In [319]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
import sklearn
from sklearn.decomposition import PCA
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn import preprocessing
from sklearn.ensemble import RandomForestClassifier
from sklearn import metrics
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn import metrics
from sklearn.model_selection import GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.preprocessing import OrdinalEncoder
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
import keras
from keras.models import Sequential
from keras.layers import Dense
from sklearn.preprocessing import StandardScaler
```

In [320]:

```
#import data set
train = pd.read_csv('train_assessment.csv')
test = pd.read_csv('test_assessment.csv')
```

Part 1: Explanatory Data Analysis

In [291]:

```
#to see the shape of our training data
train.shape[0]
```

Out[291]:

```
2100
```

In [292]:

```
train.shape[1]
```

Out[292]:

```
19
```

In [ ]:

```
#the train data set have 2100 examples with 19 attributes
```

In [293]:

```
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2100 entries, 0 to 2099
Data columns (total 19 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   expert_opinion  2100 non-null   int64  
 1   white           2100 non-null   object 
 2   green           2100 non-null   int64  
 3   brown           1761 non-null   float64
 4   purple          1724 non-null   float64
 5   black           1424 non-null   float64
 6   blue            1761 non-null   float64
 7   pink            1761 non-null   float64
 8   violet          1761 non-null   float64
 9   warm_white      1757 non-null   float64
 10  red             1757 non-null   float64
 11  orange          1757 non-null   float64
 12  lime            1761 non-null   float64
 13  navy            1761 non-null   float64
 14  magenta         1761 non-null   float64
 15  gray            1545 non-null   float64
 16  mint            1757 non-null   float64
 17  coral           1757 non-null   float64
 18  beige           2100 non-null   object 
dtypes: float64(15), int64(2), object(2)
memory usage: 311.8+ KB
```

Here we can see that twoo attribute are categorical variabls and res of the variavle are numerical attributes.

In [294]:

```
#to see the head of train dataset
train.head()
```

Out[294]:

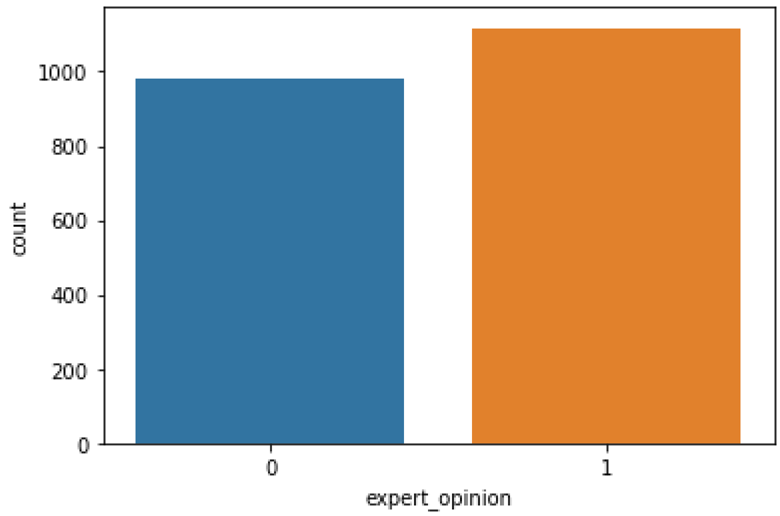
	expert_opinion	white	green	brown	purple	black
0	0	sp_zoo	1000	2.355746e+16	-9.801258e+15	0.000456
1	0	sp_komandytowa	853	1.022268e+13	-2.122440e+14	0.093995
2	1	dzialalnosc_gospodarcza	333	2.903307e+13	6.184523e+13	4594.389366
3	1	dzialalnosc_gospodarcza	1549	1.231991e+15	-1.420818e+15	0.000990
4	0	dzialalnosc_gospodarcza	388	6.386786e+14	-1.344810e+15	0.014240

In [299]:

```
sns.countplot(train['expert_opinion'])
#here expert-opinion is our target attrubutes.
```

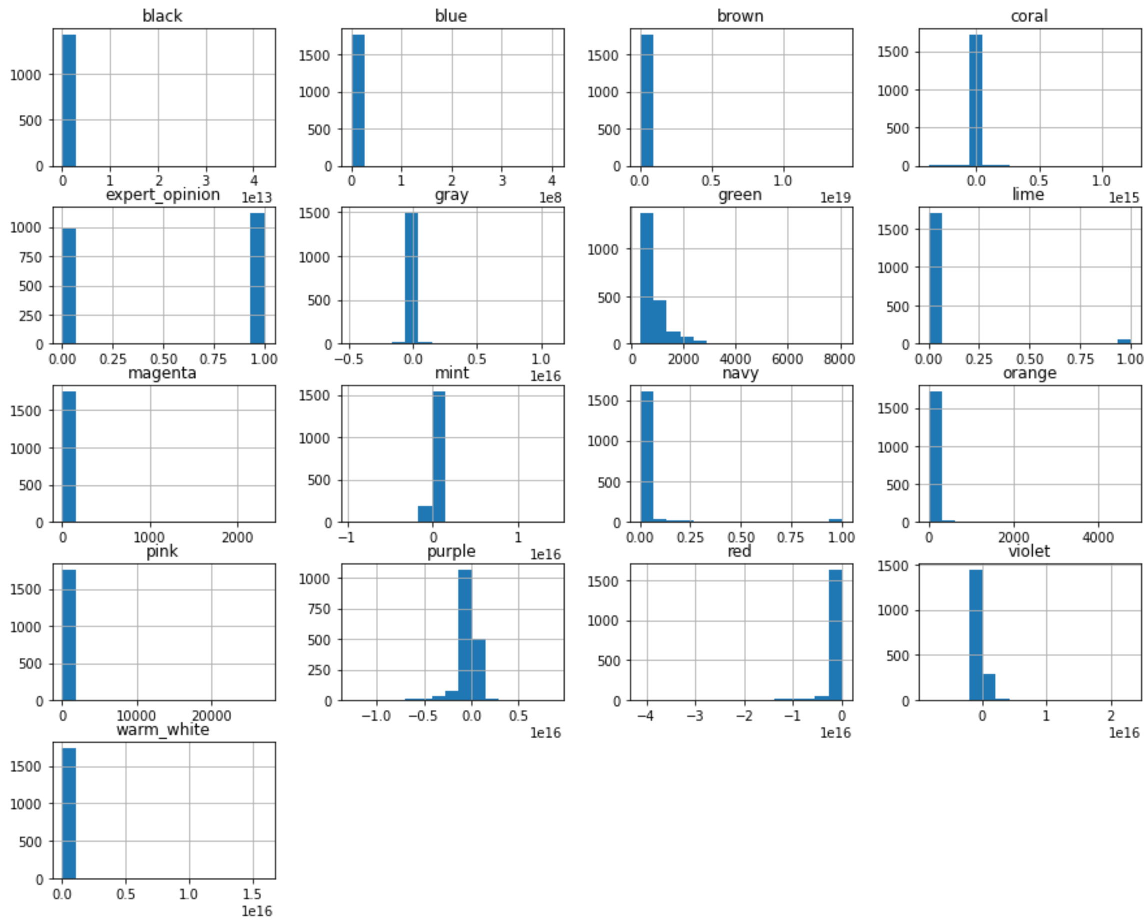
Out[299]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2203a080d90>
```



