Heart attack

September 13, 2020

[134]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import time
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import f1_score,confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
from sklearn.feature_selection import RFE
from sklearn.datasets import make_regression


def read_data(csv_file):
    try:
        return pd.read_csv(csv_file)
    except:
        print("The file is not found")
        return None


Heart_attack_data_set = read_data("C:/Users/omri1/PycharmProjects/untitled2/
 ↪heart_attack.csv")
```

[135]:
```
Heart_attack_data_set
```

[135]:

	age	anaemia	creatinine_phosphokinase	diabetes	ejection_fraction	\
0	75.0	0	582	0	20	
1	55.0	0	7861	0	38	
2	65.0	0	146	0	20	
3	50.0	1	111	0	20	
4	65.0	1	160	1	20	
..	…	…	…	…	…	
294	62.0	0	61	1	38	
295	55.0	0	1820	0	38	

```
296  45.0        0                    2060         1                60
297  45.0        0                    2413         0                38
298  50.0        0                     196         0                45

     high_blood_pressure  platelets  serum_creatinine  serum_sodium  sex  \
0                      1  265000.00               1.9           130    1
1                      0  263358.03               1.1           136    1
2                      0  162000.00               1.3           129    1
3                      0  210000.00               1.9           137    1
4                      0  327000.00               2.7           116    0
..                   …          …                 …           …  …
294                    1  155000.00               1.1           143    1
295                    0  270000.00               1.2           139    0
296                    0  742000.00               0.8           138    0
297                    0  140000.00               1.4           140    1
298                    0  395000.00               1.6           136    1

     smoking  time  DEATH_EVENT
0          0     4            1
1          0     6            1
2          1     7            1
3          0     7            1
4          0     8            1
..       …   …          …
294        1   270            0
295        0   271            0
296        0   278            0
297        1   280            0
298        1   285            0

[299 rows x 13 columns]
```

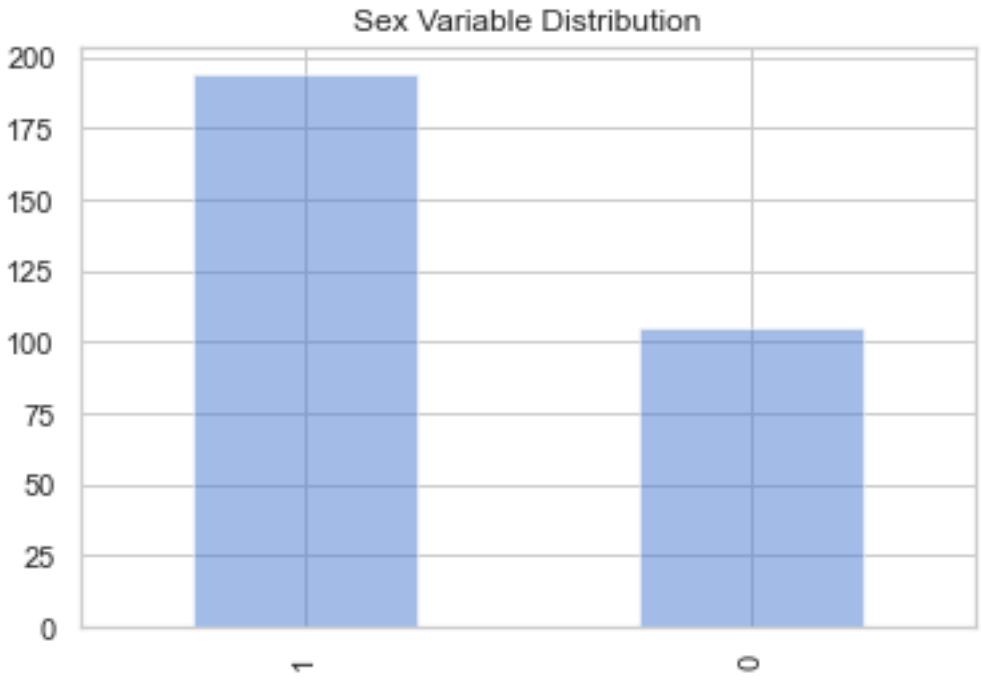
[136]:
```
# Statistical analysis

Heart_attack_data_set.describe()
```

[136]:
```
              age     anaemia  creatinine_phosphokinase    diabetes  \
count  299.000000  299.000000                299.000000  299.000000
mean    60.833893    0.431438                581.839465    0.418060
std     11.894809    0.496107                970.287881    0.494067
min     40.000000    0.000000                 23.000000    0.000000
25%     51.000000    0.000000                116.500000    0.000000
50%     60.000000    0.000000                250.000000    0.000000
75%     70.000000    1.000000                582.000000    1.000000
max     95.000000    1.000000               7861.000000    1.000000

       ejection_fraction  high_blood_pressure      platelets  \
```

```
count         299.000000           299.000000     299.000000
mean           38.083612             0.351171  263358.029264
std            11.834841             0.478136   97804.236869
min            14.000000             0.000000   25100.000000
25%            30.000000             0.000000  212500.000000
50%            38.000000             0.000000  262000.000000
75%            45.000000             1.000000  303500.000000
max            80.000000             1.000000  850000.000000

       serum_creatinine  serum_sodium         sex    smoking        time  \
count         299.00000    299.000000  299.000000  299.00000  299.000000
mean            1.39388    136.625418    0.648829    0.32107  130.260870
std             1.03451      4.412477    0.478136    0.46767   77.614208
min             0.50000    113.000000    0.000000    0.00000    4.000000
25%             0.90000    134.000000    0.000000    0.00000   73.000000
50%             1.10000    137.000000    1.000000    0.00000  115.000000
75%             1.40000    140.000000    1.000000    1.00000  203.000000
max             9.40000    148.000000    1.000000    1.00000  285.000000

       DEATH_EVENT
count    299.00000
mean       0.32107
std        0.46767
min        0.00000
25%        0.00000
50%        0.00000
75%        1.00000
max        1.00000
```

[ ]:
```
# From the first analysis I can conclude that most of the ages are on their 60,␣
↪with a little deviation.
# To most of the examined there no diabetes, blood pressure, or smoking issues.
```

[137]:
```
Heart_attack_data_set['sex'].value_counts().plot(kind="bar", title="Sex␣
↪Variable Distribution", alpha=0.5)
plt.show()
```



[ ]:
```
# There are almost two times male tested than female tested.
```

[138]:
```
def data_shape(data, label):
    print('Rows number of ' + label + " is: ", data.shape[0])
    print('Columns number of ' + label + ' is: ', data.shape[1])

def data_columns(data):
    return list(data.columns)

def describe_data(data):
    return data.describe()

data_shape(Heart_attack_data_set, 'Heart attack data set')
data_columns(Heart_attack_data_set)
describe_data(Heart_attack_data_set)
```

