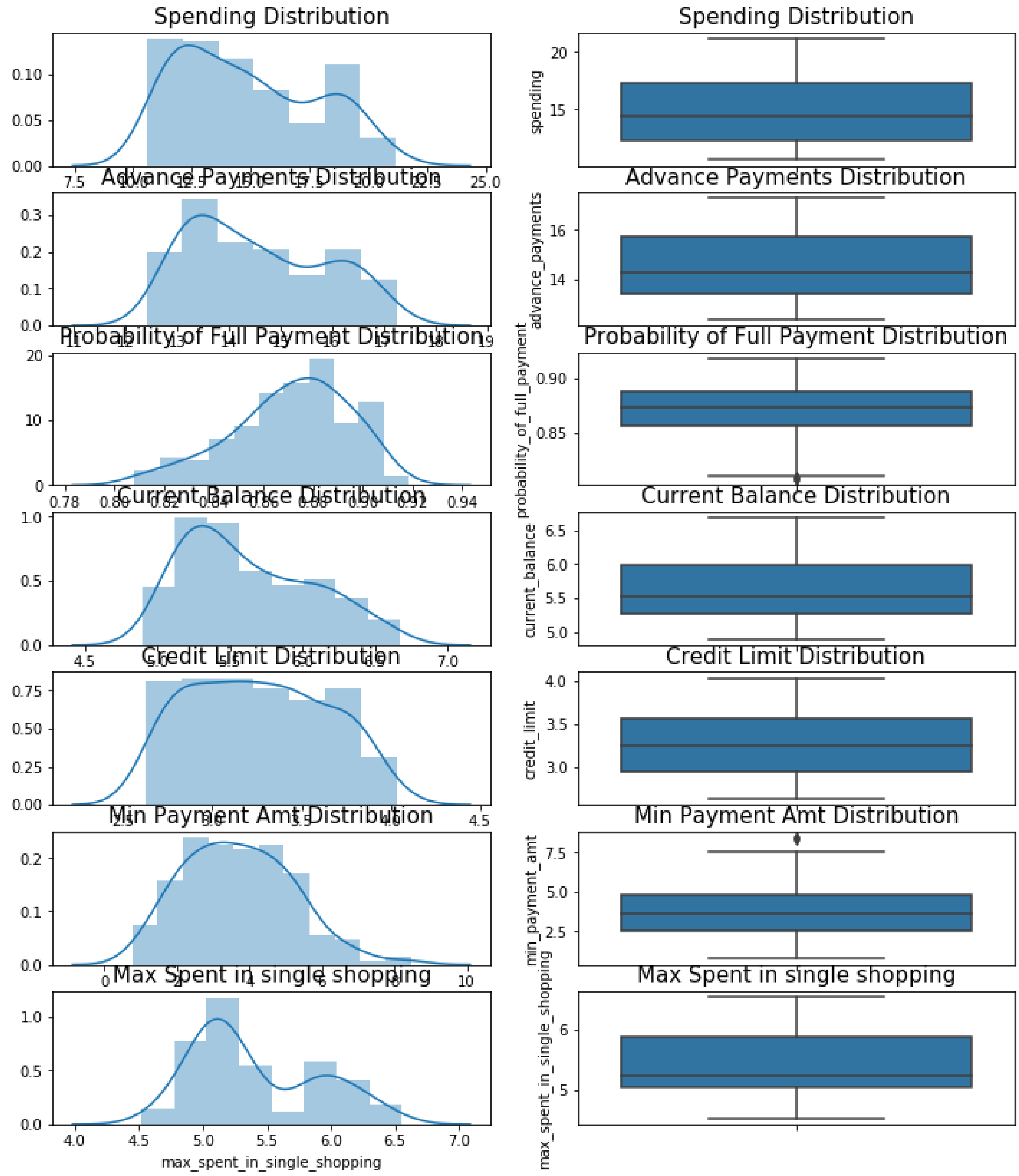
```
# Univariate and Multivariate:
```

In [28]:

```
fig , axes = plt.subplots (nrows=7,ncols=2)
fig.set_size_inches (12,14)

r = sns.distplot (df ['spending'],ax=axes [0][0]);
r.set_title ('Spending Distribution',fontsize=15)
r = sns.boxplot (df ['spending'],orient='v',ax=axes [0][1]);
r.set_title ('Spending Distribution',fontsize=15)

r = sns.distplot (df ['advance_payments'],ax=axes [1][0]);
r.set_title ('Advance Payments Distribution',fontsize=15)
r = sns.boxplot (df ['advance_payments'],orient='v',ax=axes [1][1]);
r.set_title ('Advance Payments Distribution',fontsize=15)

r = sns.distplot (df ['probability_of_full_payment'],ax=axes [2][0]);
r.set_title ('Probability of Full Payment Distribution',fontsize=15)
r = sns.boxplot (df ['probability_of_full_payment'],orient='v',ax=axes [2][1]);
r.set_title ('Probability of Full Payment Distribution',fontsize=15)

r = sns.distplot (df ['current_balance'],ax=axes [3][0]);
r.set_title ('Current Balance Distribution',fontsize=15)
r = sns.boxplot (df ['current_balance'],orient='v',ax=axes [3][1]);
r.set_title ('Current Balance Distribution',fontsize=15)

r = sns.distplot (df ['credit_limit'],ax=axes [4][0]);
r.set_title ('Credit Limit Distribution',fontsize=15)
r = sns.boxplot (df ['credit_limit'],orient='v',ax=axes [4][1]);
r.set_title ('Credit Limit Distribution',fontsize=15)

r= sns.distplot (df ['min_payment_amt'],ax=axes [5][0]);
r.set_title ('Min Payment Amt Distribution',fontsize=15)
r = sns.boxplot (df ['min_payment_amt'],orient='v',ax=axes [5][1]);
r.set_title ('Min Payment Amt Distribution',fontsize=15)

r = sns.distplot (df ['max_spent_in_single_shopping'],ax=axes[6][0]);
r.set_title ('Max Spent in single shopping',fontsize=15)
r= sns.boxplot (df ['max_spent_in_single_shopping'],orient='v', ax=axes [6][1]);
r.set_title ('Max Spent in single shopping',fontsize=15)
```

Out[28]:

```
Text(0.5, 1.0, 'Max Spent in single shopping')
```

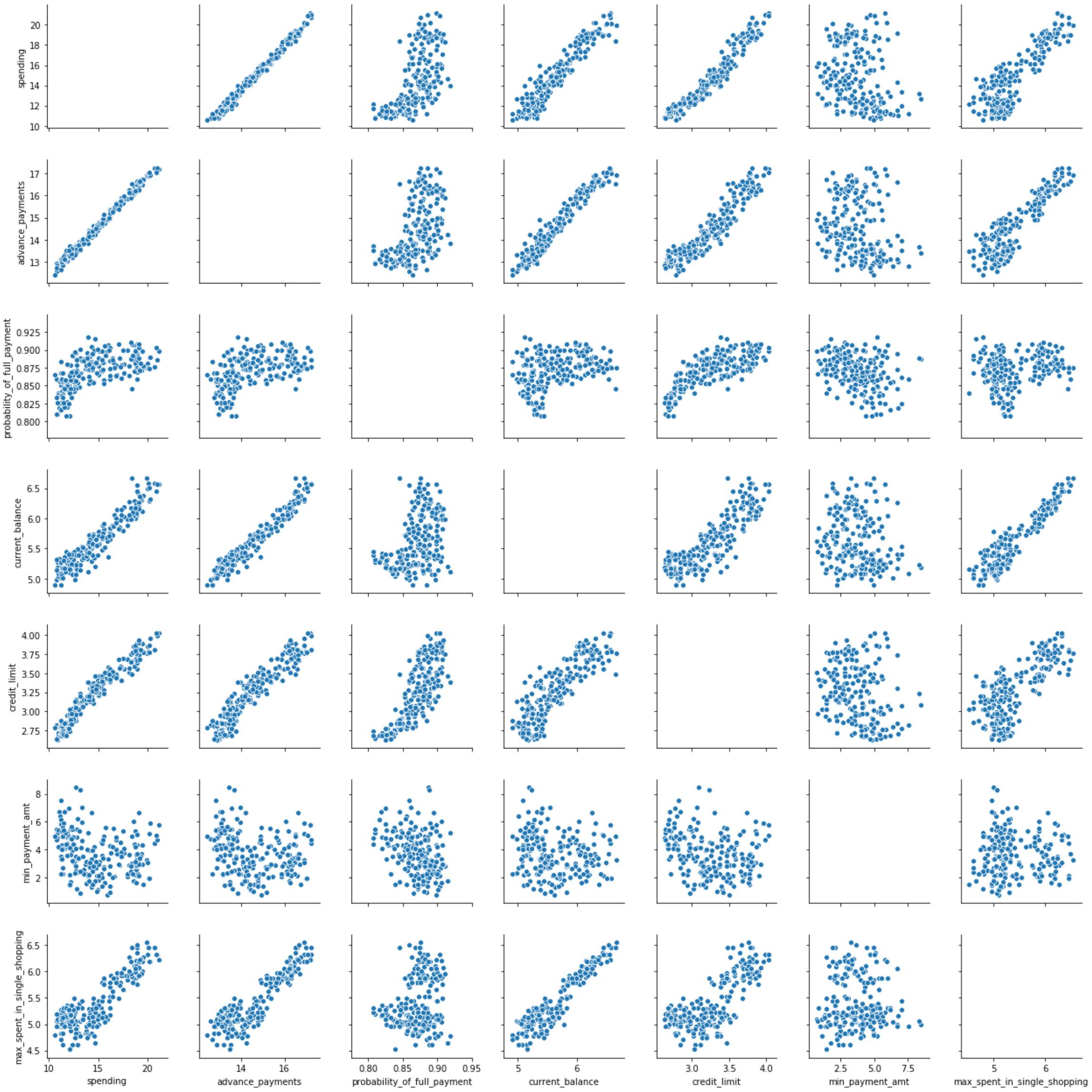

Spending Distribution
Spending Distribution
spending
Advance Payments Distribution
Advance Payments Distribution
advance_payments
Probability of Full Payment Distribution
Probability of Full Payment Distribution
probability_of_full_payment
Current Balance Distribution
Current Balance Distribution
current_balance
Credit Limit Distribution
Credit Limit Distribution
credit_limit
Min Payment Amt Distribution
Min Payment Amt Distribution
min_payment_amt
Max Spent in single shopping
Max Spent in single shopping
max_spent_in_single_shopping
max_spent_in_single_shopping

Inferences : We know that Data is not NORMALLY DISTRIBUTED as some variables are Right skewed,Left skewed etc and there are no Outliers except two Variables which we already checked,So we can proceed with this Data Set for further analysis.

In [ ]:

In [29]:

```
# PairPlot - to check the Variable importance.

sns.pairplot (df , diag_kind='hue');
plt.show()
```



Inferences : Maximum features are very much correlated with each other.

In [ ]:

In [30]:

```
# Heat Map - Get the correlation.
```

In [32]:

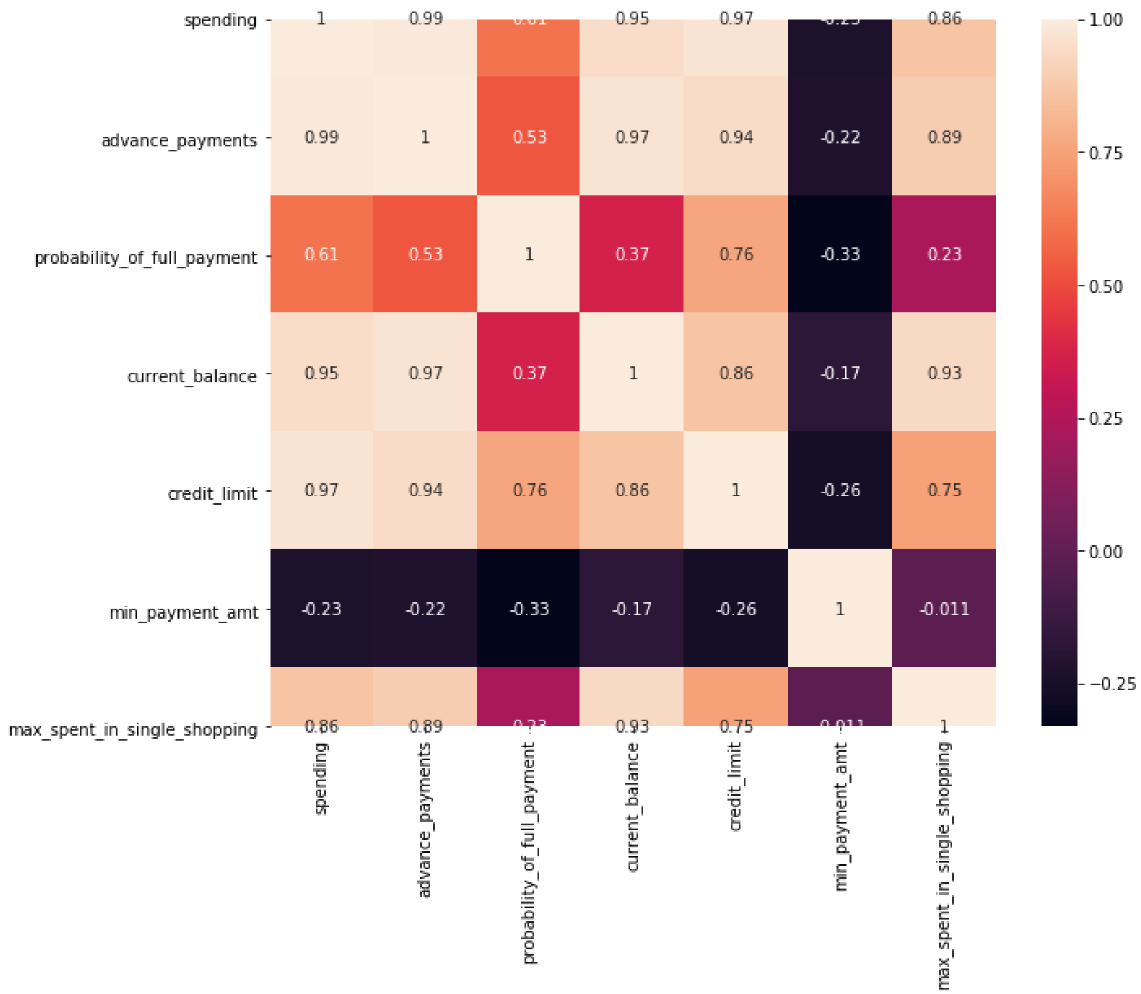
```
df.corr (method='pearson')
```

Out[32]:

	spending	advance_payments	probability_of_full_payment	curre
spending	1.000000	0.994341	0.608288	
advance_payments	0.994341	1.000000	0.529244	
probability_of_full_payment	0.608288	0.529244	1.000000	
current_balance	0.949985	0.972422	0.367915	
credit_limit	0.970771	0.944829	0.761635	
min_payment_amt	-0.229572	-0.217340	-0.331471	
max_spent_in_single_shopping	0.863693	0.890784	0.226825	

In [37]:

```
plt.subplots (figsize=(10,8))
sns.heatmap (df.corr(),annot=True);
```



Inferences :

As we can see Maximum features are highly correlated with each other like:

Spending with advance_payments probability_of_full_payment current_balance credit_limit and max_spent_in_single_shopping.

Advance Payments with spending,current_balance,credit_limit and max_spent_in_single_shopping.

Probability of full payment with spending and advance_payments.

Current balance with spending advance_payments,credit_limit and max_spent_in_single_shopping.

Credit limit with spending advance_payments probability_of_full_payment current_balance and max_spent_in_single_shopping.

Max spent in single shopping with spending advance_payments,current_balance and credit_limit.

In [ ]:

```

```

1.2 Do you think scaling is necessary for clustering in this case? Justify

First, we understand, what is Scaling, in simple words we want equality in our Data set which means all the magnitudes, values or numbers in the given data must be equal or somehow same in one line of number.

When Scaling is necessary: When we know the magnitudes are different for every given column and the Variance will also be different.

So, in this Case we will be doing Scaling.

Justification: We can see that Variance are quite similar in range for every column, but magnitudes are different hence we will be performing Scaling.

So, after scaling we will get one similar range magnitudes for every column so that we will performing Clustering which will lead to give the proper output with good accuracy as when we will provide same magnitudes for every column then we can trust the Output which we can get as Clusters.

In [43]:

```
# lets scale the Data.

from sklearn.preprocessing import StandardScaler

sc = StandardScaler ()
scaled_df = sc.fit_transform (df)
scaled_df
```

Out[43]:

```
array([[ 1.75435461,  1.81196782,  0.17822987, ...,  1.33857863,
        -0.29880602,  2.3289982 ],
       [ 0.39358228,  0.25383997,  1.501773  , ...,  0.85823561,
        -0.24280501, -0.53858174],
       [ 1.41330028,  1.42819249,  0.50487353, ...,  1.317348  ,
        -0.22147129,  1.50910692],
       ...,
       [-0.2816364 , -0.30647202,  0.36488339, ..., -0.15287318,
        -1.3221578 , -0.83023461],
       [ 0.43836719,  0.33827054,  1.23027698, ...,  0.60081421,
        -0.95348449,  0.07123789],
       [ 0.24889256,  0.45340314, -0.77624835, ..., -0.07325831,
        -0.70681338,  0.96047321]])
```

1.3 Apply hierarchical clustering to scaled data. Identify the number of optimum clusters using Dendrogram and briefly describe them

Clustering means to group all the variables which having different information so that we can define the information. It is an unsupervised learning where we do not know the Dependent and Independent Variables. Hierarchical Clustering assumes every row is a single cluster and then by doing mathematical calculations it gives one good cluster.

In [44]:

```
# Calling the libraries for Hierarchical Clustering.

from scipy.cluster.hierarchy import dendrogram,linkage
```

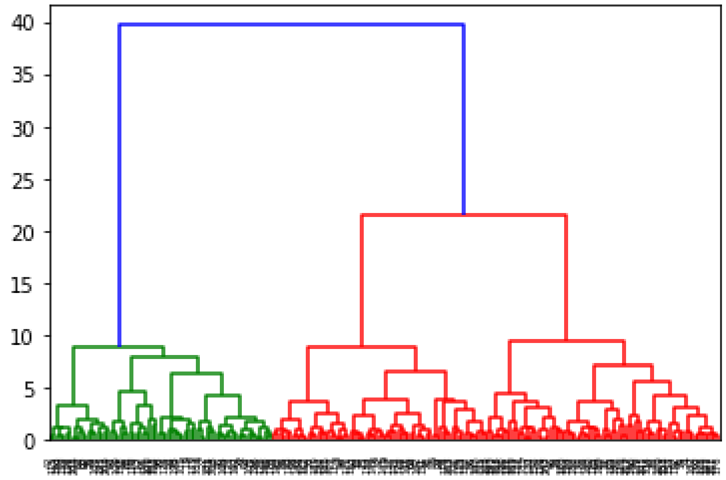
In [45]:

```
wardlink = linkage (scaled_df,method='ward') # Calculates the SSW within sum of square
 for every cluster and then compare with other clusters,whichever is having minimum dis
tance,it is considered.
```

Identifying number of clusters using Dendrogram.

In [46]:

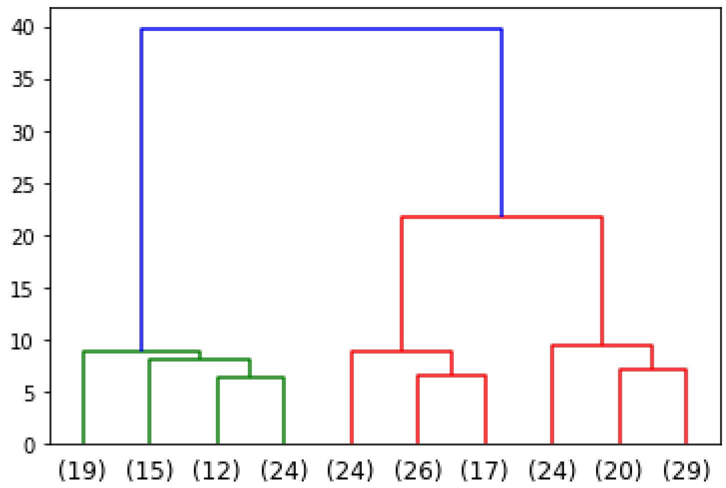
```
dend = dendrogram (wardlink)
```



We can see that there are 2 Clusters form, having colour in RED which is covering maximum information and Green is having minimum information.

