Project 2- Classification

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Data Description

1. Gender: Gender of the passengers (Female, Male)
2. Customer Type: The customer type (Loyal customer, disloyal customer)
3. Age: The actual age of the passengers
4. Type of Travel: Purpose of the flight of the passengers (Personal Travel, Business Travel)
5. Class: Travel class in the plane of the passengers (Business, Eco, Eco Plus)
6. Flight distance: The flight distance of this journey
7. Inflight wifi service: Satisfaction level of the inflight wifi service (0:Not Applicable;1-5)
8. Departure/Arrival time convenient: Satisfaction level of Departure/Arrival time convenient
9. Ease of Online booking: Satisfaction level of online booking
10. Gate location: Satisfaction level of Gate location
11. Food and drink: Satisfaction level of Food and drink
12. Online boarding: Satisfaction level of online boarding
13. Seat comfort: Satisfaction level of Seat comfort
14. Inflight entertainment: Satisfaction level of inflight entertainment
15. On-board service: Satisfaction level of On-board service
16. Leg room service: Satisfaction level of Leg room service
17. Baggage handling: Satisfaction level of baggage handling
18. Check-in service: Satisfaction level of Check-in service
19. Inflight service: Satisfaction level of inflight service
20. Cleanliness: Satisfaction level of Cleanliness
21. Departure Delay in Minutes: Minutes delayed when departure
22. Arrival Delay in Minutes: Minutes delayed when Arrival
23. Satisfaction: Airline satisfaction level(Satisfaction, neutral or dissatisfaction)

Pre- Processing

Exploratory Data Analysis

In [1]:
```
#Importing the required packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
flight=pd.read_csv("flight.csv")

flight.head()

df=pd.DataFrame(flight)

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1100 entries, 0 to 1099
Data columns (total 24 columns):
 #   Column                             Non-Null Count  Dtype
---  ------                             --------------  -----
 0   id                                 1100 non-null   int64
 1   Gender                             1100 non-null   object
 2   Customer Type                      1100 non-null   object
 3   Age                                1089 non-null   float64
 4   Type of Travel                     1100 non-null   object
 5   Class                              1100 non-null   object
 6   Flight Distance                    1100 non-null   int64
 7   Inflight wifi service              1100 non-null   int64
 8   Departure/Arrival time convenient  1100 non-null   int64
 9   Ease of Online booking             1100 non-null   int64
 10  Gate location                      1100 non-null   int64
 11  Food and drink                     1094 non-null   float64
 12  Online boarding                    1089 non-null   float64
 13  Seat comfort                       1100 non-null   int64
 14  Inflight entertainment             1090 non-null   float64
 15  On-board service                   1100 non-null   int64
 16  Leg room service                   1090 non-null   float64
 17  Baggage handling                   1100 non-null   int64
 18  Checkin service                    1100 non-null   int64
 19  Inflight service                   1090 non-null   float64
 20  Cleanliness                        1090 non-null   float64
 21  Departure Delay in Minutes         1100 non-null   int64
 22  Arrival Delay in Minutes           1098 non-null   float64
 23  satisfaction                       1100 non-null   object
dtypes: float64(8), int64(11), object(5)
memory usage: 206.4+ KB
```

In [3]:
```
df.isnull().sum()
```

Out[3]:
```
id                                    0
Gender                                0
Customer Type                         0
Age                                  11
Type of Travel                        0
Class                                 0
Flight Distance                       0
Inflight wifi service                 0
Departure/Arrival time convenient     0
Ease of Online booking                0
Gate location                         0
Food and drink                        6
Online boarding                      11
Seat comfort                          0
Inflight entertainment               10
On-board service                      0
Leg room service                     10
Baggage handling                      0
Checkin service                       0
Inflight service                     10
Cleanliness                          10
Departure Delay in Minutes            0
Arrival Delay in Minutes              2
satisfaction                          0
dtype: int64
```

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

Out[4]:

	id	Age	Flight Distance	Inflight wifi service	Departure/Arrival time convenient	Ease of Online booking	Gate location	Food and drink	Online boarding
count	1100.000000	1089.000000	1100.000000	1100.000000	1100.000000	1100.000000	1100.000000	1094.000000	1089.000000
mean	63314.668182	39.292929	1222.157273	2.701818	3.115455	2.782727	3.071818	3.237660	3.240588
std	37743.628643	15.721542	1026.014684	1.343673	1.542347	1.428003	1.277411	1.318532	1.361554
min	90.000000	7.000000	67.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
25%	29720.250000	27.000000	416.750000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
50%	62604.500000	40.000000	861.000000	3.000000	3.000000	3.000000	3.000000	3.000000	4.000000
75%	96577.000000	51.000000	1789.500000	4.000000	4.000000	4.000000	4.000000	4.000000	4.000000
max	129767.000000	80.000000	3985.000000	5.000000	5.000000	5.000000	5.000000	5.000000	5.000000

In [5]:
```
df.rename(columns={"Departure Delay in Minutes": "Depdelay", "Arrival Delay in Minutes": "Arrdelay"})
```