```
Rows number of Heart attack data set is:  299
Columns number of Heart attack data set is:  13
```

[138]:

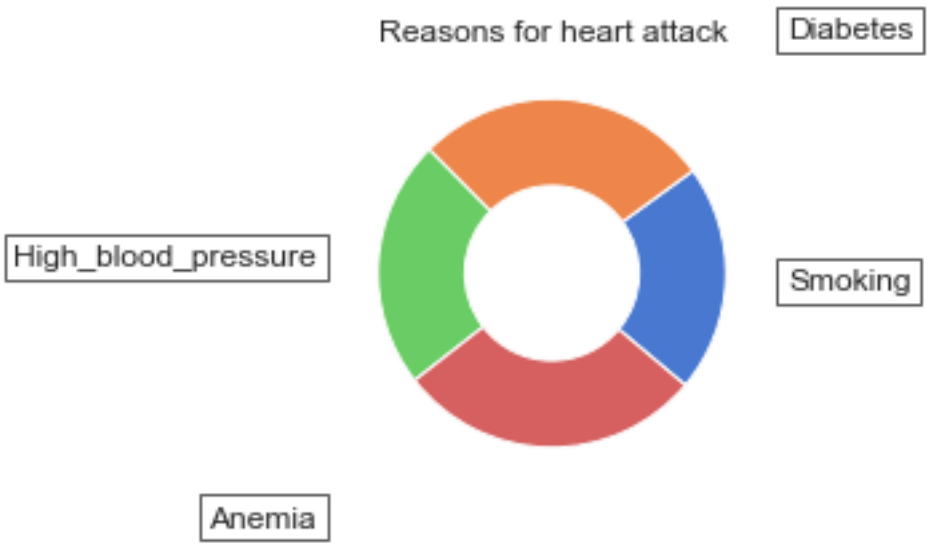
	age	anaemia	creatinine_phosphokinase	diabetes	\
count	299.000000	299.000000	299.000000	299.000000	
mean	60.833893	0.431438	581.839465	0.418060	
std	11.894809	0.496107	970.287881	0.494067	
min	40.000000	0.000000	23.000000	0.000000	
25%	51.000000	0.000000	116.500000	0.000000	

```
50%     60.000000    0.000000               250.000000    0.000000
75%     70.000000    1.000000               582.000000    1.000000
max     95.000000    1.000000              7861.000000    1.000000

       ejection_fraction  high_blood_pressure      platelets  \
count         299.000000           299.000000     299.000000
mean           38.083612             0.351171  263358.029264
std            11.834841             0.478136   97804.236869
min            14.000000             0.000000   25100.000000
25%            30.000000             0.000000  212500.000000
50%            38.000000             0.000000  262000.000000
75%            45.000000             1.000000  303500.000000
max            80.000000             1.000000  850000.000000

       serum_creatinine  serum_sodium         sex    smoking        time  \
count         299.00000    299.000000  299.000000  299.00000  299.000000
mean            1.39388    136.625418    0.648829    0.32107  130.260870
std             1.03451      4.412477    0.478136    0.46767   77.614208
min             0.50000    113.000000    0.000000    0.00000    4.000000
25%             0.90000    134.000000    0.000000    0.00000   73.000000
50%             1.10000    137.000000    1.000000    0.00000  115.000000
75%             1.40000    140.000000    1.000000    1.00000  203.000000
max             9.40000    148.000000    1.000000    1.00000  285.000000

       DEATH_EVENT
count    299.00000
mean       0.32107
std        0.46767
min        0.00000
25%        0.00000
50%        0.00000
75%        1.00000
max        1.00000
```

[211]:
```
Smoking = Heart_attack_data_set[Heart_attack_data_set['smoking'] ==␣
↪1]['smoking'].sum()
Diabetes = Heart_attack_data_set[Heart_attack_data_set['diabetes'] ==␣
↪1]['diabetes'].sum()
High_blood_pressure =␣
↪Heart_attack_data_set[Heart_attack_data_set['high_blood_pressure'] ==␣
↪1]['high_blood_pressure'].sum()
anaemia = Heart_attack_data_set[Heart_attack_data_set['anaemia'] ==␣
↪1]['anaemia'].sum()

print('Reasons for heart attack: \nSmoking = ' + str(Smoking) + '\nDiabetes = '␣
↪+ str(Diabetes) + '\nHigh blood pressure = ' +str(High_blood_pressure)
    + '\nAnemia = ' + str(anaemia))
```

```
fig, ax = plt.subplots(figsize=(6, 3), subplot_kw=dict(aspect="equal"))

reasons = ['Smoking','Diabetes','High_blood_pressure','Anemia']

data = [Smoking, Diabetes, High_blood_pressure, anaemia]

wedges, texts = ax.pie(data, wedgeprops=dict(width=0.5), startangle=-40)

bbox_props = dict(boxstyle="square,pad=0.3", fc="w", ec="k", lw=0.72)
kw = dict(arrowprops=dict(arrowstyle="-"), bbox=bbox_props, zorder=0,␣
 ↪va="center")

for i, p in enumerate(wedges):
    ang = (p.theta2 - p.theta1) / 2. + p.theta1
    y = np.sin(np.deg2rad(ang))
    x = np.cos(np.deg2rad(ang))
    horizontalalignment = {-1: "right", 1: "left"}[int(np.sign(x))]
    connectionstyle = "angle,angleA=0,angleB={}".format(ang)
    kw["arrowprops"].update({"connectionstyle": connectionstyle})
    ax.annotate(reasons[i], xy=(x, y), xytext=(1.35 * np.sign(x), 1.4 *␣
 ↪y),horizontalalignment=horizontalalignment, **kw)