In [47]:

```
# lets check the last 10 clusters for the above.

dend = dendrogram (wardlink,truncate_mode='lastp',p=10)
```



In [48]:

```
# We have form the 2 Clusters , lets check the different techniques for identifing the
 clusters numbers.

from scipy.cluster.hierarchy import fcluster

# Method 1.
clusters = fcluster (wardlink,2,criterion='maxclust')
clusters
```

Out[48]:

```
array([1, 2, 1, 2, 1, 2, 2, 2, 1, 2, 1, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2,
       1, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 1, 2, 1, 1,
       2, 2, 2, 1, 1, 1, 2, 1, 1, 1, 1, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2, 1,
       1, 2, 1, 2, 2, 2, 1, 1, 2, 1, 2, 2, 1, 2, 2, 2, 2, 1, 2, 2, 2, 1,
       1, 2, 2, 1, 2, 2, 2, 1, 1, 1, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 2, 1,
       2, 2, 1, 2, 2, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2,
       2, 1, 2, 1, 1, 2, 1, 2, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 1, 1, 2, 1, 1, 1, 2, 1, 2, 2, 2, 2, 2, 2, 1, 1, 1,
       2, 2, 1, 2, 2, 2, 2, 2, 1, 1, 2, 2, 2, 2, 2, 2, 2, 1, 2, 1, 1, 2,
       1, 2, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2], dtype=int32)
```

In [49]:

```
clusters = fcluster (wardlink,3,criterion='maxclust')
clusters
```

Out[49]:

```
array([1, 3, 1, 2, 1, 2, 2, 3, 1, 2, 1, 3, 2, 1, 3, 2, 3, 2, 3, 2, 2, 2,
       1, 2, 3, 1, 3, 2, 2, 2, 3, 2, 2, 3, 2, 2, 2, 2, 2, 1, 1, 3, 1, 1,
       2, 2, 3, 1, 1, 1, 2, 1, 1, 1, 1, 1, 2, 2, 2, 1, 3, 2, 2, 3, 3, 1,
       1, 3, 1, 2, 3, 2, 1, 1, 2, 1, 3, 2, 1, 3, 3, 3, 3, 1, 2, 3, 3, 1,
       1, 2, 3, 1, 3, 2, 2, 1, 1, 1, 2, 1, 2, 1, 3, 1, 3, 1, 1, 2, 2, 1,
       3, 3, 1, 2, 2, 1, 3, 3, 2, 1, 3, 2, 2, 2, 3, 3, 1, 2, 3, 3, 2, 3,
       3, 1, 2, 1, 1, 2, 1, 3, 3, 3, 2, 2, 3, 2, 1, 2, 3, 2, 3, 2, 3, 3,
       3, 3, 3, 2, 3, 1, 1, 2, 1, 1, 1, 2, 1, 3, 3, 3, 3, 2, 3, 1, 1, 1,
       3, 3, 1, 2, 3, 3, 3, 3, 1, 1, 3, 3, 3, 2, 3, 3, 2, 1, 3, 1, 1, 2,
       1, 2, 3, 1, 3, 2, 1, 3, 1, 3, 1, 3], dtype=int32)
```

In [50]:

```
# Method 2.

clusters = fcluster (wardlink,13,criterion='distance')
clusters
```

Out[50]:

```
array([1, 3, 1, 2, 1, 2, 2, 3, 1, 2, 1, 3, 2, 1, 3, 2, 3, 2, 3, 2, 2, 2,
       1, 2, 3, 1, 3, 2, 2, 2, 3, 2, 2, 3, 2, 2, 2, 2, 2, 1, 1, 3, 1, 1,
       2, 2, 3, 1, 1, 1, 2, 1, 1, 1, 1, 1, 2, 2, 2, 1, 3, 2, 2, 3, 3, 1,
       1, 3, 1, 2, 3, 2, 1, 1, 2, 1, 3, 2, 1, 3, 3, 3, 3, 1, 2, 3, 3, 1,
       1, 2, 3, 1, 3, 2, 2, 1, 1, 1, 2, 1, 2, 1, 3, 1, 3, 1, 1, 2, 2, 1,
       3, 3, 1, 2, 2, 1, 3, 3, 2, 1, 3, 2, 2, 2, 3, 3, 1, 2, 3, 3, 2, 3,
       3, 1, 2, 1, 1, 2, 1, 3, 3, 3, 2, 2, 3, 2, 1, 2, 3, 2, 3, 2, 3, 3,
       3, 3, 3, 2, 3, 1, 1, 2, 1, 1, 1, 2, 1, 3, 3, 3, 3, 2, 3, 1, 1, 1,
       3, 3, 1, 2, 3, 3, 3, 3, 1, 1, 3, 3, 3, 2, 3, 3, 2, 1, 3, 1, 1, 2,
       1, 2, 3, 1, 3, 2, 1, 3, 1, 3, 1, 3], dtype=int32)
```

In [51]:

```
clusters = fcluster (wardlink , 10 , criterion='distance')
clusters
```

Out[51]:

```
array([1, 3, 1, 2, 1, 2, 2, 3, 1, 2, 1, 3, 2, 1, 3, 2, 3, 2, 3, 2, 2, 2,
       1, 2, 3, 1, 3, 2, 2, 2, 3, 2, 2, 3, 2, 2, 2, 2, 2, 1, 1, 3, 1, 1,
       2, 2, 3, 1, 1, 1, 2, 1, 1, 1, 1, 1, 2, 2, 2, 1, 3, 2, 2, 3, 3, 1,
       1, 3, 1, 2, 3, 2, 1, 1, 2, 1, 3, 2, 1, 3, 3, 3, 3, 1, 2, 3, 3, 1,
       1, 2, 3, 1, 3, 2, 2, 1, 1, 1, 2, 1, 2, 1, 3, 1, 3, 1, 1, 2, 2, 1,
       3, 3, 1, 2, 2, 1, 3, 3, 2, 1, 3, 2, 2, 2, 3, 3, 1, 2, 3, 3, 2, 3,
       3, 1, 2, 1, 1, 2, 1, 3, 3, 3, 2, 2, 3, 2, 1, 2, 3, 2, 3, 2, 3, 3,
       3, 3, 3, 2, 3, 1, 1, 2, 1, 1, 1, 2, 1, 3, 3, 3, 3, 2, 3, 1, 1, 1,
       3, 3, 1, 2, 3, 3, 3, 3, 1, 1, 3, 3, 3, 2, 3, 3, 2, 1, 3, 1, 1, 2,
       1, 2, 3, 1, 3, 2, 1, 3, 1, 3, 1, 3], dtype=int32)
```

Now we will add all 3 Clusters in our original Data set so that we can define the existing data which relate all the clusters.

In [ ]:

```

```

In [52]:

```
# lets add the clusters to the original data.

df['clusters'] = clusters
df.head() # checking the Data with newly added clusters.
```

Out[52]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	mi
0	19.94	16.92	0.8752	6.675	3.763	
1	15.99	14.89	0.9064	5.363	3.582	
2	18.95	16.42	0.8829	6.248	3.755	
3	10.83	12.96	0.8099	5.278	2.641	
4	17.99	15.86	0.8992	5.890	3.694	

In [53]:

```
# we will create a new CSV file for better understanding and save it in our local syste
m.

df.to_csv ('new_df.csv')
```

In [55]:

```
# Lets check the Data.

clust_newdf = pd.read_csv ('new_df.csv')
clust_newdf.head()
```

Out[55]:

	Unnamed: 0	spending	advance_payments	probability_of_full_payment	current_balance	cre
0	0	19.94	16.92	0.8752	6.675	
1	1	15.99	14.89	0.9064	5.363	
2	2	18.95	16.42	0.8829	6.248	
3	3	10.83	12.96	0.8099	5.278	
4	4	17.99	15.86	0.8992	5.890	

Describing the Clusters:

So we have identified clusters for the given data set by using dendrogram and also validate by using 2 techniques.

We can draw a horizontal line on distance 13 to make "3 CLUSTERS".

Cluster 1 have good amount of probability of full payment to the bank and the credit limit is very high for this cluster.

Cluster 2 have less amount of probability for full payment to the bank as compared to the cluster 1 and credit limit is less.

Cluster 3 also have a good amount of probability for full payment to the bank with equal amount of credit limit as compared to cluster 1

We can draw a horizontal line on distance 13 to make "3 CLUSTERS".

1.4 Apply K-Means clustering on scaled data and determine optimum clusters. Apply elbow curve and silhouette score.

K-means clustering: At the beginning, we will specify how many clusters require and then we will proceed for the validation.

In [56]:

```
from sklearn.cluster import KMeans
```

In [62]:

```
kmeans = KMeans (n_clusters=1)
kmeans.fit(scaled_df)
kmeans.inertia_
```

Out[62]:

```
1470.0
```

In [57]:

```
kmeans = KMeans (n_clusters=2)
kmeans.fit(scaled_df) # fitting the scaled data.
kmeans.labels_
```

Out[57]:

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

In [58]:

```
kmeans.inertia_ # WSS for 2 clusters is 659.17.
```

Out[58]:

```
659.1717544870407
```

In [59]:

```
# Lets try for number of clusters 3, 4 and 5.
# for 3 clusters.
kmeans = KMeans (n_clusters=3)
kmeans.fit(scaled_df)
kmeans.inertia_
```

Out[59]:

```
430.65897315130053
```

In [60]:

```
# for 4 clusters.

kmeans = KMeans (n_clusters=4)
kmeans.fit(scaled_df)
kmeans.inertia_
```

Out[60]:

```
371.24193066313256
```

In [61]:

```
# for 5 clusters.
kmeans = KMeans (n_clusters=5)
kmeans.fit(scaled_df)
kmeans.inertia_
```

Out[61]:

```
327.3281094192773
```

For all above 5 clusters Inertia gives us a clear idea that there is a significant drop from cluster 1 to cluster 2 of around 811 and from cluster 2 to cluster 3 of 229 and for cluster 3 to 4 of 59 and from cluster 4 to cluster 5 of 44.

SO we can only take those inertia which is having a huge drop in their inertia values which we can confirmed from cluster 1 and 2 and we can also take the cluster 3 as the drop is maximum but we can exclude the cluster 4 and 5.

Clusters	Inertia	Can Take
1	1470	Yes
2	659	Yes
3	430	Yes
4	371	NO
5	327	NO

We will apply elbow curve to visualize the maximum number of clusters we can take.

In [63]:

```
wssr = []
```

In [64]:

```
wssr
```

Out[64]:

```
[]
```

In [66]:

```
for i in range (1,11):
    KM = KMeans (n_clusters=i)
    KM.fit(scaled_df)
    wssr.append (KM.inertia_)
```

In [67]:

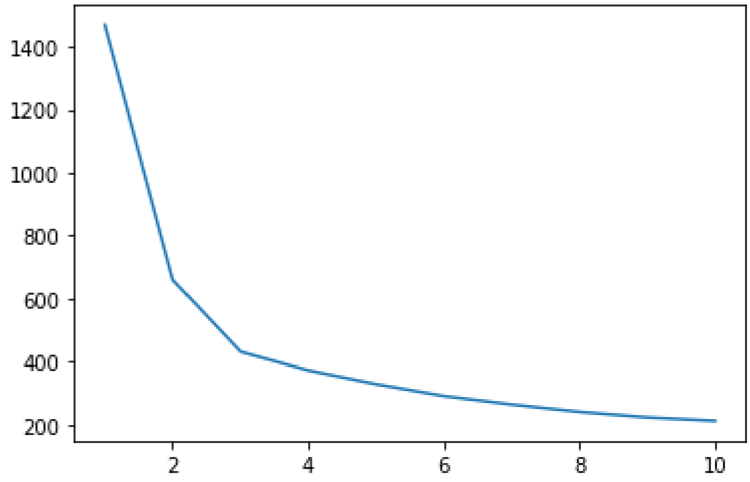
```
wssr
```

Out[67]:

```
[1470.0,
 659.1717544870407,
 430.65897315130053,
 371.301721277542,
 327.4732055881967,
 289.98904583584886,
 263.0910453972738,
 239.65012195641214,
 222.13439853914366,
 211.20447534124924]
```

In [79]:

```
plt.plot (range (1,11),wssr);
```



As we can see that there is a Significant drop from cluster 1 to 2 and a noticeable drop from cluster 2 to cluster 3.

Hence as we proved earlier that we can SELECT 3 CLUSTERS.

Silhouette score : by applying we can check how good our clusters are separated.

Benchmark - if score is +1 then good, if score is 0 then ok, if score is -1 then not good.

In [73]:

```
kmeans = KMeans (n_clusters=3)
kmeans.fit (scaled_df)
clust = kmeans.labels_
```

In [74]:

```
clust
```

Out[74]:

```
array([2, 1, 2, 0, 2, 0, 0, 1, 2, 0, 2, 1, 0, 2, 1, 0, 1, 0, 0, 0, 0, 0,
       2, 0, 1, 2, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 2, 2, 1, 2, 2,
       0, 0, 1, 2, 2, 2, 0, 2, 2, 2, 2, 2, 0, 0, 0, 2, 1, 0, 0, 1, 1, 2,
       2, 1, 2, 0, 1, 0, 2, 2, 0, 2, 1, 0, 2, 1, 1, 1, 1, 2, 0, 1, 2, 1,
       2, 0, 1, 2, 1, 0, 0, 2, 2, 2, 0, 2, 1, 2, 1, 2, 1, 2, 2, 0, 0, 2,
       1, 1, 2, 0, 0, 2, 1, 1, 0, 2, 1, 0, 0, 0, 1, 1, 2, 0, 1, 1, 0, 1,
       1, 2, 0, 2, 2, 0, 2, 1, 1, 1, 0, 0, 1, 0, 2, 0, 1, 0, 1, 0, 1, 1,
       0, 1, 1, 0, 1, 2, 2, 0, 2, 2, 2, 0, 1, 1, 1, 0, 1, 0, 1, 2, 2, 2,
       1, 0, 1, 0, 1, 1, 1, 1, 2, 2, 0, 1, 1, 0, 0, 1, 0, 2, 1, 2, 2, 0,
       2, 0, 1, 2, 1, 0, 2, 1, 2, 1, 1, 1])
```

In [75]:

```
from sklearn.metrics import silhouette_samples , silhouette_score
```

In [77]:

```
silhouette_score (scaled_df,clust)
```

Out[77]:

```
0.4007270552751299
```

Score is 40 and it is positive, so our clusters are separated properly.

In [78]:

```
sil_width = silhouette_samples (scaled_df,clust)
df ['sil_width'] = sil_width
df ['clust'] = clust
df.head()
```

Out[78]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	mi
0	19.94	16.92	0.8752	6.675	3.763	
1	15.99	14.89	0.9064	5.363	3.582	
2	18.95	16.42	0.8829	6.248	3.755	
3	10.83	12.96	0.8099	5.278	2.641	
4	17.99	15.86	0.8992	5.890	3.694	

Interpret Inferences are:

Our clusters are very well separated from each other as there is no jumping of magnitudes. We have checked the inertia which had given us the clear idea that there is a good significant drop from cluster 1 to 2 and to 3. Also, we have visualised by using the Elbow curve and our Silhouette score is 40 which is very good for cluster separation.

1.5 Describe cluster profiles for the clusters defined. Recommend different promotional strategies for different clusters.in context to the business problem in-hand

Cluster 1:

Per month spending for this cluster is maximum which is on average of 18,000. They paid almost 1600 advance in cash. 88 % customer pay their full payment for the month to the bank (so bank have good recovery rate from this cluster). At the end of the month this customer has on average of 6000 remaining in their account. Credit Limit for every customer is around 30000 for this cluster. They paid around 300 for every minimum purchases. They spent around 6000 for single purchase at one time.

Promotional strategies from BANK:

After considering all the above points, I would suggest bank to provide their promotional/product offers which will in range of 5000 to 12000.

Cluster 2:

Per month spending for this cluster is maximum which is on average of 12,000. They paid almost 1300 advance in cash. 84 % customer pay their full payment for the month to the bank (Bank can increase the rate by providing some easy solutions). At the end of the month this customer has on average of 5000 remaining in their account. Credit Limit for every customer is around 20000 for this cluster. They paid around 500 for every minimum purchases. They spent around 5000 for single purchase at one time.

Promotional strategies from BANK:

After considering all the above points, I would suggest bank to provide their promotional/product offers which will in range of 2600 to 6000. (we can increase the initial rate once recovery of payment will go above 85 %).

Cluster 3:

Per month spending for this cluster is maximum which is on average of 14,000. They paid almost 1400 advance in cash. 87 % customer pay their full payment for the month to the bank (so bank have good recovery rate from this cluster). At the end of the month this customer has on average of 5000 remaining in their account. Credit Limit for every customer is around 30000 for this cluster. They paid around 200 for every minimum purchases. They spent around 5000 for single purchase at one time.

Promotional strategies from BANK:

After considering all the above points, I would suggest bank to provide their promotional/product offers which will in range of 4000 to 9000.

Conclusion for all 3 Clusters to the Bank.

Clusters	Promotional Offers in Rupees
1	5000 to 12000
2	2600 to 6000
3	4000 to 9000

```
==========================================================================================
```

Problem 2: CART-RF-ANN

An Insurance firm providing tour insurance is facing higher claim frequency. The management decides to collect data from the past few years. You are assigned the task to make a model which predicts the claim status and provide recommendations to management. Use CART, RF & ANN and compare the models' performances in train and test sets.

2.1 Data Ingestion: Read the dataset. Do the descriptive statistics and do null value condition check.Interpret the inferences from the descriptive statistics in a detailed manner.

In [81]:

```
# Lets pull the Data and Read it.

cra = pd.read_csv (r'E:\Great Learning\Projects\Data Mining- Clusters,CART,RF,ANN\Data
 sets\insurance_part2_data.csv')
cra.head()
```

Out[81]:

	Age	Agency_Code	Type	Claimed	Commision	Channel	Duration	Sales	Product Name
0	48	C2B	Airlines	No	0.70	Online	7	2.51	Customised Plan
1	36	EPX	Travel Agency	No	0.00	Online	34	20.00	Customised Plan
2	39	CWT	Travel Agency	No	5.94	Online	3	9.90	Customised Plan
3	36	EPX	Travel Agency	No	0.00	Online	4	26.00	Cancellation Plan
4	33	JZI	Airlines	No	6.30	Online	53	18.00	Bronze Plan

1. Target: Claim Status (Claimed)
2. Code of tour firm (Agency_Code)
3. Type of tour insurance firms (Type)
4. Distribution channel of tour insurance agencies (Channel)
5. Name of the tour insurance products (Product)
6. Duration of the tour (Duration)
7. Destination of the tour (Destination)
8. Amount of sales of tour insurance policies (Sales)
9. The commission received for tour insurance firm (Commission)
10. Age of insured (Age)

Descriptive statistics:

In [82]:

```
# We will check the basic information for the above data.

cra.shape # 3000 rows and 10 columns.
```

Out[82]:

```
(3000, 10)
```

In [84]:

```
cra.columns
```

Out[84]:

```
Index(['Age', 'Agency_Code', 'Type', 'Claimed', 'Commision', 'Channel',
       'Duration', 'Sales', 'Product Name', 'Destination'],
      dtype='object')
```

In [88]:

```
cra.describe().T
```

Out[88]:

	count	mean	std	min	25%	50%	75%	max
Age	3000.0	38.091000	10.463518	8.0	32.0	36.00	42.000	84.00
Commision	3000.0	14.529203	25.481455	0.0	0.0	4.63	17.235	210.21
Duration	3000.0	70.001333	134.053313	-1.0	11.0	26.50	63.000	4580.00
Sales	3000.0	60.249913	70.733954	0.0	20.0	33.00	69.000	539.00

In [91]:

```
cra.dtypes.value_counts()
```

Out[91]:

```
object     6
float64    2
int64      2
dtype: int64
```

In [93]:

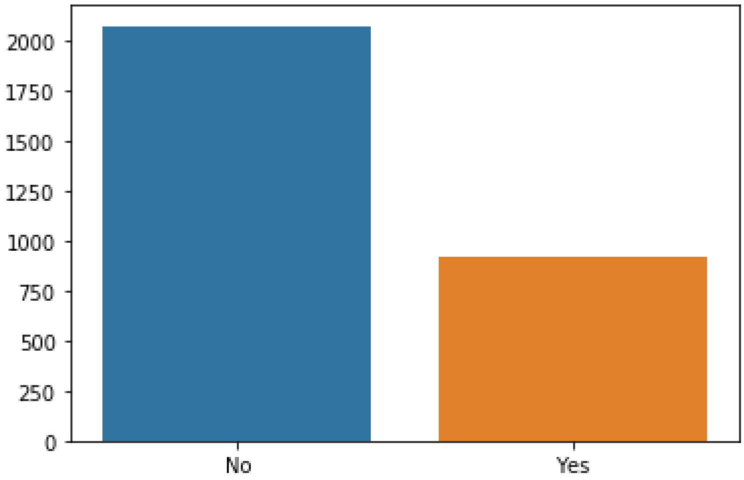
```
cra.Claimed.value_counts()
```

Out[93]:

```
No     2076
Yes     924
Name: Claimed, dtype: int64
```

In [94]:

```
sns.barplot (cra.Claimed.value_counts().index , cra.Claimed.value_counts().values);
plt.show()
print(cra.Claimed.value_counts(normalize=True))
```




```
No     0.692
Yes    0.308
Name: Claimed, dtype: float64
```

In [95]:

```
du = cra.duplicated()
du.sum()
print ('Number of Duplicates in this Data set are %d' % du.sum())
```

```
Number of Duplicates in this Data set are 139
```

Our objective is to build models which are CART,RF and ANN which require INTEGERS as data type and we have different data types,so we will be converting all of them to the INTEGERS.