Out[5]:

	id	Gender	Customer Type	Age	Type of Travel	Class	Flight Distance	Inflight wifi service	Departure/Arrival time convenient	Ease of Online booking	...	Inflight entertainment	On-board service
0	38729	Female	Loyal Customer	29.0	Personal Travel	Business	354	3	3	3	...	5.0	2
1	129651	Female	disloyal Customer	38.0	Business travel	Business	447	2	2	2	...	5.0	3
2	97346	Male	Loyal Customer	54.0	Business travel	Business	872	1	2	2	...	1.0	1
3	35305	Female	Loyal Customer	59.0	Business travel	Eco	1035	4	2	2	...	4.0	4
4	63250	Male	Loyal Customer	42.0	Business travel	Business	3908	2	2	2	...	5.0	5
...	...	...	...	...	...	...	...	...	...	...	...	...	...
1095	56128	Female	Loyal Customer	51.0	Business travel	Business	1400	5	5	4	...	4.0	4
1096	90	Male	Loyal Customer	41.0	Business travel	Business	2865	2	2	4	...	5.0	5
1097	9689	Male	Loyal Customer	45.0	Business travel	Business	3166	1	1	1	...	5.0	5
1098	91516	Female	Loyal Customer	66.0	Personal Travel	Eco	1626	3	4	3	...	5.0	5
1099	73729	Female	Loyal Customer	63.0	Personal Travel	Eco	192	2	5	2	...	3.0	3

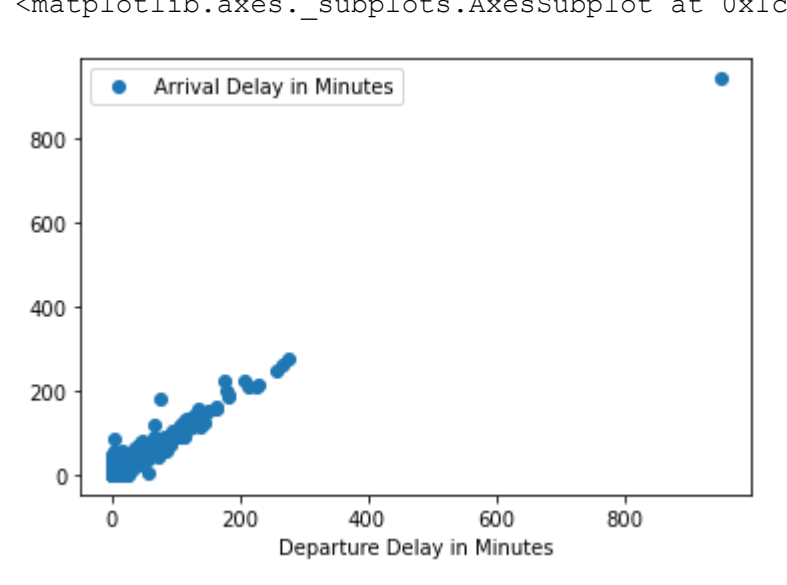
1100 rows × 24 columns

Imputing Null values in the dataset

In [6]:
```
df['Age']=df[['Age']].transform(lambda x: x.fillna(x.median()))

df['Online boarding']=df[['Online boarding']].transform(lambda x: x.fillna(int(x.mean())))

df['Food and drink']=df[['Food and drink','Class']].groupby(['Class']).transform(lambda x: x.fillna(int
(x.mean())))

df['Inflight entertainment']=df[['Inflight entertainment','Class']].groupby(['Class']).transform(lambda
 x: x.fillna(int(x.mean())))

df['Leg room service']=df[['Leg room service','Class']].groupby(['Class']).transform(lambda x: x.fillna
(int(x.mean())))

df['Inflight service']=df[['Inflight service','Class']].groupby(['Class']).transform(lambda x: x.fillna
(int(x.mean())))

df['Cleanliness']=df[['Cleanliness','Class']].groupby(['Class']).transform(lambda x: x.fillna(int(x.mea
n())))
```

In [7]:
```
df.plot(x='Departure Delay in Minutes', y='Arrival Delay in Minutes', style='o')
```

Out[7]: <matplotlib.axes._subplots.AxesSubplot at 0x1cee54936d0>



In [8]:
```
df['Arrival Delay in Minutes']=df[['Arrival Delay in Minutes','Departure Delay in Minutes']].groupby([
'Departure Delay in Minutes']).transform(lambda x: x.fillna(int(x.mean())))
```

In [9]:
```
df.info()
df.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1100 entries, 0 to 1099
Data columns (total 24 columns):
 #   Column                             Non-Null Count  Dtype
---  ------                             --------------  -----
 0   id                                 1100 non-null   int64
 1   Gender                             1100 non-null   object
 2   Customer Type                      1100 non-null   object
 3   Age                                1100 non-null   float64
 4   Type of Travel                     1100 non-null   object
 5   Class                              1100 non-null   object
 6   Flight Distance                    1100 non-null   int64
 7   Inflight wifi service              1100 non-null   int64
 8   Departure/Arrival time convenient  1100 non-null   int64
 9   Ease of Online booking             1100 non-null   int64
 10  Gate location                      1100 non-null   int64
 11  Food and drink                     1100 non-null   float64
 12  Online boarding                    1100 non-null   float64
 13  Seat comfort                       1100 non-null   int64
 14  Inflight entertainment             1100 non-null   float64
 15  On-board service                   1100 non-null   int64
 16  Leg room service                   1100 non-null   float64
 17  Baggage handling                   1100 non-null   int64
 18  Checkin service                    1100 non-null   int64
 19  Inflight service                   1100 non-null   float64
 20  Cleanliness                        1100 non-null   float64
 21  Departure Delay in Minutes         1100 non-null   int64
 22  Arrival Delay in Minutes           1100 non-null   float64
 23  satisfaction                       1100 non-null   object
dtypes: float64(8), int64(11), object(5)
memory usage: 206.4+ KB
```