ax.set_title('Reasons for heart attack')
plt.show()
```

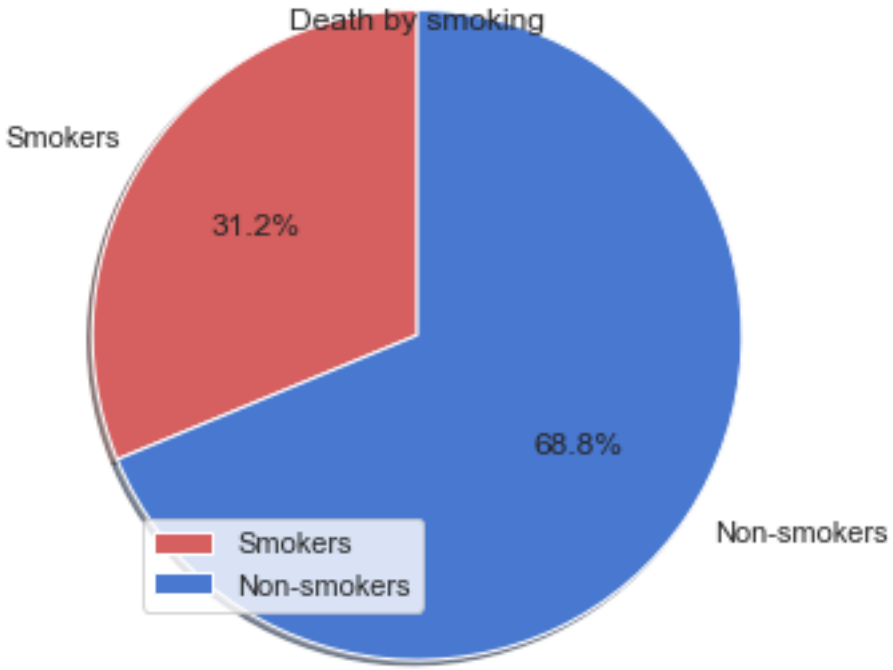
```
Reasons for heart attack:
Smoking = 96
Diabetes = 125
High blood pressure = 105
Anemia = 129
```

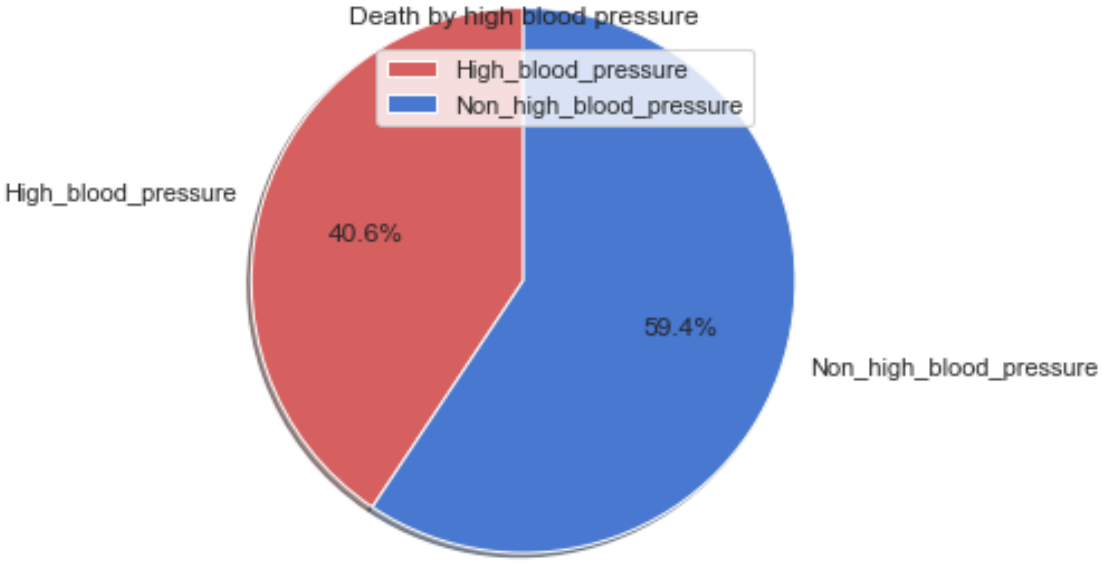


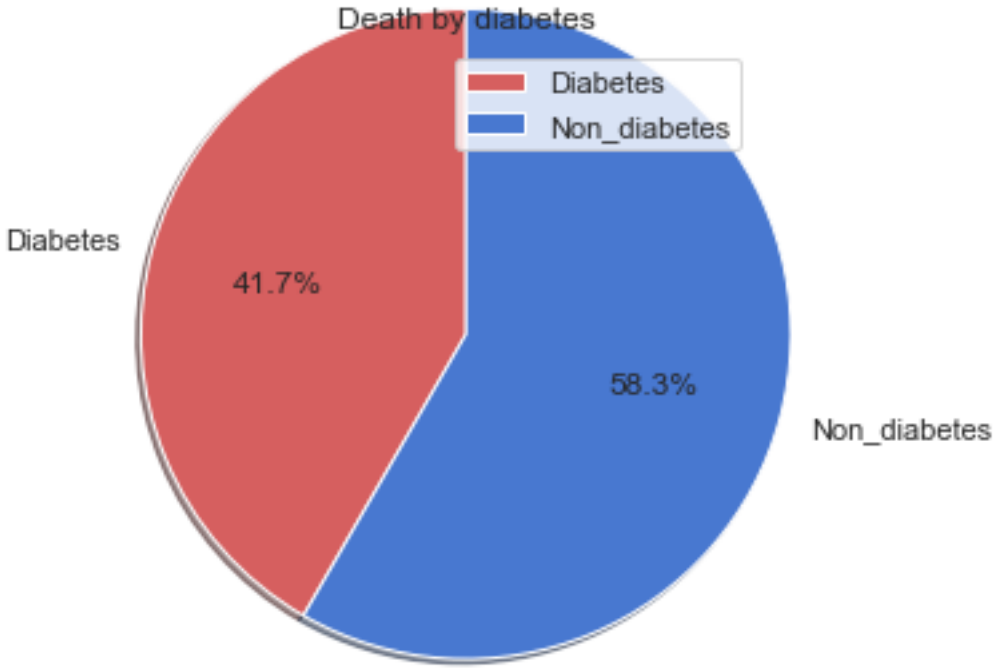
[ ]:
```
# Most of the heart attacks were caused by anemia but all the numbers are very␣
 ↪close to the mentioned reasons.
```

[194]:
```
Smokers = Heart_attack_data_set[Heart_attack_data_set['smoking'] ==␣
 ↪1]['DEATH_EVENT'].sum()
Non_smokers = Heart_attack_data_set[Heart_attack_data_set['smoking'] ==␣
 ↪0]['DEATH_EVENT'].sum()

High_blood_pressure =␣
 ↪Heart_attack_data_set[Heart_attack_data_set['high_blood_pressure'] ==␣
 ↪1]['DEATH_EVENT'].sum()
Non_high_blood_pressure =␣
 ↪Heart_attack_data_set[Heart_attack_data_set['high_blood_pressure'] ==␣
 ↪0]['DEATH_EVENT'].sum()

Diabetes = Heart_attack_data_set[Heart_attack_data_set['diabetes'] ==␣
 ↪1]['DEATH_EVENT'].sum()
Non_diabetes = Heart_attack_data_set[Heart_attack_data_set['diabetes'] ==␣
 ↪0]['DEATH_EVENT'].sum()

Deaths = ['Smokers', 'Non-smokers']
slices = [Smokers, Non_smokers]
colors = ['r','b']
plt.pie(slices, labels= Deaths, colors=colors, startangle=90, shadow=True,␣
 ↪explode=(0, 0),radius=1.4, autopct='%1.1f%%')
plt.legend()
plt.title('Death by smoking')
plt.show()

Deaths = ['High_blood_pressure', 'Non_high_blood_pressure']
slices = [High_blood_pressure, Non_high_blood_pressure]
colors = ['r','b']
plt.pie(slices, labels= Deaths, colors=colors, startangle=90, shadow=True,␣
 ↪explode=(0, 0),radius=1.4, autopct='%1.1f%%')
plt.legend()
plt.title('Death by high blood pressure')
plt.show()

Deaths = ['Diabetes', 'Non_diabetes']
slices = [Diabetes, Non_diabetes]
colors = ['r','b']
plt.pie(slices, labels= Deaths, colors=colors, startangle=90, shadow=True,␣
 ↪explode=(0, 0),radius=1.4, autopct='%1.1f%%')
plt.legend()
plt.title('Death by diabetes')
```

```
plt.show()
```


Death by smoking
Smokers
31.2%
68.8%
Non-smokers
Smokers
Non-smokers


Death by high blood pressure
High_blood_pressure
Non_high_blood_pressure
High_blood_pressure
40.6%
59.4%
Non_high_blood_pressure



[ ]:
```
#Smoking, diabetes and high blood pressure do not necessarily affect death from␣
↪a heart attack.
```

[139]:
```
sns.set(style="whitegrid", palette="muted")
new_data = (Heart_attack_data_set - Heart_attack_data_set.mean()) /␣
↪(Heart_attack_data_set.std())
new_data = pd.concat([Heart_attack_data_set['DEATH_EVENT'], new_data.iloc[:,0:
↪12]], axis=1)
new_data
```

[139]:

	DEATH_EVENT	age	anaemia	creatinine_phosphokinase	diabetes	\
0	1	1.190949	-0.869647	0.000165	-0.846161	
1	1	-0.490457	-0.869647	7.502063	-0.846161	
2	1	0.350246	-0.869647	-0.449186	-0.846161	
3	1	-0.910808	1.146046	-0.485257	-0.846161	
4	1	0.350246	1.146046	-0.434757	1.177856	
..	…	…	…	…	…	
294	0	0.098035	-0.869647	-0.536789	1.177856	
295	0	-0.490457	-0.869647	1.276075	-0.846161	
296	0	-1.331160	-0.869647	1.523425	1.177856	
297	0	-1.331160	-0.869647	1.887234	-0.846161	
298	0	-0.910808	-0.869647	-0.397655	-0.846161	

	ejection_fraction	high_blood_pressure	platelets	serum_creatinine	\
0	-1.527998	1.356997	1.678834e-02	0.489237	