In [107]:

```
for feature in cra.columns:
    if cra [feature].dtype=='object':
        cra [feature]=pd.Categorical (cra[feature]).codes # coverting all dtypes in Int
egers.
```

In [108]:

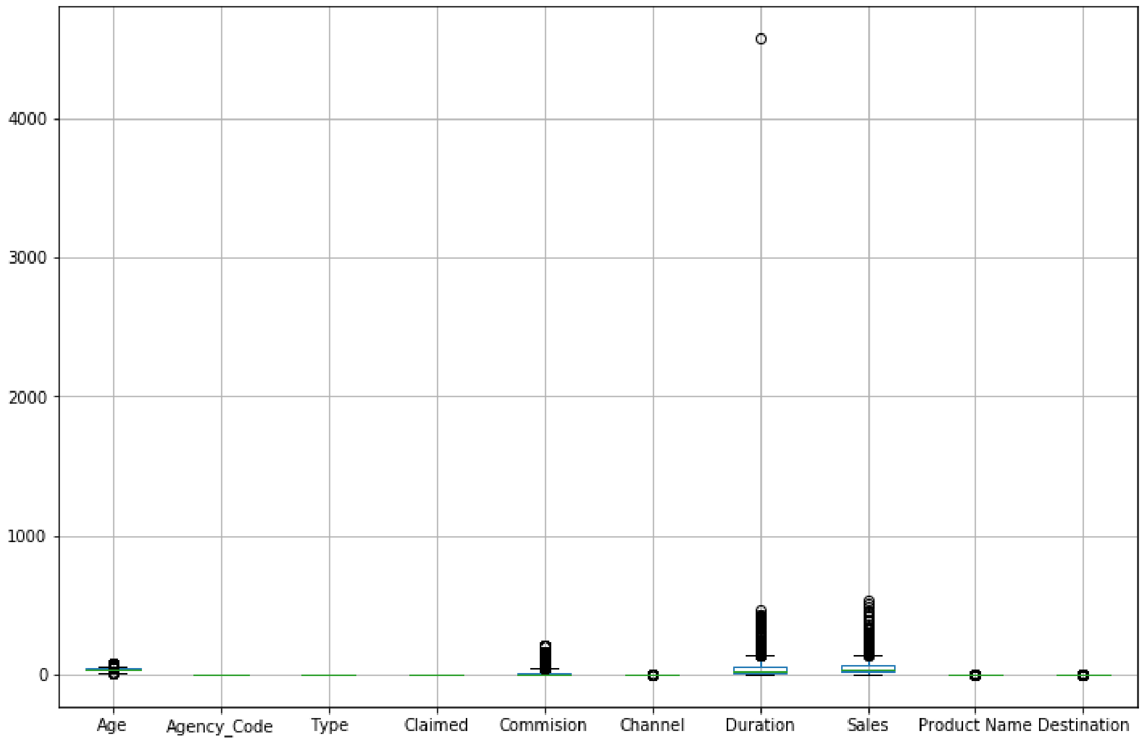
```
cra.dtypes.value_counts() # Now we have all Data types in Numerical.
```

Out[108]:

```
int8       6
int64      2
float64    2
dtype: int64
```

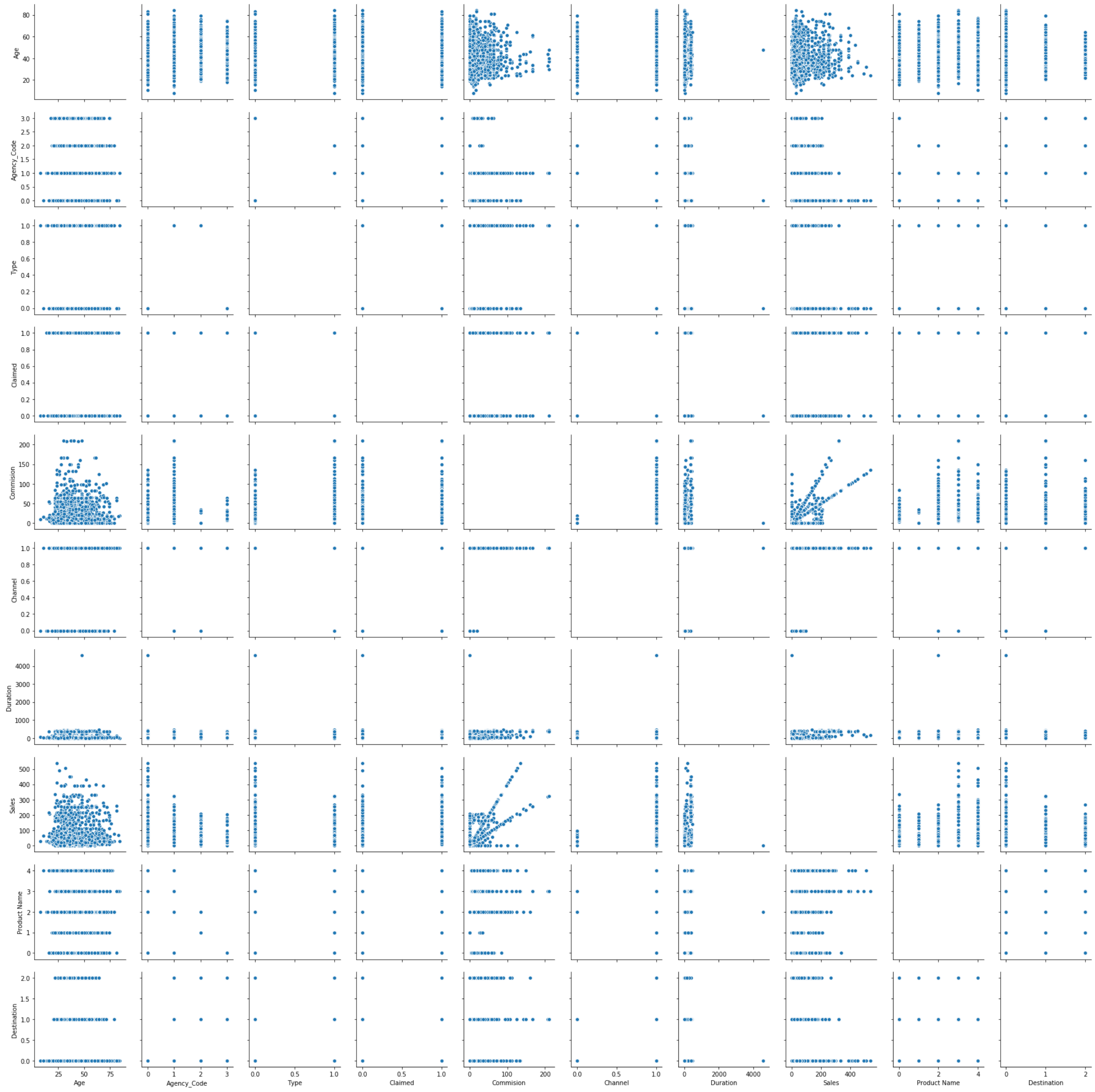
In [109]:

```
# Outliers:

cra.boxplot (figsize=(12,8));
```



In [110]:

```
# Feature relations.

sns.pairplot (cra,diag_kind='hue');
```


Age
Agency_Code
Type
Claimed
Commision
Channel
Duration
Sales
Product Name
Destination

In [111]:

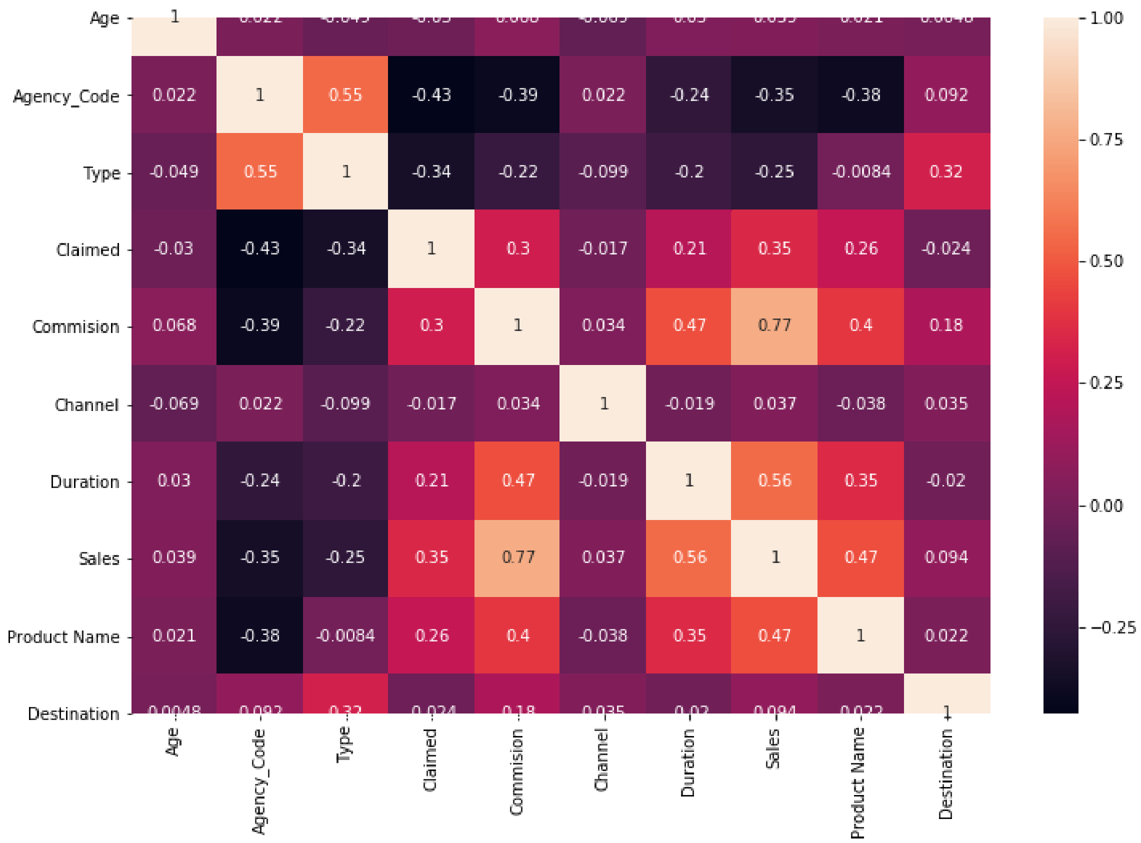
```
# Correlation
cra.corr(method='pearson')
```

Out[111]:

	Age	Agency_Code	Type	Claimed	Commision	Channel	Duratio
Age	1.000000	0.021939	-0.048992	-0.030027	0.067717	-0.068927	0.03042
Agency_Code	0.021939	1.000000	0.552247	-0.428647	-0.392585	0.022085	-0.23928
Type	-0.048992	0.552247	1.000000	-0.343505	-0.216599	-0.099291	-0.19821
Claimed	-0.030027	-0.428647	-0.343505	1.000000	0.297498	-0.016641	0.21492
Commision	0.067717	-0.392585	-0.216599	0.297498	1.000000	0.033563	0.47138
Channel	-0.068927	0.022085	-0.099291	-0.016641	0.033563	1.000000	-0.01938
Duration	0.030425	-0.239285	-0.198219	0.214923	0.471389	-0.019389	1.00000
Sales	0.039455	-0.346404	-0.254868	0.348877	0.766505	0.037418	0.55893
Product Name	0.020643	-0.379233	-0.008416	0.257951	0.399306	-0.037859	0.35476
Destination	0.004750	0.092274	0.317289	-0.023851	0.184017	0.035373	-0.01966

In [112]:

```
# Heatmap.
plt.figure(figsize=(12,8))
sns.heatmap (cra.corr(), annot=True),
plt.show()
```



In [103]:

```
# Null Value

cra.isnull().sum() # No missing values.
```

Out[103]:

```
Age             0
Agency_Code     0
Type            0
Claimed         0
Commision       0
Channel         0
Duration        0
Sales           0
Product Name    0
Destination     0
dtype: int64
```

Null Value Condition:

We have checked from the above that there are no NULL (Missing value) in Data set.

Interpret the inferences from the descriptive statistics in a detailed manner.

As of now we have learned the information from the Data set and where we had done a several checks. From null value condition, we had confirmed that there are no missing values in the given data set. There are duplicates in the Data which are 139 (5% of complete Data), which include the repeatative Claimed status,Agency code,Type,Channel,Product name and destination, so each feature represents the given information for one particular row hence we have to keep the exact numbers for every column and row.

Data is Balanced as 70-30, 70 percent consisting of CLAIMED (NO) and 30 percent consisting of CLAIMED (YES). Magnitudes and Variance for all the columns are different from each other, which can either seen in their MEANS also, hence scaling will need for specific modelling. There are Outliers in 7 columns (Age,Commision,Channel,Duration,Sales,Product Name,Destination) we will be treating them for specific model too.

Below Features have Good Correlation which we have seen in Heat-Map. Commission and Sales good correlation (77 %) Duration and Sales good correlation (56 %) Product name and Sales good correlation (47 %) Sales is correlated with commission, duration and product name Duration and commission (47 %) Type and Agency code (55 %).

In [ ]:

```

```

2.2 Data Split: Split the data into test and train, build classification model CART, Random Forest, Artificial Neural Network.

In [113]:

```
# Before splitting the data, lets define a new variable x and y where we will keep inde
pendent (x) and dependent (y) variables.

x = cra.drop (['Claimed'],axis=1)
y = cra.pop ('Claimed')
```

In [114]:

```
x.shape
```

Out[114]:

```
(3000, 9)
```

In [115]:

```
y.shape
```

Out[115]:

```
(3000,)
```

In [116]:

```
# Lets split the Data into training and test set, where x will define independent varia
bles and y will define dependent variables.

from sklearn.model_selection import train_test_split
```

In [120]:

```
xtrain, xtest, ytrain, ytest = train_test_split (x, y, test_size = .30, random_state =
8)
```

In [123]:

```
xtrain.shape
```

Out[123]:

```
(2100, 9)
```

In [125]:

```
ytest.shape
```

Out[125]:

```
(900,)
```

In [126]:

```
xtest.shape
```

Out[126]:

```
(900, 9)
```

In [127]:

```
ytrain.shape
```

Out[127]:

```
(2100,)
```

In [ ]:

```
# Building Models.
```

Building Classification Model or Decision Tree (CART) model:

No need to treat the outliers and no need to perform scaling.

In [128]:

```
from sklearn.tree import DecisionTreeClassifier
```

In [130]:

```
dt = DecisionTreeClassifier(criterion='gini',random_state=8)
```

In [131]:

```
dt.fit (xtrain , ytrain)
```

Out[131]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=Non
e,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=8, splitter='best')
```

In [ ]:

```

```

Building Random Forest (RF):

For this model, we don’t need to treat outliers and no requirement for scaling the data.

In [132]:

```
from sklearn.ensemble import RandomForestClassifier
```

In [133]:

```
rf = RandomForestClassifier (n_estimators=50, oob_score=True)
```

In [134]:

```
rf.fit (xtrain, ytrain)
```

Out[134]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gin
i',
                       max_depth=None, max_features='auto', max_leaf_nodes
=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=50,
                       n_jobs=None, oob_score=True, random_state=None,
                       verbose=0, warm_start=False)
```

In [135]:

```
rf.oob_score_ # checking how the model performs.
```

Out[135]:

```
0.7509523809523809
```

Out of Bag score given us value of 75 %, so we can say that Error rate is of 25 % and our accuracy is 75 %, we can also increase it by fine tunning the model.

In [ ]:

```

```

Building Artificial Neural Netwrok (ANN):

For this model, we will require to treat the outliers and scaling needs to be done as this is mandatory for this specific model.

Lets create a Copy of our original data set and then we will work for this model.

In [136]:

```
new_cra = cra.copy()
```

In [137]:

```
new_cra.shape
```

Out[137]:

```
(3000, 9)
```

In [144]:

```
# Lets treat the outliers by defining one function.

def remove_outlier (col):
    sorted (col)
    Q1,Q3 = np.percentile (col,[25,75])
    IQR = Q3 - Q1
    lower_range = Q1 - (1.5 * IQR)
    upper_range = Q3 + (1.5 * IQR)
    return lower_range,upper_range
```

In [142]:

```
new_cra.columns
```

Out[142]:

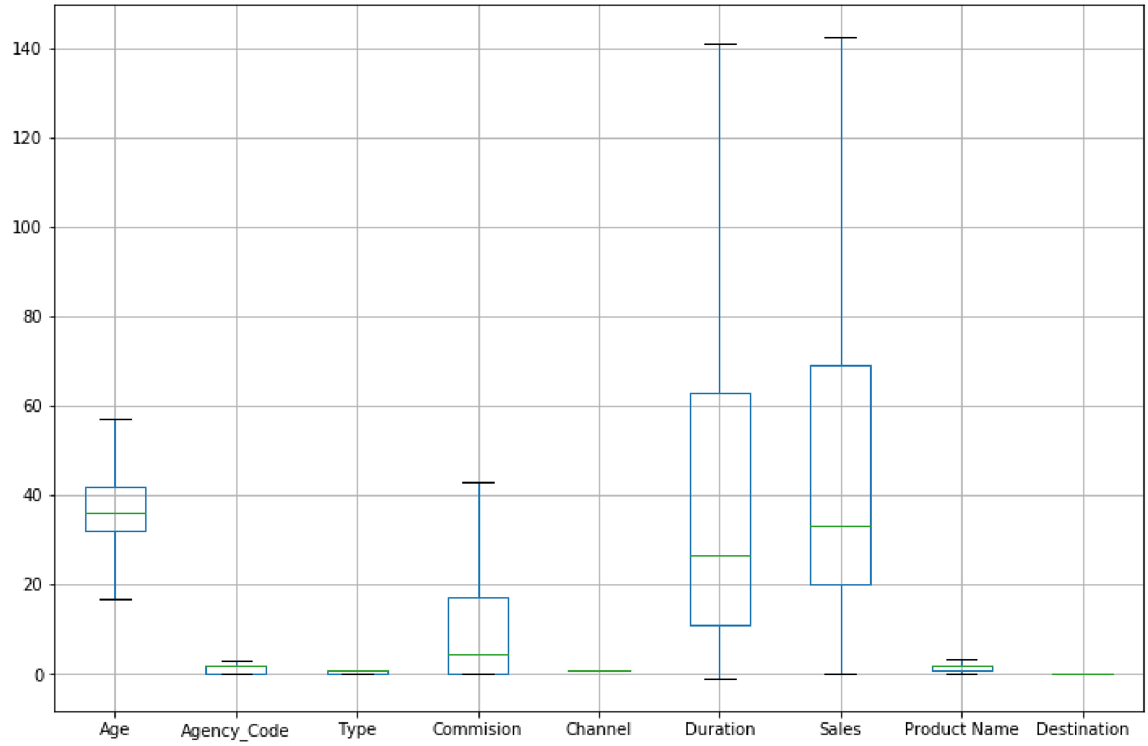
```
Index(['Age', 'Agency_Code', 'Type', 'Commision', 'Channel', 'Duration',
       'Sales', 'Product Name', 'Destination'],
      dtype='object')
```

In [145]:

```
lage , uage = remove_outlier (new_cra ['Age'])
new_cra ['Age'] = np.where (new_cra ['Age'] > uage,uage, new_cra ['Age'])
new_cra ['Age'] = np.where (new_cra ['Age'] < lage,lage, new_cra ['Age'])

lcom , ucom = remove_outlier (new_cra ['Commision'])
new_cra ['Commision'] = np.where (new_cra ['Commision'] > ucom, ucom, new_cra ['Commisi
on'])
new_cra ['Commision'] = np.where (new_cra ['Commision'] < lcom, lcom, new_cra ['Commisi
on'])

lch , uch = remove_outlier (new_cra ['Channel'])
new_cra ['Channel'] = np.where (new_cra ['Channel'] > uch, uch, new_cra ['Channel'])
new_cra ['Channel'] = np.where (new_cra ['Channel'] < lch, lch, new_cra ['Channel'])

ldu, udu = remove_outlier (new_cra ['Duration'])
new_cra ['Duration'] = np.where (new_cra ['Duration'] > udu , udu , new_cra ['Duration'
])
new_cra ['Duration'] = np.where (new_cra ['Duration'] < ldu, ldu, new_cra ['Duration'])

lsal, usal = remove_outlier (new_cra ['Sales'])
new_cra ['Sales'] = np.where (new_cra ['Sales'] > usal, usal, new_cra ['Sales'])
new_cra ['Sales']= np.where (new_cra ['Sales'] < lsal, lsal, new_cra ['Sales'])

lpr, upr = remove_outlier (new_cra ['Product Name'])
new_cra ['Product Name'] = np.where (new_cra ['Product Name'] > upr, upr , new_cra ['Pr
oduct Name'])
new_cra ['Product Name'] = np.where (new_cra ['Product Name'] < lpr, lpr, new_cra ['Pro
duct Name'])

udes, ldes = remove_outlier (new_cra ['Destination'])
new_cra ['Destination'] = np.where (new_cra ['Destination'] > udes , udes, new_cra ['De
stination'])
new_cra ['Destination'] = np.where (new_cra ['Destination'] < ldes, ldes, new_cra ['Des
tination'])
```

In [146]:

```
new_cra.boxplot (figsize=(12,8));
```



So we have treated the Outliers.