Out[9]:

	id	Gender	Customer Type	Age	Type of Travel	Class	Flight Distance	Inflight wifi service	Departure/Arrival time convenient	Ease of Online booking	...	Inflight entertainment	On-board service	Leg room service
0	38729	Female	Loyal Customer	29.0	Personal Travel	Business	354	3	3	3	...	5.0	2	2.0
1	129651	Female	disloyal Customer	38.0	Business travel	Business	447	2	2	2	...	5.0	3	2.0
2	97346	Male	Loyal Customer	54.0	Business travel	Business	872	1	2	2	...	1.0	1	1.0
3	35305	Female	Loyal Customer	59.0	Business travel	Eco	1035	4	2	2	...	4.0	4	4.0
4	63250	Male	Loyal Customer	42.0	Business travel	Business	3908	2	2	2	...	5.0	5	5.0

5 rows × 24 columns

In [10]:
```
df['Gender']=pd.factorize(df['Gender'])[0]

df['satisfaction']=pd.factorize(df['satisfaction'])[0]

df['Type of Travel']=pd.factorize(df['Type of Travel'])[0]

df['Customer Type']=pd.factorize(df['Customer Type'])[0]

df.head()
```

Out[10]:

	id	Gender	Customer Type	Age	Type of Travel	Class	Flight Distance	Inflight wifi service	Departure/Arrival time convenient	Ease of Online booking	...	Inflight entertainment	On-board service	Leg room service
0	38729	0	0	29.0	0	Business	354	3	3	3	...	5.0	2	2.0
1	129651	0	1	38.0	1	Business	447	2	2	2	...	5.0	3	2.0
2	97346	1	0	54.0	1	Business	872	1	2	2	...	1.0	1	1.0
3	35305	0	0	59.0	1	Eco	1035	4	2	2	...	4.0	4	4.0
4	63250	1	0	42.0	1	Business	3908	2	2	2	...	5.0	5	5.0

5 rows × 24 columns

Using one hot encoding to convert categorical features to numerical features

In [11]:
```
cl=pd.get_dummies(df['Class'],columns='Class',prefix='Class')

df[cl.columns]= cl

df.drop(('Class'),axis=1, inplace=True)

df = df.set_index('id')
```

Splitting the data into train and test sets

In [12]:
```
X=df.drop('satisfaction',axis=1)
Y=df['satisfaction']
```

In [13]:
```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler
from sklearn import metrics
from sklearn.model_selection import GridSearchCV
from sklearn.svm import SVC,LinearSVC
```

In [14]:
```
X_train_org,X_test_org,Y_train,Y_test= train_test_split(X,Y,test_size=0.2, random_state=0)

scaler= MinMaxScaler()
scaler.fit(X_train_org)
X_train= scaler.transform(X_train_org)
X_test= scaler.transform(X_test_org)

X_train_df= pd.DataFrame(X_train,columns=X_train_org.columns)

X_test_df= pd.DataFrame(X_test,columns=X_test_org.columns)
```

Voting Classifiers

In [15]:
```
from sklearn.ensemble import VotingClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
```

Hard Voting

In [16]:
```
log_clf = LogisticRegression(C=100, penalty= 'l2')
svc_clf = SVC(kernel = 'linear', gamma = 1, C=1, probability=True)
dt_clf = DecisionTreeClassifier(max_depth= 5)
```

In [17]:
```
log_clf.fit(X_train, Y_train)
svc_clf.fit(X_train, Y_train)
dt_clf.fit(X_train, Y_train)
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lb
fgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

Out[17]: DecisionTreeClassifier(max_depth=5)

In [18]:
```
voting = VotingClassifier(estimators=[('lr', log_clf), ('svc', svc_clf), ('dt', dt_clf)], voting = 'har
d')
```

In [19]:
```
print('log_clf: ', log_clf.score(X_train, Y_train))
print('svc_clf: ', svc_clf.score(X_train, Y_train))
print('dt_clf: ', dt_clf.score(X_train, Y_train))
```

```
log_clf:  0.8761363636363636
svc_clf:  0.8715909090909091
dt_clf:  0.9193181818181818
```

In [20]:
```
voting.fit(X_train, Y_train)
print('vot_clf Train: ', voting.score(X_train, Y_train))
print('vot_clf Test: ', voting.score(X_test, Y_test))
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lb
fgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

```
vot_clf Train:  0.8818181818181818
vot_clf Test:  0.8545454545454545
```

Soft voting

In [21]:
```
soft_voting = VotingClassifier(estimators=[('lr', log_clf), ('svc', svc_clf), ('dt', dt_clf)], voting =
 'soft')
```

In [22]:
```
soft_voting.fit(X_train, Y_train)
print('vot_clf Train: ', soft_voting.score(X_train, Y_train))
print('vot_clf Test: ', soft_voting.score(X_test, Y_test))
```

```
vot_clf Train:  0.9034090909090909
vot_clf Test:  0.8863636363636364
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lb
fgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

In [23]:
```
voting_classifier_comparision=pd.DataFrame(columns=['Hard Voting',' Soft Voting'],
                                    index=['Train','Test'])
```

In [24]:
```
voting_classifier_comparision.loc['Train'] = [voting.score(X_train, Y_train),soft_voting.score(X_train,
 Y_train)]
voting_classifier_comparision.loc['Test'] = [voting.score(X_test, Y_test),soft_voting.score(X_train, Y_
train)]
voting_classifier_comparision
```

Out[24]:

	Hard Voting	Soft Voting
Train	0.881818	0.903409
Test	0.854545	0.903409

Bagging Classifier with Decision Tree Classifier

In [25]:
```
from sklearn.ensemble import BaggingClassifier

dt_clf = DecisionTreeClassifier(random_state = 0, max_depth= 5)
bag_clf = BaggingClassifier(dt_clf, bootstrap=True, n_jobs=-1, random_state=0)
param_grid={'n_estimators':[50,100,150],'max_samples':[100,200,300]}
grid=GridSearchCV(bag_clf,param_grid,cv=5,return_train_score=True)
grid.fit(X_train, Y_train)
train=grid.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid.score(X_test,Y_test)))
```

```
Best Parameters: {'max_samples': 200, 'n_estimators': 50}
Train score: 0.9293560606060605
Test score: 0.95
```

Bagging Classifier with Logistic Regression

In [26]:
```
log_clf.fit(X_train, Y_train)
bag_clf = BaggingClassifier(log_clf, bootstrap=True, n_jobs=-1, random_state=0)
param_grid={'n_estimators':[50,100,150],'max_samples':[100,200,300]}
grid1=GridSearchCV(bag_clf,param_grid,cv=5,return_train_score=True)
grid1.fit(X_train, Y_train)
train=grid1.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid1.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid1.score(X_test,Y_test)))
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lb
fgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

```
Best Parameters: {'max_samples': 300, 'n_estimators': 50}
Train score: 0.8725378787878788
Test score: 0.8590909090909091
```

Pasting with Decision Tree Classifier

In [27]:
```
from sklearn.ensemble import BaggingClassifier

dt_clf = DecisionTreeClassifier(random_state = 0, max_depth= 5)
bag_clf = BaggingClassifier(dt_clf, bootstrap=False, n_jobs=-1, random_state=0)
param_grid={'n_estimators':[50,100,150],'max_samples':[100,200,300]}
grid=GridSearchCV(bag_clf,param_grid,cv=5,return_train_score=True)
grid.fit(X_train, Y_train)
train=grid.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid.score(X_test,Y_test)))
```

```
Best Parameters: {'max_samples': 300, 'n_estimators': 150}
Train score: 0.929229797979798
Test score: 0.9363636363636364
```

Pasting with Logistic Regression

In [28]:
```
log_clf.fit(X_train, Y_train)
bag_clf = BaggingClassifier(log_clf, bootstrap=False, n_jobs=-1, random_state=0)
param_grid={'n_estimators':[50,100,150],'max_samples':[100,200,300]}
grid1=GridSearchCV(bag_clf,param_grid,cv=5,return_train_score=True)
grid1.fit(X_train, Y_train)
train=grid1.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid1.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid1.score(X_test,Y_test)))
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\linear_model\_logistic.py:762: ConvergenceWarning: lb
fgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

```
Best Parameters: {'max_samples': 200, 'n_estimators': 50}
Train score: 0.8727272727272727
Test score: 0.8454545454545455
```

Adaboosting using Logistic Regression

In [29]:
```
from sklearn.ensemble import AdaBoostClassifier
ada_clf = AdaBoostClassifier(LogisticRegression(solver="lbfgs"), random_state=0)
param_grid={'n_estimators':[50,100,150],'learning_rate':[0.5,1]}
grid4=GridSearchCV(ada_clf,param_grid,cv=5,return_train_score=True)
grid4.fit(X_train, Y_train)
train=grid4.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid4.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid4.score(X_test,Y_test)))
```

```
Best Parameters: {'learning_rate': 0.5, 'n_estimators': 150}
Train score: 0.8546401515151515
Test score: 0.8454545454545455
```

Adaboosting using Decision Tree Classifier

In [30]:
```
from sklearn.ensemble import AdaBoostClassifier
ada_clf = AdaBoostClassifier(DecisionTreeClassifier(max_depth=1), random_state=0)
param_grid={'n_estimators':[50,100,150],'learning_rate':[0.5,1]}
grid4=GridSearchCV(ada_clf,param_grid,cv=5,return_train_score=True)
grid4.fit(X_train, Y_train)
train=grid4.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid4.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid4.score(X_test,Y_test)))
```

```
Best Parameters: {'learning_rate': 0.5, 'n_estimators': 50}
Train score: 0.9506155303030304
Test score: 0.9318181818181818
```

Gradient Boosting Classifier

In [31]:
```
from  sklearn.ensemble import GradientBoostingClassifier

gbrt = GradientBoostingClassifier(max_depth=2, random_state=0)
param_grid={'n_estimators':[50,100,150],'learning_rate':[0.5,1]}
grid6=GridSearchCV(gbrt,param_grid,cv=5,return_train_score=True)
grid6.fit(X_train, Y_train)
train=grid6.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid6.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid6.score(X_test,Y_test)))
```

```
Best Parameters: {'learning_rate': 0.5, 'n_estimators': 100}
Train score: 0.9960700757575757
Test score: 0.9318181818181818
```

PCA with KNN Classifier

In [32]:
```
from sklearn.decomposition import PCA
from sklearn.neighbors import KNeighborsClassifier
from sklearn.pipeline import Pipeline

clf = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("knn", KNeighborsClassifier())
    ])
param_grid5 = {'knn__n_neighbors': [3,5,7,10,19],'knn__weights': ['uniform','distance'],'knn__metric':
['euclidean','manhattan']}
grid7=GridSearchCV(clf,param_grid5,cv=3,return_train_score=True)
grid7.fit(X_train,Y_train)
train=grid7.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid7.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid7.score(X_test,Y_test)))
```

```
Best Parameters: {'knn__metric': 'manhattan', 'knn__n_neighbors': 5, 'knn__weights': 'distance'}
Train score: 0.9416782951821123
Test score: 0.8772727272727273
```

PCA with Logistic Regression

In [33]:
```
clf1 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("lr", LogisticRegression())
    ])
penalty = ['l1', 'l2']
C = [0.001, 0.01, 0.1, 1, 10, 100]
hyperparameters = {"lr__C":C, "lr__penalty":penalty}
grid8=GridSearchCV(clf1,hyperparameters,cv=3,return_train_score=True)
grid8.fit(X_train,Y_train)
train=grid8.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid8.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid8.score(X_test,Y_test)))
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\model_selection\_validation.py:548: FitFailedWarning:
Estimator fit failed. The score on this train-test partition for these parameters will be set to nan.
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    solver = _check_solver(self.solver, self.penalty, self.dual)
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    raise ValueError("Solver %s supports only 'l2' or 'none' penalties, "
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

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  warnings.warn("Estimator fit failed. The score on this train-test"
```

```
Best Parameters: {'lr__C': 1, 'lr__penalty': 'l2'}
Train score: nan
Test score: 0.8590909090909091
```

PCA with Decision Tree Classifier

In [34]:
```
from sklearn.tree import DecisionTreeClassifier
tree_para = {'dt__criterion':['gini','entropy'],'dt__max_depth':[4,5,6,7,8,9,10,11,12,15,20,30,40,50,70
,90,120,150]}
clf2 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("dt", DecisionTreeClassifier())
    ])
grid9=GridSearchCV(clf2,tree_para,cv=3,return_train_score=True)
grid9.fit(X_train,Y_train)
train=grid9.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid9.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid9.score(X_test,Y_test)))
```

```
Best Parameters: {'dt__criterion': 'entropy', 'dt__max_depth': 4}
Train score: 0.9804281048728433
Test score: 0.8545454545454545
```

PCA with Linear SVC

In [35]:
```
clf5 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("lsvr", LinearSVC())
    ])
parameters2={'lsvr__C':[1,10,100]}
grid12=GridSearchCV(clf5,parameters2,cv=3,return_train_score=True)
grid12.fit(X_train,Y_train)
train=grid12.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid12.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid12.score(X_test,Y_test)))
```

```
Best Parameters: {'lsvr__C': 100}
Train score: 0.8621261836052145
Test score: 0.8590909090909091
```

```
D:\Softwares\Anaconda\lib\site-packages\sklearn\svm\_base.py:976: ConvergenceWarning: Liblinear faile
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  warnings.warn("Liblinear failed to converge, increase "
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D:\Softwares\Anaconda\lib\site-packages\sklearn\svm\_base.py:976: ConvergenceWarning: Liblinear faile
d to converge, increase the number of iterations.
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D:\Softwares\Anaconda\lib\site-packages\sklearn\svm\_base.py:976: ConvergenceWarning: Liblinear faile
d to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
D:\Softwares\Anaconda\lib\site-packages\sklearn\svm\_base.py:976: ConvergenceWarning: Liblinear faile
d to converge, increase the number of iterations.
  warnings.warn("Liblinear failed to converge, increase "
```
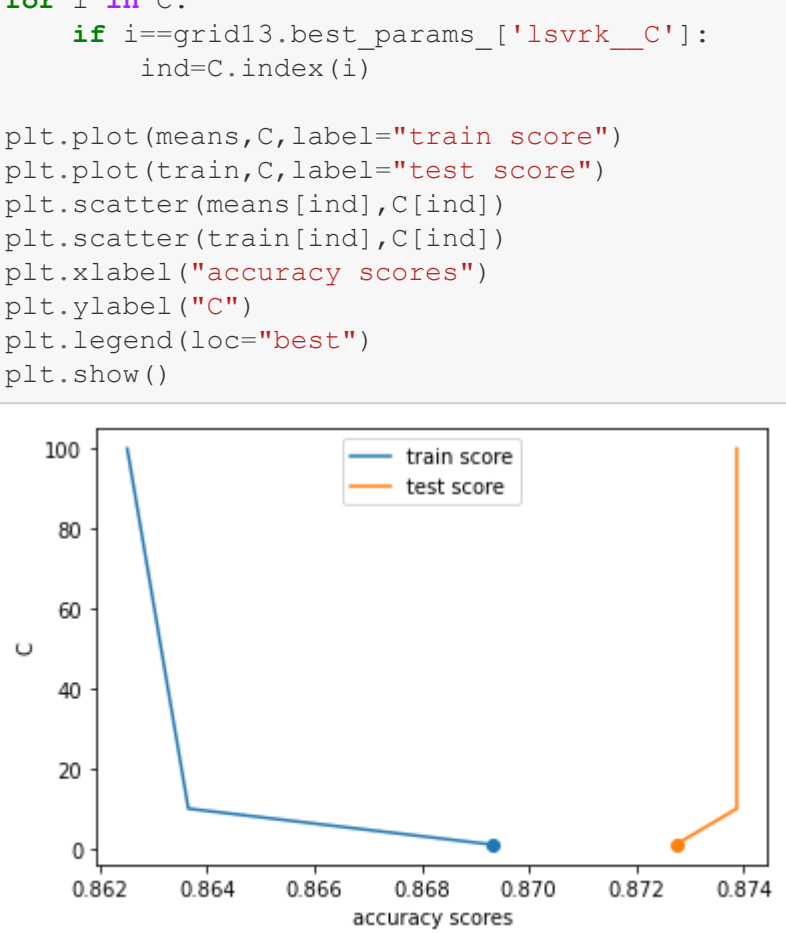

In [36]:
```
C=[1,10,100]
means = grid12.cv_results_['mean_test_score']
for i in C:
    if i==grid12.best_params_['lsvr__C']:
        ind=C.index(i)

plt.plot(means,C,label="train score")
plt.plot(train,C,label="test score")
plt.scatter(means[ind],C[ind])
plt.scatter(train[ind],C[ind])
plt.xlabel("accuracy scores")
plt.ylabel("C")
plt.legend(loc="best")
plt.show()
```

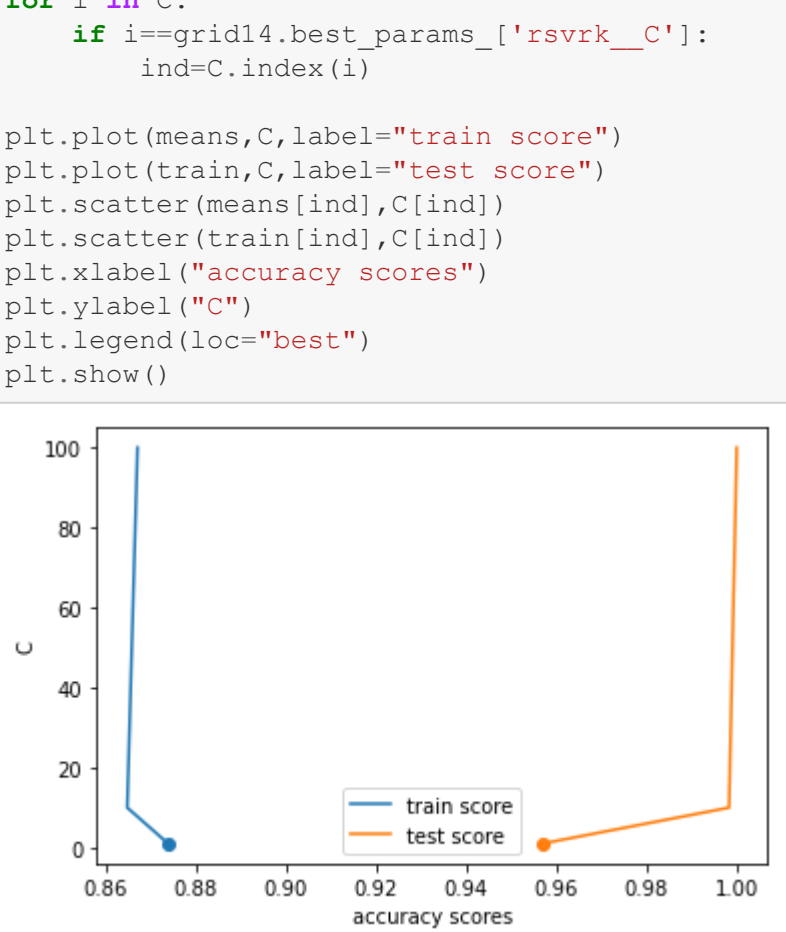


PCA with SVC with Linear Kernel

In [37]:
```
clf6 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("lsvrk", SVC(kernel='linear'))
    ])
parameters2={"lsvrk__C":[1,10,100]}
grid13=GridSearchCV(clf6,parameters2,cv=3,return_train_score=True)
grid13.fit(X_train,Y_train)
train=grid13.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid13.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid13.score(X_test,Y_test)))
```

```
Best Parameters: {'lsvrk__C': 1}
Train score: 0.8734885352528137
Test score: 0.8636363636363636
```

In [38]:
```
C=[1,10,100]
means = grid13.cv_results_['mean_test_score']
for i in C:
    if i==grid13.best_params_['lsvrk__C']:
        ind=C.index(i)

plt.plot(means,C,label="train score")
plt.plot(train,C,label="test score")
plt.scatter(means[ind],C[ind])
plt.scatter(train[ind],C[ind])
plt.xlabel("accuracy scores")
plt.ylabel("C")
plt.legend(loc="best")
plt.show()
```

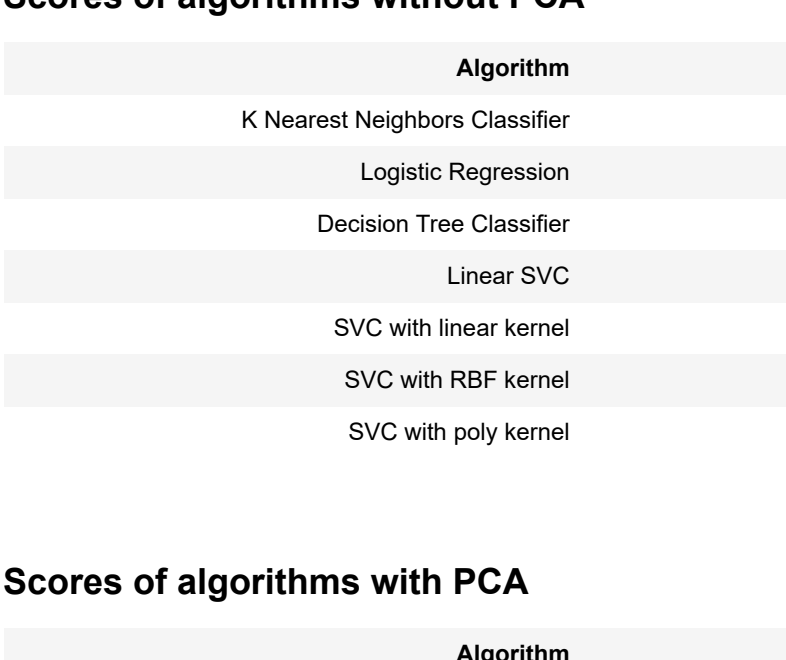


PCA with SVC with RBF Kernel

In [39]:
```
clf7 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("rsvrk", SVC(kernel='rbf',C=100,gamma=1))
    ])
parameters2={"rsvrk__C":[1,10,100]}
grid14=GridSearchCV(clf7,parameters2,cv=3,return_train_score=True)
grid14.fit(X_train,Y_train)
train=grid14.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid14.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid14.score(X_test,Y_test)))
```

```
Best Parameters: {'rsvrk__C': 1}
Train score: 0.9850389458363131
Test score: 0.9136363636363637
```

In [40]:
```
C=[1,10,100]
means = grid14.cv_results_['mean_test_score']
for i in C:
    if i==grid14.best_params_['rsvrk__C']:
        ind=C.index(i)

plt.plot(means,C,label="train score")
plt.plot(train,C,label="test score")
plt.scatter(means[ind],C[ind])
plt.scatter(train[ind],C[ind])
plt.xlabel("accuracy scores")
plt.ylabel("C")
plt.legend(loc="best")
plt.show()
```



PCA with SVC with Poly Kernel

In [41]:
```
clf8 = Pipeline([
        ("pca", PCA(n_components=0.95)),
        ("psvrk", SVC(kernel='poly',C=100,degree=1))
    ])
parameters2={"psvrk__C":[1,10,100],"psvrk__degree":[1,2,3]}
grid15=GridSearchCV(clf8,parameters2,cv=3,return_train_score=True)
grid15.fit(X_train,Y_train)
train=grid15.cv_results_['mean_train_score']
print("Best Parameters: {}".format(grid15.best_params_))
print("Train score: {}".format(train.mean()))
print("Test score: {}".format(grid15.score(X_test,Y_test)))
```

```
Best Parameters: {'psvrk__C': 1, 'psvrk__degree': 3}
Train score: 0.9224799015107811
Test score: 0.9045454545454545
```

Scores of algorithms without PCA

Algorithm	Train Score	Test Score
K Nearest Neighbors Classifier	0.9443201341970235	0.8863636363636364
Logistic Regression	0.7950520833333333	0.8647727272727272
Decision Tree Classifier	0.9809738005050505	0.8886363636363637
Linear SVC	0.8324810606060605	0.865909090909091
SVC with linear kernel	0.8090435606060605	0.8693181818181818
SVC with RBF kernel	0.7608585858585859	0.8886363636363637
SVC with poly kernel	0.7071575126262627	0.8852272727272728

Scores of algorithms with PCA

Algorithm	Train Score	Test Score
K Nearest Neighbors Classifier	0.9421287912206978	0.8772727272727273
Logistic Regression	0.8142948400444743	0.8590909090909091
Decision Tree Classifier	0.9797817148601319	0.8545454545454545
Linear SVC	0.8621217163391711	0.8636363636363636
SVC with linear kernel	0.8740522754418415	0.8636363636363636
SVC with RBF kernel	0.9852285244776713	0.9136363636363637
SVC with poly kernel	0.8014535861114765	0.8681818181818182

PCA performs considerably well with algorithms using Kernel trick than without PCA. PCA, achieves a better training and testing score in certain algorithms like Logistic Regression and Linear SVC.

Deep Learning for Classification

In [42]:
```
import tensorflow as tf
from tensorflow import keras
from keras.models import Sequential
from keras.layers import Dense
from keras.wrappers.scikit_learn import KerasClassifier
```

In [43]:
```
# Step 1: Build the model
model1 = Sequential()
#Input leyer
model1.add(Dense(126, input_dim = 24, activation = 'relu'))
#Hidden layer
model1.add(Dense(50, activation = 'relu'))
model1.add(Dense(25, activation = 'relu'))
#Output layer
model1.add(Dense(1, kernel_initializer='normal'))

# Step 2: Build the computational graph - compile
model1.compile(loss = 'mean_absolute_error', optimizer = 'adam', metrics = ['mean_absolute_error'] )

# Step 3: Train the model
model1.fit(X_train, Y_train, epochs = 30, batch_size = 50)
```

```
Epoch 1/30
18/18 [==============================] - 0s 665us/step - loss: 0.4242 - mean_absolute_error: 0.4242
Epoch 2/30
18/18 [==============================] - 0s 609us/step - loss: 0.3836 - mean_absolute_error: 0.3836
Epoch 3/30
18/18 [==============================] - 0s 554us/step - loss: 0.2787 - mean_absolute_error: 0.2787
Epoch 4/30
18/18 [==============================] - 0s 554us/step - loss: 0.2356 - mean_absolute_error: 0.2356
Epoch 5/30
18/18 [==============================] - 0s 609us/step - loss: 0.2241 - mean_absolute_error: 0.2241
Epoch 6/30
18/18 [==============================] - 0s 609us/step - loss: 0.2140 - mean_absolute_error: 0.2140
Epoch 7/30
18/18 [==============================] - 0s 610us/step - loss: 0.2022 - mean_absolute_error: 0.2022
Epoch 8/30
18/18 [==============================] - 0s 610us/step - loss: 0.1954 - mean_absolute_error: 0.1954
Epoch 9/30
18/18 [==============================] - 0s 609us/step - loss: 0.1866 - mean_absolute_error: 0.1866
Epoch 10/30
18/18 [==============================] - 0s 665us/step - loss: 0.1798 - mean_absolute_error: 0.1798
Epoch 11/30
18/18 [==============================] - 0s 554us/step - loss: 0.1766 - mean_absolute_error: 0.1766
Epoch 12/30
18/18 [==============================] - 0s 665us/step - loss: 0.1732 - mean_absolute_error: 0.1732
Epoch 13/30
18/18 [==============================] - 0s 720us/step - loss: 0.1666 - mean_absolute_error: 0.1666
Epoch 14/30
18/18 [==============================] - 0s 720us/step - loss: 0.1670 - mean_absolute_error: 0.1670
Epoch 15/30
18/18 [==============================] - 0s 776us/step - loss: 0.1643 - mean_absolute_error: 0.1643
Epoch 16/30
18/18 [==============================] - 0s 720us/step - loss: 0.1558 - mean_absolute_error: 0.1558
Epoch 17/30
18/18 [==============================] - 0s 665us/step - loss: 0.1535 - mean_absolute_error: 0.1535
Epoch 18/30
18/18 [==============================] - 0s 720us/step - loss: 0.1509 - mean_absolute_error: 0.1509
Epoch 19/30
18/18 [==============================] - 0s 720us/step - loss: 0.1506 - mean_absolute_error: 0.1506
Epoch 20/30
18/18 [==============================] - ETA: 0s - loss: 0.1457 - mean_absolute_error: 0.145 - 0s 720
us/step - loss: 0.1457 - mean_absolute_error: 0.1457
Epoch 21/30
18/18 [==============================] - 0s 776us/step - loss: 0.1421 - mean_absolute_error: 0.1421
Epoch 22/30
18/18 [==============================] - 0s 720us/step - loss: 0.1397 - mean_absolute_error: 0.1397
Epoch 23/30
18/18 [==============================] - 0s 609us/step - loss: 0.1353 - mean_absolute_error: 0.1353
Epoch 24/30
18/18 [==============================] - 0s 610us/step - loss: 0.1331 - mean_absolute_error: 0.1331
Epoch 25/30
18/18 [==============================] - 0s 609us/step - loss: 0.1299 - mean_absolute_error: 0.1299
Epoch 26/30
18/18 [==============================] - 0s 609us/step - loss: 0.1299 - mean_absolute_error: 0.1299
Epoch 27/30
18/18 [==============================] - 0s 609us/step - loss: 0.1256 - mean_absolute_error: 0.1256
Epoch 28/30
18/18 [==============================] - 0s 609us/step - loss: 0.1214 - mean_absolute_error: 0.1214
Epoch 29/30
18/18 [==============================] - 0s 609us/step - loss: 0.1228 - mean_absolute_error: 0.1228
Epoch 30/30
18/18 [==============================] - 0s 554us/step - loss: 0.1243 - mean_absolute_error: 0.1243
```

Out[43]:
```
<tensorflow.python.keras.callbacks.History at 0x1cef85d4970>
```

In [44]:
```
seed = 10
np.random.seed(10)
```

In [45]:
```
loss_and_metrics = model1.evaluate(X_test, Y_test)

print("Test Loss", loss_and_metrics[0])
print("Test Accuracy", loss_and_metrics[1])
```

```
7/7 [==============================] - 0s 536us/step - loss: 0.1279 - mean_absolute_error: 0.1279
Test Loss 0.1279391646385193
Test Accuracy 0.1279391646385193
```