```
1            -0.007065           -0.734457  7.523047e-09         -0.284076
2            -1.527998           -0.734457 -1.036336e+00         -0.090748
3            -1.527998           -0.734457 -5.455595e-01          0.489237
4            -1.527998           -0.734457  6.507077e-01          1.262550
..                 …                   …           …                 …
294          -0.007065            1.356997 -1.107907e+00         -0.284076
295          -0.007065           -0.734457  6.791087e-02         -0.187412
296           1.851853           -0.734457  4.893878e+00         -0.574068
297          -0.007065           -0.734457 -1.261275e+00          0.005916
298           0.584409           -0.734457  1.345974e+00          0.199244

     serum_sodium       sex   smoking      time
0       -1.501519  0.734457 -0.686531 -1.626775
1       -0.141739  0.734457 -0.686531 -1.601007
2       -1.728149  0.734457  1.451727 -1.588122
3        0.084892  0.734457 -0.686531 -1.588122
4       -4.674340 -1.356997 -0.686531 -1.575238
..            …       …        …        …
294      1.444672  0.734457  1.451727  1.800432
295      0.538152 -1.356997 -0.686531  1.813317
296      0.311522 -1.356997 -0.686531  1.903506
297      0.764782  0.734457  1.451727  1.929275
298     -0.141739  0.734457  1.451727  1.993696

[299 rows x 13 columns]
```

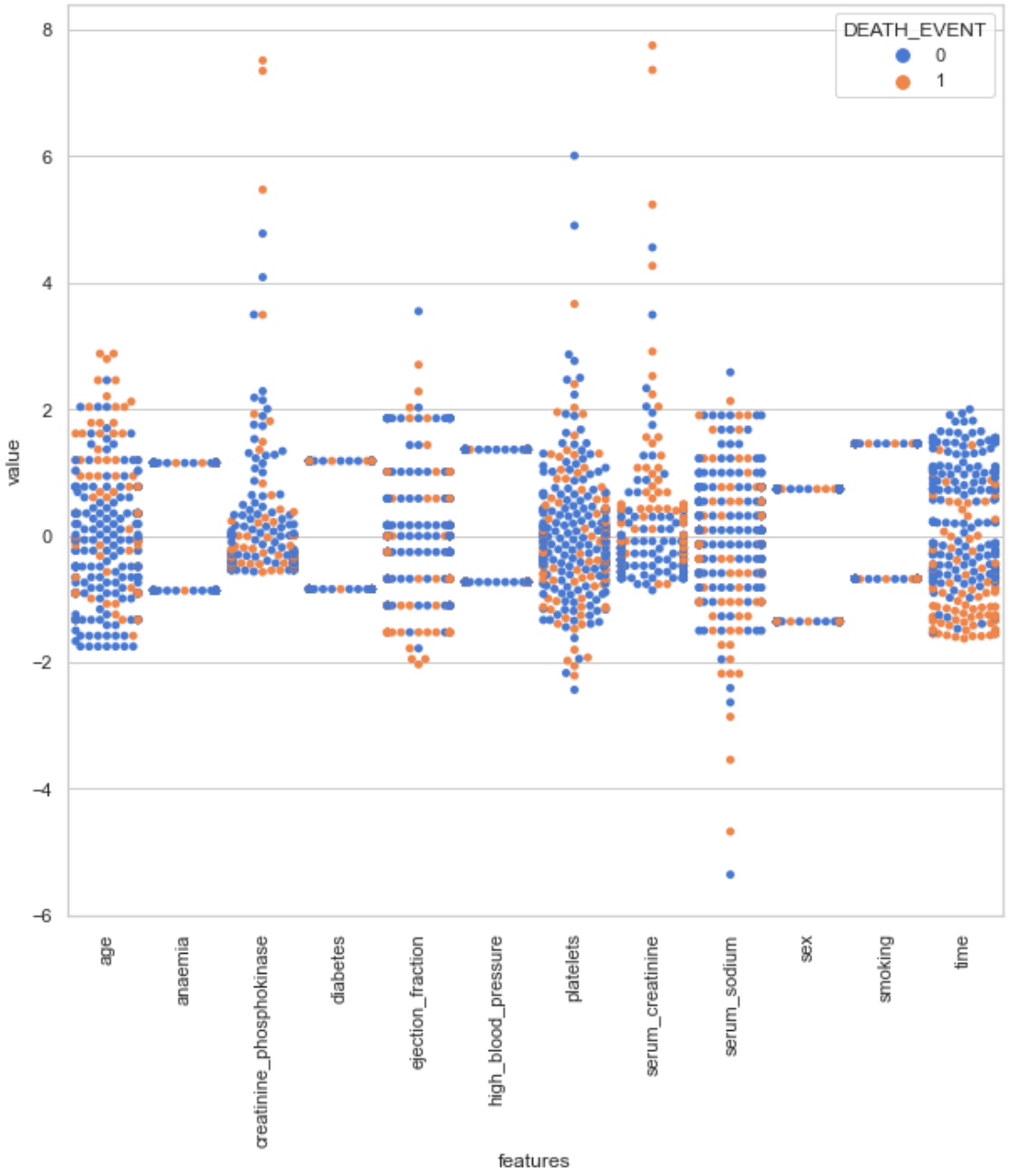
[140]:
```
new_data = pd.melt(new_data, id_vars="DEATH_EVENT", var_name="features",␣
 ↪value_name='value')
new_data
```

[140]:
```
      DEATH_EVENT features     value
0               1      age  1.190949
1               1      age -0.490457
2               1      age  0.350246
3               1      age -0.910808
4               1      age  0.350246
…             …      …        …
3583            0     time  1.800432
3584            0     time  1.813317
3585            0     time  1.903506
3586            0     time  1.929275
3587            0     time  1.993696