In [ ]:

```

```

Now we will be scaling the Data set.

In [147]:

```
from sklearn.preprocessing import StandardScaler
```

In [148]:

```
sc = StandardScaler()
```

In [150]:

```
xtrain = sc.fit_transform (xtrain)
```

In [151]:

```
xtest = sc.transform (xtest)
```

In [152]:

```
xtrain
```

Out[152]:

```
array([[-0.65698385, -0.31079598,  0.79320231, ..., -0.56423715,
         0.2763925 , -0.4417093 ],
       [-0.17740026,  0.69641321,  0.79320231, ..., -0.56137973,
         0.2763925 , -0.4417093 ],
       [-1.23248416, -1.31800517, -1.26071242, ..., -0.51137483,
        -1.3181796 , -0.4417093 ],
       ...,
       [-0.56106713, -0.31079598,  0.79320231, ...,  0.28441737,
         0.2763925 ,  1.2888682 ],
       [-1.80798447,  0.69641321,  0.79320231, ...,  0.29584706,
        -0.52089355, -0.4417093 ],
       [-0.17740026,  0.69641321,  0.79320231, ..., -0.21848901,
         0.2763925 , -0.4417093 ]])
```

In [153]:

```
xtest
```

Out[153]:

```
array([[-0.17740026,  0.69641321,  0.79320231, ..., -0.33278592,
         0.2763925 , -0.4417093 ],
       [-0.17740026, -1.31800517, -1.26071242, ..., -0.5828104 ,
         1.8709646 , -0.4417093 ],
       [-1.23248416, -0.31079598,  0.79320231, ..., -0.43279571,
         0.2763925 , -0.4417093 ],
       ...,
       [ 2.60418459, -0.31079598,  0.79320231, ..., -0.4185086 ,
         0.2763925 , -0.4417093 ],
       [-0.17740026,  0.69641321,  0.79320231, ..., -0.50423127,
         0.2763925 , -0.4417093 ],
       [-0.17740026,  0.69641321,  0.79320231, ...,  0.13868882,
         0.2763925 ,  1.2888682 ]])
```

So we have Scaled the given Data and now we can build our ANN model.

In [154]:

```
from sklearn.neural_network import MLPClassifier
```

In [155]:

```
mlp = MLPClassifier (hidden_layer_sizes=50 , max_iter=500, solver='adam', verbose=True,
tol = 0.001)
```

In [157]:

```
mlp.fit (xtrain , ytrain)
```

```
Iteration 1, loss = 0.66734678
Iteration 2, loss = 0.61234238
Iteration 3, loss = 0.57359428
Iteration 4, loss = 0.54652214
Iteration 5, loss = 0.52685568
Iteration 6, loss = 0.51378469
Iteration 7, loss = 0.50466535
Iteration 8, loss = 0.49887967
Iteration 9, loss = 0.49445303
Iteration 10, loss = 0.49165051
Iteration 11, loss = 0.48983594
Iteration 12, loss = 0.48844674
Iteration 13, loss = 0.48740281
Iteration 14, loss = 0.48627778
Iteration 15, loss = 0.48561194
Iteration 16, loss = 0.48515982
Iteration 17, loss = 0.48461145
Iteration 18, loss = 0.48416163
Iteration 19, loss = 0.48376906
Iteration 20, loss = 0.48345773
Iteration 21, loss = 0.48283792
Iteration 22, loss = 0.48262768
Iteration 23, loss = 0.48210111
Iteration 24, loss = 0.48181265
Iteration 25, loss = 0.48151750
Training loss did not improve more than tol=0.001000 for 10 consecutive ep
ochs. Stopping.
```

Out[157]:

```
MLPClassifier(activation='relu', alpha=0.0001, batch_size='auto', beta_1=
0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=50, learning_rate='constant',
              learning_rate_init=0.001, max_iter=500, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.001,
              validation_fraction=0.1, verbose=True, warm_start=False)
```

In [ ]:

```

```

2.3 Performance Metrics: Check the performance of Predictions on Train and Test sets using Accuracy, Confusion Matrix, Plot ROC curve and get ROC_AUC score for each model.

We will get all the Perofrmance measures on every model.

1: Classification Model (CART): Decision Tree.

In [159]:

```
# Lets Fine tune the model by upgrading the features.

dt_fine = DecisionTreeClassifier (criterion='gini',max_depth=5,max_features=5,random_st
ate=8)
```

In [160]:

```
dt_fine.fit (xtrain,ytrain)
```

Out[160]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=5,
                       max_features=5, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=8, splitter='best')
```

In [161]:

```
y_train_pre_dt = dt_fine.predict (xtrain)

y_test_pre_dt = dt_fine.predict (xtest)
```

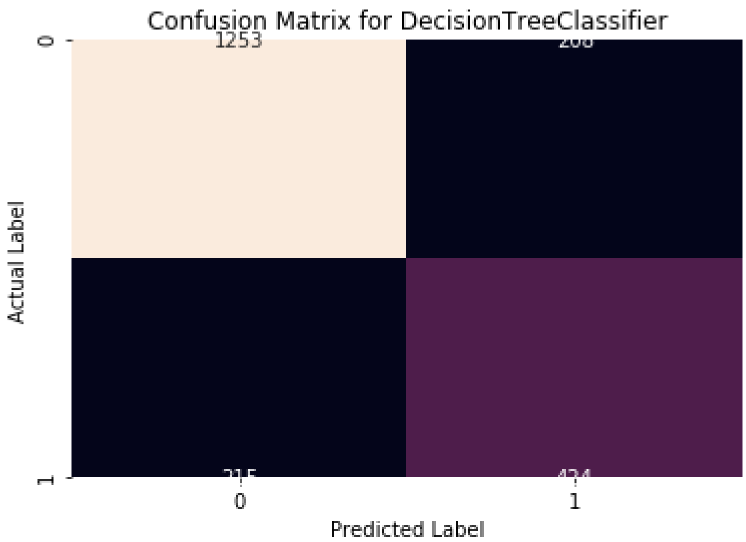
In [163]:

```
from sklearn.metrics import confusion_matrix, classification_report, roc_auc_score, roc
_curve,accuracy_score
```

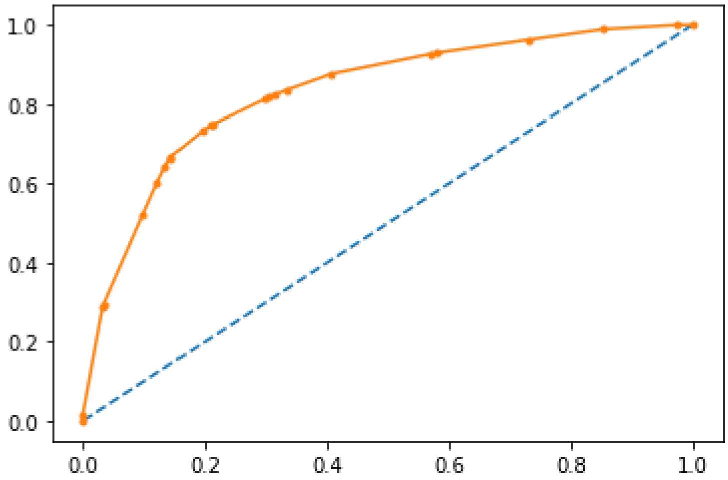
In [200]:

```
# Performance measures on Train set.

models_names={dt_fine:'DecisionTreeClassifier'}

print('Accuracy for {} model is'.format(models_names[dt_fine]),'\n',accuracy_score(ytra
in,y_train_pre_dt))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[dt_fine]),'\n',roc_auc_score
(ytrain,y_train_pre_dt))

print('\n')

print('Classification report for {} model is'.format(models_names[dt_fine]),'\n',classi
fication_report(ytrain,y_train_pre_dt))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[dt_fine]),'\n',confusion_m
atrix(ytrain,y_train_pre_dt))

print ('\n')


print('Confusion Matrix for {} model is'.format(models_names[dt_fine]))


sns.heatmap(confusion_matrix(ytrain,y_train_pre_dt),annot=True,fmt='d',cbar=False)
plt.title('Confusion Matrix for {}'.format(models_names[dt_fine]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = dt_fine.predict_proba (xtrain)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytrain, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytrain, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for DecisionTreeClassifier model is
 0.7985714285714286


ROC AUC score for DecisionTreeClassifier model is
 0.7605842676409815


Classification report for DecisionTreeClassifier model is
               precision    recall  f1-score   support

           0       0.85      0.86      0.86      1461
           1       0.67      0.66      0.67       639

    accuracy                           0.80      2100
   macro avg       0.76      0.76      0.76      2100
weighted avg       0.80      0.80      0.80      2100



Confusion Matrix for DecisionTreeClassifier model is
 [[1253  208]
 [ 215  424]]


Confusion Matrix for DecisionTreeClassifier model is
```




```
AUC: 0.831
```

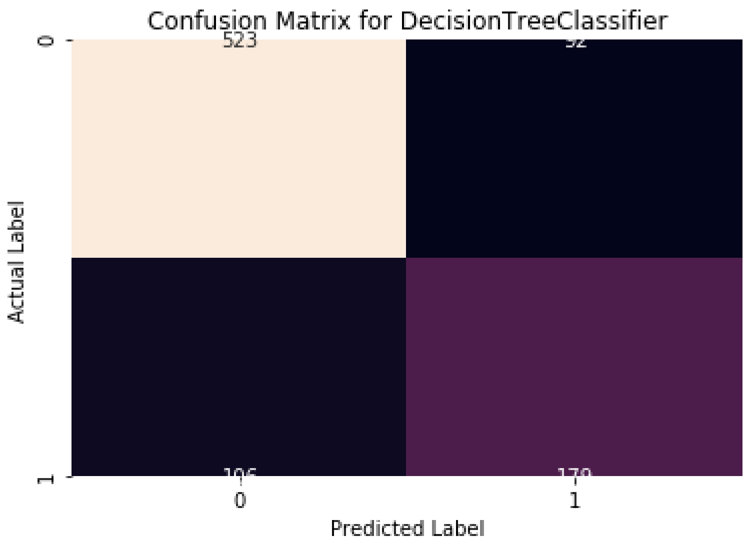


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

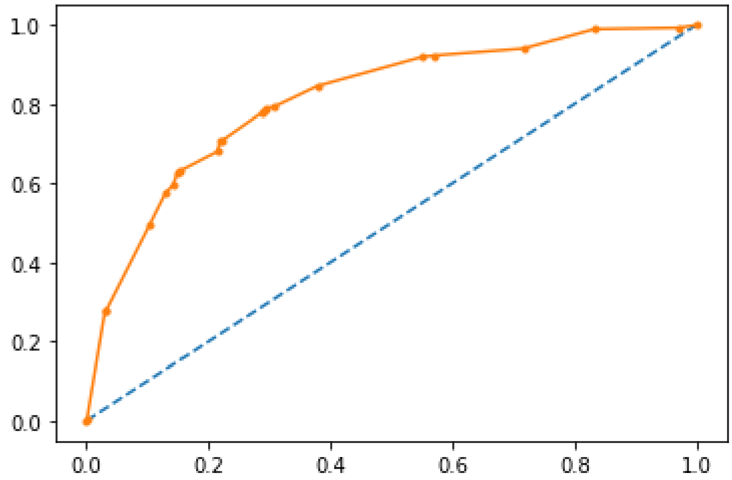
In [202]:

```
# Performance measures on Test set.

models_names={dt_fine:'DecisionTreeClassifier'}

print('Accuracy for {} model is'.format(models_names[dt_fine]),'\n',accuracy_score(ytes
t,y_test_pre_dt))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[dt_fine]),'\n',roc_auc_score
(ytest,y_test_pre_dt))

print('\n')

print('Classification report for {} model is'.format(models_names[dt_fine]),'\n',classi
fication_report(ytest,y_test_pre_dt))

print('\n')


print('Confusion Matrix for {} model is'.format(models_names[dt_fine]),'\n',confusion_m
atrix(ytest,y_test_pre_dt))

print ('\n')

print('Confusion Matrix for {} model is'.format(models_names[dt_fine]))


sns.heatmap(confusion_matrix(ytest,y_test_pre_dt),annot=True,fmt='d',cbar=False)
plt.title('Confusion Matrix for {}'.format(models_names[dt_fine]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = dt_fine.predict_proba (xtest)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytest, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytest, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for DecisionTreeClassifier model is
 0.78


ROC AUC score for DecisionTreeClassifier model is
 0.7392383397518185


Classification report for DecisionTreeClassifier model is
               precision    recall  f1-score   support

           0       0.83      0.85      0.84       615
           1       0.66      0.63      0.64       285

    accuracy                           0.78       900
   macro avg       0.75      0.74      0.74       900
weighted avg       0.78      0.78      0.78       900



Confusion Matrix for DecisionTreeClassifier model is
 [[523  92]
 [106 179]]


Confusion Matrix for DecisionTreeClassifier model is
```




```
AUC: 0.812
```



Inferences for Classification Model (CART) Model:Decision Tree.

Only checking for 1's. Performance Metrics on Training set has given us Accuracy of 79.85 %. ROC AUC score of 76 %. Recall 66 %. Precision 67 %. f1 score is also 67 %. AUC is 83 %.

False positives (FP) are 215 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1.

Only checking for 1's. Performance Metrics on Test set has given us Accuracy of 78 %. ROC AUC score of 73 %. Recall 63 %. Precision 66 %. f1 score is also 64 %. AUC is 81 %.

False positives (FP) are 106 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1.

In [ ]:

```

```

In [ ]:

```

```

2: Random Forest (RF):

In [ ]:

```

```

In [170]:

```
# Lets fine tune the model by upgrading the Features.

rf_ft = RandomForestClassifier (n_estimators=1000,
                                max_depth=5,
                                max_features=8,
                               min_samples_leaf=300,
                               min_samples_split=450,
                               random_state=8,
                               oob_score=True)
```

In [171]:

```
rf_ft = rf_ft.fit (xtrain, ytrain)
```

In [172]:

```
rf_ft.oob_score_
```

Out[172]:

```
0.7566666666666667
```

In [173]:

```
# Lets check how accurate our model with all the above values are by performing GRID SE
ARCH.

from sklearn.model_selection import GridSearchCV
```

In [174]:

```
param_grid = {'n_estimators': [501,1008],
             'max_depth': [4,6],
             'max_features': [5,8],
             'min_samples_leaf': [300,600],
             'min_samples_split': [900,1800],
             }
```

In [175]:

```
rf_ft = RandomForestClassifier()
```

In [176]:

```
grid_search_rf = GridSearchCV (estimator=rf_ft, param_grid= param_grid, cv=3)
```

In [177]:

```
grid_search_rf.fit (xtrain, ytrain)
```

Out[177]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=RandomForestClassifier(bootstrap=True, class_weight
=None,
                                              criterion='gini', max_depth=
None,
                                              max_features='auto',
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.
0,
                                              n_estimators='warn', n_jobs=
None,
                                              oob_score=False,
                                              random_state=None, verbose=
0,
                                              warm_start=False),
             iid='warn', n_jobs=None,
             param_grid={'max_depth': [4, 6], 'max_features': [5, 8],
                         'min_samples_leaf': [300, 600],
                         'min_samples_split': [900, 1800],
                         'n_estimators': [501, 1008]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
```

In [178]:

```
grid_search_rf.best_params_
```

Out[178]:

```
{'max_depth': 4,
 'max_features': 5,
 'min_samples_leaf': 300,
 'min_samples_split': 900,
 'n_estimators': 501}
```

In [179]:

```
grid_search_rf.best_estimator_
```

Out[179]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gin
i',
                       max_depth=4, max_features=5, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=300, min_samples_split=900,
                       min_weight_fraction_leaf=0.0, n_estimators=501,
                       n_jobs=None, oob_score=False, random_state=None,
                       verbose=0, warm_start=False)
```

In [180]:

```
best_model = grid_search_rf.best_estimator_
```

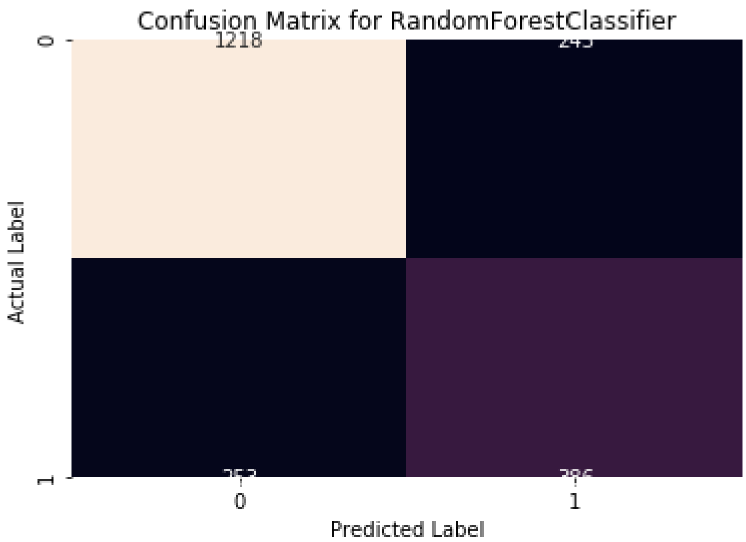
In [182]:

```
ytrain_predict_rf = best_model.predict (xtrain)
ytest_predict_rf = best_model.predict (xtest)
```

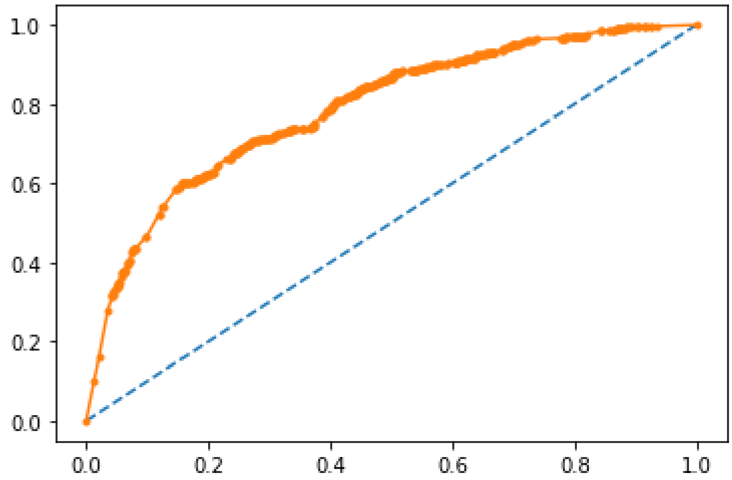
In [205]:

```
# Performance measures on Train set.

models_names={best_model:'RandomForestClassifier'}

print('Accuracy for {} model is'.format(models_names[best_model]),'\n',accuracy_score(y
train,ytrain_predict_rf))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[best_model]),'\n',roc_auc_sco
re (ytrain,ytrain_predict_rf))

print('\n')

print('Classification report for {} model is'.format(models_names[best_model]),'\n',cla
ssification_report(ytrain,ytrain_predict_rf))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[best_model]),'\n',confusio
n_matrix(ytrain,ytrain_predict_rf))

print ('\n')


print('Confusion Matrix for {} model is'.format(models_names[best_model]))

sns.heatmap(confusion_matrix(ytrain,ytrain_predict_rf),annot=True,fmt='d',cbar=False)

plt.title('Confusion Matrix for {}'.format(models_names[best_model]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = best_model.predict_proba (xtrain)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytrain, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytrain, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for RandomForestClassifier model is
 0.7638095238095238


ROC AUC score for RandomForestClassifier model is
 0.7188722111358546


Classification report for RandomForestClassifier model is
               precision    recall  f1-score   support

           0       0.83      0.83      0.83      1461
           1       0.61      0.60      0.61       639

    accuracy                           0.76      2100
   macro avg       0.72      0.72      0.72      2100
weighted avg       0.76      0.76      0.76      2100



Confusion Matrix for RandomForestClassifier model is
 [[1218  243]
 [ 253  386]]


Confusion Matrix for RandomForestClassifier model is
```



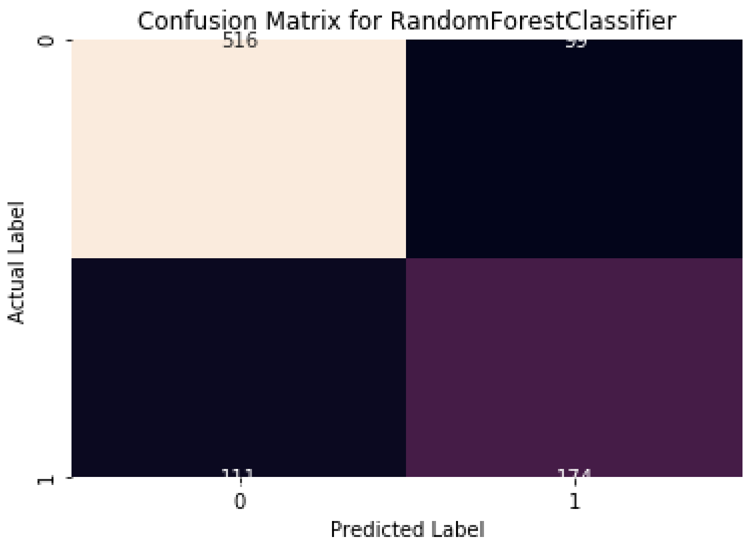

```
AUC: 0.788
```


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

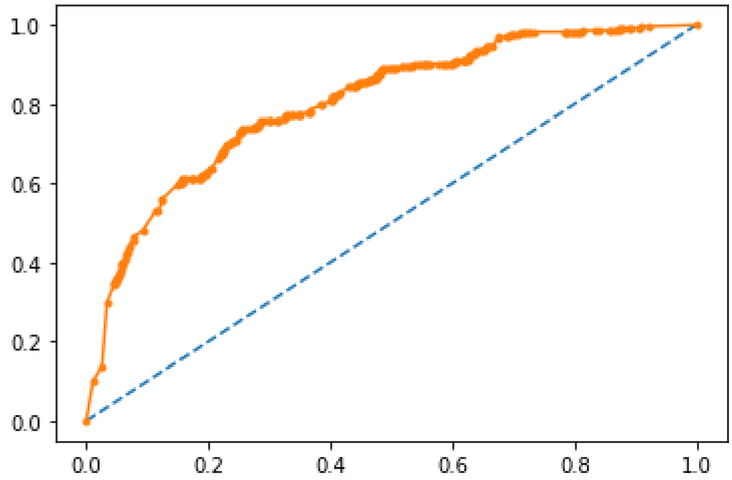
In [206]:

```
# Performance measures on Test set.

models_names={best_model:'RandomForestClassifier'}

print('Accuracy for {} model is'.format(models_names[best_model]),'\n',accuracy_score(y
test,ytest_predict_rf))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[best_model]),'\n',roc_auc_sco
re (ytest,ytest_predict_rf))

print('\n')

print('Classification report for {} model is'.format(models_names[best_model]),'\n',cla
ssification_report(ytest,ytest_predict_rf))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[best_model]),'\n',confusio
n_matrix(ytest,ytest_predict_rf))

print ('\n')


print('Confusion Matrix for {} model is'.format(models_names[best_model]))

sns.heatmap(confusion_matrix(ytest,ytest_predict_rf),annot=True,fmt='d',cbar=False)

plt.title('Confusion Matrix for {}'.format(models_names[best_model]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = best_model.predict_proba (xtest)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytest, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytest, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for RandomForestClassifier model is
 0.7666666666666667


ROC AUC score for RandomForestClassifier model is
 0.724775353016688


Classification report for RandomForestClassifier model is
               precision    recall  f1-score   support

           0       0.82      0.84      0.83       615
           1       0.64      0.61      0.62       285

    accuracy                           0.77       900
   macro avg       0.73      0.72      0.73       900
weighted avg       0.76      0.77      0.77       900



Confusion Matrix for RandomForestClassifier model is
 [[516  99]
 [111 174]]


Confusion Matrix for RandomForestClassifier model is
```




```
AUC: 0.804
```



Inferences for Random Forest (RF):

On Training Data Set Only checking for 1's. Performance Metrics on Training set has given us Accuracy of 76 %. ROC AUC score of 71 %. Recall 60 %. Precision 61 %. f1 score is also 61 %. AUC is 78 %.

False positives (FP) are 253 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1.

Only checking for 1's. Performance Metrics on Test set has given us Accuracy of 76 %. ROC AUC score of 72 %. Recall 61 %. Precision 64 %. f1 score is also 62 %. AUC is 80 %.

False positives (FP) are 111 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1.

So, both the Training and Test gives us the nearby similar score for all the Performance measures.

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

3: Artificial Neural Netwrok (ANN):

In [216]:

```
# lets fine tune the model and we will be using the features.

param_grid_ann = {'hidden_layer_sizes': [100,300],
                  'max_iter': [300,500],
                  'tol': [0.1,0.000001],
                  'solver':['adam'],
                  'verbose': ['true'],
                  }
```

In [218]:

```
mlp = MLPClassifier()
```

In [219]:

```
grid_search_ann = GridSearchCV (estimator=mlp, param_grid=param_grid_ann,cv=3)
```

In [220]:

```
grid_search_ann.fit (xtrain,ytrain)
```

```
Iteration 1, loss = 0.63686509
Iteration 2, loss = 0.59726647
Iteration 3, loss = 0.56917134
Iteration 4, loss = 0.54694730
Iteration 5, loss = 0.53020592
Iteration 6, loss = 0.51713298
Iteration 7, loss = 0.50654580
Iteration 8, loss = 0.49918397
Iteration 9, loss = 0.49308125
Iteration 10, loss = 0.48895490
Iteration 11, loss = 0.48589515
Iteration 12, loss = 0.48334300
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.59203268
Iteration 2, loss = 0.56205919
Iteration 3, loss = 0.54005918
Iteration 4, loss = 0.52318335
Iteration 5, loss = 0.51179474
Iteration 6, loss = 0.50331295
Iteration 7, loss = 0.49699078
Iteration 8, loss = 0.49427795
Iteration 9, loss = 0.49064980
Iteration 10, loss = 0.48893585
Iteration 11, loss = 0.48772182
Iteration 12, loss = 0.48646589
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.70156943
Iteration 2, loss = 0.63926737
Iteration 3, loss = 0.59468705
Iteration 4, loss = 0.56267514
Iteration 5, loss = 0.54041521
Iteration 6, loss = 0.52521953
Iteration 7, loss = 0.51549284
Iteration 8, loss = 0.50820088
Iteration 9, loss = 0.50315085
Iteration 10, loss = 0.49996212
Iteration 11, loss = 0.49725667
Iteration 12, loss = 0.49521720
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.67854489
Iteration 2, loss = 0.62701478
Iteration 3, loss = 0.58650712
Iteration 4, loss = 0.55724204
Iteration 5, loss = 0.53570137
Iteration 6, loss = 0.52021629
Iteration 7, loss = 0.50904534
Iteration 8, loss = 0.50161986
Iteration 9, loss = 0.49533131
Iteration 10, loss = 0.49112050
Iteration 11, loss = 0.48787814
Iteration 12, loss = 0.48538535
Iteration 13, loss = 0.48366964
Iteration 14, loss = 0.48199109
Iteration 15, loss = 0.48063039
Iteration 16, loss = 0.47989130
Iteration 17, loss = 0.47898473
Iteration 18, loss = 0.47802523
Iteration 19, loss = 0.47707722
```

```
Iteration 20, loss = 0.47636328
Iteration 21, loss = 0.47575798
Iteration 22, loss = 0.47511769
Iteration 23, loss = 0.47440276
Iteration 24, loss = 0.47380977
Iteration 25, loss = 0.47320956
Iteration 26, loss = 0.47266804
Iteration 27, loss = 0.47222703
Iteration 28, loss = 0.47210784
Iteration 29, loss = 0.47140196
Iteration 30, loss = 0.47069027
Iteration 31, loss = 0.47029411
Iteration 32, loss = 0.46981737
Iteration 33, loss = 0.46941133
Iteration 34, loss = 0.46880085
Iteration 35, loss = 0.46852722
Iteration 36, loss = 0.46794601
Iteration 37, loss = 0.46768628
Iteration 38, loss = 0.46719754
Iteration 39, loss = 0.46682494
Iteration 40, loss = 0.46640698
Iteration 41, loss = 0.46602547
Iteration 42, loss = 0.46562009
Iteration 43, loss = 0.46524889
Iteration 44, loss = 0.46498989
Iteration 45, loss = 0.46450098
Iteration 46, loss = 0.46410577
Iteration 47, loss = 0.46400029
Iteration 48, loss = 0.46332734
Iteration 49, loss = 0.46297624
Iteration 50, loss = 0.46262527
Iteration 51, loss = 0.46235214
Iteration 52, loss = 0.46202890
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Iteration 80, loss = 0.45449195
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Iteration 263, loss = 0.42958660
```

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Iteration 3, loss = 0.61992390
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Iteration 5, loss = 0.54553775
Iteration 6, loss = 0.52660072

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

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Iteration 66, loss = 0.46426397
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Iteration 128, loss = 0.44831412
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```

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Iteration 12, loss = 0.49569733
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Iteration 17, loss = 0.48938170
Iteration 18, loss = 0.48870416
Iteration 19, loss = 0.48790293

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

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Iteration 21, loss = 0.48614826
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Iteration 23, loss = 0.48492017
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Iteration 29, loss = 0.48148069
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Iteration 41, loss = 0.47586137
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Iteration 262, loss = 0.43309868
Iteration 263, loss = 0.43280290
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Iteration 264, loss = 0.43265060
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Iteration 296, loss = 0.42875458
Iteration 297, loss = 0.42863464
Iteration 298, loss = 0.42883907
Iteration 299, loss = 0.42839322
Iteration 300, loss = 0.42861709
Iteration 1, loss = 0.70934017
Iteration 2, loss = 0.65563811
Iteration 3, loss = 0.61431013
Iteration 4, loss = 0.58146967

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

```
Iteration 5, loss = 0.55653102
Iteration 6, loss = 0.53668810
Iteration 7, loss = 0.52133940
Iteration 8, loss = 0.51010408
Iteration 9, loss = 0.50097433
Iteration 10, loss = 0.49478146
Iteration 11, loss = 0.49037974
Iteration 12, loss = 0.48653796
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.65153072
Iteration 2, loss = 0.60331339
Iteration 3, loss = 0.56956820
Iteration 4, loss = 0.54364693
Iteration 5, loss = 0.52636732
Iteration 6, loss = 0.51478294
Iteration 7, loss = 0.50690247
Iteration 8, loss = 0.50161272
Iteration 9, loss = 0.49807954
Iteration 10, loss = 0.49620165
Iteration 11, loss = 0.49428552
Iteration 12, loss = 0.49286163
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.66078570
Iteration 2, loss = 0.60784720
Iteration 3, loss = 0.57028367
Iteration 4, loss = 0.54584073
Iteration 5, loss = 0.52838990
Iteration 6, loss = 0.51612417
Iteration 7, loss = 0.50829183
Iteration 8, loss = 0.50246854
Iteration 9, loss = 0.49842353
Iteration 10, loss = 0.49522495
Iteration 11, loss = 0.49328603
Iteration 12, loss = 0.49148059
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.68368246
Iteration 2, loss = 0.62559529
Iteration 3, loss = 0.57938351
Iteration 4, loss = 0.54668647
Iteration 5, loss = 0.52441220
Iteration 6, loss = 0.50984131
Iteration 7, loss = 0.49971664
Iteration 8, loss = 0.49308582
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Iteration 11, loss = 0.48429615
Iteration 12, loss = 0.48280440
Iteration 13, loss = 0.48136777
Iteration 14, loss = 0.48036651
Iteration 15, loss = 0.47945134
Iteration 16, loss = 0.47840417
Iteration 17, loss = 0.47753286
Iteration 18, loss = 0.47687040
Iteration 19, loss = 0.47606223
Iteration 20, loss = 0.47546756
Iteration 21, loss = 0.47472801
Iteration 22, loss = 0.47418027
Iteration 23, loss = 0.47362286
```

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Iteration 24, loss = 0.47278600
Iteration 25, loss = 0.47236664
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Iteration 29, loss = 0.47018677
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Iteration 42, loss = 0.46452619
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Iteration 84, loss = 0.45242245
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C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (500) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
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C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (500) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
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Iteration 498, loss = 0.41171717
```

```
Iteration 499, loss = 0.41218876
Iteration 500, loss = 0.41178969
Iteration 1, loss = 0.59800190
Iteration 2, loss = 0.53673879
Iteration 3, loss = 0.50567194
Iteration 4, loss = 0.49261220
Iteration 5, loss = 0.48748673
Iteration 6, loss = 0.48369453
Iteration 7, loss = 0.48159773

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (500) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

```
Iteration 8, loss = 0.47987736
Iteration 9, loss = 0.47862452
Iteration 10, loss = 0.47712823
Iteration 11, loss = 0.47605385
Iteration 12, loss = 0.47517208
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.62805716
Iteration 2, loss = 0.55981069
Iteration 3, loss = 0.52379328
Iteration 4, loss = 0.50746259
Iteration 5, loss = 0.50065867
Iteration 6, loss = 0.49690598
Iteration 7, loss = 0.49508530
Iteration 8, loss = 0.49232605
Iteration 9, loss = 0.49081778
Iteration 10, loss = 0.48881896
Iteration 11, loss = 0.48743242
Iteration 12, loss = 0.48622119
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.61487900
Iteration 2, loss = 0.55260379
Iteration 3, loss = 0.51881695
Iteration 4, loss = 0.50257711
Iteration 5, loss = 0.49467481
Iteration 6, loss = 0.49095241
Iteration 7, loss = 0.48898448
Iteration 8, loss = 0.48739296
Iteration 9, loss = 0.48642977
Iteration 10, loss = 0.48513475
Iteration 11, loss = 0.48382394
Iteration 12, loss = 0.48266984
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.70199709
Iteration 2, loss = 0.60623986
Iteration 3, loss = 0.54855067
Iteration 4, loss = 0.51722161
Iteration 5, loss = 0.50040550
Iteration 6, loss = 0.49150357
Iteration 7, loss = 0.48561836
Iteration 8, loss = 0.48361008
Iteration 9, loss = 0.48141296
Iteration 10, loss = 0.48034491
Iteration 11, loss = 0.47870532
Iteration 12, loss = 0.47736763
Iteration 13, loss = 0.47638166
Iteration 14, loss = 0.47534724
Iteration 15, loss = 0.47410666
Iteration 16, loss = 0.47366681
Iteration 17, loss = 0.47256283
Iteration 18, loss = 0.47190757
Iteration 19, loss = 0.47083206
Iteration 20, loss = 0.47001430
Iteration 21, loss = 0.46910763
Iteration 22, loss = 0.46853905
Iteration 23, loss = 0.46801633
Iteration 24, loss = 0.46704682
Iteration 25, loss = 0.46644403
Iteration 26, loss = 0.46566024
```

```
Iteration 27, loss = 0.46498846
Iteration 28, loss = 0.46456511
Iteration 29, loss = 0.46371364
Iteration 30, loss = 0.46354596
Iteration 31, loss = 0.46331542
Iteration 32, loss = 0.46245558
Iteration 33, loss = 0.46151491
Iteration 34, loss = 0.46114480
Iteration 35, loss = 0.46064699
Iteration 36, loss = 0.46003663
Iteration 37, loss = 0.45986706
Iteration 38, loss = 0.45921976
Iteration 39, loss = 0.45886767
Iteration 40, loss = 0.45836387
Iteration 41, loss = 0.45771824
Iteration 42, loss = 0.45757674
Iteration 43, loss = 0.45701442
Iteration 44, loss = 0.45639700
Iteration 45, loss = 0.45651159
Iteration 46, loss = 0.45601240
Iteration 47, loss = 0.45552436
Iteration 48, loss = 0.45505261
Iteration 49, loss = 0.45427544
Iteration 50, loss = 0.45436308
Iteration 51, loss = 0.45411410
Iteration 52, loss = 0.45323772
Iteration 53, loss = 0.45300129
Iteration 54, loss = 0.45284959
Iteration 55, loss = 0.45247492
Iteration 56, loss = 0.45208721
Iteration 57, loss = 0.45204411
Iteration 58, loss = 0.45170180
Iteration 59, loss = 0.45090736
Iteration 60, loss = 0.45062394
Iteration 61, loss = 0.45064186
Iteration 62, loss = 0.44998215
Iteration 63, loss = 0.44984682
Iteration 64, loss = 0.44919126
Iteration 65, loss = 0.44957818
Iteration 66, loss = 0.44919136
Iteration 67, loss = 0.44886040
Iteration 68, loss = 0.44800554
Iteration 69, loss = 0.44778414
Iteration 70, loss = 0.44750162
Iteration 71, loss = 0.44697250
Iteration 72, loss = 0.44671015
Iteration 73, loss = 0.44673205
Iteration 74, loss = 0.44624490
Iteration 75, loss = 0.44616754
Iteration 76, loss = 0.44615195
Iteration 77, loss = 0.44537962
Iteration 78, loss = 0.44550616
Iteration 79, loss = 0.44512496
Iteration 80, loss = 0.44463920
Iteration 81, loss = 0.44453595
Iteration 82, loss = 0.44486105
Iteration 83, loss = 0.44416076
Iteration 84, loss = 0.44352706
Iteration 85, loss = 0.44409830
Iteration 86, loss = 0.44399294
Iteration 87, loss = 0.44380457
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Iteration 88, loss = 0.44298442
Iteration 89, loss = 0.44215324
Iteration 90, loss = 0.44197865
Iteration 91, loss = 0.44198011
Iteration 92, loss = 0.44171987
Iteration 93, loss = 0.44135163
Iteration 94, loss = 0.44140965
Iteration 95, loss = 0.44103810
Iteration 96, loss = 0.44117058
Iteration 97, loss = 0.44065262
Iteration 98, loss = 0.44015953
Iteration 99, loss = 0.44022270
Iteration 100, loss = 0.43978396
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Iteration 102, loss = 0.43937353
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Iteration 104, loss = 0.43970536
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Iteration 106, loss = 0.43822631
Iteration 107, loss = 0.43810104
Iteration 108, loss = 0.43841383
Iteration 109, loss = 0.43805760
Iteration 110, loss = 0.43801491
Iteration 111, loss = 0.43737289
Iteration 112, loss = 0.43754122
Iteration 113, loss = 0.43662769
Iteration 114, loss = 0.43658398
Iteration 115, loss = 0.43667094
Iteration 116, loss = 0.43641354
Iteration 117, loss = 0.43608833
Iteration 118, loss = 0.43573625
Iteration 119, loss = 0.43587482
Iteration 120, loss = 0.43506544
Iteration 121, loss = 0.43521825
Iteration 122, loss = 0.43471576
Iteration 123, loss = 0.43463147
Iteration 124, loss = 0.43419423
Iteration 125, loss = 0.43403035
Iteration 126, loss = 0.43479804
Iteration 127, loss = 0.43387973
Iteration 128, loss = 0.43355869
Iteration 129, loss = 0.43378538
Iteration 130, loss = 0.43334619
Iteration 131, loss = 0.43276215
Iteration 132, loss = 0.43278910
Iteration 133, loss = 0.43267042
Iteration 134, loss = 0.43271865
Iteration 135, loss = 0.43171046
Iteration 136, loss = 0.43199066
Iteration 137, loss = 0.43208845
Iteration 138, loss = 0.43182657
Iteration 139, loss = 0.43232819
Iteration 140, loss = 0.43121268
Iteration 141, loss = 0.43264928
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Iteration 144, loss = 0.43130680
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Iteration 147, loss = 0.43035921
Iteration 148, loss = 0.43071045
```

```
Iteration 149, loss = 0.42995965
Iteration 150, loss = 0.42942339
Iteration 151, loss = 0.42966885
Iteration 152, loss = 0.42932584
Iteration 153, loss = 0.42901288
Iteration 154, loss = 0.42882480
Iteration 155, loss = 0.42886646
Iteration 156, loss = 0.42859859
Iteration 157, loss = 0.42908251
Iteration 158, loss = 0.42874710
Iteration 159, loss = 0.42814192
Iteration 160, loss = 0.42843201
Iteration 161, loss = 0.42855631
Iteration 162, loss = 0.42855426
Iteration 163, loss = 0.42696147
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Iteration 165, loss = 0.42697696
Iteration 166, loss = 0.42674193
Iteration 167, loss = 0.42643749
Iteration 168, loss = 0.42630593
Iteration 169, loss = 0.42662264
Iteration 170, loss = 0.42717325
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Iteration 173, loss = 0.42577753
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Iteration 175, loss = 0.42586952
Iteration 176, loss = 0.42554147
Iteration 177, loss = 0.42470873
Iteration 178, loss = 0.42475845
Iteration 179, loss = 0.42513437
Iteration 180, loss = 0.42403301
Iteration 181, loss = 0.42414081
Iteration 182, loss = 0.42470188
Iteration 183, loss = 0.42509917
Iteration 184, loss = 0.42446442
Iteration 185, loss = 0.42368511
Iteration 186, loss = 0.42332434
Iteration 187, loss = 0.42311256
Iteration 188, loss = 0.42306618
Iteration 189, loss = 0.42278511
Iteration 190, loss = 0.42289810
Iteration 191, loss = 0.42344702
Iteration 192, loss = 0.42299090
Iteration 193, loss = 0.42242447
Iteration 194, loss = 0.42347282
Iteration 195, loss = 0.42186149
Iteration 196, loss = 0.42167821
Iteration 197, loss = 0.42185271
Iteration 198, loss = 0.42136653
Iteration 199, loss = 0.42157584
Iteration 200, loss = 0.42147068
Iteration 201, loss = 0.42258057
Iteration 202, loss = 0.42131225
Iteration 203, loss = 0.42122896
Iteration 204, loss = 0.42132125
Iteration 205, loss = 0.42148822
Iteration 206, loss = 0.42022704
Iteration 207, loss = 0.42098668
Iteration 208, loss = 0.42006821
Iteration 209, loss = 0.42144114
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Iteration 210, loss = 0.42003832
Iteration 211, loss = 0.42104032
Iteration 212, loss = 0.41998939
Iteration 213, loss = 0.42121144
Iteration 214, loss = 0.41864141
Iteration 215, loss = 0.42001166
Iteration 216, loss = 0.42061605
Iteration 217, loss = 0.41938790
Iteration 218, loss = 0.41856971
Iteration 219, loss = 0.41846780
Iteration 220, loss = 0.41999468
Iteration 221, loss = 0.41917908
Iteration 222, loss = 0.41861830
Iteration 223, loss = 0.41853747
Iteration 224, loss = 0.41814245
Iteration 225, loss = 0.41827002
Iteration 226, loss = 0.41774427
Iteration 227, loss = 0.41871441
Iteration 228, loss = 0.41801109
Iteration 229, loss = 0.41772846
Iteration 230, loss = 0.41782089
Iteration 231, loss = 0.41724281
Iteration 232, loss = 0.41741487
Iteration 233, loss = 0.41682702
Iteration 234, loss = 0.41721905
Iteration 235, loss = 0.41653724
Iteration 236, loss = 0.41766426
Iteration 237, loss = 0.41719458
Iteration 238, loss = 0.41661931
Iteration 239, loss = 0.41666096
Iteration 240, loss = 0.41589630
Iteration 241, loss = 0.41638575
Iteration 242, loss = 0.41622348
Iteration 243, loss = 0.41636298
Iteration 244, loss = 0.41568652
Iteration 245, loss = 0.41706053
Iteration 246, loss = 0.41483012
Iteration 247, loss = 0.41593031
Iteration 248, loss = 0.41547696
Iteration 249, loss = 0.41514489
Iteration 250, loss = 0.41491136
Iteration 251, loss = 0.41531816
Iteration 252, loss = 0.41407400
Iteration 253, loss = 0.41413580
Iteration 254, loss = 0.41535295
Iteration 255, loss = 0.41469016
Iteration 256, loss = 0.41429748
Iteration 257, loss = 0.41352715
Iteration 258, loss = 0.41478522
Iteration 259, loss = 0.41422488
Iteration 260, loss = 0.41418525
Iteration 261, loss = 0.41399202
Iteration 262, loss = 0.41307145
Iteration 263, loss = 0.41346286
Iteration 264, loss = 0.41384122
Iteration 265, loss = 0.41336652
Iteration 266, loss = 0.41259963
Iteration 267, loss = 0.41298332
Iteration 268, loss = 0.41267585
Iteration 269, loss = 0.41277444
Iteration 270, loss = 0.41342491
```

```
Iteration 271, loss = 0.41202280
Iteration 272, loss = 0.41259404
Iteration 273, loss = 0.41193007
Iteration 274, loss = 0.41259949
Iteration 275, loss = 0.41260761
Iteration 276, loss = 0.41194109
Iteration 277, loss = 0.41213796
Iteration 278, loss = 0.41149294
Iteration 279, loss = 0.41193078
Iteration 280, loss = 0.41127470
Iteration 281, loss = 0.41193214
Iteration 282, loss = 0.41165808
Iteration 283, loss = 0.41145745
Iteration 284, loss = 0.41147578
Iteration 285, loss = 0.41161824
Iteration 286, loss = 0.41114649
Iteration 287, loss = 0.41067657
Iteration 288, loss = 0.41049034
Iteration 289, loss = 0.41061704
Iteration 290, loss = 0.41069769
Iteration 291, loss = 0.41070909
Iteration 292, loss = 0.41073182
Iteration 293, loss = 0.41102261
Iteration 294, loss = 0.41000430
Iteration 295, loss = 0.41060282
Iteration 296, loss = 0.41041770
Iteration 297, loss = 0.41067628
Iteration 298, loss = 0.40981059
Iteration 299, loss = 0.40975504
Iteration 300, loss = 0.40963940
Iteration 1, loss = 0.67755459
Iteration 2, loss = 0.59503581
Iteration 3, loss = 0.54472907

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

```
Iteration 4, loss = 0.51738436
Iteration 5, loss = 0.50404487
Iteration 6, loss = 0.49705721
Iteration 7, loss = 0.49371258
Iteration 8, loss = 0.49086631
Iteration 9, loss = 0.48903754
Iteration 10, loss = 0.48770665
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Iteration 12, loss = 0.48465175
Iteration 13, loss = 0.48371692
Iteration 14, loss = 0.48204856
Iteration 15, loss = 0.48109837
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Iteration 24, loss = 0.47363853
Iteration 25, loss = 0.47319107
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Iteration 27, loss = 0.47166570
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Iteration 36, loss = 0.46680387
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Iteration 59, loss = 0.45501365
Iteration 60, loss = 0.45493988
Iteration 61, loss = 0.45454139
Iteration 62, loss = 0.45386452
Iteration 63, loss = 0.45380708
Iteration 64, loss = 0.45312647
```

```
Iteration 65, loss = 0.45292757
Iteration 66, loss = 0.45232958
Iteration 67, loss = 0.45200031
Iteration 68, loss = 0.45159027
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Iteration 72, loss = 0.45055157
Iteration 73, loss = 0.44990104
Iteration 74, loss = 0.44990742
Iteration 75, loss = 0.44988259
Iteration 76, loss = 0.44908584
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Iteration 78, loss = 0.44885457
Iteration 79, loss = 0.44915776
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Iteration 101, loss = 0.44293422
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Iteration 103, loss = 0.44167499
Iteration 104, loss = 0.44145570
Iteration 105, loss = 0.44079922
Iteration 106, loss = 0.44161246
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Iteration 124, loss = 0.43618761
Iteration 125, loss = 0.43641262
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Iteration 126, loss = 0.43588344
Iteration 127, loss = 0.43543591
Iteration 128, loss = 0.43508550
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Iteration 130, loss = 0.43457999
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Iteration 133, loss = 0.43403136
Iteration 134, loss = 0.43347251
Iteration 135, loss = 0.43345420
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Iteration 137, loss = 0.43332600
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Iteration 183, loss = 0.42387706
Iteration 184, loss = 0.42367255
Iteration 185, loss = 0.42401706
Iteration 186, loss = 0.42334387
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Iteration 187, loss = 0.42467017
Iteration 188, loss = 0.42265847
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Iteration 222, loss = 0.41858889
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Iteration 229, loss = 0.41629121
Iteration 230, loss = 0.41638596
Iteration 231, loss = 0.41645218
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Iteration 233, loss = 0.41561604
Iteration 234, loss = 0.41652518
Iteration 235, loss = 0.41685323
Iteration 236, loss = 0.41566737
Iteration 237, loss = 0.41571496
Iteration 238, loss = 0.41542081
Iteration 239, loss = 0.41527651
Iteration 240, loss = 0.41601265
Iteration 241, loss = 0.41615130
Iteration 242, loss = 0.41403663
Iteration 243, loss = 0.41456951
Iteration 244, loss = 0.41598256
Iteration 245, loss = 0.41298966
Iteration 246, loss = 0.41444800
Iteration 247, loss = 0.41323350
```

```
Iteration 248, loss = 0.41333942
Iteration 249, loss = 0.41291926
Iteration 250, loss = 0.41286688
Iteration 251, loss = 0.41339747
Iteration 252, loss = 0.41188107
Iteration 253, loss = 0.41270944
Iteration 254, loss = 0.41188804
Iteration 255, loss = 0.41257289
Iteration 256, loss = 0.41199247
Iteration 257, loss = 0.41294466
Iteration 258, loss = 0.41161388
Iteration 259, loss = 0.41150812
Iteration 260, loss = 0.41132117
Iteration 261, loss = 0.41124892
Iteration 262, loss = 0.41052716
Iteration 263, loss = 0.41246568
Iteration 264, loss = 0.41030832
Iteration 265, loss = 0.41108521
Iteration 266, loss = 0.41096708
Iteration 267, loss = 0.41055450
Iteration 268, loss = 0.41000236
Iteration 269, loss = 0.41011824
Iteration 270, loss = 0.41021699
Iteration 271, loss = 0.41095942
Iteration 272, loss = 0.40938046
Iteration 273, loss = 0.40907059
Iteration 274, loss = 0.41011676
Iteration 275, loss = 0.40910643
Iteration 276, loss = 0.40911822
Iteration 277, loss = 0.40854559
Iteration 278, loss = 0.40837835
Iteration 279, loss = 0.40824986
Iteration 280, loss = 0.40850131
Iteration 281, loss = 0.40826261
Iteration 282, loss = 0.40769230
Iteration 283, loss = 0.40761799
Iteration 284, loss = 0.40738713
Iteration 285, loss = 0.40783282
Iteration 286, loss = 0.40888912
Iteration 287, loss = 0.40734724
Iteration 288, loss = 0.40712479
Iteration 289, loss = 0.40823243
Iteration 290, loss = 0.40700799
Iteration 291, loss = 0.40698478
Iteration 292, loss = 0.40893951
Iteration 293, loss = 0.40729376
Iteration 294, loss = 0.40812703
Iteration 295, loss = 0.40711640
Iteration 296, loss = 0.40648879
Iteration 297, loss = 0.40649125
Iteration 298, loss = 0.40578128
Iteration 299, loss = 0.40575997
Iteration 300, loss = 0.40598228
Iteration 1, loss = 0.62259431
Iteration 2, loss = 0.54894778
Iteration 3, loss = 0.51566751
Iteration 4, loss = 0.50001843
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

```
Iteration 5, loss = 0.49463503
Iteration 6, loss = 0.49236299
Iteration 7, loss = 0.49009066
Iteration 8, loss = 0.48841763
Iteration 9, loss = 0.48728535
Iteration 10, loss = 0.48574612
Iteration 11, loss = 0.48420210
Iteration 12, loss = 0.48335490
Iteration 13, loss = 0.48214447
Iteration 14, loss = 0.48120675
Iteration 15, loss = 0.48010069
Iteration 16, loss = 0.47908842
Iteration 17, loss = 0.47861701
Iteration 18, loss = 0.47766380
Iteration 19, loss = 0.47662287
Iteration 20, loss = 0.47602265
Iteration 21, loss = 0.47512318
Iteration 22, loss = 0.47440001
Iteration 23, loss = 0.47361313
Iteration 24, loss = 0.47325448
Iteration 25, loss = 0.47246430
Iteration 26, loss = 0.47164413
Iteration 27, loss = 0.47096265
Iteration 28, loss = 0.47040531
Iteration 29, loss = 0.46941590
Iteration 30, loss = 0.46928066
Iteration 31, loss = 0.46810426
Iteration 32, loss = 0.46750919
Iteration 33, loss = 0.46674889
Iteration 34, loss = 0.46651316
Iteration 35, loss = 0.46569772
Iteration 36, loss = 0.46510038
Iteration 37, loss = 0.46480757
Iteration 38, loss = 0.46406489
Iteration 39, loss = 0.46344414
Iteration 40, loss = 0.46288813
Iteration 41, loss = 0.46251860
Iteration 42, loss = 0.46147919
Iteration 43, loss = 0.46149839
Iteration 44, loss = 0.46151141
Iteration 45, loss = 0.46062160
Iteration 46, loss = 0.45995333
Iteration 47, loss = 0.45938112
Iteration 48, loss = 0.45902813
Iteration 49, loss = 0.45833602
Iteration 50, loss = 0.45809705
Iteration 51, loss = 0.45768078
Iteration 52, loss = 0.45715470
Iteration 53, loss = 0.45701008
Iteration 54, loss = 0.45640024
Iteration 55, loss = 0.45607053
Iteration 56, loss = 0.45556838
Iteration 57, loss = 0.45530458
Iteration 58, loss = 0.45486234
Iteration 59, loss = 0.45439971
Iteration 60, loss = 0.45398013
Iteration 61, loss = 0.45352432
Iteration 62, loss = 0.45348414
Iteration 63, loss = 0.45276859
Iteration 64, loss = 0.45343970
Iteration 65, loss = 0.45246088
```

```
Iteration 66, loss = 0.45184573
Iteration 67, loss = 0.45140951
Iteration 68, loss = 0.45152449
Iteration 69, loss = 0.45085510
Iteration 70, loss = 0.45036689
Iteration 71, loss = 0.45007387
Iteration 72, loss = 0.44987574
Iteration 73, loss = 0.44932572
Iteration 74, loss = 0.44885884
Iteration 75, loss = 0.44882864
Iteration 76, loss = 0.44881476
Iteration 77, loss = 0.44806191
Iteration 78, loss = 0.44815989
Iteration 79, loss = 0.44728524
Iteration 80, loss = 0.44763497
Iteration 81, loss = 0.44672861
Iteration 82, loss = 0.44685840
Iteration 83, loss = 0.44615054
Iteration 84, loss = 0.44569959
Iteration 85, loss = 0.44538346
Iteration 86, loss = 0.44647031
Iteration 87, loss = 0.44500182
Iteration 88, loss = 0.44571283
Iteration 89, loss = 0.44444858
Iteration 90, loss = 0.44413611
Iteration 91, loss = 0.44430367
Iteration 92, loss = 0.44352636
Iteration 93, loss = 0.44309583
Iteration 94, loss = 0.44375274
Iteration 95, loss = 0.44299787
Iteration 96, loss = 0.44294895
Iteration 97, loss = 0.44250915
Iteration 98, loss = 0.44203915
Iteration 99, loss = 0.44196094
Iteration 100, loss = 0.44164451
Iteration 101, loss = 0.44090102
Iteration 102, loss = 0.44177166
Iteration 103, loss = 0.44053777
Iteration 104, loss = 0.44053185
Iteration 105, loss = 0.44024042
Iteration 106, loss = 0.44048331
Iteration 107, loss = 0.44011567
Iteration 108, loss = 0.43971416
Iteration 109, loss = 0.43869890
Iteration 110, loss = 0.43888637
Iteration 111, loss = 0.43874619
Iteration 112, loss = 0.44092960
Iteration 113, loss = 0.43831010
Iteration 114, loss = 0.43892825
Iteration 115, loss = 0.43813383
Iteration 116, loss = 0.43708556
Iteration 117, loss = 0.43718815
Iteration 118, loss = 0.43759299
Iteration 119, loss = 0.43710136
Iteration 120, loss = 0.43685931
Iteration 121, loss = 0.43607095
Iteration 122, loss = 0.43620442
Iteration 123, loss = 0.43576600
Iteration 124, loss = 0.43657042
Iteration 125, loss = 0.43727623
Iteration 126, loss = 0.43597794
```

```
Iteration 127, loss = 0.43529250
Iteration 128, loss = 0.43460823
Iteration 129, loss = 0.43441503
Iteration 130, loss = 0.43418074
Iteration 131, loss = 0.43396091
Iteration 132, loss = 0.43404726
Iteration 133, loss = 0.43359148
Iteration 134, loss = 0.43363295
Iteration 135, loss = 0.43382226
Iteration 136, loss = 0.43354150
Iteration 137, loss = 0.43299421
Iteration 138, loss = 0.43325421
Iteration 139, loss = 0.43246505
Iteration 140, loss = 0.43178364
Iteration 141, loss = 0.43197530
Iteration 142, loss = 0.43154155
Iteration 143, loss = 0.43138259
Iteration 144, loss = 0.43175297
Iteration 145, loss = 0.43183836
Iteration 146, loss = 0.43104290
Iteration 147, loss = 0.43183383
Iteration 148, loss = 0.43044081
Iteration 149, loss = 0.43066664
Iteration 150, loss = 0.43054133
Iteration 151, loss = 0.43079657
Iteration 152, loss = 0.42959709
Iteration 153, loss = 0.42941785
Iteration 154, loss = 0.42952100
Iteration 155, loss = 0.42897661
Iteration 156, loss = 0.42892753
Iteration 157, loss = 0.42859200
Iteration 158, loss = 0.42917014
Iteration 159, loss = 0.42910374
Iteration 160, loss = 0.42808609
Iteration 161, loss = 0.42760175
Iteration 162, loss = 0.42814130
Iteration 163, loss = 0.42745504
Iteration 164, loss = 0.42779332
Iteration 165, loss = 0.42708354
Iteration 166, loss = 0.42776317
Iteration 167, loss = 0.42755189
Iteration 168, loss = 0.42686277
Iteration 169, loss = 0.42733397
Iteration 170, loss = 0.42742995
Iteration 171, loss = 0.42701306
Iteration 172, loss = 0.42746276
Iteration 173, loss = 0.42552602
Iteration 174, loss = 0.42606386
Iteration 175, loss = 0.42500139
Iteration 176, loss = 0.42591113
Iteration 177, loss = 0.42496117
Iteration 178, loss = 0.42578786
Iteration 179, loss = 0.42464237
Iteration 180, loss = 0.42460402
Iteration 181, loss = 0.42479607
Iteration 182, loss = 0.42442972
Iteration 183, loss = 0.42462224
Iteration 184, loss = 0.42465211
Iteration 185, loss = 0.42407544
Iteration 186, loss = 0.42330210
Iteration 187, loss = 0.42358714
```

```
Iteration 188, loss = 0.42296420
Iteration 189, loss = 0.42342821
Iteration 190, loss = 0.42291901
Iteration 191, loss = 0.42343934
Iteration 192, loss = 0.42244321
Iteration 193, loss = 0.42351694
Iteration 194, loss = 0.42388568
Iteration 195, loss = 0.42177353
Iteration 196, loss = 0.42244566
Iteration 197, loss = 0.42294526
Iteration 198, loss = 0.42212496
Iteration 199, loss = 0.42123578
Iteration 200, loss = 0.42096387
Iteration 201, loss = 0.42143422
Iteration 202, loss = 0.42042879
Iteration 203, loss = 0.42088333
Iteration 204, loss = 0.42148641
Iteration 205, loss = 0.42053224
Iteration 206, loss = 0.42053900
Iteration 207, loss = 0.42018978
Iteration 208, loss = 0.42054712
Iteration 209, loss = 0.41989513
Iteration 210, loss = 0.41996285
Iteration 211, loss = 0.41962304
Iteration 212, loss = 0.41995998
Iteration 213, loss = 0.41935564
Iteration 214, loss = 0.41894521
Iteration 215, loss = 0.41889311
Iteration 216, loss = 0.41883342
Iteration 217, loss = 0.42077602
Iteration 218, loss = 0.41898500
Iteration 219, loss = 0.41870937
Iteration 220, loss = 0.41968395
Iteration 221, loss = 0.41751184
Iteration 222, loss = 0.41758109
Iteration 223, loss = 0.41740922
Iteration 224, loss = 0.41746997
Iteration 225, loss = 0.41764623
Iteration 226, loss = 0.41691411
Iteration 227, loss = 0.41863153
Iteration 228, loss = 0.41821411
Iteration 229, loss = 0.41663789
Iteration 230, loss = 0.41759840
Iteration 231, loss = 0.41647455
Iteration 232, loss = 0.41659695
Iteration 233, loss = 0.41715755
Iteration 234, loss = 0.41554776
Iteration 235, loss = 0.41728450
Iteration 236, loss = 0.41573996
Iteration 237, loss = 0.41643140
Iteration 238, loss = 0.41657170
Iteration 239, loss = 0.41638502
Iteration 240, loss = 0.41591218
Iteration 241, loss = 0.41560497
Iteration 242, loss = 0.41532781
Iteration 243, loss = 0.41498276
Iteration 244, loss = 0.41497922
Iteration 245, loss = 0.41477997
Iteration 246, loss = 0.41480615
Iteration 247, loss = 0.41406982
Iteration 248, loss = 0.41497500
```

```
Iteration 249, loss = 0.41400477
Iteration 250, loss = 0.41406379
Iteration 251, loss = 0.41383069
Iteration 252, loss = 0.41371055
Iteration 253, loss = 0.41360837
Iteration 254, loss = 0.41368322
Iteration 255, loss = 0.41302495
Iteration 256, loss = 0.41296752
Iteration 257, loss = 0.41303710
Iteration 258, loss = 0.41329353
Iteration 259, loss = 0.41310196
Iteration 260, loss = 0.41334334
Iteration 261, loss = 0.41273739
Iteration 262, loss = 0.41301150
Iteration 263, loss = 0.41215485
Iteration 264, loss = 0.41280236
Iteration 265, loss = 0.41177360
Iteration 266, loss = 0.41188284
Iteration 267, loss = 0.41406938
Iteration 268, loss = 0.41303662
Iteration 269, loss = 0.41118489
Iteration 270, loss = 0.41162680
Iteration 271, loss = 0.41204779
Iteration 272, loss = 0.41237349
Iteration 273, loss = 0.41062417
Iteration 274, loss = 0.41093457
Iteration 275, loss = 0.41061756
Iteration 276, loss = 0.41050252
Iteration 277, loss = 0.41052620
Iteration 278, loss = 0.41040049
Iteration 279, loss = 0.41016830
Iteration 280, loss = 0.41032701
Iteration 281, loss = 0.41074775
Iteration 282, loss = 0.40979021
Iteration 283, loss = 0.41292702
Iteration 284, loss = 0.41202562
Iteration 285, loss = 0.41088527
Iteration 286, loss = 0.40911591
Iteration 287, loss = 0.40881658
Iteration 288, loss = 0.40885228
Iteration 289, loss = 0.40935070
Iteration 290, loss = 0.41155142
Iteration 291, loss = 0.40826178
Iteration 292, loss = 0.40846693
Iteration 293, loss = 0.40899991
Iteration 294, loss = 0.40798498
Iteration 295, loss = 0.40887715
Iteration 296, loss = 0.40737321
Iteration 297, loss = 0.40837431
Iteration 298, loss = 0.40824063
Iteration 299, loss = 0.40766063
Iteration 300, loss = 0.40806897
Iteration 1, loss = 0.69105230
Iteration 2, loss = 0.60506783
Iteration 3, loss = 0.55050626
Iteration 4, loss = 0.51929946
Iteration 5, loss = 0.50090024
Iteration 6, loss = 0.49162798
Iteration 7, loss = 0.48639816
Iteration 8, loss = 0.48323471
Iteration 9, loss = 0.48154331
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (300) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

```
Iteration 10, loss = 0.48007175
Iteration 11, loss = 0.47884530
Iteration 12, loss = 0.47773123
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.61649757
Iteration 2, loss = 0.55791777
Iteration 3, loss = 0.52316519
Iteration 4, loss = 0.50631783
Iteration 5, loss = 0.49845502
Iteration 6, loss = 0.49392022
Iteration 7, loss = 0.49134925
Iteration 8, loss = 0.48987722
Iteration 9, loss = 0.48797077
Iteration 10, loss = 0.48668115
Iteration 11, loss = 0.48547811
Iteration 12, loss = 0.48434990
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.65441362
Iteration 2, loss = 0.57845330
Iteration 3, loss = 0.53596807
Iteration 4, loss = 0.51201911
Iteration 5, loss = 0.49887935
Iteration 6, loss = 0.49182107
Iteration 7, loss = 0.48809982
Iteration 8, loss = 0.48663552
Iteration 9, loss = 0.48515239
Iteration 10, loss = 0.48406585
Iteration 11, loss = 0.48318366
Iteration 12, loss = 0.48202288
Training loss did not improve more than tol=0.100000 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.68959871
Iteration 2, loss = 0.60447535
Iteration 3, loss = 0.55242003
Iteration 4, loss = 0.52246310
Iteration 5, loss = 0.50508820
Iteration 6, loss = 0.49386288
Iteration 7, loss = 0.48725060
Iteration 8, loss = 0.48418627
Iteration 9, loss = 0.48122351
Iteration 10, loss = 0.47999676
Iteration 11, loss = 0.47864362
Iteration 12, loss = 0.47764839
Iteration 13, loss = 0.47651802
Iteration 14, loss = 0.47526795
Iteration 15, loss = 0.47400905
Iteration 16, loss = 0.47315271
Iteration 17, loss = 0.47240530
Iteration 18, loss = 0.47136647
Iteration 19, loss = 0.47072978
Iteration 20, loss = 0.46978529
Iteration 21, loss = 0.46958482
Iteration 22, loss = 0.46867203
Iteration 23, loss = 0.46750342
Iteration 24, loss = 0.46707011
Iteration 25, loss = 0.46643900
Iteration 26, loss = 0.46601083
Iteration 27, loss = 0.46527771
Iteration 28, loss = 0.46491170
```

```
Iteration 29, loss = 0.46395719
Iteration 30, loss = 0.46335473
Iteration 31, loss = 0.46299323
Iteration 32, loss = 0.46232403
Iteration 33, loss = 0.46187975
Iteration 34, loss = 0.46159072
Iteration 35, loss = 0.46102809
Iteration 36, loss = 0.46023243
Iteration 37, loss = 0.45984126
Iteration 38, loss = 0.45929128
Iteration 39, loss = 0.45863504
Iteration 40, loss = 0.45827830
Iteration 41, loss = 0.45795880
Iteration 42, loss = 0.45736465
Iteration 43, loss = 0.45676496
Iteration 44, loss = 0.45627962
Iteration 45, loss = 0.45611797
Iteration 46, loss = 0.45545689
Iteration 47, loss = 0.45490812
Iteration 48, loss = 0.45494518
Iteration 49, loss = 0.45403457
Iteration 50, loss = 0.45399250
Iteration 51, loss = 0.45347584
Iteration 52, loss = 0.45319586
Iteration 53, loss = 0.45296946
Iteration 54, loss = 0.45199716
Iteration 55, loss = 0.45240040
Iteration 56, loss = 0.45119773
Iteration 57, loss = 0.45155501
Iteration 58, loss = 0.45111673
Iteration 59, loss = 0.45040039
Iteration 60, loss = 0.45000592
Iteration 61, loss = 0.44976468
Iteration 62, loss = 0.44987722
Iteration 63, loss = 0.44929057
Iteration 64, loss = 0.44888430
Iteration 65, loss = 0.44869873
Iteration 66, loss = 0.44875315
Iteration 67, loss = 0.44760828
Iteration 68, loss = 0.44741339
Iteration 69, loss = 0.44757200
Iteration 70, loss = 0.44717714
Iteration 71, loss = 0.44674309
Iteration 72, loss = 0.44585451
Iteration 73, loss = 0.44553993
Iteration 74, loss = 0.44558435
Iteration 75, loss = 0.44547869
Iteration 76, loss = 0.44495931
Iteration 77, loss = 0.44456973
Iteration 78, loss = 0.44468491
Iteration 79, loss = 0.44410335
Iteration 80, loss = 0.44374671
Iteration 81, loss = 0.44362981
Iteration 82, loss = 0.44324120
Iteration 83, loss = 0.44334866
Iteration 84, loss = 0.44324689
Iteration 85, loss = 0.44233113
Iteration 86, loss = 0.44223112
Iteration 87, loss = 0.44191075
Iteration 88, loss = 0.44121862
Iteration 89, loss = 0.44119149
```

```
Iteration 90, loss = 0.44162668
Iteration 91, loss = 0.44091039
Iteration 92, loss = 0.44020646
Iteration 93, loss = 0.44029329
Iteration 94, loss = 0.44011542
Iteration 95, loss = 0.43992633
Iteration 96, loss = 0.44005477
Iteration 97, loss = 0.43921443
Iteration 98, loss = 0.43941358
Iteration 99, loss = 0.43887384
Iteration 100, loss = 0.43855969
Iteration 101, loss = 0.43786821
Iteration 102, loss = 0.43815617
Iteration 103, loss = 0.43825434
Iteration 104, loss = 0.43767826
Iteration 105, loss = 0.43707632
Iteration 106, loss = 0.43697547
Iteration 107, loss = 0.43705531
Iteration 108, loss = 0.43698659
Iteration 109, loss = 0.43630203
Iteration 110, loss = 0.43622759
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Iteration 112, loss = 0.43582319
Iteration 113, loss = 0.43606408
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Iteration 115, loss = 0.43509981
Iteration 116, loss = 0.43521716
Iteration 117, loss = 0.43476977
Iteration 118, loss = 0.43442563
Iteration 119, loss = 0.43397911
Iteration 120, loss = 0.43434148
Iteration 121, loss = 0.43435401
Iteration 122, loss = 0.43351984
Iteration 123, loss = 0.43386575
Iteration 124, loss = 0.43398164
Iteration 125, loss = 0.43313817
Iteration 126, loss = 0.43308007
Iteration 127, loss = 0.43268131
Iteration 128, loss = 0.43318018
Iteration 129, loss = 0.43245015
Iteration 130, loss = 0.43210129
Iteration 131, loss = 0.43173929
Iteration 132, loss = 0.43154926
Iteration 133, loss = 0.43189470
Iteration 134, loss = 0.43206986
Iteration 135, loss = 0.43134970
Iteration 136, loss = 0.43136910
Iteration 137, loss = 0.43077877
Iteration 138, loss = 0.43098552
Iteration 139, loss = 0.43081261
Iteration 140, loss = 0.43040618
Iteration 141, loss = 0.43006232
Iteration 142, loss = 0.42988608
Iteration 143, loss = 0.42968338
Iteration 144, loss = 0.42959576
Iteration 145, loss = 0.42876927
Iteration 146, loss = 0.42902559
Iteration 147, loss = 0.42872856
Iteration 148, loss = 0.42875970
Iteration 149, loss = 0.42908126
Iteration 150, loss = 0.42849471
```

```
Iteration 151, loss = 0.42847763
Iteration 152, loss = 0.42786631
Iteration 153, loss = 0.42799518
Iteration 154, loss = 0.42837790
Iteration 155, loss = 0.42782640
Iteration 156, loss = 0.42788784
Iteration 157, loss = 0.42766734
Iteration 158, loss = 0.42740402
Iteration 159, loss = 0.42752096
Iteration 160, loss = 0.42762265
Iteration 161, loss = 0.42667295
Iteration 162, loss = 0.42720852
Iteration 163, loss = 0.42684462
Iteration 164, loss = 0.42610729
Iteration 165, loss = 0.42550612
Iteration 166, loss = 0.42576033
Iteration 167, loss = 0.42629018
Iteration 168, loss = 0.42594763
Iteration 169, loss = 0.42560073
Iteration 170, loss = 0.42559723
Iteration 171, loss = 0.42476505
Iteration 172, loss = 0.42456765
Iteration 173, loss = 0.42579026
Iteration 174, loss = 0.42490952
Iteration 175, loss = 0.42518893
Iteration 176, loss = 0.42375476
Iteration 177, loss = 0.42370349
Iteration 178, loss = 0.42367207
Iteration 179, loss = 0.42376490
Iteration 180, loss = 0.42440441
Iteration 181, loss = 0.42301013
Iteration 182, loss = 0.42318762
Iteration 183, loss = 0.42344602
Iteration 184, loss = 0.42359695
Iteration 185, loss = 0.42355664
Iteration 186, loss = 0.42326579
Iteration 187, loss = 0.42227571
Iteration 188, loss = 0.42408618
Iteration 189, loss = 0.42338754
Iteration 190, loss = 0.42262685
Iteration 191, loss = 0.42196435
Iteration 192, loss = 0.42292019
Iteration 193, loss = 0.42202131
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Iteration 211, loss = 0.41920984
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Iteration 394, loss = 0.39962405
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Iteration 433, loss = 0.39456618
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Iteration 435, loss = 0.39515533
Iteration 436, loss = 0.39532402
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Iteration 438, loss = 0.39580106
Iteration 439, loss = 0.39506771
Iteration 440, loss = 0.39489654
Iteration 441, loss = 0.39531401
Training loss did not improve more than tol=0.000001 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.62322411
Iteration 2, loss = 0.55972838
Iteration 3, loss = 0.52407060
Iteration 4, loss = 0.50838967
Iteration 5, loss = 0.50167734
Iteration 6, loss = 0.49656301
Iteration 7, loss = 0.49364963
Iteration 8, loss = 0.49157446
Iteration 9, loss = 0.48961346
Iteration 10, loss = 0.48809823
Iteration 11, loss = 0.48650103
Iteration 12, loss = 0.48502781
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Iteration 13, loss = 0.48370642
Iteration 14, loss = 0.48305336
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Iteration 19, loss = 0.47817922
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Iteration 72, loss = 0.44948510
Iteration 73, loss = 0.44937904
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Iteration 355, loss = 0.39666249
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Iteration 378, loss = 0.39363181
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Iteration 379, loss = 0.39312690
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Iteration 436, loss = 0.38709774
Iteration 437, loss = 0.38700625
Iteration 438, loss = 0.38799129
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Iteration 440, loss = 0.38672617
Iteration 441, loss = 0.38685819
Iteration 442, loss = 0.38840714
Iteration 443, loss = 0.38783312
Training loss did not improve more than tol=0.000001 for 10 consecutive ep
ochs. Stopping.
Iteration 1, loss = 0.66171873
Iteration 2, loss = 0.57968207
Iteration 3, loss = 0.53462373
Iteration 4, loss = 0.51132736
Iteration 5, loss = 0.49966246
Iteration 6, loss = 0.49392235
Iteration 7, loss = 0.49116885
Iteration 8, loss = 0.48937134
Iteration 9, loss = 0.48801914
Iteration 10, loss = 0.48665594
Iteration 11, loss = 0.48541132
Iteration 12, loss = 0.48440045
Iteration 13, loss = 0.48353448
Iteration 14, loss = 0.48247223
Iteration 15, loss = 0.48152458
Iteration 16, loss = 0.48041023
Iteration 17, loss = 0.47954881
Iteration 18, loss = 0.47862974
Iteration 19, loss = 0.47801125
Iteration 20, loss = 0.47690280
Iteration 21, loss = 0.47644688
Iteration 22, loss = 0.47557836
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Iteration 24, loss = 0.47448853
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Iteration 27, loss = 0.47224216
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Iteration 30, loss = 0.47021516
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Iteration 39, loss = 0.46515120
Iteration 40, loss = 0.46449731
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Iteration 44, loss = 0.46281040
Iteration 45, loss = 0.46218997
Iteration 46, loss = 0.46156158
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Iteration 51, loss = 0.45966384
Iteration 52, loss = 0.45912255
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Iteration 54, loss = 0.45814323
Iteration 55, loss = 0.45779045
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Iteration 72, loss = 0.45164764
Iteration 73, loss = 0.45141372
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Iteration 115, loss = 0.44139118
Iteration 116, loss = 0.43966039
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Iteration 179, loss = 0.42703103
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Iteration 237, loss = 0.41842018
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Iteration 239, loss = 0.41827426
Iteration 240, loss = 0.41765712
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Iteration 300, loss = 0.41095978
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Iteration 481, loss = 0.39306350
Iteration 482, loss = 0.39494779
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Iteration 483, loss = 0.39303576
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Iteration 497, loss = 0.39190526
Iteration 498, loss = 0.39192081
Iteration 499, loss = 0.39160343
Iteration 500, loss = 0.39192577

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (500) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

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Iteration 1, loss = 0.67006897
Iteration 2, loss = 0.58681633
Iteration 3, loss = 0.53920839
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C:\ProgramData\Anaconda3\lib\site-packages\sklearn\neural_network\multilay
er_perceptron.py:566: ConvergenceWarning: Stochastic Optimizer: Maximum it
erations (500) reached and the optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

Out[220]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=MLPClassifier(activation='relu', alpha=0.0001,
                                     batch_size='auto', beta_1=0.9,
                                     beta_2=0.999, early_stopping=False,
                                     epsilon=1e-08, hidden_layer_sizes=(10
0,),
                                     learning_rate='constant',
                                     learning_rate_init=0.001, max_iter=20
0,
                                     momentum=0.9, n_iter_no_change=10,
                                     nesterovs_momentum=True, power_t=0.5,
                                     random_state=None, shuffle=True,
                                     solver='adam', tol=0.0001,
                                     validation_fraction=0.1, verbose=Fals
e,
                                     warm_start=False),
             iid='warn', n_jobs=None,
             param_grid={'hidden_layer_sizes': [100, 300],
                         'max_iter': [300, 500], 'solver': ['adam'],
                         'tol': [0.1, 1e-06], 'verbose': ['true']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
```

In [221]:

```
grid_search_ann.best_params_ # Best Parameters.
```

Out[221]:

```
{'hidden_layer_sizes': 100,
 'max_iter': 500,
 'solver': 'adam',
 'tol': 1e-06,
 'verbose': 'true'}
```

In [222]:

```
grid_search_ann.best_estimator_ # Best Model.
```

Out[222]:

```
MLPClassifier(activation='relu', alpha=0.0001, batch_size='auto', beta_1=
0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=100, learning_rate='constant',
              learning_rate_init=0.001, max_iter=500, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=1e-06,
              validation_fraction=0.1, verbose='true', warm_start=False)
```

In [223]:

```
best_model_ann = grid_search_ann.best_estimator_
```

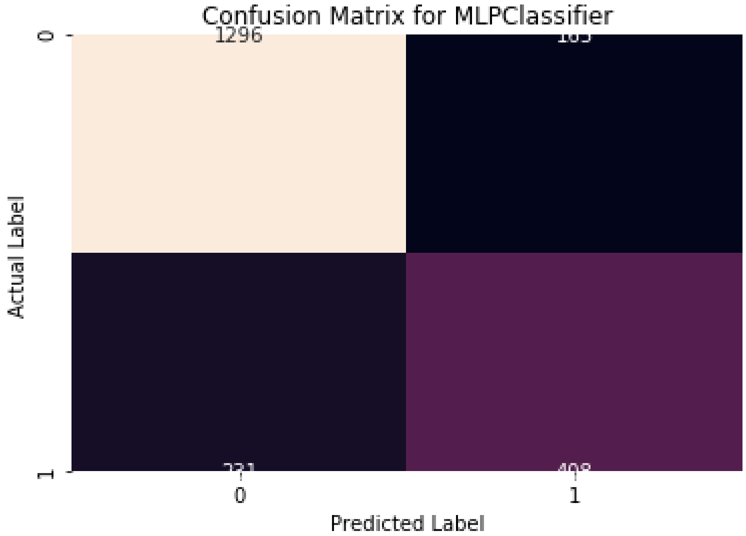
In [224]:

```
y_train_pre_ann = best_model_ann.predict (xtrain)
y_test_pre_ann = best_model_ann.predict (xtest)
```

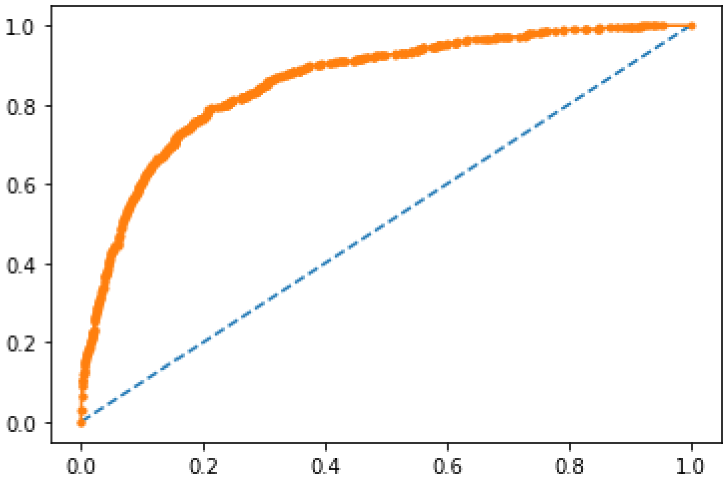
In [225]:

```
# Performance measures on Train set.

models_names={best_model_ann:'MLPClassifier'}

print('Accuracy for {} model is'.format(models_names[best_model_ann]),'\n',accuracy_sco
re(ytrain,y_train_pre_ann))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[best_model_ann]),'\n',roc_auc
_score (ytrain,y_train_pre_ann))

print('\n')

print('Classification report for {} model is'.format(models_names[best_model_ann]),'\n'
,classification_report(ytrain,y_train_pre_ann))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[best_model_ann]),'\n',conf
usion_matrix(ytrain,y_train_pre_ann))

print ('\n')


print('Confusion Matrix for {} model is'.format(models_names[best_model_ann]))

sns.heatmap(confusion_matrix(ytrain,y_train_pre_ann),annot=True,fmt='d',cbar=False)

plt.title('Confusion Matrix for {}'.format(models_names[best_model_ann]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = best_model_ann.predict_proba (xtrain)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytrain, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytrain, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for MLPClassifier model is
 0.8114285714285714


ROC AUC score for MLPClassifier model is
 0.7627806538064802


Classification report for MLPClassifier model is
               precision    recall  f1-score   support

           0       0.85      0.89      0.87      1461
           1       0.71      0.64      0.67       639

    accuracy                           0.81      2100
   macro avg       0.78      0.76      0.77      2100
weighted avg       0.81      0.81      0.81      2100



Confusion Matrix for MLPClassifier model is
 [[1296  165]
 [ 231  408]]


Confusion Matrix for MLPClassifier model is
```



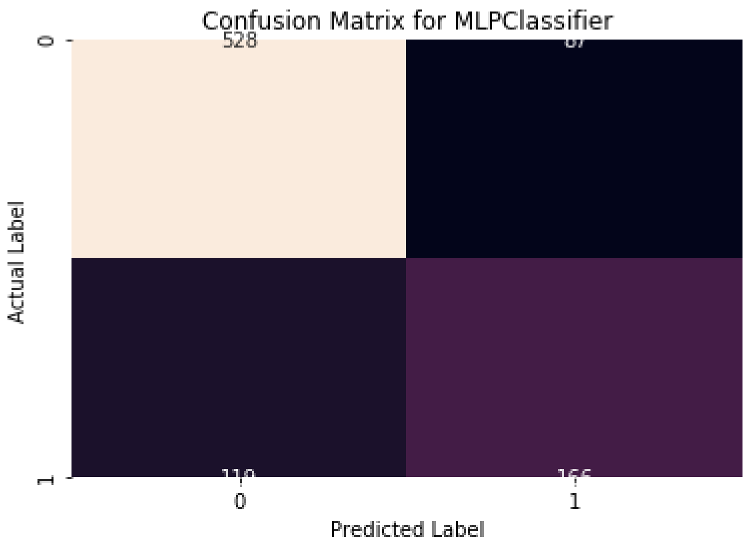
```
AUC: 0.858
```



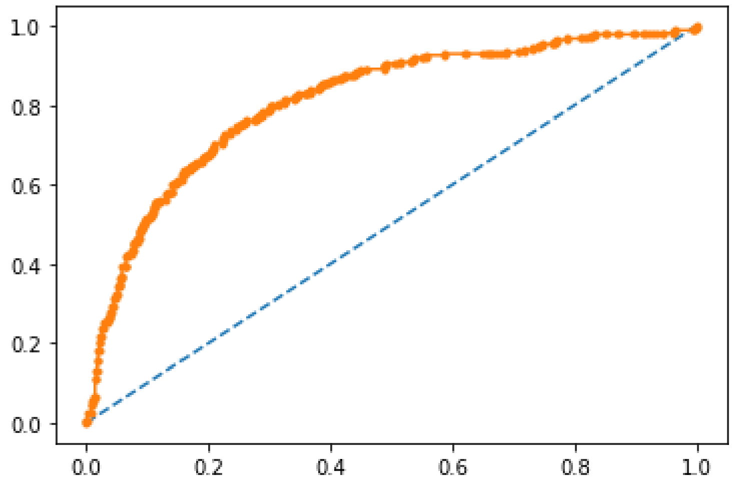
In [226]:

```
# Performance measures on Test set.

models_names={best_model_ann:'MLPClassifier'}

print('Accuracy for {} model is'.format(models_names[best_model_ann]),'\n',accuracy_sco
re(ytest,y_test_pre_ann))

print('\n')

print('ROC AUC score for {} model is'.format(models_names[best_model_ann]),'\n',roc_auc
_score (ytest,y_test_pre_ann))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[best_model_ann]),'\n',conf
usion_matrix(ytest,y_test_pre_ann))

print ('\n')


print('Classification report for {} model is'.format(models_names[best_model_ann]),'\n'
,classification_report(ytest,y_test_pre_ann))

print('\n')

print('Confusion Matrix for {} model is'.format(models_names[best_model_ann]))

sns.heatmap(confusion_matrix(ytest,y_test_pre_ann),annot=True,fmt='d',cbar=False)

plt.title('Confusion Matrix for {}'.format(models_names[best_model_ann]))
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.show()

print('\n')


# predict probabilities
probs = best_model_ann.predict_proba (xtest)
# keep probabilities for the positive outcome only
probs = probs[:, 1]
# calculate AUC
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(ytest, probs)
print('AUC: %.3f' % auc)
# calculate roc curve
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(ytest, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
# plot the roc curve for the model
plt.plot(fpr, tpr, marker='.')
# show the plot
plt.show()
```

```
Accuracy for MLPClassifier model is
 0.7711111111111111


ROC AUC score for MLPClassifier model is
 0.7204963628583654


Confusion Matrix for MLPClassifier model is
 [[528  87]
 [119 166]]


Classification report for MLPClassifier model is
               precision    recall  f1-score   support

           0       0.82      0.86      0.84       615
           1       0.66      0.58      0.62       285

    accuracy                           0.77       900
   macro avg       0.74      0.72      0.73       900
weighted avg       0.77      0.77      0.77       900



Confusion Matrix for MLPClassifier model is
```




```
AUC: 0.812
```



Inferences for Artifical Neural Network (ANN):

On Training Data Set Only checking for 1's. Performance Metrics on Training set has given us Accuracy of 81 %. ROC AUC score of 76 %. Recall 64 %. Precision 71 %. f1 score is also 67 %. AUC is 85 %.

False positives (FP) are 231 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1 and TYPE 1 error is very much less than TYPE 2 in this model.

Only checking for 1's. Performance Metrics on Test set has given us Accuracy of 77 %. ROC AUC score of 72 %. Recall 58 %. Precision 66 %. f1 score is also 62 %. AUC is 81 %.

False positives (FP) are 119 means precision is more so Type 1 error is more than Type 2 and, in this problem, we should be more focus on Type 1 and TYPE 1 error is very much less than TYPE 2 in this model.

So, both the Training and Test gives us the nearby similar score for all the Performance measures.

In [238]:

```
# lets also compare the probabilities for all the models:
#:1 Classification Model (DT)
ytest_predict_prob_dt = dt_fine.predict_proba(xtest)
ytest_predict_prob_dt.mean()
```

Out[238]:

```
0.5
```

In [239]:

```
pd.DataFrame (ytest_predict_prob_dt).head()
```

Out[239]:

	0	1
0	0.753012	0.246988
1	0.397727	0.602273
2	0.912821	0.087179
3	0.962162	0.037838
4	0.650000	0.350000

In [233]:

```
# 2: Random Forest (RF)

ytest_predict_prob_rf = best_model.predict_proba(xtest)
ytest_predict_prob_rf.mean()
```

Out[233]:

```
0.5000000000000001
```

In [240]:

```
pd.DataFrame (ytest_predict_prob_rf).head()
```

Out[240]:

	0	1
0	0.790304	0.209696
1	0.468871	0.531129
2	0.789091	0.210909
3	0.867491	0.132509
4	0.725967	0.274033

In [243]:

```
# 3: Artifical Neural Netwrok.

ytest_predict_prob_ann = best_model_ann.predict_proba(xtest)
ytest_predict_prob_ann.mean()
```

Out[243]:

```
0.5
```

In [242]:

```
pd.DataFrame (ytest_predict_prob_ann).head()
```

Out[242]:

	0	1
0	0.709045	0.290955
1	0.378787	0.621213
2	0.551067	0.448933
3	0.948233	0.051767
4	0.722020	0.277980

So as per Probability all the Models have given the Average of 0.50 % as we knew when we checked the accuracy,hence AREA UNDER CURVE will be the identifier for selecting the Best Model.

2.4 Final Model: Compare all the model and write an inference which model is best/optimized.

Comparing all the Models on the basis of Performance Metrics in Structured tabular manner.

Performance Matrix	Models					
	Classification Model (DT)		Random Forest (RF)		Artificial Neural Network	
	Training	Testing	Training	Testing	Training	Testing
Accuracy	79	78	76	76	81	77
AUC	83	81	78	80	85	81
ROC AUC score	76	73	71	72	76	72
Precision						
0	0.85	0.83	0.83	0.82	0.85	0.82
1	0.67	0.66	0.61	0.64	0.71	0.66
Recall						
0	0.86	0.85	0.83	0.84	0.89	0.86
1	0.66	0.63	0.6	0.61	0.64	0.58
f1 score						
0	0.86	0.84	0.83	0.83	0.87	0.84
1	0.67	0.64	0.61	0.62	0.67	0.62
Confusion Matrix	[1253 208 215 424]	[523 92 106 179]	[1218 243 253 386]	[516 99 111 174	[1296 165 231 408]	[528 87 119 166]

Best/Optimized Model is Artificial Neural Network (ANN)

Sensitivity of the Model is directly proportional to the Opposite values in the model, in this case Our main objective is build the model which will PREDICT the customers who will CLAIMED or NOT CLAIMED.

We are mostly focus on prevention of Wrongly Claimed.

Company is more likely to predict those claims which should not be claimed but it has been claimed and then they can evaluate the Inputs.

So, this ANN model is giving us the Precision on Training and Testing Data of 71 % (only considering 1s) and when it compares to other models RF, CART gives maximum of 67 %.

As per the objective we are more focus on PRECISION i.e., on Type 1 error where our model is predicting those customers which should not be claimed but our model has been predicted as they are CLAIMED.

In [ ]:

```

```

In [ ]:

```

```

2.5 Inference: Based on the whole Analysis, what are the business insights and recommendations.

Business Insights:

Objective of this case study was to check why there is a higher Claim frequency. By working on multiple models, we came across that although the given data was Balanced with 69-31 ratio as Not claimed and Claimed, we came across different outputs from all the 3 models after fine tuning where we were able to understand that Models have given average Accuracy of above 75 % which is good in real scenario once deploy this model. Also, all the Models had given the Accuracy for Training and Testing Data is In line with each other.

If in case company had given the Data for more towards CLAIMED people, then we should have a different output and because of that we had figure out the MODEL (ANN) with High Precision so that not claimed will also consider as claimed and based on the INPUT parameters Company can verify the actual behaviour of its INPUTS which they are giving to the Customers and later they can work on those inputs with the same model.

Let’s check the Feature importance for all the above data set, which will help the client to understand the important parameters for their high frequency of Claim.

Lets check the Feature Importance by using Decision Tree and Random Forest.

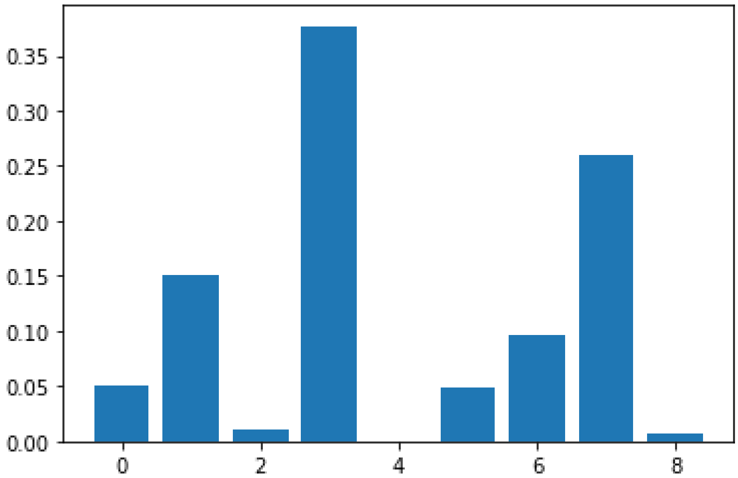
In [210]:

```
imp = dt_fine.feature_importances_
```

In [211]:

```
for i,v in enumerate(imp):
    print('Feature: %0d, Score: %.5f' % (i,v))
plt.bar([x for x in range(len(imp))], imp)
plt.show()
```

```
Feature: 0, Score: 0.04980
Feature: 1, Score: 0.15056
Feature: 2, Score: 0.01095
Feature: 3, Score: 0.37691
Feature: 4, Score: 0.00000
Feature: 5, Score: 0.04795
Feature: 6, Score: 0.09646
Feature: 7, Score: 0.26066
Feature: 8, Score: 0.00671
```



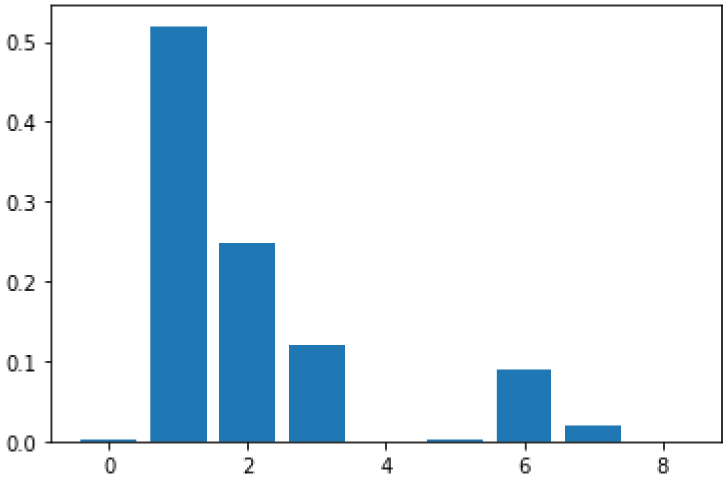
In [214]:

```
fea = best_model.feature_importances_
```

In [215]:

```
for i,v in enumerate(fea):
    print('Feature: %0d, Score: %.5f' % (i,v))
plt.bar([x for x in range(len(imp))], imp)
plt.show()
```

```
Feature: 0, Score: 0.00195
Feature: 1, Score: 0.51969
Feature: 2, Score: 0.24821
Feature: 3, Score: 0.11958
Feature: 4, Score: 0.00000
Feature: 5, Score: 0.00307
Feature: 6, Score: 0.08906
Feature: 7, Score: 0.01845
Feature: 8, Score: 0.00000
```



By checking the Feature importance and comparing for both the Models.

Common Features with high Importance are: 1: Agency Code. 2: Commision. 3: Product Name. 4: Type.

1: Lets check the Highest Agency claiming for YES.

Claimed	Yes	No	ALL
Agency_Code			
C2B	560	364	924
CWT	141	331	472
EPX	193	1172	1365
JZI	30	209	239
ALL	924	2076	3000

So the AGENCY name "C2B" is the highest agency which are claiming YES and with almost 61 % of total claim they receive. Management needs to check whether this agency is following complete SOP's.

2: Agency EPX does not get any commision and C2B is the highest Commission gainer of 924 times which proves that Agency_Code and Commission both are directly dependent.

3: Product Name:

Product Name	Bronze	Cancellation	Customised	Gold	Silver	Total
Agency_Code						
C2B	392	0	60	60	412	924
CWT	19	0	389	49	15	472
EPX	0	678	687	0	0	1365
JZI	239	0	0	0	0	239
ALL	650	678	1136	109	427	3000

So agency C2B is the highest seller of the GOLD plan which gives us confirmation that this GOLD plan is the Highest commision and then also it concludes that Gold, Silver and Bronze are the most important plans which gets highest commission and also same have they higher claim rate.

4: Type:

Type	Airlines	Travel Agency	ALL
Agency_Code			
C2B	924	0	924
CWT	0	472	472
EPX	0	1365	1365
JZI	239	0	239
ALL	1163	1837	3000

So above calculation shows that Type of Booking is also high with 100 % booking rate with Airlines itself for the agency C2B. Which conclude that if booking is done with the Airlines, they are getting the maximum claimed and with Agency there are 0 with the specific agency C2B.

So agency C2B is directly having insurance from Airlines itself hence they are getting the high claimed rate as compared to the other and when we compared the other 2 agencies which are CWT and EPX they both have "0" insurance from Airlines and hence their claimed statues for YES is also very low.

Recommendations:

Management needs to check the Agency C2B whether they are following all the SOP's from the company's book.

Almost 61 % they have the positive claimed status which means in future also they will be having the same rate for the claim status.

And that is the only agency which is the highest seller of the GOLD plan (which I believe is the highest covering plan) and will have the high price for the same hence the same agency is also having the highest Commission.

Also, Management team needs to TRAIN the other Agencies for more focusing on the other plans so that Claimed status will bring down...

And almost 80 % are positive claimed when people booked via Airlines hence management also needs to more focus on how to increase the Agency insurance type rather than Airlines which in future will bring down the Claim's.

```
Thanks,

Romil Totade
```

In [ ]:

```

```