In [295]:

```
train.hist(figsize=(15,12),bins = 15)
plt.title("Features Distribution")
plt.show()
```



In [ ]:

```
#From this histogram, we can see that data is not normally distributed
```

In [296]:

```
#checking the missing value of train data
train.isnull().sum()
```

Out[296]:

```
expert_opinion      0
white               0
green               0
brown             339
purple            376
black             676
blue              339
pink              339
violet            339
warm_white        343
red               343
orange            343
lime              339
navy              339
magenta           339
gray              555
mint              343
coral             343
beige               0
dtype: int64
```

In [297]:

```
#checking the missing value of test data
test.isnull().sum()
```

Out[297]:

```
expert_opinion      0
white               0
green               0
brown              78
purple             88
black             159
blue               78
pink               78
violet             78
warm_white         83
red                83
orange             83
lime               78
navy               78
magenta            78
gray              178
mint               83
coral              83
beige               0
dtype: int64
```

In [33]:

```
#to see the data types
train.dtypes.value_counts()
```

Out[33]:

```
float64    15
int64       2
object      2
dtype: int64
```

In [34]:

```
#to see the data types
test.dtypes.value_counts()
```

Out[34]:

```
float64    15
int64       2
object      2
dtype: int64
```

In [321]:

```
#filling missing value
train.fillna(train.median(), inplace=True)
test.fillna(train.median(), inplace=True)
```

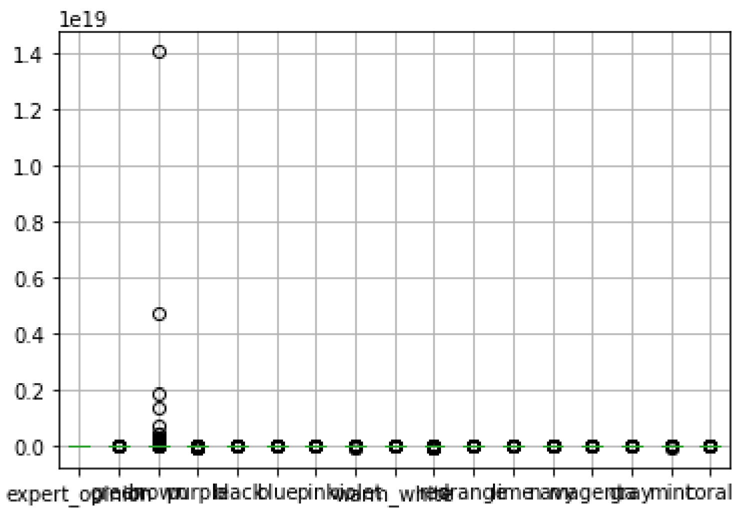
We have lot of missing valuee. If we drop the observation which has missing value, it might decrease our model accuracy. So, that's why I just filled the missing values with median of the attributes. I could use other approaches; for example, cosidaring the mean of attributes, Machine learning approach(e.g, KNN imputation).Our data is not normally distributed.So, I did not use mean(). I Used only median() to fill up.

In [36]:

```
#to check the outliers of our training data
train.boxplot()
```

Out[36]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x220105cf970>
```



This chart is not so clear to check the outliers. I will take a look separately for some of attributes to get idea of outliers.

In [249]:

```
#we can get a idea from this chart as well. Here, we can  understand distribution of  d
ata. Like mean,
#median, std, quantiles etc.
train.describe()
```

Out[249]:

	expert_opinion	green	brown	purple	black	blue
count	2100.000000	2100.000000	2.100000e+03	2.100000e+03	2.100000e+03	2.100000e+03
mean	0.531905	829.804286	1.591236e+16	-1.554441e+14	2.163349e+10	1.915547e+05
std	0.499100	578.302479	3.291706e+17	1.127393e+15	9.234966e+11	8.778137e+06
min	0.000000	324.000000	9.370240e+05	-1.267966e+16	3.750117e-07	0.000000e+00
25%	0.000000	445.000000	4.867840e+13	6.482129e+12	7.234965e-01	7.756300e-10
50%	1.000000	648.000000	2.457546e+14	3.645189e+13	1.339756e+01	8.959645e-07
75%	1.000000	1000.000000	1.090044e+15	9.641899e+13	2.862328e+02	9.788727e-05
max	1.000000	8068.000000	1.406204e+19	8.618625e+15	4.225000e+13	4.022648e+08

In [44]:

```
test.describe()
```

Out[44]:

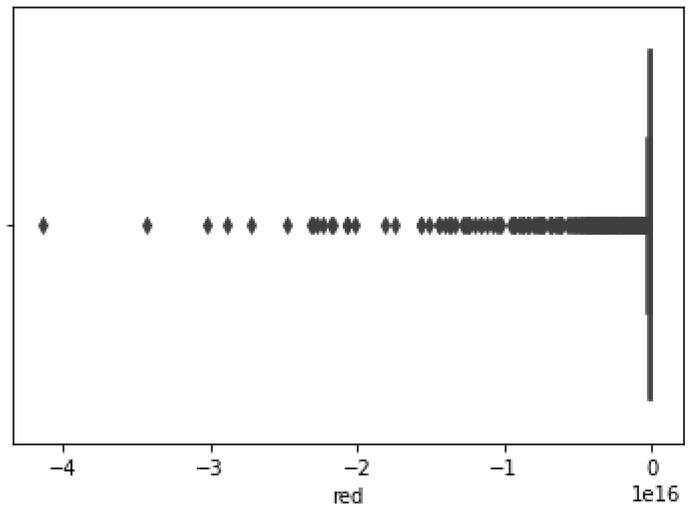
	expert_opinion	green	brown	purple	black	blue
count	496.000000	496.000000	4.960000e+02	4.960000e+02	4.960000e+02	4.960000e+02
mean	0.516129	854.590726	4.619773e+15	-1.854158e+13	2.302365e+08	4.456070e-02
std	0.500244	565.749814	2.791904e+16	2.641332e+14	3.849395e+09	6.899108e-01
min	0.000000	361.000000	6.250000e+08	-1.436244e+15	4.051340e-05	0.000000e+00
25%	0.000000	461.000000	6.095880e+13	3.925157e+12	2.904317e+00	4.553418e-11
50%	1.000000	617.000000	2.457546e+14	2.752894e+13	1.339756e+01	8.959645e-07
75%	1.000000	986.000000	1.119109e+15	3.936350e+13	3.334457e+03	2.136416e-05
max	1.000000	3610.000000	5.325811e+17	1.640259e+15	8.506944e+10	1.332476e+01

In [37]:

```
sns.boxplot(train['red'])
```

Out[37]:

<matplotlib.axes._subplots.AxesSubplot at 0x2201f91a790>

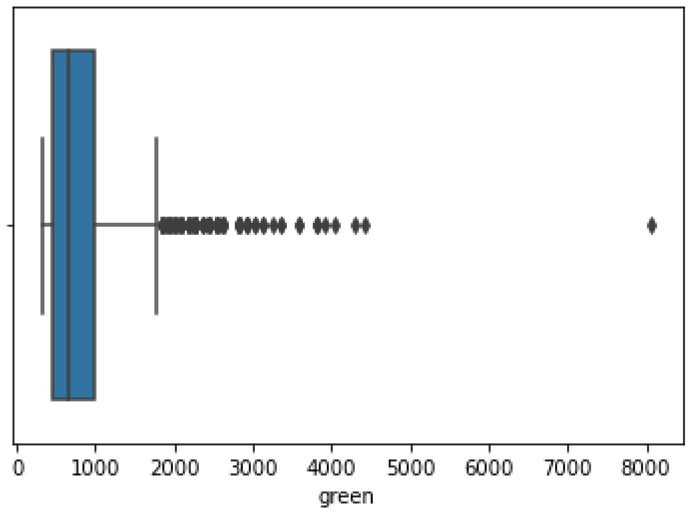


In [38]:

```
sns.boxplot(train['green'])
```

Out[38]:

<matplotlib.axes._subplots.AxesSubplot at 0x2201f9614f0>

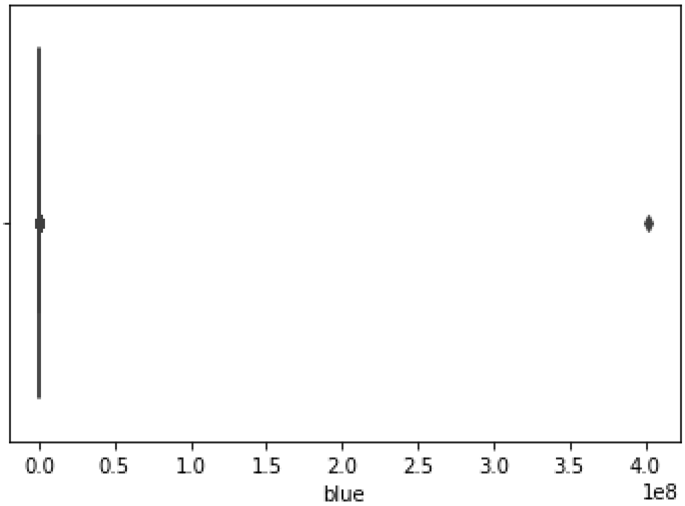


In [39]:

```
sns.boxplot(train['blue'])
```

Out[39]:

```
&lt;matplotlib.axes._subplots.AxesSubplot at 0x2201f9c4640&gt;
```

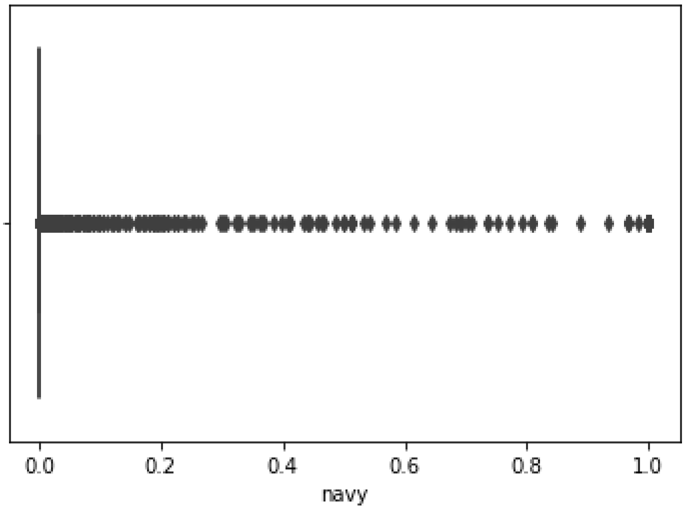


In [40]:

```
sns.boxplot(train['navy'])
```

Out[40]:

```
&lt;matplotlib.axes._subplots.AxesSubplot at 0x2201f953ee0&gt;
```



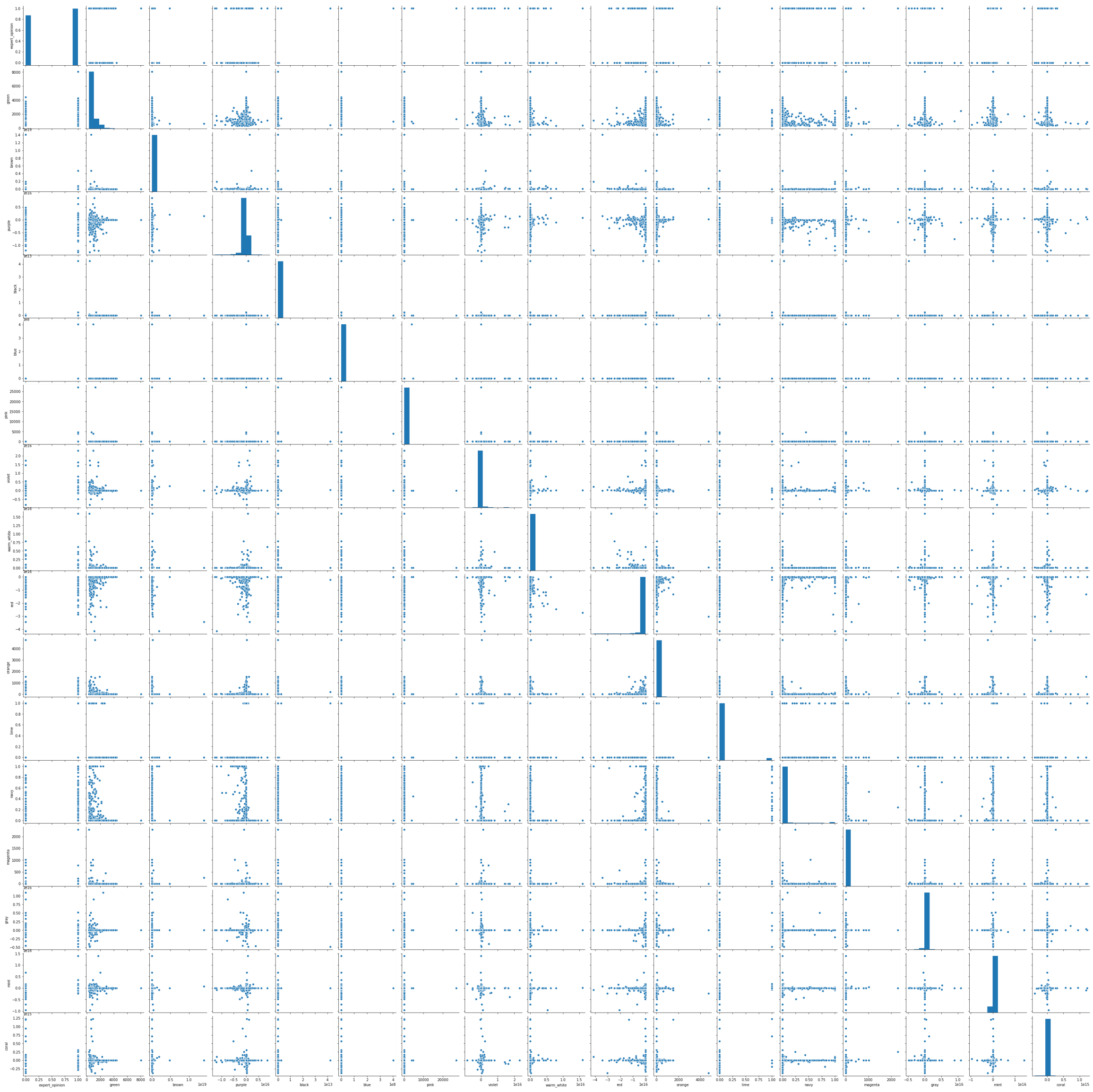
I have checked for the couples of attributes to detect the outliers.I am seeing that mostly all attributes have outliers. So, this would not be a good decison to remove the outlier. If we remove the outliers, we will remove all of the observations. So, removing outlier is worthless for this task.

In [41]:

```
sns.pairplot(train)
```

Out[41]:

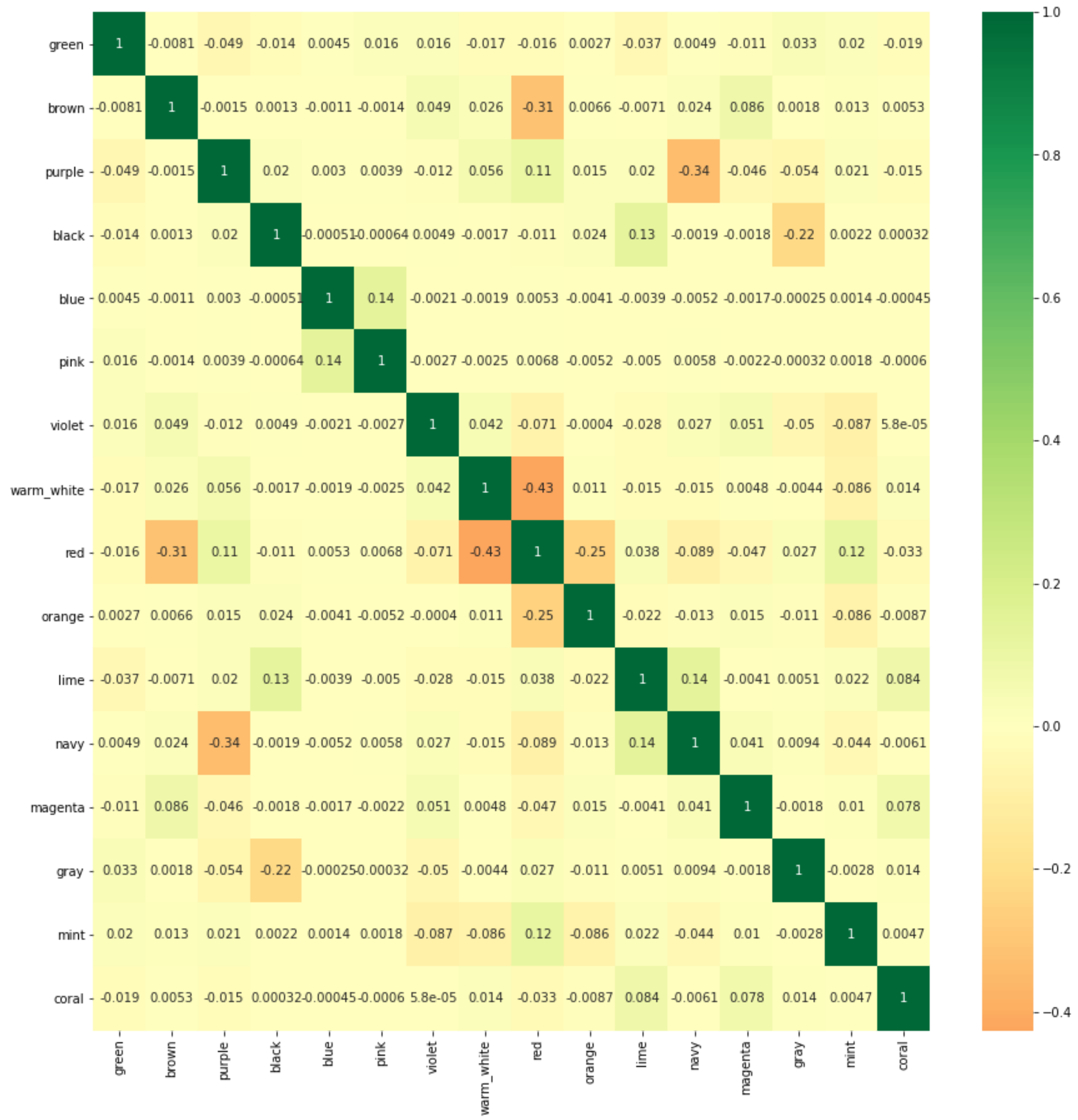
```
<seaborn.axisgrid.PairGrid at 0x2201fa74d90>
```



This is the pairplot which draw the scatter plots for all possible combination of our dataset attributes.As, we have a little bit more attributes, this is not easliy interpretable.I am not seeing any highly co-related feature here. But, to be more sure I will draw a cur() plot in the next step as well.

In [78]:

```
plt.figure(figsize=(15,15))
p=sns.heatmap(X_train.corr(), annot=True,cmap='RdYlGn',center=0)
```



From this cor() plot we can also see that co-relation between independent variable not so clear. We are not seeing variables are highly co-related with each other. Except for some variables.

Part 2: Feature Engineering

In [310]:

```
data_train=train # I am making  copy of my entire dataset to encode the catagorical val
ues.
data_test=test
```

In [311]:

```
ord_enc = OrdinalEncoder()
data_train["white_code"] = ord_enc.fit_transform(data_train[["white"]])
data_train["beige_code"] = ord_enc.fit_transform(data_train[["beige"]])
data_test["white_code"] = ord_enc.fit_transform(data_test[["white"]])
data_test["beige_code"] = ord_enc.fit_transform(data_test[["beige"]])
X_train_encoded= data_train.drop(['expert_opinion','white', 'beige'], axis=1)#train dat
a after encoding
y_train_encoded= data_train['expert_opinion']
X_test_encoded= data_test.drop(['expert_opinion','white', 'beige'], axis=1) #test data
 after encoding
y_test_encoded= data_train['expert_opinion']
```

In [312]:

```
X_train_encoded.head()
```

Out[312]:

	green	brown	purple	black	blue	pink	violet	wa
0	1000	2.355746e+16	-9.801258e+15	0.000456	0.014385	0.000007	2.477787e+14	1.86
1	853	1.022268e+13	-2.122440e+14	0.093995	0.010588	0.000999	1.880886e+14	8.54
2	333	2.903307e+13	6.184523e+13	4594.389366	0.001103	5.067338	4.572419e+12	0.00
3	1549	1.231991e+15	-1.420818e+15	0.000990	0.014826	0.000015	-5.759893e+13	1.86
4	388	6.386786e+14	-1.344810e+15	0.014240	0.009785	0.000141	-9.862662e+12	1.00

In [313]:

```
#here white attribute is encoded  into 0 to 5, as white attribute contain six different
values.
#Similarly, beige attributed is encoded into 0 and 1, as this has only two catagorical
 values.
```

In [314]:

```
y_train_encoded.head()
```

Out[314]:

```
0    0
1    0
2    1
3    1
4    0
Name: expert_opinion, dtype: int64
```

In [315]:

```
# Fitting  Model withy out any level encoding for the catagorical values
#and removing the catgorical attributes
```

In [325]:

```
X_train= train.drop(['expert_opinion','white', 'beige'], axis=1)
y_train= train['expert_opinion']
X_test= test.drop(['expert_opinion','white', 'beige'], axis=1)
y_test= test['expert_opinion']
```

Part 3: Modeling

Based on explanatory data analysis, we can easily understand that this is a classification problem. As this is a classification problem, we will use some supervised technique to solve this problem; for example decosion tree, knn, randomforest. At last, i will try to implemant a small neural network.

3.1 Random Forest

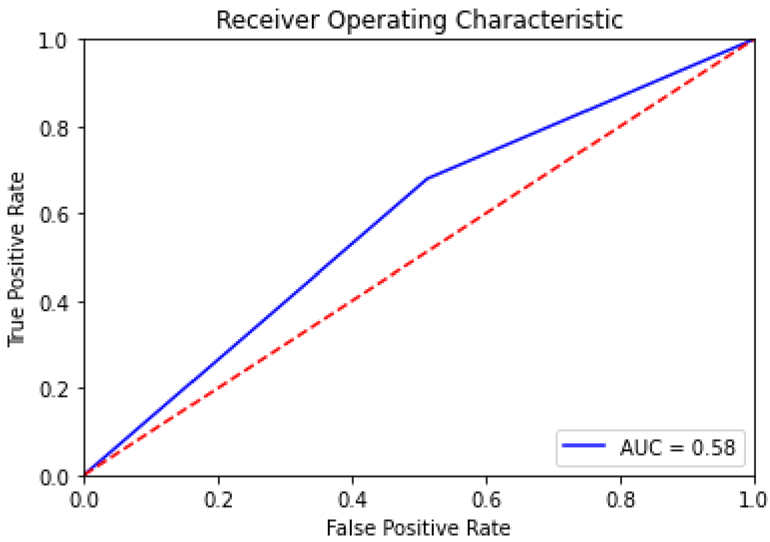
In [328]:

```
#Create a Gaussian Classifier
def ml(x_train,y_train,x_test,y_test,model):
    #clf=RandomForestClassifier()

#Train the model
    model.fit(x_train,y_train)

    y_pred=clf.predict(x_test)
# Model Accuracy
    print("Accuracy:",metrics.accuracy_score(y_test, y_pred)) #Accuracy on test Data
    confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Pred
icted'])
    print (confusion_matrix)
    fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
    roc_auc = metrics.auc(fpr, tpr)


    plt.title('Receiver Operating Characteristic')
    plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
    plt.legend(loc = 'lower right')
    plt.plot([0, 1], [0, 1],'r--')
    plt.xlim([0, 1])
    plt.ylim([0, 1])
    plt.ylabel('True Positive Rate')
    plt.xlabel('False Positive Rate')
    plt.show()
```

In [329]:

```
clf=RandomForestClassifier()
ml(X_train,y_train,X_test,y_test,clf) # result without encoding the catagorical values.
```

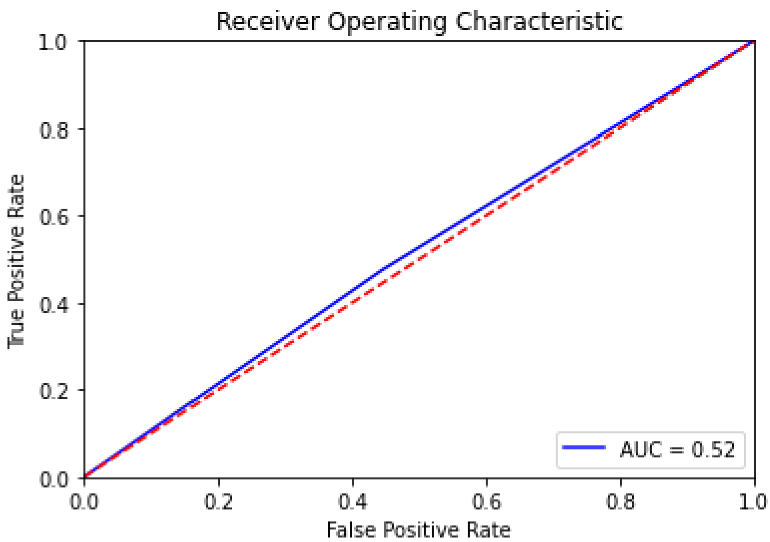
```
Accuracy: 0.5866935483870968
Predicted    0    1
Actual
0          117  123
1           82  174
```



In [330]:

```
ml(X_train_encoded,y_train,X_test_encoded,y_test,clf) #with encoding of catagorical val
ues.
```

```
Accuracy: 0.5141129032258065
Predicted    0    1
Actual
0          133  107
1          134  122
```



Here, we are not seeing any improvement after encoding as well. Befor encoding, AUC was 58 but, after encoding AUC is 0.52. In the next step, I will apply all technique without encoding of our catagorical values.

Hyper Parameter optimaization using using RandomaizedSearCV

In [331]:

```
# Number of trees in random forest
n_estimators = [int(x) for x in np.linspace(start = 50, stop = 2000, num = 10)]
# Number of features to consider at every split
max_features = ['auto', 'sqrt']
# Maximum number of levels in tree
max_depth = [int(x) for x in np.linspace(10, 110, num = 11)]
max_depth.append(None)
# Minimum number of samples required to split a node
min_samples_split = [2, 5, 10]
# Minimum number of samples required at each leaf node
min_samples_leaf = [1, 2, 4]
# Method of selecting samples for training each tree
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
```

In [332]:

```
rf_random = RandomizedSearchCV(estimator = clf, param_distributions = random_grid, n_it
er = 100, cv = 3, verbose=2, random_state=42, n_jobs = -1)
```

In [333]:

```
rf_random.fit(X_train,y_train)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent worker
s.
[Parallel(n_jobs=-1)]: Done  25 tasks      | elapsed:   38.4s
[Parallel(n_jobs=-1)]: Done 146 tasks      | elapsed:  3.1min
[Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed:  6.4min finished
```

Out[333]:

```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(), n_iter=100,
                   n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [10, 20, 30, 40, 50,
60,
                                                      70, 80, 90, 100, 11
0,
                                                      None],
                                        'max_features': ['auto', 'sqrt'],
                                        'min_samples_leaf': [1, 2, 4],
                                        'min_samples_split': [2, 5, 10],
                                        'n_estimators': [50, 266, 483, 70
0, 916,
                                                         1133, 1350, 1566,
1783,
                                                         2000]},
                   random_state=42, verbose=2)
```

In [334]:

```
rf_random.best_estimator_
```

Out[334]:

```
RandomForestClassifier(max_depth=10, min_samples_split=5, n_estimators=156
6)
```

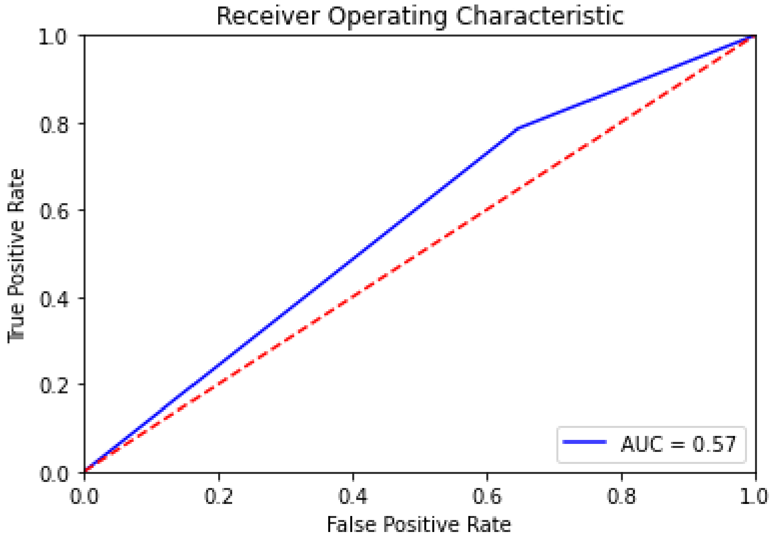
In [335]:

```
y_pred=rf_random.predict(X_test)
```

In [336]:

```
# Model Accuracy
print("Accuracy:",metrics.accuracy_score(y_test, y_pred)) #Accuracy on test data
confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Predicte
d'])
print (confusion_matrix)
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```

```
Accuracy: 0.5766129032258065
Predicted   0    1
Actual
0          85  155
1          55  201
```



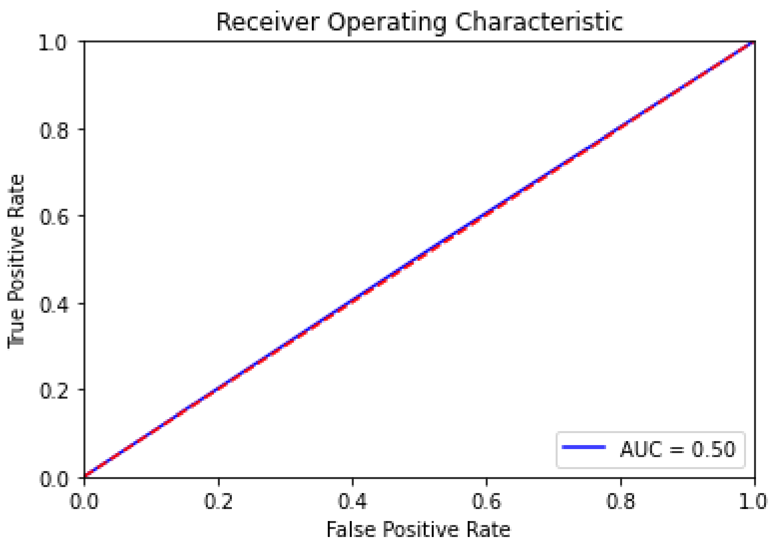
After, tuning some parameters, we get accuracy which is mostly similar as default setting.If we do tuning with a large number of parameter we might get a good accuracy.

3.2 Decision Tree

In [262]:

```
clf = DecisionTreeClassifier()
# Train Decision Tree Classifer
clf = clf.fit(X_train,y_train)
#Predict the response for test dataset
y_pred = clf.predict(X_test)
print("Accuracy:",metrics.accuracy_score(y_test, y_pred)) #Accuracy on test data
confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Predicte
d'])
print (confusion_matrix)
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```

```
Accuracy: 0.5040322580645161
Predicted    0    1
Actual
0          114  126
1          120  136
```



Here, we are getting only 50% accuracy which is poor than random forest.

In [ ]:

```
#Some hyperparameter optimaization
clf = DecisionTreeClassifier()
param_dict={'criterion':['gini','entropy'],
            'max_depth':range(1,10),
            'min_samples_leaf':range(1,5)}
grid_decisiontree = GridSearchCV(clf, param_dict, cv=10,n_jobs=1, verbose = 3)
```

In [264]:

```
grid_decisiontree
```

Out[264]:

```
GridSearchCV(cv=10, estimator=DecisionTreeClassifier(), n_jobs=1,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': range(1, 10),
                         'min_samples_leaf': range(1, 5)},
             verbose=3)
```

In [265]:

```
# fitting the model for grid search
grid_decisiontree.fit(X_train,y_train)
```

```
Fitting 10 folds for each of 72 candidates, totalling 720 fits
[CV] criterion=gini, max_depth=1, min_samples_leaf=1 .................
[CV]  criterion=gini, max_depth=1, min_samples_leaf=1, score=0.552, total=
0.0s
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0.0s
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[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:
0.0s
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    0.0s remaining:
0.0s
```

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0.0s
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[CV]  criterion=gini, max_depth=7, min_samples_leaf=1, score=0.538, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=1 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=1, score=0.552, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=1 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=1, score=0.619, total=
0.0s
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=1 .................
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
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0.0s
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.524, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.581, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.552, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.543, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=2 .................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.610, total=
0.0s
```

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[CV] criterion=gini, max_depth=7, min_samples_leaf=2 ................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=2, score=0.567, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=3 ................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=3, score=0.538, total=
0.0s
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[CV]  criterion=gini, max_depth=7, min_samples_leaf=3, score=0.624, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=3 ................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=3, score=0.543, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=3 ................
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0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=3 ................
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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[CV]  criterion=gini, max_depth=7, min_samples_leaf=4, score=0.557, total=
0.0s
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0.0s
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0.0s
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[CV]  criterion=gini, max_depth=7, min_samples_leaf=4, score=0.524, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=4 ................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=4, score=0.576, total=
0.0s
[CV] criterion=gini, max_depth=7, min_samples_leaf=4 ................
[CV]  criterion=gini, max_depth=7, min_samples_leaf=4, score=0.533, total=
0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=1 ................
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0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=1 ................
[CV]  criterion=gini, max_depth=8, min_samples_leaf=1, score=0.557, total=
0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=1 ................
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=2 ................
[CV]  criterion=gini, max_depth=8, min_samples_leaf=2, score=0.590, total=
0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=2 ................
[CV]  criterion=gini, max_depth=8, min_samples_leaf=2, score=0.548, total=
0.0s
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0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=2 ................
[CV]  criterion=gini, max_depth=8, min_samples_leaf=2, score=0.505, total=
0.0s
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0.0s
[CV] criterion=gini, max_depth=8, min_samples_leaf=2 ................
[CV]  criterion=gini, max_depth=8, min_samples_leaf=2, score=0.529, total=
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
[CV] criterion=gini, max_depth=9, min_samples_leaf=3 .................
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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0.0s
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al=   0.0s
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al=   0.0s
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al=   0.0s
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al=   0.0s
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al=   0.0s
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al=   0.0s
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[CV]  criterion=entropy, max_depth=9, min_samples_leaf=4, score=0.533, tot
al=   0.0s


[Parallel(n_jobs=1)]: Done 720 out of 720 | elapsed:    7.5s finished
```

Out[265]:

```
GridSearchCV(cv=10, estimator=DecisionTreeClassifier(), n_jobs=1,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': range(1, 10),
                         'min_samples_leaf': range(1, 5)},
             verbose=3)
```

In [267]:

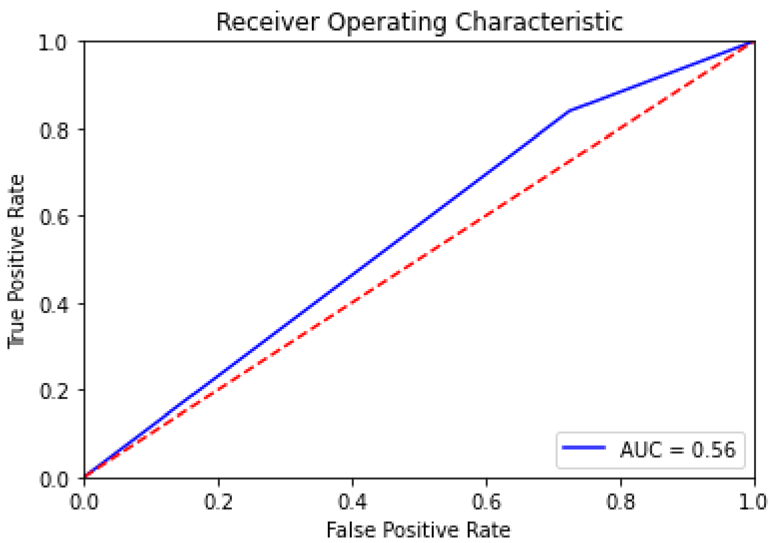
```
print(grid_decisiontree.best_params_)
y_pred = grid_decisiontree.predict(X_test)
```

```
{'criterion': 'entropy', 'max_depth': 2, 'min_samples_leaf': 1}
```

In [268]:

```
# Model Accuracy
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Predicte
d'])
print (confusion_matrix)
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```

```
Accuracy: 0.5665322580645161
Predicted   0    1
Actual
0          66  174
1          41  215
```



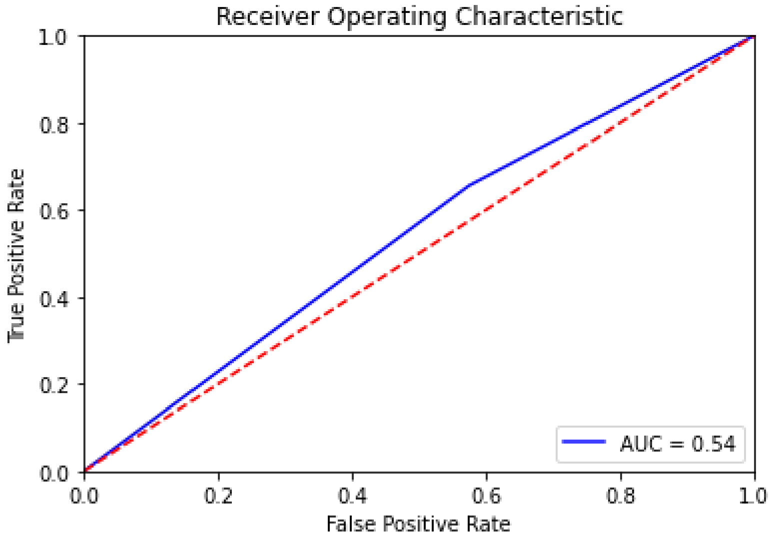
Here we can see that after doing hyper paramter optimaization for some parameter, we get some improvement here. Maybe. if we make optimaization for range of parameter we might get a good accuracy.

3.3 KNN

In [276]:

```
model = KNeighborsClassifier(n_neighbors=19)
# Train the model using the training sets
model.fit(X_train,y_train)
y_pred=model.predict(X_test)
# Model Accuracy
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Predicte
d'])
print (confusion_matrix)
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```

```
Accuracy: 0.5443548387096774
Predicted    0    1
Actual
0          102  138
1           88  168
```



My laptop GPU is not so high, thats why I did not try to optimaize here. I could optimaize here leaf_size, p, n_neighbors these attributes.Maybe, I could get a good accuracy and roc .

3.4 KNN with PCA

In [277]:

```
#Trying with PCA
```

In [278]:

```
X_train_normalise=preprocessing.normalize(X_train) # normalize the train and test data
X_test_normalise=preprocessing.normalize(X_test)
```

In [279]:

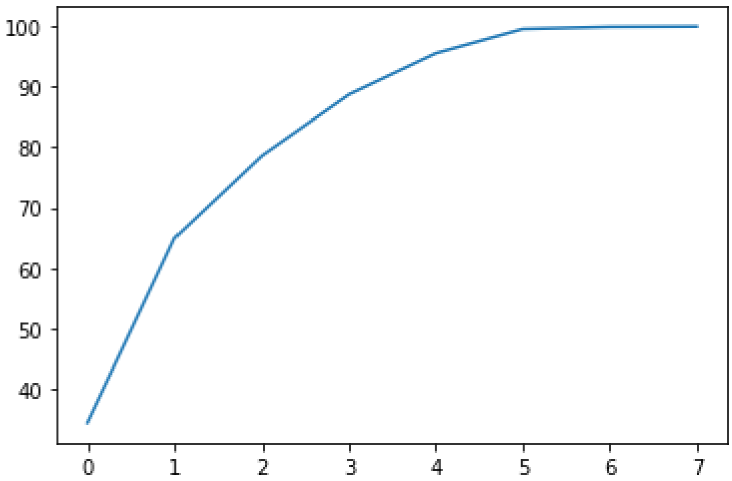
```
pca = PCA(n_components=8)
pca.fit(X_train_normalise)
#The amount of variance that each PC explains
var= pca.explained_variance_ratio_

#Cumulative Variance explains
var1=np.cumsum(np.round(pca.explained_variance_ratio_, decimals=4)*100)

plt.plot(var1)
```

Out[279]:

```
[<matplotlib.lines.Line2D at 0x2207d4c6a30>]
```



From this graphs we can see mainly two elbow one is at 1 and another is at 5.We can, choose first five principal components as its explain almost 95 variance of our original datasets. But, I used here 12, because I have seen that If use 12 I get better result than 5.

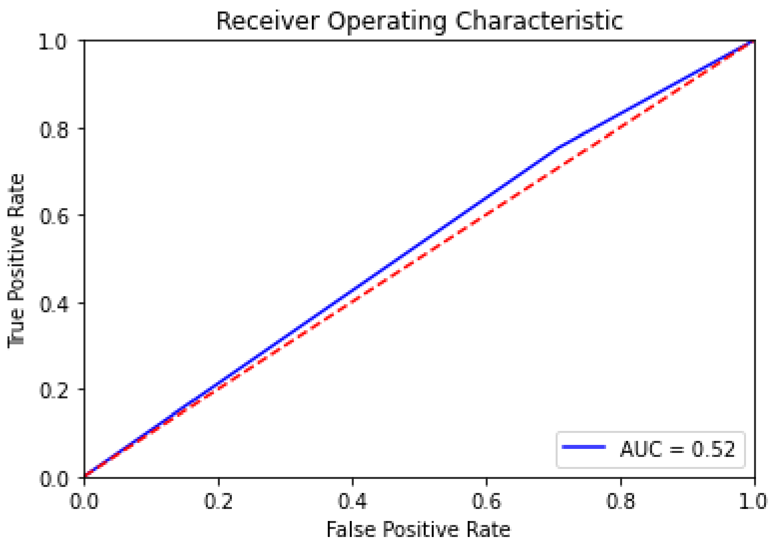
In [280]:

```
pca = PCA(n_components=12)
X_train_pca= pca.fit_transform(X_train_normalise)
X_test_pca= pca.fit_transform(X_test_normalise)
```

In [281]:

```
model = KNeighborsClassifier(n_neighbors=3)
# Train the model using the training sets
model.fit(X_train_pca,y_train)
y_pred=model.predict(X_test_pca)
# Model Accuracy
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
confusion_matrix = pd.crosstab(y_test, y_pred, rownames=['Actual'], colnames=['Predicte
d'])
print (confusion_matrix)
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
roc_auc = metrics.auc(fpr, tpr)
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```

```
Accuracy: 0.530241935483871
Predicted   0    1
Actual
0          70  170
1          63  193
```



Even, after implementing, we are not getting good accuracy.Here, pca is not giving good performance.

3.5 Artificial Neural Network(ANN)

Tying With ANN

In [337]:

```
# Feature Scaling because yes we don't want one independent variable dominating the oth
er and it makes computations easy
sc = StandardScaler()
X_train= sc.fit_transform(X_train)
X_test= sc.transform(X_test)
```

Sequential model to initialise our ann and dense module to build the layers

In [345]:

```
classifier = Sequential()
# Adding the input layer and the first hidden layer
classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu', in
put_dim = 16))

# Adding the second hidden layer
classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu'))

# Adding the output layer
classifier.add(Dense(units = 1, kernel_initializer = 'uniform', activation = 'sigmoid'
))

# Compiling the ANN | means applying SGD on the whole ANN
classifier.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accura
cy'])

# Fitting the ANN to the Training set
classifier.fit(X_train, y_train, batch_size = 10, epochs = 100,verbose = 0)

score, acc = classifier.evaluate(X_train, y_train,
                            batch_size=10)
print('Train score:', score)
print('Train accuracy:', acc)
# Part 3 - Making predictions and evaluating the model

# Predicting the Test set results
y_pred = classifier.predict(X_test)
y_pred = (y_pred > 0.5)

print('*'*20)
score, acc = classifier.evaluate(X_test, y_test,
                            batch_size=10)
print('Test score:', score)
print('Test accuracy:', acc)
```

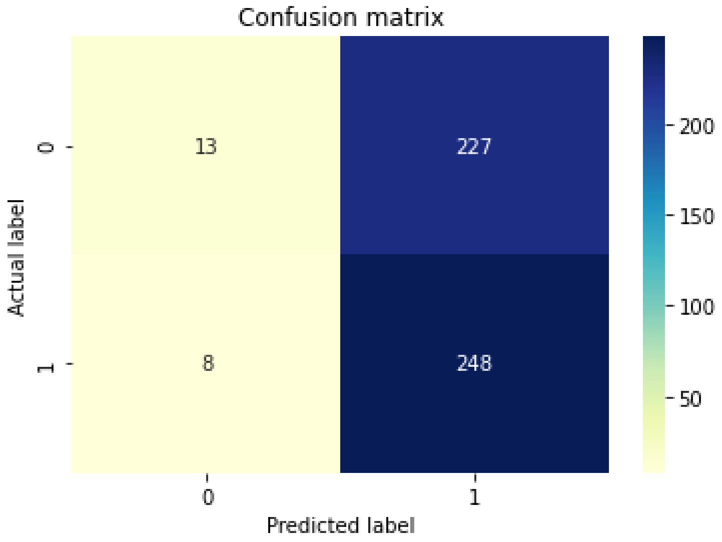
```
210/210 [==============================] - 1s 1ms/step - loss: 0.6576 - ac
curacy: 0.5933
Train score: 0.6576150059700012
Train accuracy: 0.5933333039283752
********************
50/50 [==============================] - 1s 1ms/step - loss: 0.6913 - accu
racy: 0.5323
Test score: 0.6912969350814819
Test accuracy: 0.5322580933570862
```

In [349]:

```
p = sns.heatmap(pd.DataFrame(cm), annot=True, cmap="YlGnBu" ,fmt='g')  #confusion matri
x using seaboran
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

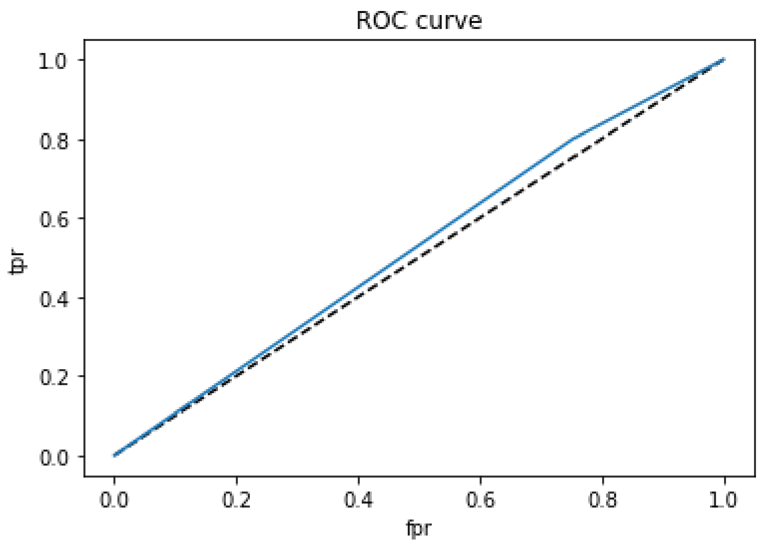
Out[349]:

```
Text(0.5, 15.0, 'Predicted label')
```



In [350]:

```
fpr, tpr, thresholds = roc_curve(y_test, y_pred)
plt.plot([0,1],[0,1],'k--')
plt.plot(fpr,tpr, label='ANN')
plt.xlabel('fpr')
plt.ylabel('tpr')
plt.title('ROC curve')
plt.show()
```



From this graph we can see that, this ROC curve shows that this is not giving good performance over random forest and decision tree.

In [351]:

```
# Tuning the ANN
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import GridSearchCV
from keras.models import Sequential
from keras.layers import Dense
def build_classifier(optimizer):
    classifier = Sequential()
    classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu'
, input_dim = 16))
    classifier.add(Dense(units = 6, kernel_initializer = 'uniform', activation = 'relu'
))
    classifier.add(Dense(units = 1, kernel_initializer = 'uniform', activation = 'sigmo
id'))
    classifier.compile(optimizer = optimizer, loss = 'binary_crossentropy', metrics = [
'accuracy'])
    return classifier
classifier = KerasClassifier(build_fn = build_classifier)
parameters = {'batch_size': [16, 32],
              'epochs': [50,100],
              'optimizer': ['adam', 'rmsprop','SGD']}
grid_search = GridSearchCV(estimator = classifier,
                           param_grid = parameters,
                           scoring = 'accuracy',
                           cv = 10)
grid_search = grid_search.fit(X_train, y_train,verbose = 0)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_
```

```
C:\Users\49157\anaconda3\lib\site-packages\keras\engine\sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed a
fter 2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-
1)`,   if your model does multi-class classification   (e.g. if it uses a
`softmax` last-layer activation).* `(model.predict(x) > 0.5).astype("int3
2")`,   if your model does binary classification   (e.g. if it uses a `sig
moid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

In [128]:

```
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
```

```
Best Parameters after tuning: {'batch_size': 32, 'epochs': 50, 'optimize
r': 'adam'}
Best Accuracy after tuning: 0.5480952380952381
```

Here, we can see that only 54% accuracy on training data, which is really poor. In ANN, there are a lot parameter, like number of hidden layer , optimaization fuction, epoch, batch size, number of neuro etc, if do optimaization for more parameter with a large range maybe we can get a good accuracy.

part 4: Final model selection

From all of the models which I have tried, I can see that random forest give the best result.I have got 58% accuracy. Although this is not good result, random forest perform better over other approach.If we do more quality checking of our dataset, and do more hyper- parameter optimaization, we will get more better result.

One thing that I did not try, I could use Auto ML technique to see which model perform better. And, I could know better about all feautre of the dataset which are important for the model. If I get opportunity to work on this dataset again, I will try best to improve the accuracy.

In [ ]:

```

```