[3588 rows x 3 columns]
```

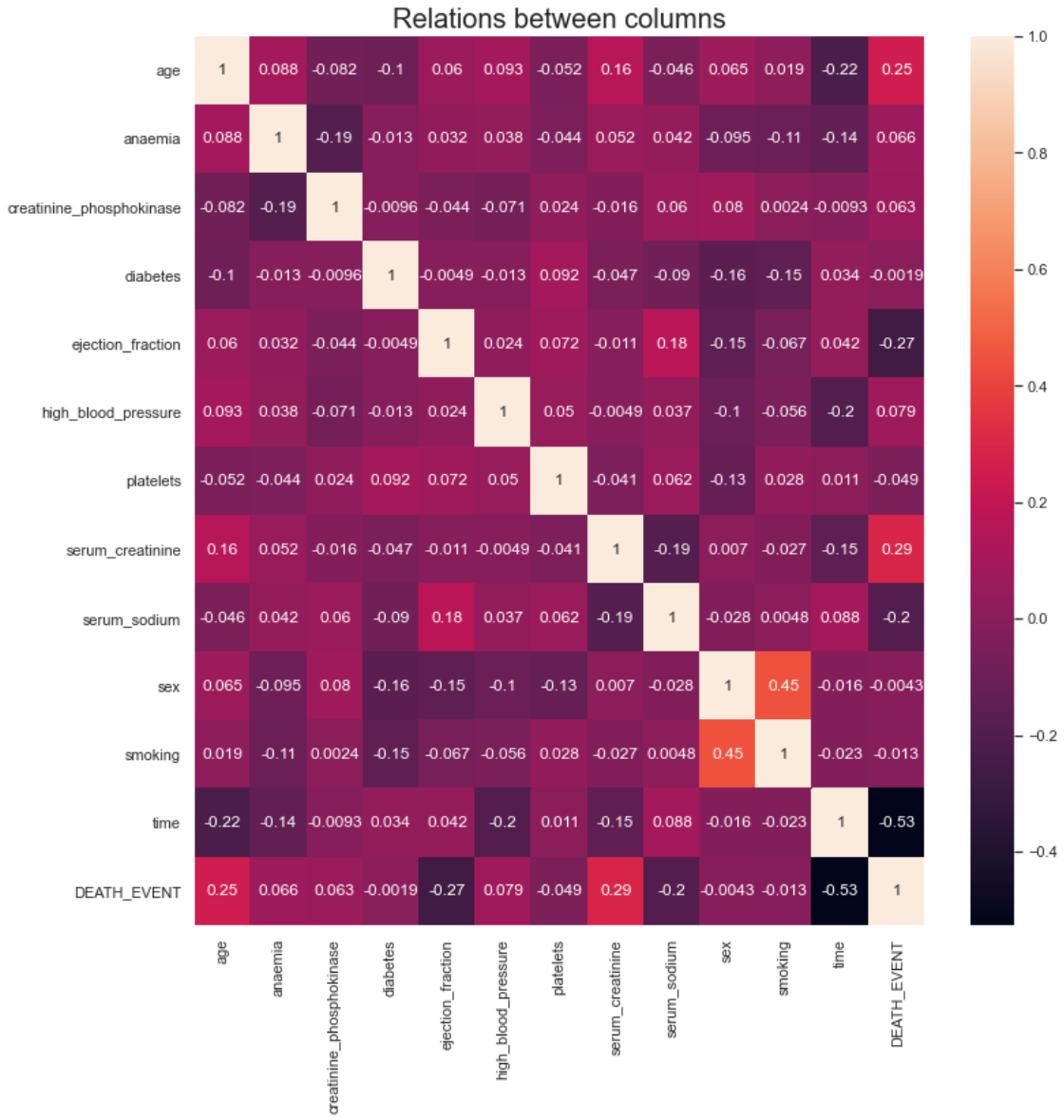
[141]:
```
# 0 = Death
plt.figure(figsize=(10,10))
```

```
sns.swarmplot(x="features", y="value", hue="DEATH_EVENT", data=new_data)
plt.xticks(rotation=90)
```

[141]:
```
(array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11]),
 [Text(0, 0, 'age'),
  Text(1, 0, 'anaemia'),
  Text(2, 0, 'creatinine_phosphokinase'),
  Text(3, 0, 'diabetes'),
  Text(4, 0, 'ejection_fraction'),
  Text(5, 0, 'high_blood_pressure'),
  Text(6, 0, 'platelets'),
  Text(7, 0, 'serum_creatinine'),
  Text(8, 0, 'serum_sodium'),
  Text(9, 0, 'sex'),
  Text(10, 0, 'smoking'),
  Text(11, 0, 'time')])
```



[142]:
```
fig, ax = plt.subplots(figsize=(12,12))
sns.heatmap(Heart_attack_data_set.corr(), annot = True, ax=ax)
plt.title('Relations between columns', fontsize = 20)
plt.show()
```



[ ]:
```
#There is a high relation between the sex of the individual to smoking but the␣
 ↪interesting conclusion is
#that have a very strong relationship between the serum sodium and age to heart␣
 ↪attacks
#and negative relation between ejection fraction to heart attacks.
```

[143]:
```
drop_list = ['time', 'DEATH_EVENT']
fs_corr = Heart_attack_data_set.drop(columns=drop_list)
fs_corr.head()
```

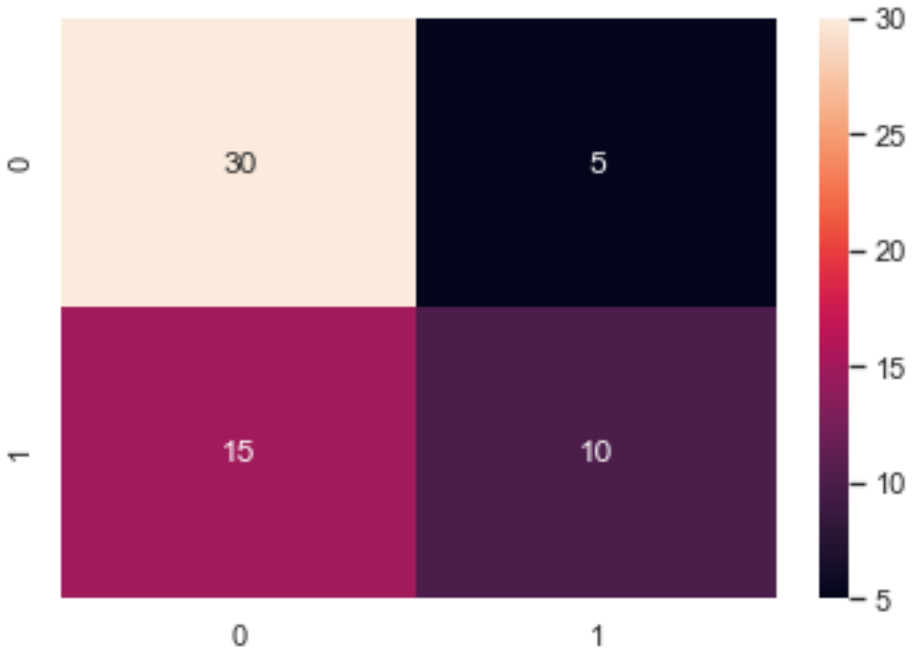
[143]:
```
    age  anaemia  creatinine_phosphokinase  diabetes  ejection_fraction  \
0  75.0        0                       582         0                 20
1  55.0        0                      7861         0                 38
2  65.0        0                       146         0                 20
3  50.0        1                       111         0                 20
4  65.0        1                       160         1                 20

   high_blood_pressure  platelets  serum_creatinine  serum_sodium  sex  \
0                    1  265000.00               1.9           130    1
1                    0  263358.03               1.1           136    1
2                    0  162000.00               1.3           129    1
3                    0  210000.00               1.9           137    1
4                    0  327000.00               2.7           116    0

   smoking
0        0
1        0
2        1
3        0
4        0
```

[144]:
```
y = Heart_attack_data_set['DEATH_EVENT']
x_train, x_test, y_train, y_test = train_test_split(fs_corr, y, test_size=0.
 ↪2,random_state=42)
clf_rf = RandomForestClassifier(n_estimators=20)
clr_rf = clf_rf.fit(x_train,y_train)
```

[145]:
```
print('Accuracy',accuracy_score(y_test,clf_rf.predict(x_test)))
cm = confusion_matrix(y_test,clf_rf.predict(x_test))
sns.heatmap(cm,annot=True,fmt="d")
```

```
Accuracy 0.6666666666666666
```

[145]:
```
<AxesSubplot:>
```



[146]:
```
K = range(1, len(x_train.columns))
for k in K:
    select_feature = SelectKBest(chi2, k=k).fit(x_train, y_train)
    scores = zip(x_train.columns, select_feature.scores_)
    print("Selected K:", k)
    for i, (column, score) in enumerate(scores):
        if i < k:
            print("Feature:", column, ", Score:", score)
    print("-----------")
```

```
Selected K: 1
Feature: age , Score: 46.9889849693994
-----------
Selected K: 2
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
-----------
Selected K: 3
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
-----------
Selected K: 4
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
```

```
Feature: diabetes , Score: 0.0016732698597080864
-----------
Selected K: 5
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
-----------
Selected K: 6
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
Feature: high_blood_pressure , Score: 0.5289514866979651
-----------
Selected K: 7
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
Feature: high_blood_pressure , Score: 0.5289514866979651
Feature: platelets , Score: 27714.885624462317
-----------
Selected K: 8
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
Feature: high_blood_pressure , Score: 0.5289514866979651
Feature: platelets , Score: 27714.885624462317
Feature: serum_creatinine , Score: 18.105974482139235
-----------
Selected K: 9
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
Feature: high_blood_pressure , Score: 0.5289514866979651
Feature: platelets , Score: 27714.885624462317
Feature: serum_creatinine , Score: 18.105974482139235
Feature: serum_sodium , Score: 1.2352740846996069
-----------
Selected K: 10
```

```
Feature: age , Score: 46.9889849693994
Feature: anaemia , Score: 0.44381997110870225
Feature: creatinine_phosphokinase , Score: 460.053375481774
Feature: diabetes , Score: 0.0016732698597080864
Feature: ejection_fraction , Score: 55.896406551208116
Feature: high_blood_pressure , Score: 0.5289514866979651
Feature: platelets , Score: 27714.885624462317
Feature: serum_creatinine , Score: 18.105974482139235
Feature: serum_sodium , Score: 1.2352740846996069
Feature: sex , Score: 0.23498621599728284
-----------
```

[147]:
```
clf_rf_ = RandomForestClassifier(n_estimators=20)
rfe = RFE(estimator=clf_rf_, n_features_to_select=5, step=1)
rfe = rfe.fit(x_train, y_train)
```

[148]:
```
print('Chosen best 5 feature by RFE:',x_train.columns[rfe.support_])
```

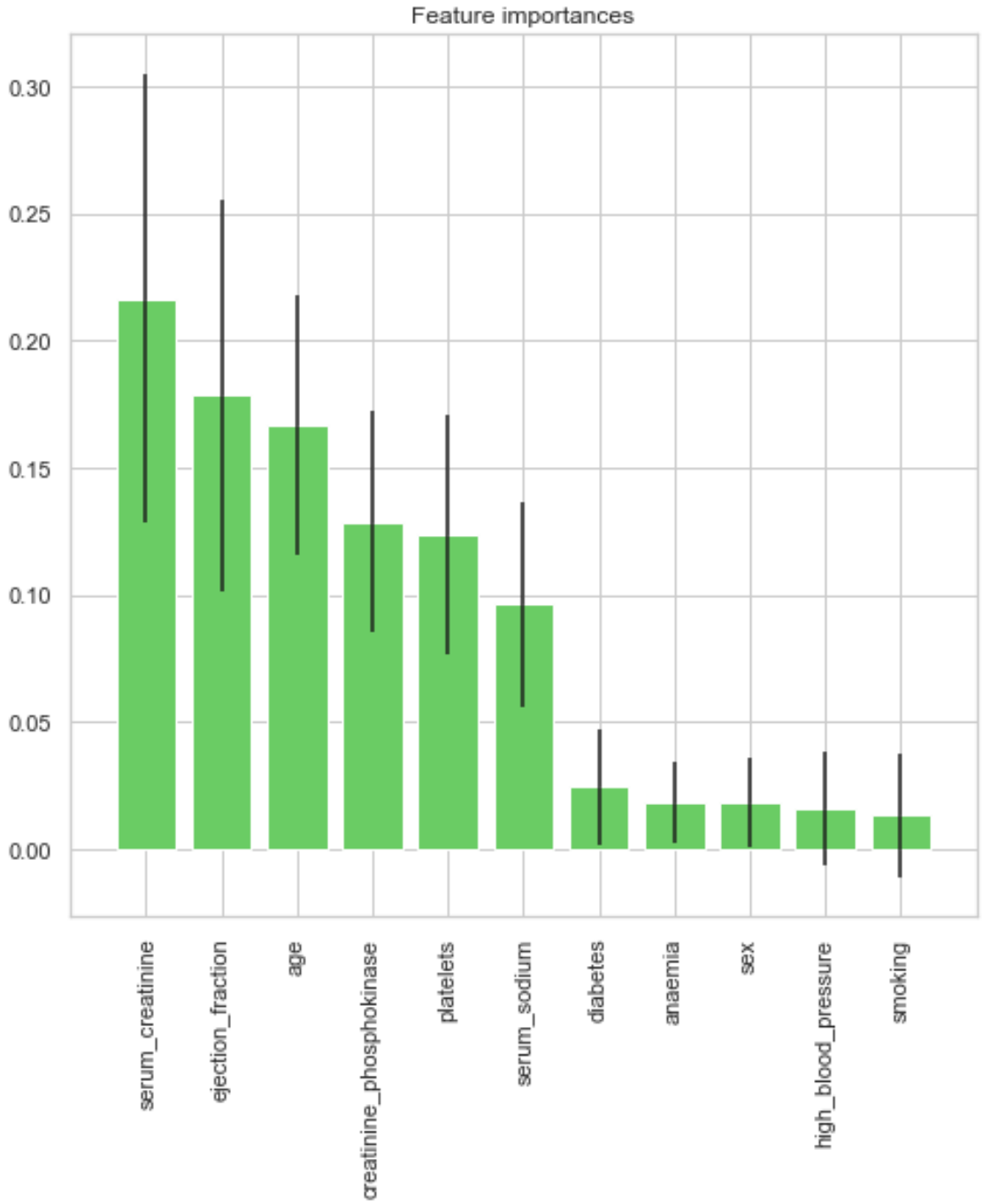
```
Chosen best 5 feature by RFE: Index(['age', 'creatinine_phosphokinase',
'ejection_fraction', 'platelets',
       'serum_creatinine'],
      dtype='object')
```

[149]:
```
clf_rf_ = RandomForestClassifier(n_estimators=20)
clr_rf_ = clf_rf_.fit(x_train,y_train)
importances = clr_rf_.feature_importances_
std = np.std([tree.feature_importances_ for tree in clf_rf.estimators_],axis=0)
indices = np.argsort(importances)[::-1]
```

[150]:
```
print("Feature ranking:")
for f in range(x_train.shape[1]):
    print("%d. feature %d (%f)" % (f + 1, indices[f], importances[indices[f]]))
```

```
Feature ranking:
1. feature 7 (0.216425)
2. feature 4 (0.178312)
3. feature 0 (0.166893)
4. feature 2 (0.128674)
5. feature 6 (0.123567)
6. feature 8 (0.096415)
7. feature 3 (0.024396)
8. feature 1 (0.018207)
9. feature 9 (0.018093)
10. feature 5 (0.015762)
11. feature 10 (0.013257)
```

[151]:
```
plt.figure(1, figsize=(8, 8))
plt.title("Feature importances")
plt.bar(range(x_train.shape[1]), importances[indices],
color="g", yerr=std[indices], align="center")
plt.xticks(range(x_train.shape[1]), x_train.columns[indices],rotation=90)
plt.xlim([-1, x_train.shape[1]])
plt.show()
```



[152]:
```
#SVM algorithm
from sklearn.svm import SVC
from sklearn.metrics import classification_report,confusion_matrix
df_feat = Heart_attack_data_set
df_feat.info()
X_train, X_test, y_train, y_test = train_test_split(df_feat, np.ravel(y),␣
 ↪test_size=0.30, random_state=101)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 299 entries, 0 to 298
Data columns (total 13 columns):
age                         299 non-null float64
anaemia                     299 non-null int64
creatinine_phosphokinase    299 non-null int64
diabetes                    299 non-null int64
ejection_fraction           299 non-null int64
high_blood_pressure         299 non-null int64
platelets                   299 non-null float64
serum_creatinine            299 non-null float64
serum_sodium                299 non-null int64
sex                         299 non-null int64
smoking                     299 non-null int64
time                        299 non-null int64
DEATH_EVENT                 299 non-null int64
dtypes: float64(3), int64(10)
memory usage: 30.5 KB
```

[153]:
```
model = SVC()
model.fit(X_train,y_train)
```

[153]:
```
SVC()
```

[154]:
```
predictions = model.predict(X_test)
print(confusion_matrix(y_test,predictions))
```

```
[[62  0]
 [28  0]]
```

[155]:
```
print(classification_report(y_test,predictions))
```

```
              precision    recall  f1-score   support

           0       0.69      1.00      0.82        62
           1       0.00      0.00      0.00        28

    accuracy                           0.69        90
```

```
   macro avg       0.34      0.50      0.41        90
weighted avg       0.47      0.69      0.56        90
```

```
C:\Users\omri1\Anaconda3\lib\site-
packages\sklearn\metrics\_classification.py:1221: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[156]:
```
#Gridsearch
from sklearn.model_selection import GridSearchCV
param_grid = {'C': [0.1,1, 10, 100, 1000], 'gamma': [1,0.1,0.01,0.001,0.0001],␣
 ↪'kernel': ['rbf']}
grid = GridSearchCV(SVC(),param_grid,refit=True,verbose=3)
grid.fit(X_train,y_train)
```

```
Fitting 5 folds for each of 25 candidates, totalling 125 fits
[CV] C=0.1, gamma=1, kernel=rbf …
[CV] … C=0.1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=1, kernel=rbf …
[CV] … C=0.1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=1, kernel=rbf …
[CV] … C=0.1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=1, kernel=rbf …
[CV] … C=0.1, gamma=1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=0.1, gamma=1, kernel=rbf …
[CV] … C=0.1, gamma=1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf …
[CV] … C=0.1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf …
[CV] … C=0.1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf …
[CV] … C=0.1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf …

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[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

[CV] … C=0.1, gamma=0.1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf …
[CV] … C=0.1, gamma=0.1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=0.1, gamma=0.01, kernel=rbf …
[CV] … C=0.1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.01, kernel=rbf …
[CV] … C=0.1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.01, kernel=rbf …
[CV] … C=0.1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
```

```
[CV] C=0.1, gamma=0.01, kernel=rbf …
[CV] … C=0.1, gamma=0.01, kernel=rbf, score=0.690, total=   0.0s
[CV] C=0.1, gamma=0.01, kernel=rbf …
[CV] … C=0.1, gamma=0.01, kernel=rbf, score=0.683, total=   0.0s
[CV] C=0.1, gamma=0.001, kernel=rbf …
[CV] … C=0.1, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.001, kernel=rbf …
[CV] … C=0.1, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.001, kernel=rbf …
[CV] … C=0.1, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.001, kernel=rbf …
[CV] … C=0.1, gamma=0.001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=0.1, gamma=0.001, kernel=rbf …
[CV] … C=0.1, gamma=0.001, kernel=rbf, score=0.683, total=   0.0s
[CV] C=0.1, gamma=0.0001, kernel=rbf …
[CV] … C=0.1, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.0001, kernel=rbf …
[CV] … C=0.1, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.0001, kernel=rbf …
[CV] … C=0.1, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=0.1, gamma=0.0001, kernel=rbf …
[CV] … C=0.1, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=0.1, gamma=0.0001, kernel=rbf …
[CV] … C=0.1, gamma=0.0001, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1, gamma=1, kernel=rbf …
[CV] … C=1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=1, kernel=rbf …
[CV] … C=1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=1, kernel=rbf …
[CV] … C=1, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=1, kernel=rbf …
[CV] … C=1, gamma=1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1, gamma=1, kernel=rbf …
[CV] … C=1, gamma=1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1, gamma=0.1, kernel=rbf …
[CV] … C=1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.1, kernel=rbf …
[CV] … C=1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.1, kernel=rbf …
[CV] … C=1, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.1, kernel=rbf …
[CV] … C=1, gamma=0.1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1, gamma=0.1, kernel=rbf …
[CV] … C=1, gamma=0.1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1, gamma=0.01, kernel=rbf …
[CV] … C=1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.01, kernel=rbf …
[CV] … C=1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
```

```
[CV] C=1, gamma=0.01, kernel=rbf …
[CV] … C=1, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.01, kernel=rbf …
[CV] … C=1, gamma=0.01, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1, gamma=0.01, kernel=rbf …
[CV] … C=1, gamma=0.01, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1, gamma=0.001, kernel=rbf …
[CV] … C=1, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.001, kernel=rbf …
[CV] … C=1, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.001, kernel=rbf …
[CV] … C=1, gamma=0.001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1, gamma=0.001, kernel=rbf …
[CV] … C=1, gamma=0.001, kernel=rbf, score=0.714, total=   0.0s
[CV] C=1, gamma=0.001, kernel=rbf …
[CV] … C=1, gamma=0.001, kernel=rbf, score=0.707, total=   0.0s
[CV] C=1, gamma=0.0001, kernel=rbf …
[CV] … C=1, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.0001, kernel=rbf …
[CV] … C=1, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1, gamma=0.0001, kernel=rbf …
[CV] … C=1, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1, gamma=0.0001, kernel=rbf …
[CV] … C=1, gamma=0.0001, kernel=rbf, score=0.738, total=   0.0s
[CV] C=1, gamma=0.0001, kernel=rbf …
[CV] … C=1, gamma=0.0001, kernel=rbf, score=0.707, total=   0.0s
[CV] C=10, gamma=1, kernel=rbf …
[CV] … C=10, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=1, kernel=rbf …
[CV] … C=10, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=1, kernel=rbf …
[CV] … C=10, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=1, kernel=rbf …
[CV] … C=10, gamma=1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=10, gamma=1, kernel=rbf …
[CV] … C=10, gamma=1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=10, gamma=0.1, kernel=rbf …
[CV] … C=10, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.1, kernel=rbf …
[CV] … C=10, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.1, kernel=rbf …
[CV] … C=10, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.1, kernel=rbf …
[CV] … C=10, gamma=0.1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=10, gamma=0.1, kernel=rbf …
[CV] … C=10, gamma=0.1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=10, gamma=0.01, kernel=rbf …
[CV] … C=10, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
```

```
[CV] C=10, gamma=0.01, kernel=rbf …
[CV] … C=10, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.01, kernel=rbf …
[CV] … C=10, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.01, kernel=rbf …
[CV] … C=10, gamma=0.01, kernel=rbf, score=0.690, total=   0.0s
[CV] C=10, gamma=0.01, kernel=rbf …
[CV] … C=10, gamma=0.01, kernel=rbf, score=0.683, total=   0.0s
[CV] C=10, gamma=0.001, kernel=rbf …
[CV] … C=10, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.001, kernel=rbf …
[CV] … C=10, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.001, kernel=rbf …
[CV] … C=10, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.001, kernel=rbf …
[CV] … C=10, gamma=0.001, kernel=rbf, score=0.714, total=   0.0s
[CV] C=10, gamma=0.001, kernel=rbf …
[CV] … C=10, gamma=0.001, kernel=rbf, score=0.707, total=   0.0s
[CV] C=10, gamma=0.0001, kernel=rbf …
[CV] … C=10, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=10, gamma=0.0001, kernel=rbf …
[CV] … C=10, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=10, gamma=0.0001, kernel=rbf …
[CV] … C=10, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=10, gamma=0.0001, kernel=rbf …
[CV] … C=10, gamma=0.0001, kernel=rbf, score=0.762, total=   0.0s
[CV] C=10, gamma=0.0001, kernel=rbf …
[CV] … C=10, gamma=0.0001, kernel=rbf, score=0.683, total=   0.0s
[CV] C=100, gamma=1, kernel=rbf …
[CV] … C=100, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=1, kernel=rbf …
[CV] … C=100, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=1, kernel=rbf …
[CV] … C=100, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=1, kernel=rbf …
[CV] … C=100, gamma=1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=100, gamma=1, kernel=rbf …
[CV] … C=100, gamma=1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=100, gamma=0.1, kernel=rbf …
[CV] … C=100, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.1, kernel=rbf …
[CV] … C=100, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.1, kernel=rbf …
[CV] … C=100, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.1, kernel=rbf …
[CV] … C=100, gamma=0.1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=100, gamma=0.1, kernel=rbf …
[CV] … C=100, gamma=0.1, kernel=rbf, score=0.683, total=   0.0s
```

```
[CV] C=100, gamma=0.01, kernel=rbf …
[CV] … C=100, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.01, kernel=rbf …
[CV] … C=100, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.01, kernel=rbf …
[CV] … C=100, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.01, kernel=rbf …
[CV] … C=100, gamma=0.01, kernel=rbf, score=0.690, total=   0.0s
[CV] C=100, gamma=0.01, kernel=rbf …
[CV] … C=100, gamma=0.01, kernel=rbf, score=0.683, total=   0.0s
[CV] C=100, gamma=0.001, kernel=rbf …
[CV] … C=100, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.001, kernel=rbf …
[CV] … C=100, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.001, kernel=rbf …
[CV] … C=100, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.001, kernel=rbf …
[CV] … C=100, gamma=0.001, kernel=rbf, score=0.714, total=   0.0s
[CV] C=100, gamma=0.001, kernel=rbf …
[CV] … C=100, gamma=0.001, kernel=rbf, score=0.707, total=   0.0s
[CV] C=100, gamma=0.0001, kernel=rbf …
[CV] … C=100, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=100, gamma=0.0001, kernel=rbf …
[CV] … C=100, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=100, gamma=0.0001, kernel=rbf …
[CV] … C=100, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=100, gamma=0.0001, kernel=rbf …
[CV] … C=100, gamma=0.0001, kernel=rbf, score=0.762, total=   0.0s
[CV] C=100, gamma=0.0001, kernel=rbf …
[CV] … C=100, gamma=0.0001, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1000, gamma=1, kernel=rbf …
[CV] … C=1000, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=1, kernel=rbf …
[CV] … C=1000, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=1, kernel=rbf …
[CV] … C=1000, gamma=1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=1, kernel=rbf …
[CV] … C=1000, gamma=1, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1000, gamma=1, kernel=rbf …
[CV] … C=1000, gamma=1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1000, gamma=0.1, kernel=rbf …
[CV] … C=1000, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.1, kernel=rbf …
[CV] … C=1000, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.1, kernel=rbf …
[CV] … C=1000, gamma=0.1, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.1, kernel=rbf …
[CV] … C=1000, gamma=0.1, kernel=rbf, score=0.690, total=   0.0s
```

```
[CV] C=1000, gamma=0.1, kernel=rbf …
[CV] … C=1000, gamma=0.1, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1000, gamma=0.01, kernel=rbf …
[CV] … C=1000, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.01, kernel=rbf …
[CV] … C=1000, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.01, kernel=rbf …
[CV] … C=1000, gamma=0.01, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.01, kernel=rbf …
[CV] … C=1000, gamma=0.01, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1000, gamma=0.01, kernel=rbf …
[CV] … C=1000, gamma=0.01, kernel=rbf, score=0.683, total=   0.0s
[CV] C=1000, gamma=0.001, kernel=rbf …
[CV] … C=1000, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.001, kernel=rbf …
[CV] … C=1000, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.001, kernel=rbf …
[CV] … C=1000, gamma=0.001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.001, kernel=rbf …
[CV] … C=1000, gamma=0.001, kernel=rbf, score=0.714, total=   0.0s
[CV] C=1000, gamma=0.001, kernel=rbf …
[CV] … C=1000, gamma=0.001, kernel=rbf, score=0.707, total=   0.0s
[CV] C=1000, gamma=0.0001, kernel=rbf …
[CV] … C=1000, gamma=0.0001, kernel=rbf, score=0.667, total=   0.0s
[CV] C=1000, gamma=0.0001, kernel=rbf …
[CV] … C=1000, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1000, gamma=0.0001, kernel=rbf …
[CV] … C=1000, gamma=0.0001, kernel=rbf, score=0.690, total=   0.0s
[CV] C=1000, gamma=0.0001, kernel=rbf …
[CV] … C=1000, gamma=0.0001, kernel=rbf, score=0.762, total=   0.0s
[CV] C=1000, gamma=0.0001, kernel=rbf …
[CV] … C=1000, gamma=0.0001, kernel=rbf, score=0.683, total=   0.0s

[Parallel(n_jobs=1)]: Done 125 out of 125 | elapsed:    1.4s finished
```

[156]:
```
GridSearchCV(estimator=SVC(),
             param_grid={'C': [0.1, 1, 10, 100, 1000],
                         'gamma': [1, 0.1, 0.01, 0.001, 0.0001],
                         'kernel': ['rbf']},
             verbose=3)
```

[157]:
```
grid.best_params_
grid.best_estimator_
grid_predictions = grid.predict(X_test)
print(confusion_matrix(y_test,grid_predictions))
print(classification_report(y_test,grid_predictions))
```

```
[[60  2]
```

```
 [26  2]]
              precision    recall  f1-score   support

           0       0.70      0.97      0.81        62
           1       0.50      0.07      0.12        28

    accuracy                           0.69        90
   macro avg       0.60      0.52      0.47        90
weighted avg       0.64      0.69      0.60        90
```

[ ]:

[ ]: