In [2]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
import os
import statsmodels.api as sm
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score, roc_curve, roc_auc_score
from mlxtend.evaluate import confusion_matrix
from sklearn import preprocessing
from sklearn import model_selection
from sklearn.ensemble import BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import KFold, cross_val_score
from sklearn.pipeline import make_pipeline
from sklearn.linear_model import LogisticRegression
from sklearn.preprocessing import StandardScaler
```

In [4]:

```
df = pd.read_csv('C:/Users/VISHY/Desktop/Great
Learning/Classification/data/cryotherapy_dataset.csv')
df.head()
```

Out[4]:

	sex	age	time	number_of_warts	type	area	result_of_treatment
0	1	35	12.00	5	1	100	0
1	1	29	7.00	5	1	96	1
2	1	50	8.00	1	3	132	0
3	1	32	11.75	7	3	750	0
4	1	67	9.25	1	1	42	0

In [3]:

```
df.describe()
```

Out[3]:

	sex	age	time	number_of_warts	type	area	result_of_treatment
count	90.000000	90.000000	90.000000	90.000000	90.000000	90.000000	90.000000
mean	1.477778	28.600000	7.666667	5.511111	1.700000	85.833333	0.533333
std	0.502304	13.360852	3.406661	3.567155	0.905042	131.733153	0.501683
min	1.000000	15.000000	0.250000	1.000000	1.000000	4.000000	0.000000
25%	1.000000	18.000000	4.562500	2.000000	1.000000	20.000000	0.000000
50%	1.000000	25.500000	8.500000	5.000000	1.000000	70.000000	1.000000
75%	2.000000	35.000000	10.687500	8.000000	3.000000	100.000000	1.000000
max	2.000000	67.000000	12.000000	12.000000	3.000000	750.000000	1.000000

In [5]:

```
df['sex'].value_counts()
```

Out[5]:

```
1    47
2    43
Name: sex, dtype: int64
```

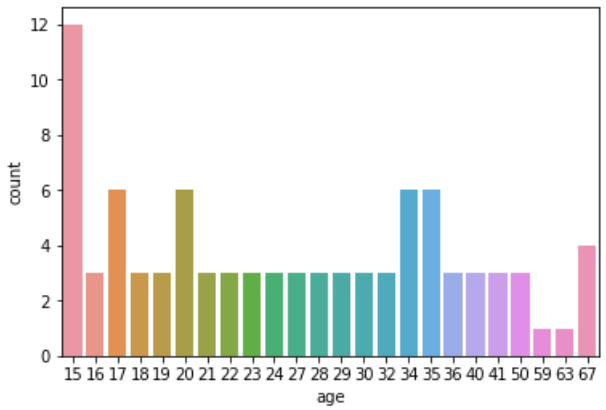
EDA

In [6]:

```
sns.countplot(df['age'])
```

Out[6]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211db84a208>
```



from above plot maximum number of warts are present at the age of 15 itself.

Gender Description

1 - Male 2 - Female

In [7]:

```
df['sex'].value_counts()
```

Out[7]:

```
1    47
2    43
Name: sex, dtype: int64
```

In [6]:

```
df['result_of_treatment'].value_counts()
```

Out[6]:

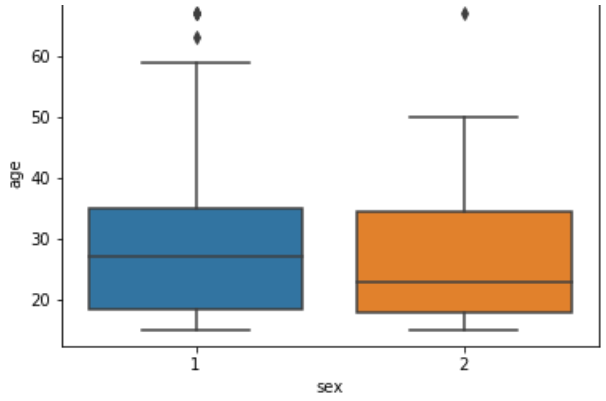
```
1    48
0    42
Name: result_of_treatment, dtype: int64
```

In [8]:

```
sns.boxplot(df['sex'], df['age'])
```

Out[8]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211dbfe5b70>
```

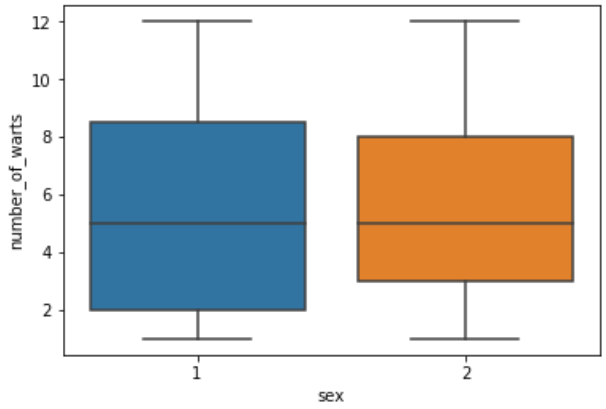


In [70]:

```
sns.boxplot(x=df['sex'], y=df['number_of_warts'])
```

Out[70]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211e242b198>
```



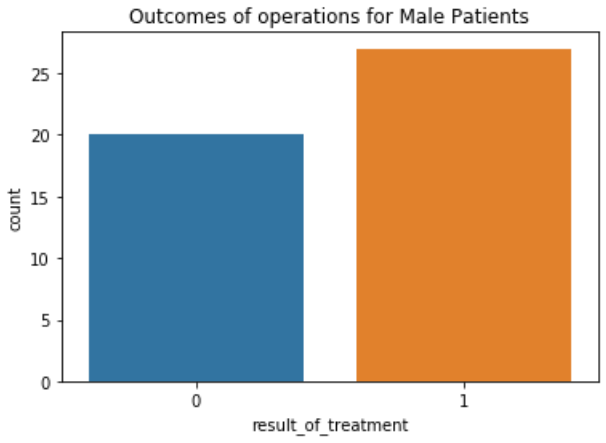
When compared the Sex 1 and Sex 2 number of warts with Sex 1 is higher when compared to Sex 2.

In [13]:

```
sns.countplot(df[df['sex']==1]['result_of_treatment'])
plt.title('Outcomes of operations for Male Patients')
```

Out[13]:

```
Text(0.5, 1.0, 'Outcomes of operations for Male Patients')
```



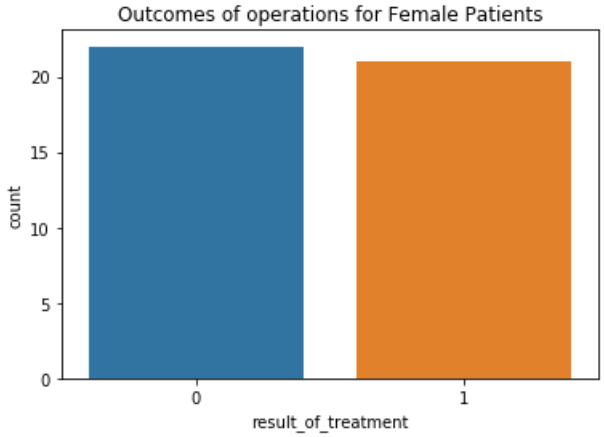
In [14]:

```
sns.countplot(df[df['sex']==2]['result_of_treatment'])
```

```
plt.title('Outcomes of operations for Female Patients')
```

Out[14]:

```
Text(0.5, 1.0, 'Outcomes of operations for Female Patients')
```

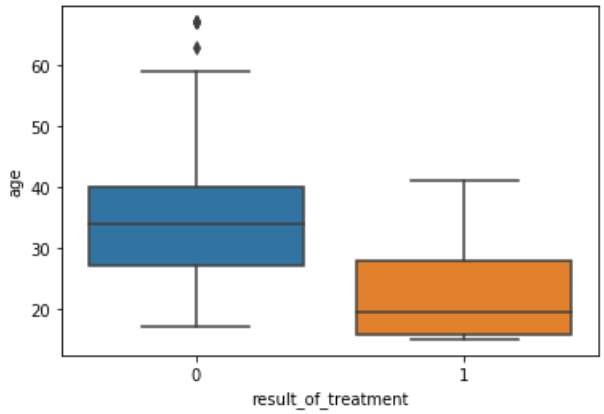


In [39]:

```
sns.boxplot(x=df['result_of_treatment'],y=df['age'])
```

Out[39]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x224d464d888>
```

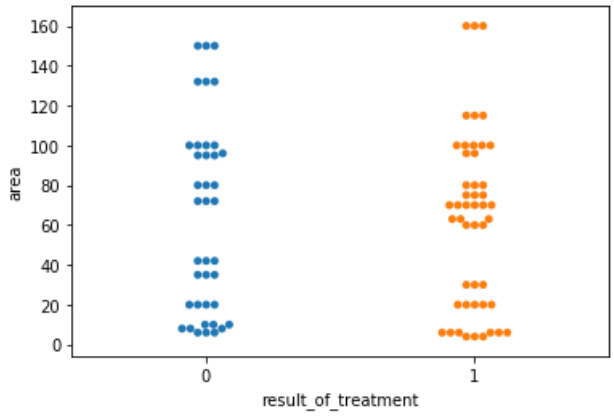


In [47]:

```
sns.swarmplot(x=df['result_of_treatment'],y=df['area'])
```

Out[47]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x224d45f9588>
```

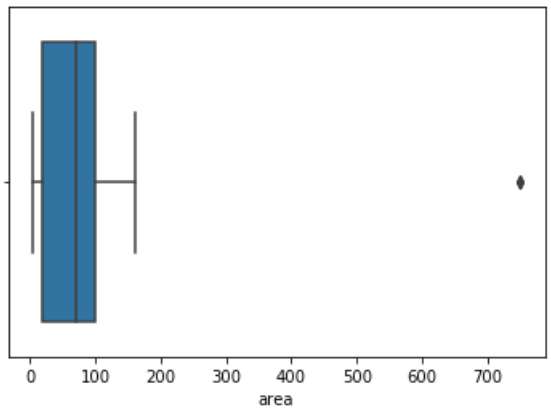


In [15]:

```
sns.boxplot(df['area'])
```

Out[15]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x279f90ee808>
```



In [16]:

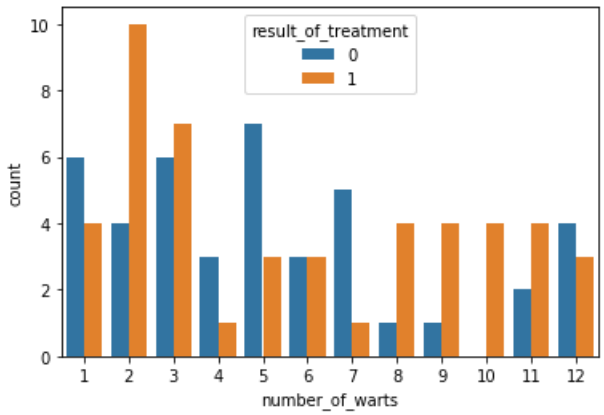
```
df=df[df['area']<200]
```

In [9]:

```
sns.countplot(x=df['number_of_warts'],hue=df['result_of_treatment'])
```

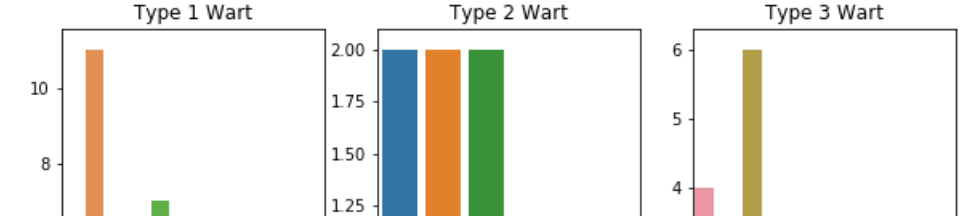
Out[9]:

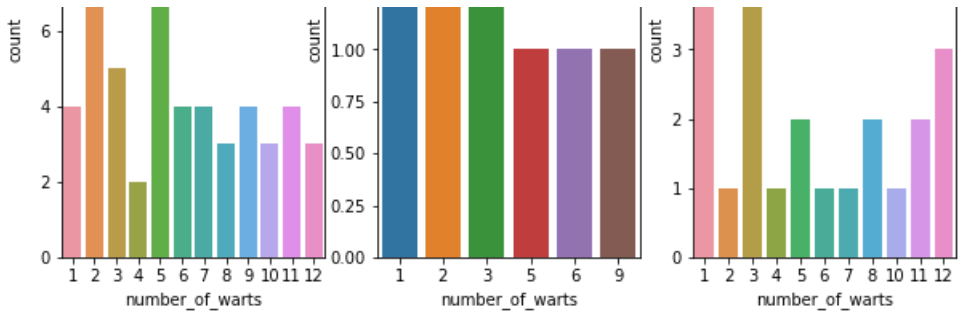
```
<matplotlib.axes._subplots.AxesSubplot at 0x224d26af4c8>
```



In [52]:

```
f,(ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(10,5))
sns.countplot(df[df['type']==1]['number_of_warts'],ax=ax1)
sns.countplot(df[df['type']==2]['number_of_warts'],ax=ax2)
sns.countplot(df[df['type']==3]['number_of_warts'],ax=ax3)
ax1.title.set_text('Type 1 Wart')
ax2.title.set_text('Type 2 Wart')
ax3.title.set_text('Type 3 Wart')
```



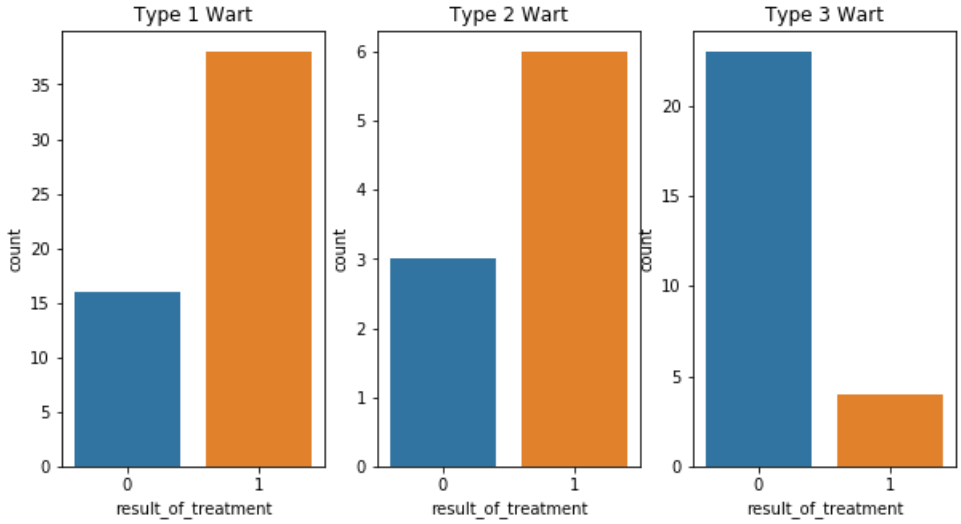


In [ ]:

```
sns.countplot(df[df['type']==1]['number_of_warts'])
```

In [38]:

```
f,(ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(10,5))
sns.countplot(df[df['type']==1]['result_of_treatment'],ax=ax1)
sns.countplot(df[df['type']==2]['result_of_treatment'],ax=ax2)
sns.countplot(df[df['type']==3]['result_of_treatment'],ax=ax3)
ax1.title.set_text('Type 1 Wart')
ax2.title.set_text('Type 2 Wart')
ax3.title.set_text('Type 3 Wart')
```

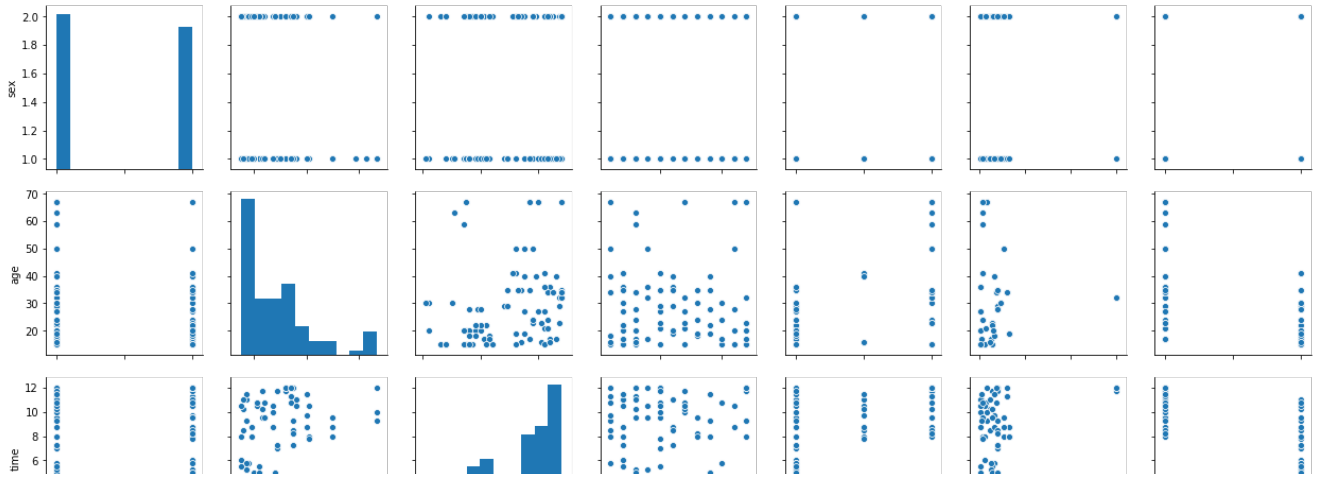


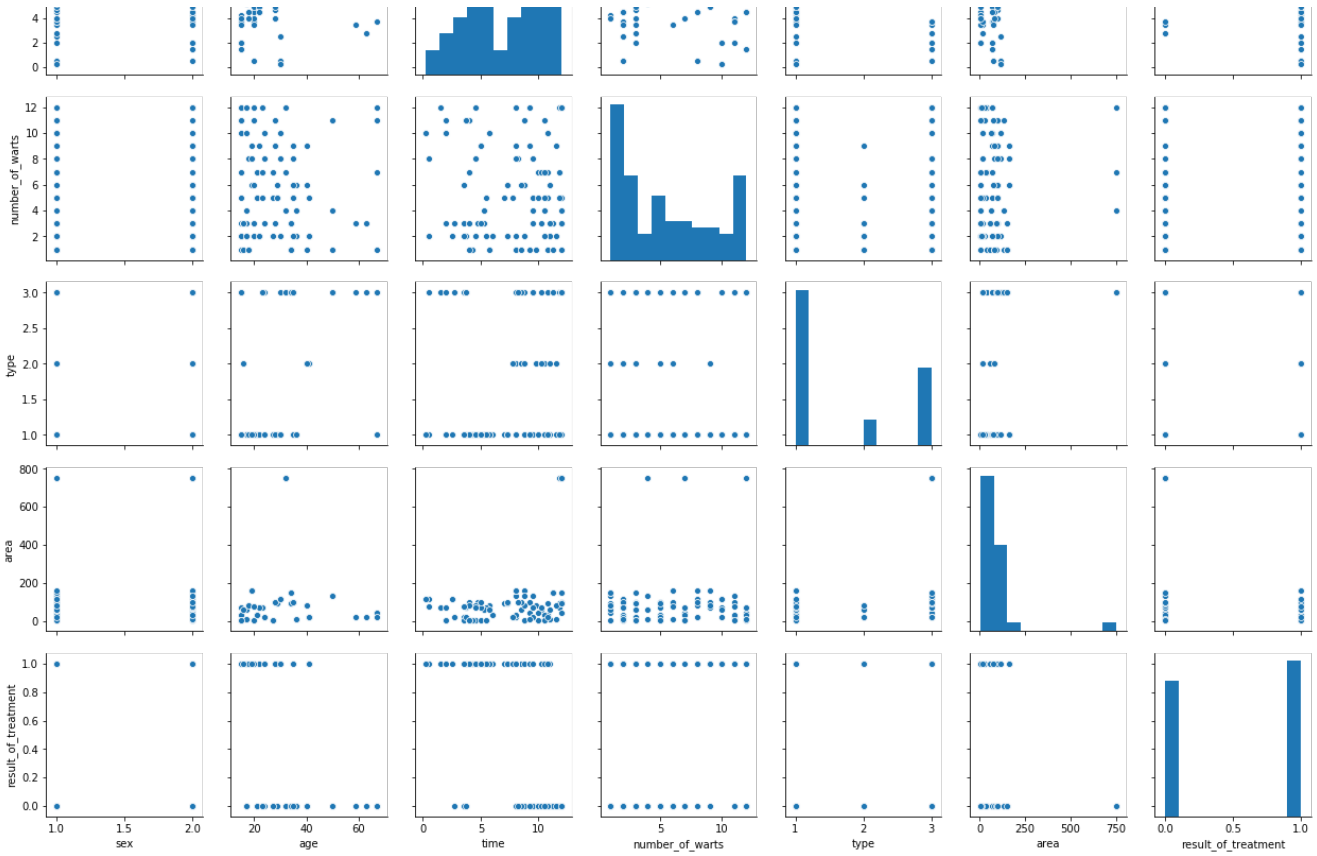
In [14]:

```
sns.pairplot(df)
```

Out[14]:

```
<seaborn.axisgrid.PairGrid at 0x211dc046a90>
```





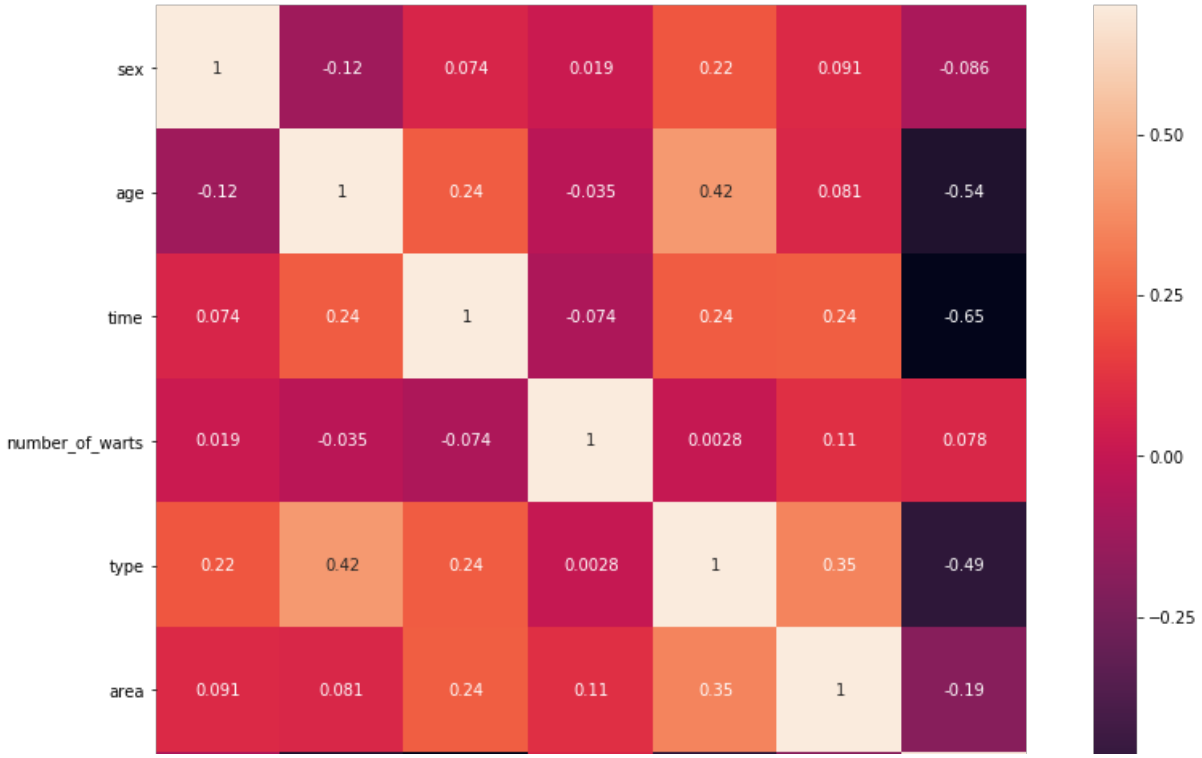
We can infer from the pairplot that area of the wart region lies within range of 0-250 in most of the cases like number of warts, area, time.

In [15]:

```
import seaborn as sns
plt.subplots(figsize=(15,10))
corrmat = df.corr()
sns.heatmap(corrmat, square=True, vmax=0.7, annot=True)
```

Out[15]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211dc158780>
```



In [16]:

```
df.cov()
```

Out[16]:

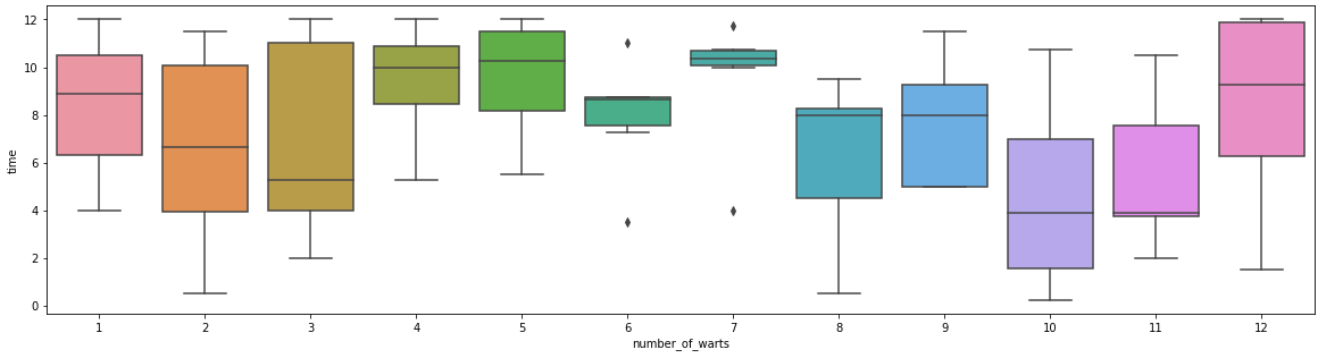
	sex	age	time	number_of_warts	type	area	result_of_treatment
sex	0.252310	-0.773034	0.127341	0.033958	0.100000	6.035581	-0.021723
age	-0.773034	178.512360	10.755618	-1.658427	5.024719	142.415730	-3.638202
time	0.127341	10.755618	11.605337	-0.903558	0.724719	108.404494	-1.117978
number_of_warts	0.033958	-1.658427	-0.903558	12.724594	0.008989	51.108614	0.140075
type	0.100000	5.024719	0.724719	0.008989	0.819101	42.252809	-0.220225
area	6.035581	142.415730	108.404494	51.108614	42.252809	17353.623596	-12.483146
result_of_treatment	-0.021723	-3.638202	-1.117978	0.140075	-0.220225	-12.483146	0.251685

In [67]:

```
a4_dims = (20, 5)
fig, ax = plt.subplots(figsize=a4_dims)
sns.boxplot(data=df,y='time',x='number_of_warts',ax=ax)
```

Out[67]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211e1f5c198>
```



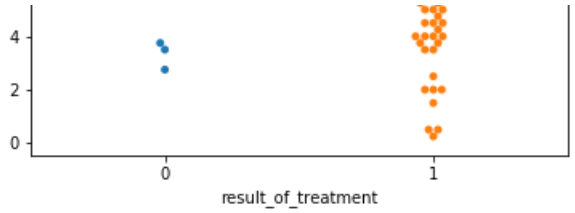
In the above plot the number of warts 1,2,3 people are concerned about the treatment. Patients with 3 warts take lesser time to get the treatment compared to patients with 1 wart. Clearly, patients get more anxious when number of warts increases, hence time decreases

In [31]:

```
sns.swarmplot(df['result_of_treatment'],y=df['time'])
```

Out[31]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x211e0d3e240>
```



From the above plot we can infer that if treatment is delayed beyond 7 months there is high chance of treatment failure.

In [20]:

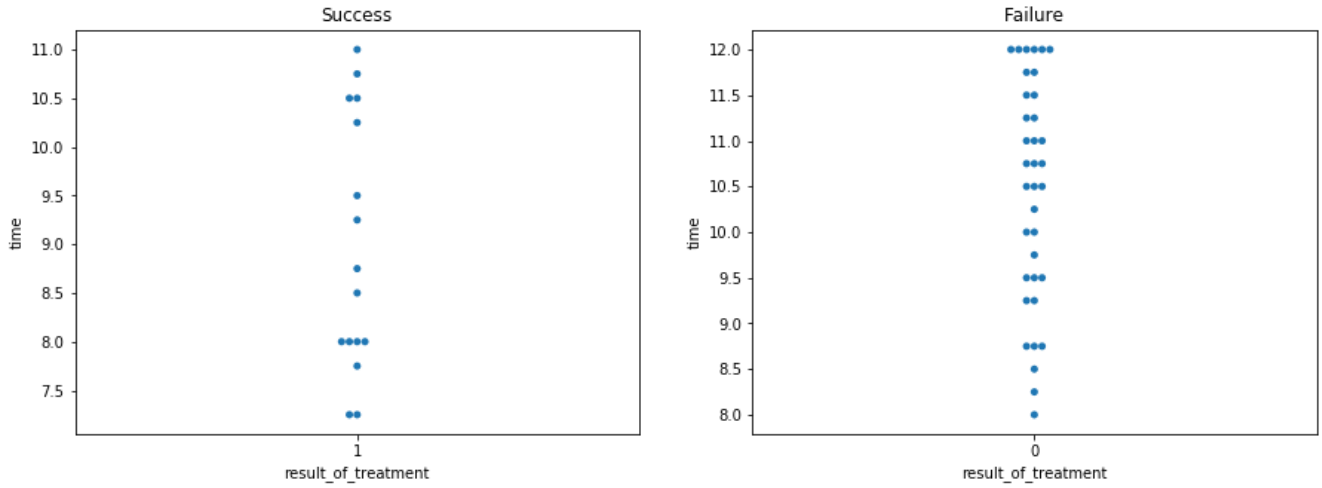
```
a = df[(df['time']>7) & (df['result_of_treatment']==1)]
```

In [21]:

```
b = df[(df['time']>7) & (df['result_of_treatment']==0)]
```

In [26]:

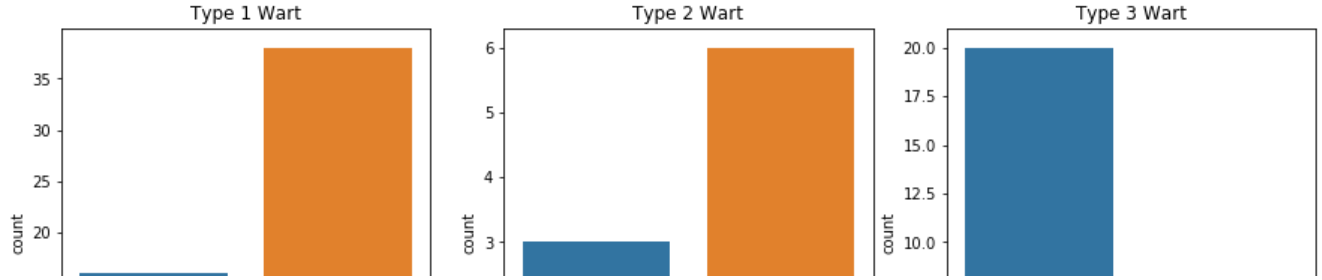
```
f,(ax1, ax2) = plt.subplots(1, 2, figsize=(15,5))
sns.swarmplot(a['result_of_treatment'], a['time'],ax=ax1)
sns.swarmplot(b['result_of_treatment'], b['time'],ax=ax2)

ax1.title.set_text('Success')
ax2.title.set_text('Failure')
```

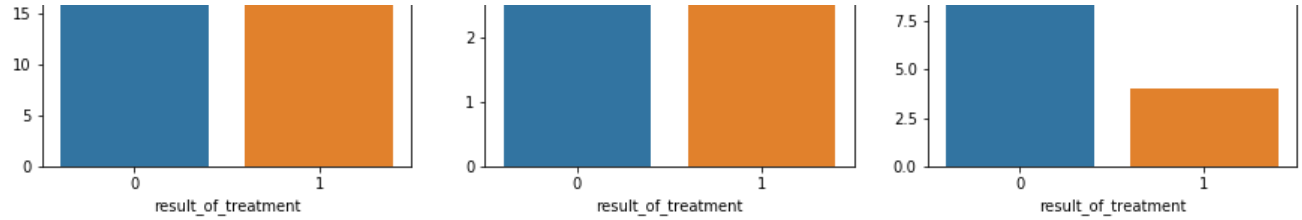


From the above two plots we can see the distribution of failure is spread evenly than success rate distribution for time taken more than 7 months to treatment.

In [18]:

```
f,(ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(15,5))
sns.countplot(df[df['type']==1]['result_of_treatment'],ax=ax1)
sns.countplot(df[df['type']==2]['result_of_treatment'],ax=ax2)
sns.countplot(df[df['type']==3]['result_of_treatment'],ax=ax3)
ax1.title.set_text('Type 1 Wart')
ax2.title.set_text('Type 2 Wart')
ax3.title.set_text('Type 3 Wart')
```





Supervised Learning

Classifications

In [9]:

```
y=df['result_of_treatment']
x=df.drop('result_of_treatment',axis=1)
```

In [10]:

```
from sklearn.model_selection import train_test_split
xtrain, xtest, ytrain, ytest = train_test_split(x, y, test_size = 0.30, random_state = 42)
```

Logistic Regression

In [11]:

```
logreg = LogisticRegression(random_state=0)
logreg.fit(xtrain,ytrain)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:432: FutureWarning: De
fault solver will be changed to 'lbfgs' in 0.22. Specify a solver to silence this warning.
  FutureWarning)
```

Out[11]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=0, solver='warn', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [12]:

```
ypred=logreg.predict(xtest)
```

In [13]:

```
cm = confusion_matrix(y_target=ytest, y_predicted=ypred, binary=False)
cm
```

Out[13]:

```
array([[11,  3],
       [ 4,  9]])
```

In [16]:

```
print('Score for Train Set: ',logreg.score(xtrain, ytrain))
print('Score for Test Set: ',logreg.score(xtest, ytest))
```

```
Score for Train Set:  0.8888888888888888
Score for Test Set:  0.7407407407407407
```

In [17]:

```
accuracy_score(ytest,ypred)
```

Out[17]:

```
0.7407407407407407
```

In [18]:

```
recall_score(ytest,ypred)
```

Out[18]:

```
0.6923076923076923
```

In [19]:

```
precision_score(ytest,ypred)
```

Out[19]:

```
0.75
```

Decision Tree

Entropy

In [20]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
decisiontree.fit(xtrain, ytrain)
```

Out[20]:

```
DecisionTreeClassifier(class_weight=None, criterion='entropy', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [21]:

```
ypred=decisiontree.predict(xtest)
```

In [86]:

```
from sklearn.model_selection import cross_val_score

decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')

print(scores.mean())
```

```
0.8758333333333332
```

Gini

In [31]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='gini', random_state=40)
```

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

Out[31]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [32]:

```
ypred=decisiontree.predict(xtest)
```

In [33]:

```
accuracy_score(ytest,ypred)
```

Out[33]:

```
0.7407407407407407
```

In [85]:

```
from sklearn.model_selection import cross_val_score
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
0.8758333333333332
```

Random Forest

In [87]:

```
from sklearn.ensemble import RandomForestClassifier

#Create a Gaussian Classifier
ranforest= RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)

#Train the model using the training sets y_pred=clf.predict(X_test)
ranforest.fit(xtrain,ytrain)
```

Out[87]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
                       max_depth=None, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
                       oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
```

In [88]:

```
ypred=ranforest.predict(xtest)
```

In [89]:

```
accuracy_score(ytest,ypred)
```

Out[89]:

```
0.8148148148148148
```

In [90]:

```
from sklearn.model_selection import cross_val_score
random = RandomForestClassifier(criterion='entropy')
scores=cross_val_score(random,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

```
0.9180555555555555
```

KNN

In [107]:

```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
classifier.fit(xtrain, ytrain)
```

Out[107]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [108]:

```
ypred = classifier.predict(xtest)
```

In [109]:

```
accuracy_score(ytest,ypred)
```

Out[109]:

```
0.6666666666666666
```

In [110]:

```
from sklearn.model_selection import cross_val_score
krange=range(1,31)
kscores=[]
for k in krange:
    knn=KNeighborsClassifier(n_neighbors=k)
    scores=cross_val_score(knn,x,y,cv=10,scoring='accuracy')
    kscores.append(scores.mean())
print(kscores)
```

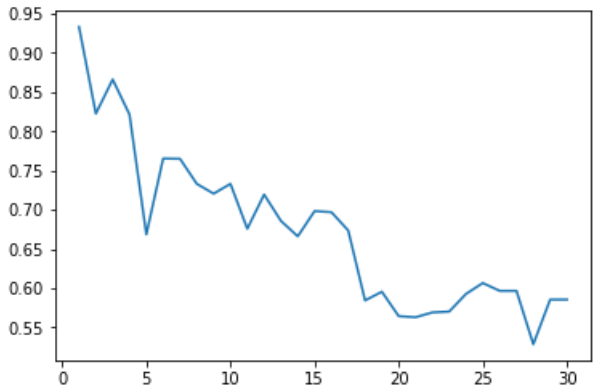
```
[0.9330555555555555, 0.8225, 0.8661111111111112, 0.8213888888888888, 0.668611111111111,
0.7652777777777777, 0.765, 0.7330555555555555, 0.7205555555555555, 0.7330555555555555,
0.6758333333333333, 0.7194444444444444, 0.6858333333333333, 0.6661111111111111,
0.6983333333333334, 0.6969444444444444, 0.673611111111111, 0.5844444444444445, 0.5955555555555556,
0.5644444444444444, 0.5630555555555555, 0.5691666666666666, 0.5702777777777778,
0.5927777777777777, 0.6066666666666667, 0.5966666666666667, 0.5966666666666667,
0.5286111111111111, 0.5855555555555556, 0.5855555555555555]
```

In [111]:

```
plt.plot(krange,kscores)
```

Out[111]:

```
[<matplotlib.lines.Line2D at 0x200ded437c8>]
```



In [115]:

```
from sklearn.model_selection import GridSearchCV
krange=list(range(1,31))
weight_options=['uniform','distance']
```

In [116]:

```
param_grid=dict(n_neighbors=krange, weights=weight_options)
knn=KNeighborsClassifier()
```

In [117]:

```
grid=GridSearchCV(knn, param_grid, cv=10, scoring='accuracy')
grid.fit(x,y)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_search.py:814:
DeprecationWarning: The default of the `iid` parameter will change from True to False in version 0
.22 and will be removed in 0.24. This will change numeric results when test-set sizes are unequal.
  DeprecationWarning)
```

Out[117]:

```
GridSearchCV(cv=10, error_score='raise-deprecating',
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=30,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=None
```

```
                                     metric_params=None, n_jobs=None,
                                     n_neighbors=5, p=2,
                                     weights='uniform'),
             iid='warn', n_jobs=None,
             param_grid={'n_neighbors': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
                                        13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
                                        23, 24, 25, 26, 27, 28, 29, 30],
                         'weights': ['uniform', 'distance']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=0)
```

In [118]:

```
print(grid.best_score_)
print(grid.best_params_)
print(grid.best_estimator_)
```

```
0.9444444444444444
{'n_neighbors': 5, 'weights': 'distance'}
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='distance')
```

In [119]:

```
from sklearn.neighbors import KNeighborsClassifier
knnup = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
knnup.fit(xtrain, ytrain)
```

Out[119]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [120]:

```
ypred = knnup.predict(xtest)
```

In [121]:

```
accuracy_score(ytest,ypred)
```

Out[121]:

```
0.6666666666666666
```

Naive Bayes

In [103]:

```
from sklearn.naive_bayes import GaussianNB
model=GaussianNB()
model.fit(xtrain,ytrain)
```

Out[103]:

```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [104]:

```
ypred=model.predict(xtest)
```

In [105]:

```
accuracy_score(ytest,ypred)
```

Out[105]:

```
0.7777777777777778
```

In [106]:

```
recall_score(ytest,ypred, average='micro')
```

Out[106]:

```
0.7777777777777778
```

Bagging

In [150]:

```
kfold = model_selection.KFold(n_splits=10, random_state=21)
cart = DecisionTreeClassifier()
num_trees = 100
model = BaggingClassifier(base_estimator=cart, n_estimators=num_trees, random_state=40)
results = model_selection.cross_val_score(model, x, y, cv=kfold)
print(results.mean())
```

```
0.9111111111111112
```

In [151]:

```
model = BaggingClassifier()
model.fit(xtrain, ytrain)
print(); print(model)
```

```
BaggingClassifier(base_estimator=None, bootstrap=True, bootstrap_features=False,
                  max_features=1.0, max_samples=1.0, n_estimators=10,
                  n_jobs=None, oob_score=False, random_state=None, verbose=0,
                  warm_start=False)
```

In [152]:

```
# make predictions
expected_y  = ytest
predicted_y = model.predict(xtest)
```

In [153]:

```
print(accuracy_score(expected_y, predicted_y))
print(classification_report(expected_y, predicted_y))
```

```
0.8518518518518519
              precision    recall  f1-score   support

           0       0.78      1.00      0.88        14
           1       1.00      0.69      0.82        13

    accuracy                           0.85        27
   macro avg       0.89      0.85      0.85        27
weighted avg       0.88      0.85      0.85        27
```

Adaboost classifier

In [136]:

```
from sklearn.ensemble import AdaBoostClassifier

classifier = AdaBoostClassifier(
    DecisionTreeClassifier(max_depth=1),
```

```
    n_estimators=200
)
classifier.fit(xtrain, ytrain)
```

Out[136]:

```
AdaBoostClassifier(algorithm='SAMME.R',
                   base_estimator=DecisionTreeClassifier(class_weight=None,
                                                         criterion='gini',
                                                         max_depth=1,
                                                         max_features=None,
                                                         max_leaf_nodes=None,
                                                         min_impurity_decrease=0.0,
                                                         min_impurity_split=None,
                                                         min_samples_leaf=1,
                                                         min_samples_split=2,
                                                         min_weight_fraction_leaf=0.0,
                                                         presort=False,
                                                         random_state=None,
                                                         splitter='best'),
                   learning_rate=1.0, n_estimators=200, random_state=None)
```

In [138]:

```
ypred = classifier.predict(xtest)
```

In [140]:

```
confusion_matrix(ytest, ypred)
```

Out[140]:

```
array([[11,  3],
       [ 2, 11]])
```

In [141]:

```
accuracy_score(ytest,ypred)
```

Out[141]:

```
0.8148148148148148
```

Gradient Descent

In [142]:

```
from sklearn.ensemble import GradientBoostingClassifier
```

In [145]:

```
lr_list = [0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1]

for learning_rate in lr_list:
    gb_clf = GradientBoostingClassifier(n_estimators=20, learning_rate=learning_rate, max_features=
2, max_depth=2, random_state=0)
    gb_clf.fit(xtrain, ytrain)

    print("Learning rate: ", learning_rate)
    print("Accuracy score (training): {0:.3f}".format(gb_clf.score(xtrain, ytrain)))
    print("Accuracy score (validation): {0:.3f}".format(gb_clf.score(xtest, ytest)))
```

```
Learning rate:  0.05
Accuracy score (training): 0.968
Accuracy score (validation): 0.778
Learning rate:  0.075
Accuracy score (training): 0.984
Accuracy score (validation): 0.815
Learning rate:  0.1
```

```
Accuracy score (training): 1.000
Accuracy score (validation): 0.815
Learning rate:  0.25
Accuracy score (training): 1.000
Accuracy score (validation): 0.815
Learning rate:  0.5
Accuracy score (training): 1.000
Accuracy score (validation): 0.815
Learning rate:  0.75
Accuracy score (training): 1.000
Accuracy score (validation): 0.815
Learning rate:  1
Accuracy score (training): 1.000
Accuracy score (validation): 0.815
```

In [149]:

```
gb_clf2 = GradientBoostingClassifier(n_estimators=20, learning_rate=0.5, max_features=2, max_depth=
2, random_state=0)
gb_clf2.fit(xtrain, ytrain)
predictions = gb_clf2.predict(xtest)

print("Confusion Matrix:")
print(confusion_matrix(ytest, predictions))

print("Accuracy:",accuracy_score(ytest, predictions))

print("Classification Report")
print(classification_report(ytest, predictions))
```

```
Confusion Matrix:
[[11  3]
 [ 2 11]]
Accuracy: 0.8148148148148148
Classification Report
              precision    recall  f1-score   support

           0       0.85      0.79      0.81        14
           1       0.79      0.85      0.81        13

    accuracy                           0.81        27
   macro avg       0.82      0.82      0.81        27
weighted avg       0.82      0.81      0.81        27
```

Stacking

In [127]:

```
from xgboost import XGBClassifier
from vecstack import stacking

models = [
    KNeighborsClassifier(n_neighbors=5,
                         n_jobs=-1),

    RandomForestClassifier(random_state=0, n_jobs=-1,
                           n_estimators=100, max_depth=3),

    XGBClassifier(random_state=0, n_jobs=-1, learning_rate=0.1,
                  n_estimators=100, max_depth=3)
]
```

In [129]:

```
S_train, S_test = stacking(models,
                           xtrain, ytrain, xtest,
                           regression=False,

                           mode='oof_pred_bag',

                           needs_proba=False,
```

```
                          save_dir=None,

                          metric=accuracy_score,

                          n_folds=4,

                          stratified=True,

                          shuffle=True,

                          random_state=0,

                          verbose=2)
```

```
task:         [classification]
n_classes:    [2]
metric:       [accuracy_score]
mode:         [oof_pred_bag]
n_models:     [3]

model  0:     [KNeighborsClassifier]
    fold  0:  [0.87500000]
    fold  1:  [0.81250000]
    fold  2:  [0.81250000]
    fold  3:  [0.66666667]
    ----
    MEAN:     [0.79166667] + [0.07654655]
    FULL:     [0.79365079]

model  1:     [RandomForestClassifier]
    fold  0:  [1.00000000]
    fold  1:  [0.87500000]
    fold  2:  [0.87500000]
    fold  3:  [0.93333333]
    ----
    MEAN:     [0.92083333] + [0.05153882]
    FULL:     [0.92063492]

model  2:     [XGBClassifier]
    fold  0:  [0.93750000]
    fold  1:  [1.00000000]
    fold  2:  [0.87500000]
    fold  3:  [0.80000000]
    ----
    MEAN:     [0.90312500] + [0.07414882]
    FULL:     [0.90476190]
```

Random Forest Classifier has the maximum accuracy among other models.

Unsupervised

K Means

In [389]:

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

In [390]:

```
y=df.iloc[:,-1]
df=df.iloc[:,:-1]
```

In [391]:

```
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
df=sc.fit_transform(df)
```

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

In [392]:

```
krange=range(1,21)
clerror=[]


for k in krange:
    cluster=KMeans(k)
    cluster.fit(df)
    clerror.append(cluster.inertia_)
clusters_df=pd.DataFrame({'k':krange,'Cluster Error':clerror})
clusters_df.head()
```

Out[392]:

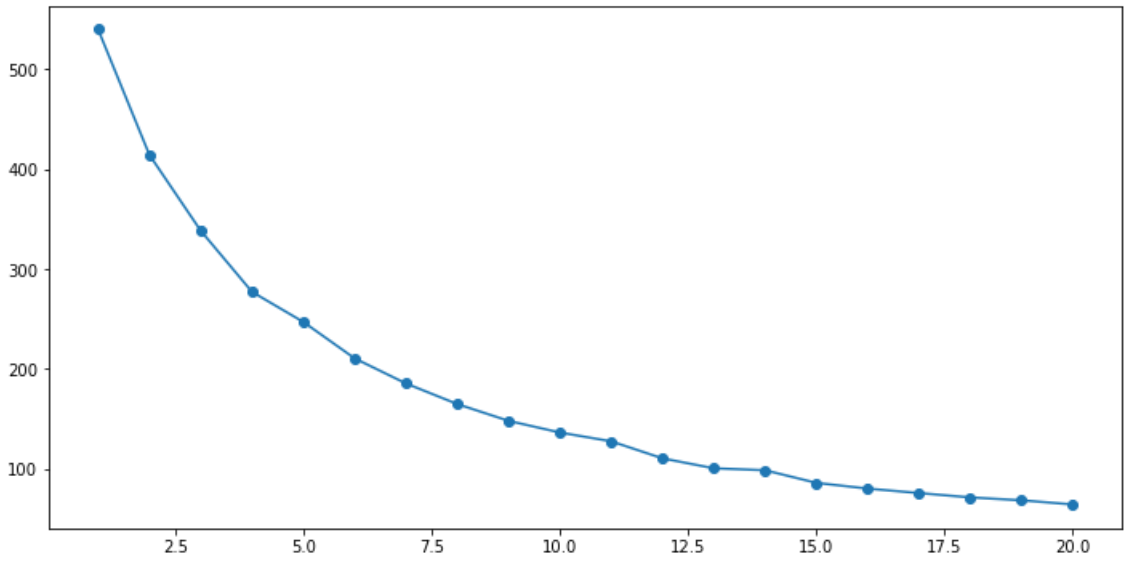
	k	Cluster Error
0	1	540.000000
1	2	414.386269
2	3	338.471508
3	4	277.229065
4	5	247.133019

In [393]:

```
plt.figure(figsize=(12,6))
plt.plot(clusters_df['k'],clusters_df['Cluster Error'],marker='o')
```

Out[393]:

```
[<matplotlib.lines.Line2D at 0x1e676e23bc8>]
```



In [394]:

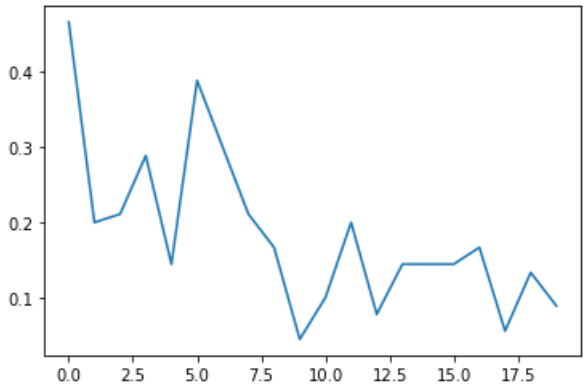
```
a=[]
for k in range(1,21):
    kmeans = KMeans(n_clusters=k, random_state=40).fit(df)
    ypredkm=kmeans.labels_
    a.append(accuracy_score(y,ypredkm))
```

In [395]:

```
plt.plot(a)
```

Out[395]:

```
[<matplotlib.lines.Line2D at 0x1e677003608>]
```



In [396]:

```
kmeans = KMeans(n_clusters=3, random_state=40).fit(df)
ypredkm1=kmeans.labels_
```

In [397]:

```
accuracy_score(ypredkm1,y)
```

Out[397]:

```
0.2111111111111111
```

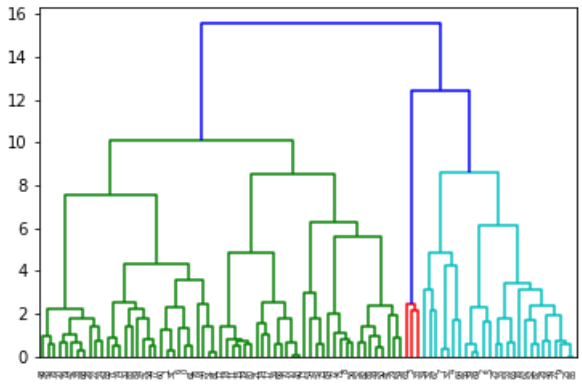
Hierarchial

In [398]:

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

In [399]:

```
z=linkage(df,'ward') #single, complete, average, centroid, wards
dendrogram(z)
plt.show()
```



In [400]:

```
from sklearn.cluster import AgglomerativeClustering

cluster = AgglomerativeClustering(n_clusters=2, affinity='euclidean',linkage='ward')
ypredhr=cluster.fit_predict(df)
```

In [401]:

```
accuracy_score(y,ypredhr)
```

Out[401]:

```
0.7888888888888889
```

Classification, Again...

In [402]:

```
confusion_matrix(y,ypredhr)
```

Out[402]:

```
array([[26, 16],
       [ 3, 45]], dtype=int64)
```

In [403]:

```
ypredhr=pd.DataFrame({'Predict':ypredhr})
ypredhr.head()
```

Out[403]:

	Predict
0	1
1	1
2	0
3	0
4	0

In [404]:

```
df=pd.DataFrame(df)
```

In [405]:

```
df=pd.concat([df,ypredhr],axis=1)
```

Logistic Regression

In [406]:

```
y=df['Predict']
x=df.drop('Predict',axis=1)
```

In [407]:

```
from sklearn.model_selection import train_test_split
xtrain, xtest, ytrain, ytest = train_test_split(x, y, test_size = 0.30, random_state = 42)
```

In [408]:

```
logreg = LogisticRegression(random_state=0)
logreg.fit(xtrain,ytrain)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:432: FutureWarning: De
fault solver will be changed to 'lbfgs' in 0.22. Specify a solver to silence this warning.
  FutureWarning)
```

Out[408]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=0, solver='warn', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [409]:

```
ypred=logreg.predict(xtest)
```

In [410]:

```
print('Score for Train Set: ',logreg.score(xtrain, ytrain))
print('Score for Test Set: ',logreg.score(xtest, ytest))
```

```
Score for Train Set:  0.9841269841269841
Score for Test Set:  0.9629629629629629
```

In [411]:

```
accuracy_score(ytest,ypred)
```

Out[411]:

```
0.9629629629629629
```

In [412]:

```
recall_score(ytest,ypred)
```

Out[412]:

```
0.9444444444444444
```

In [413]:

```
precision_score(ytest,ypred)
```

Out[413]:

```
1.0
```

Decision Tree

Entropy

In [414]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
decisiontree.fit(xtrain, ytrain)
```

Out[414]:

```
DecisionTreeClassifier(class_weight=None, criterion='entropy', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [415]:

```
ypred=decisiontree.predict(xtest)
```

In [416]:

```
from sklearn.model_selection import cross_val_score

decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')

print(scores.mean())
```

```
0.9219444444444445
```

Gini

In [417]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='gini', random_state=40)
decisiontree.fit(xtrain, ytrain)
```

Out[417]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [418]:

```
ypred=decisiontree.predict(xtest)
```

In [419]:

```
accuracy_score(ytest,ypred)
```

Out[419]:

```
0.8888888888888888
```

In [420]:

```
from sklearn.model_selection import cross_val_score
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
0.9219444444444445
```

Random Forest

In [421]:

```
from sklearn.ensemble import RandomForestClassifier

#Create a Gaussian Classifier
ranforest= RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)

#Train the model using the training sets y_pred=clf.predict(X_test)
ranforest.fit(xtrain,ytrain)
```

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

Out[421]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
                       max_depth=None, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
                       oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
```

In [422]:

```
ypred=ranforest.predict(xtest)
```

In [423]:

```
accuracy_score(ytest,ypred)
```

Out[423]:

```
0.9629629629629629
```

In [424]:

```
from sklearn.model_selection import cross_val_score
random = RandomForestClassifier(criterion='entropy')
scores=cross_val_score(random,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

```
0.9541666666666666
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The defa
ult value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

KNN

In [425]:

```
from sklearn.neighbors import KNeighborsClassifier
```

```
classifier = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
classifier.fit(xtrain, ytrain)
```

Out[425]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [426]:

```
ypred = classifier.predict(xtest)
```

In [427]:

```
accuracy_score(ytest,ypred)
```

Out[427]:

```
1.0
```

In [428]:

```
from sklearn.model_selection import cross_val_score
krange=range(1,31)
kscores=[]
for k in krange:
    knn=KNeighborsClassifier(n_neighbors=k)
    scores=cross_val_score(knn,x,y,cv=10,scoring='accuracy')
    kscores.append(scores.mean())
print(kscores)
```

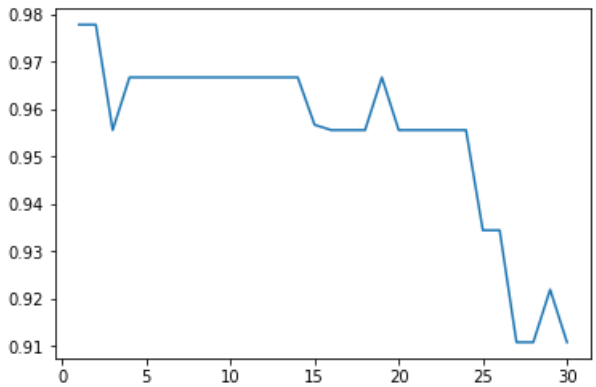
```
[0.9777777777777779, 0.9777777777777779, 0.9555555555555555, 0.9666666666666666,
0.9666666666666666, 0.9666666666666666, 0.9666666666666666, 0.9666666666666666,
0.9666666666666666, 0.9666666666666666, 0.9666666666666666, 0.9666666666666666,
0.9666666666666666, 0.9666666666666666, 0.9566666666666667, 0.9555555555555555,
0.9555555555555555, 0.9555555555555555, 0.9666666666666666, 0.9555555555555555,
0.9555555555555555, 0.9555555555555555, 0.9555555555555555, 0.9555555555555555,
0.9344444444444445, 0.9344444444444445, 0.9108333333333334, 0.9108333333333334,
0.9219444444444445, 0.9108333333333334]
```

In [429]:

```
plt.plot(krange,kscores)
```

Out[429]:

```
[<matplotlib.lines.Line2D at 0x1e6785a28c8>]
```



In [430]:

```
from sklearn.model_selection import GridSearchCV
krange=list(range(1,31))
weight_options=['uniform','distance']
```

In [431]:

```
param_grid=dict(n_neighbors=krange, weights=weight_options)
knn=KNeighborsClassifier()
```

In [432]:

```
grid=GridSearchCV(knn, param_grid, cv=10, scoring='accuracy')
grid.fit(x,y)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_search.py:814:
DeprecationWarning: The default of the `iid` parameter will change from True to False in version 0
.22 and will be removed in 0.24. This will change numeric results when test-set sizes are unequal.
  DeprecationWarning)
```

Out[432]:

```
GridSearchCV(cv=10, error_score='raise-deprecating',
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=30,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=None,
                                            n_neighbors=5, p=2,
                                            weights='uniform'),
             iid='warn', n_jobs=None,
             param_grid={'n_neighbors': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
                                         13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
                                         23, 24, 25, 26, 27, 28, 29, 30],
                         'weights': ['uniform', 'distance']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=0)
```

In [433]:

```
print(grid.best_score_)
print(grid.best_params_)
print(grid.best_estimator_)
```

```
0.9777777777777777
{'n_neighbors': 1, 'weights': 'uniform'}
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=1, p=2,
                     weights='uniform')
```

In [434]:

```
from sklearn.neighbors import KNeighborsClassifier
knnup = KNeighborsClassifier(n_neighbors = 1, metric = 'minkowski', p = 2)
knnup.fit(xtrain, ytrain)
```

Out[434]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=1, p=2,
                     weights='uniform')
```

In [435]:

```
ypred = knnup.predict(xtest)
```

In [436]:

```
accuracy_score(ytest,ypred)
```

Out[436]:

```
1.0
```

Naive Bayes

In [437]:

```
from sklearn.naive_bayes import GaussianNB
model=GaussianNB()
model.fit(xtrain,ytrain)
```

Out[437]:

```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [438]:

```
ypred=model.predict(xtest)
```

In [439]:

```
accuracy_score(ytest,ypred)
```

Out[439]:

```
0.9629629629629629
```

In [440]:

```
recall_score(ytest,ypred, average='micro')
```

Out[440]:

```
0.9629629629629629
```

Bagging

In [441]:

```
kfold = model_selection.KFold(n_splits=10, random_state=21)
cart = DecisionTreeClassifier()
num_trees = 100
model = BaggingClassifier(base_estimator=cart, n_estimators=num_trees, random_state=40)
results = model_selection.cross_val_score(model, x, y, cv=kfold)
print(results.mean())
```

```
0.9444444444444444
```

In [442]:

```
model = BaggingClassifier()
model.fit(xtrain, ytrain)
print(); print(model)
```

```
BaggingClassifier(base_estimator=None, bootstrap=True, bootstrap_features=False,
                  max_features=1.0, max_samples=1.0, n_estimators=10,
                  n_jobs=None, oob_score=False, random_state=None, verbose=0,
                  warm_start=False)
```

In [443]:

```
# make predictions
expected_y  = ytest
predicted_y = model.predict(xtest)
```

In [444]:

```
print(accuracy_score(expected_y, predicted_y))
```

```
print(classification_report(expected_y, predicted_y))
```

```
0.9629629629629629
              precision    recall  f1-score   support

           0       0.90      1.00      0.95         9
           1       1.00      0.94      0.97        18

    accuracy                           0.96        27
   macro avg       0.95      0.97      0.96        27
weighted avg       0.97      0.96      0.96        27
```

Adaboost classifier

In [445]:

```
from sklearn.ensemble import AdaBoostClassifier

classifier = AdaBoostClassifier(
    DecisionTreeClassifier(max_depth=1),
    n_estimators=200
)
classifier.fit(xtrain, ytrain)
```

Out[445]:

```
AdaBoostClassifier(algorithm='SAMME.R',
                   base_estimator=DecisionTreeClassifier(class_weight=None,
                                                         criterion='gini',
                                                         max_depth=1,
                                                         max_features=None,
                                                         max_leaf_nodes=None,
                                                         min_impurity_decrease=0.0,
                                                         min_impurity_split=None,
                                                         min_samples_leaf=1,
                                                         min_samples_split=2,
                                                         min_weight_fraction_leaf=0.0,
                                                         presort=False,
                                                         random_state=None,
                                                         splitter='best'),
                   learning_rate=1.0, n_estimators=200, random_state=None)
```

In [446]:

```
ypred = classifier.predict(xtest)
```

In [447]:

```
confusion_matrix(ytest, ypred)
```

Out[447]:

```
array([[ 9,  0],
       [ 0, 18]], dtype=int64)
```

In [448]:

```
accuracy_score(ytest,ypred)
```

Out[448]:

```
1.0
```

Gradient Descent

In [449]:

```
from sklearn.ensemble import GradientBoostingClassifier
```

In [450]:

```
lr_list = [0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1]

for learning_rate in lr_list:
    gb_clf = GradientBoostingClassifier(n_estimators=20, learning_rate=learning_rate, max_features=
2, max_depth=2, random_state=0)
    gb_clf.fit(xtrain, ytrain)

    print("Learning rate: ", learning_rate)
    print("Accuracy score (training): {0:.3f}".format(gb_clf.score(xtrain, ytrain)))
    print("Accuracy score (validation): {0:.3f}".format(gb_clf.score(xtest, ytest)))
```

```
Learning rate:  0.05
Accuracy score (training): 0.952
Accuracy score (validation): 0.926
Learning rate:  0.075
Accuracy score (training): 0.968
Accuracy score (validation): 0.889
Learning rate:  0.1
Accuracy score (training): 0.968
Accuracy score (validation): 0.926
Learning rate:  0.25
Accuracy score (training): 1.000
Accuracy score (validation): 0.963
Learning rate:  0.5
Accuracy score (training): 1.000
Accuracy score (validation): 0.963
Learning rate:  0.75
Accuracy score (training): 1.000
Accuracy score (validation): 0.963
Learning rate:  1
Accuracy score (training): 1.000
Accuracy score (validation): 0.963
```

In [451]:

```
gb_clf2 = GradientBoostingClassifier(n_estimators=20, learning_rate=0.05, max_features=2,
max_depth=2, random_state=0)
gb_clf2.fit(xtrain, ytrain)
predictions = gb_clf2.predict(xtest)

print("Confusion Matrix:")
print(confusion_matrix(ytest, predictions))

print("Accuracy:",accuracy_score(ytest, predictions))

print("Classification Report")
print(classification_report(ytest, predictions))
```

```
Confusion Matrix:
[[ 7  2]
 [ 0 18]]
Accuracy: 0.9259259259259259
Classification Report
              precision    recall  f1-score   support

           0       1.00      0.78      0.88         9
           1       0.90      1.00      0.95        18

    accuracy                           0.93        27
   macro avg       0.95      0.89      0.91        27
weighted avg       0.93      0.93      0.92        27
```

Stacking

In [452]:

```
from xgboost import XGBClassifier
from vecstack import stacking

models = [
    KNeighborsClassifier(n_neighbors=5,
                         n_jobs=-1),

    RandomForestClassifier(random_state=0, n_jobs=-1,
                           n_estimators=100, max_depth=3),

    XGBClassifier(random_state=0, n_jobs=-1, learning_rate=0.1,
                  n_estimators=100, max_depth=3)
]
```

In [453]:

```
S_train, S_test = stacking(models,
                           xtrain, ytrain, xtest,
                           regression=False,

                           mode='oof_pred_bag',

                           needs_proba=False,

                           save_dir=None,

                           metric=accuracy_score,

                           n_folds=4,

                           stratified=True,

                           shuffle=True,

                           random_state=0,

                           verbose=2)
```

```
task:         [classification]
n_classes:    [2]
metric:       [accuracy_score]
mode:         [oof_pred_bag]
n_models:     [3]

model  0:     [KNeighborsClassifier]
    fold  0:  [1.00000000]
    fold  1:  [0.93750000]
    fold  2:  [1.00000000]
    fold  3:  [0.93333333]
    ----
    MEAN:     [0.96770833] + [0.03232525]
    FULL:     [0.96825397]

model  1:     [RandomForestClassifier]
    fold  0:  [0.93750000]
    fold  1:  [0.93750000]
    fold  2:  [0.93750000]
    fold  3:  [0.80000000]
    ----
    MEAN:     [0.90312500] + [0.05953925]
    FULL:     [0.90476190]

model  2:     [XGBClassifier]
    fold  0:  [0.93750000]
    fold  1:  [1.00000000]
    fold  2:  [0.87500000]
    fold  3:  [0.80000000]
    ----
    MEAN:     [0.90312500] + [0.07414882]
    FULL:     [0.90476190]
```

Now, PCA

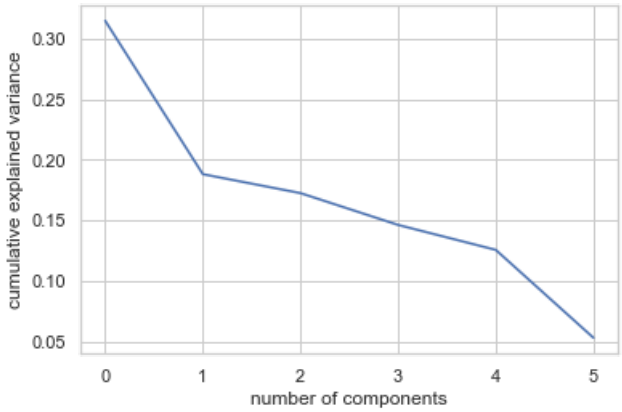
Now, PCA

In [29]:

```
pca = PCA()
xtrain = pca.fit_transform(xtrain)
xtest = pca.transform(xtest)
```

In [30]:

```
plt.plot(pca.explained_variance_ratio_)
plt.xlabel('number of components')
plt.ylabel('cumulative explained variance')
plt.show()
```



In [31]:

```
pca = PCA(n_components=2)
xtrain = pca.fit_transform(xtrain)
xtest = pca.transform(xtest)
```

In [32]:

```
print(pd.DataFrame(pca.components_,columns=X.columns,index = ['PC-1','PC-2']))
```

```
       sex  age          time  number_of_warts          type          area
PC-1   1.0  0.0 -0.000000e+00    -0.000000e+00 -0.000000e+00 -0.000000e+00
PC-2  -0.0  1.0 -2.089751e-15     6.218063e-16  9.271806e-16 -2.491581e-16
```

Classifications

In [36]:

```
logreg = LogisticRegression(random_state=0)
logreg.fit(xtrain,ytrain)
```

```
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:432:
FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. Specify a solver to silence this
warning.
  FutureWarning)
```

Out[36]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=0, solver='warn', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [37]:

```
ypred=logreg.predict(xtest)
```

In [38]:

```
print('Score for Train Set: ',logreg.score(xtrain, ytrain))
print('Score for Test Set: ',logreg.score(xtest, ytest))
```

```
Score for Train Set:  0.8571428571428571
Score for Test Set:  0.7777777777777778
```

In [39]:

```
accuracy_score(ytest,ypred)
```

Out[39]:

```
0.7777777777777778
```

In [40]:

```
recall_score(ytest,ypred)
```

Out[40]:

```
0.8461538461538461
```

In [41]:

```
precision_score(ytest,ypred)
```

Out[41]:

```
0.7333333333333333
```

Decision Tree

Entropy

In [42]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
decisiontree.fit(xtrain, ytrain)
```

Out[42]:

```
DecisionTreeClassifier(class_weight=None, criterion='entropy', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [43]:

```
ypred=decisiontree.predict(xtest)
```

In [44]:

```
from sklearn.model_selection import cross_val_score

decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')

print(scores.mean())
```

```
0.8758333333333332
```

Gini

In [45]:

```
from sklearn.tree import DecisionTreeClassifier
decisiontree = DecisionTreeClassifier(criterion='gini', random_state=40)
decisiontree.fit(xtrain, ytrain)
```

Out[45]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=40, splitter='best')
```

In [46]:

```
ypred=decisiontree.predict(xtest)
```

In [47]:

```
accuracy_score(ytest,ypred)
```

Out[47]:

```
0.6666666666666666
```

In [48]:

```
from sklearn.model_selection import cross_val_score
decisiontree = DecisionTreeClassifier(criterion='entropy', random_state=40)
scores=cross_val_score(decisiontree,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
0.8758333333333332
```

Random Forest

In [49]:

```
from sklearn.ensemble import RandomForestClassifier

#Create a Gaussian Classifier
ranforest= RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)

#Train the model using the training sets y_pred=clf.predict(X_test)
ranforest.fit(xtrain,ytrain)
```

Out[49]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
                       max_depth=None, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
                       oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
```

In [50]:

```
ypred=ranforest.predict(xtest)
```

In [51]:

```
accuracy_score(ytest,ypred)
```

Out[51]:

```
0.6666666666666666
```

In [52]:

```
from sklearn.model_selection import cross_val_score
random = RandomForestClassifier(criterion='entropy')
scores=cross_val_score(random,x,y,cv=10,scoring='accuracy')
print(scores.mean())
```

```
0.9305555555555556
```

```
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The
default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

KNN

In [53]:

```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
classifier.fit(xtrain, ytrain)
```

Out[53]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [54]:

```
ypred = classifier.predict(xtest)
```

In [55]:

```
accuracy_score(ytest,ypred)
```

Out[55]:

```
0.7037037037037037
```

In [56]:

```
from sklearn.model_selection import cross_val_score
krange=range(1,31)
kscores=[]
for k in krange:
    knn=KNeighborsClassifier(n_neighbors=k)
    scores=cross_val_score(knn,x,y,cv=10,scoring='accuracy')
    kscores.append(scores.mean())
print(kscores)
```

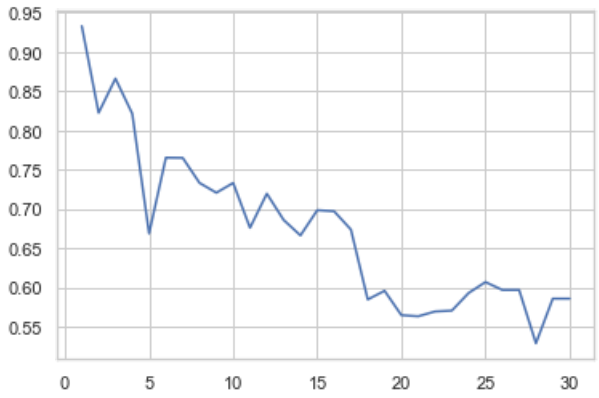
```
[0.9330555555555555, 0.8225, 0.8661111111111112, 0.8213888888888888, 0.668611111111111,
0.7652777777777777, 0.765, 0.7330555555555555, 0.7205555555555555, 0.7330555555555555,
0.6758333333333333, 0.7194444444444444, 0.6858333333333333, 0.6661111111111111,
0.6983333333333334, 0.6969444444444444, 0.673611111111111, 0.5844444444444445, 0.5955555555555556,
0.5644444444444444, 0.5630555555555555, 0.5691666666666666, 0.5702777777777778,
0.5927777777777777, 0.6066666666666667, 0.5966666666666667, 0.5966666666666667,
0.5286111111111111, 0.5855555555555556, 0.5855555555555555]
```

In [57]:

```
plt.plot(krange,kscores)
```

Out[57]:

```
[<matplotlib.lines.Line2D at 0x17aecbfb940>]
```



In [58]:

```
from sklearn.model_selection import GridSearchCV
krange=list(range(1,31))
weight_options=['uniform','distance']
```

In [59]:

```
param_grid=dict(n_neighbors=krange, weights=weight_options)
knn=KNeighborsClassifier()
```

In [60]:

```
grid=GridSearchCV(knn, param_grid, cv=10, scoring='accuracy')
grid.fit(x,y)
```

```
C:\Users\krishnaraj\Anaconda3\lib\site-packages\sklearn\model_selection\_search.py:813:
DeprecationWarning: The default of the `iid` parameter will change from True to False in version 0
.22 and will be removed in 0.24. This will change numeric results when test-set sizes are unequal.
  DeprecationWarning)
```

Out[60]:

```
GridSearchCV(cv=10, error_score='raise-deprecating',
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=30,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=None,
                                            n_neighbors=5, p=2,
                                            weights='uniform'),
             iid='warn', n_jobs=None,
             param_grid={'n_neighbors': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
                                         13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
                                         23, 24, 25, 26, 27, 28, 29, 30],
                         'weights': ['uniform', 'distance']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=0)
```

In [61]:

```
print(grid.best_score_)
print(grid.best_params_)
print(grid.best_estimator_)
```

```
0.9444444444444444
{'n_neighbors': 5, 'weights': 'distance'}
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='distance')
```

In [62]:

```
from sklearn.neighbors import KNeighborsClassifier
knnup = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
knnup.fit(xtrain, ytrain)
```

Out[62]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [63]:

```
ypred = knnup.predict(xtest)
```

In [64]:

```
accuracy_score(ytest,ypred)
```

Out[64]:

```
0.7037037037037037
```

Naive Bayes

In [65]:

```
from sklearn.naive_bayes import GaussianNB
model=GaussianNB()
model.fit(xtrain,ytrain)
```

Out[65]:

```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [66]:

```
ypred=model.predict(xtest)
```

In [67]:

```
accuracy_score(ytest,ypred)
```

Out[67]:

```
0.7037037037037037
```

In [68]:

```
recall_score(ytest,ypred, average='micro')
```

Out[68]:

```
0.7037037037037037
```

Bagging

In [69]:

```
kfold = model_selection.KFold(n_splits=10, random_state=21)
cart = DecisionTreeClassifier()
num_trees = 100
model = BaggingClassifier(base_estimator=cart, n_estimators=num_trees, random_state=40)
results = model_selection.cross_val_score(model, x, y, cv=kfold)
print(results.mean())
```

```
0.9111111111111112
```

In [70]:

```
model = BaggingClassifier()
model.fit(xtrain, ytrain)
print(); print(model)
```

```
BaggingClassifier(base_estimator=None, bootstrap=True, bootstrap_features=False,
                  max_features=1.0, max_samples=1.0, n_estimators=10,
                  n_jobs=None, oob_score=False, random_state=None, verbose=0,
                  warm_start=False)
```

In [71]:

```
# make predictions
expected_y  = ytest
predicted_y = model.predict(xtest)
```

In [72]:

```
print(accuracy_score(expected_y, predicted_y))
print(classification_report(expected_y, predicted_y))
```

```
0.6666666666666666
              precision    recall  f1-score   support

           0       0.69      0.64      0.67        14
           1       0.64      0.69      0.67        13

    accuracy                           0.67        27
   macro avg       0.67      0.67      0.67        27
weighted avg       0.67      0.67      0.67        27
```

Adaboost classifier

In [73]:

```
from sklearn.ensemble import AdaBoostClassifier

classifier = AdaBoostClassifier(
    DecisionTreeClassifier(max_depth=1),
    n_estimators=200
)
classifier.fit(xtrain, ytrain)
```

Out[73]:

```
AdaBoostClassifier(algorithm='SAMME.R',
                   base_estimator=DecisionTreeClassifier(class_weight=None,
                                                         criterion='gini',
                                                         max_depth=1,
                                                         max_features=None,
                                                         max_leaf_nodes=None,
                                                         min_impurity_decrease=0.0,
                                                         min_impurity_split=None,
                                                         min_samples_leaf=1,
                                                         min_samples_split=2,
                                                         min_weight_fraction_leaf=0.0,
                                                         presort=False,
                                                         random_state=None,
                                                         splitter='best'),
                   learning_rate=1.0, n_estimators=200, random_state=None)
```

In [74]:

```
ypred = classifier.predict(xtest)
```

In [75]:

```
confusion_matrix(ytest, ypred)
```

Out[75]:

```
array([[10,  4],
       [ 5,  8]])
```

In [76]:

```
accuracy_score(ytest,ypred)
```

Out[76]:

```
0.6666666666666666
```

Gradient Descent

In [77]:

```
from sklearn.ensemble import GradientBoostingClassifier
```

In [82]:

```
lr_list = [0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1]

for learning_rate in lr_list:
    gb_clf = GradientBoostingClassifier(n_estimators=20, learning_rate=learning_rate, max_features=
2, max_depth=2, random_state=0)
    gb_clf.fit(xtrain, ytrain)

    print("Learning rate: ", learning_rate)
```

```
    print("Accuracy score (training): {0:.3f}".format(gb_clf.score(xtrain, ytrain)))
    print("Accuracy score (validation): {0:.3f}".format(gb_clf.score(xtest, ytest)))
```

```
Learning rate:  0.05
Accuracy score (training): 0.873
Accuracy score (validation): 0.667
Learning rate:  0.075
Accuracy score (training): 0.873
Accuracy score (validation): 0.667
Learning rate:  0.1
Accuracy score (training): 0.889
Accuracy score (validation): 0.667
Learning rate:  0.25
Accuracy score (training): 0.968
Accuracy score (validation): 0.667
Learning rate:  0.5
Accuracy score (training): 1.000
Accuracy score (validation): 0.667
Learning rate:  0.75
Accuracy score (training): 1.000
Accuracy score (validation): 0.630
Learning rate:  1
Accuracy score (training): 1.000
Accuracy score (validation): 0.667
```

In [83]:

```
gb_clf2 = GradientBoostingClassifier(n_estimators=20, learning_rate=0.075, max_features=2, max_dept
h=2, random_state=0)
gb_clf2.fit(xtrain, ytrain)
predictions = gb_clf2.predict(xtest)

print("Confusion Matrix:")
print(confusion_matrix(ytest, predictions))

print("Accuracy:",accuracy_score(ytest, predictions))

print("Classification Report")
print(classification_report(ytest, predictions))
```

```
Confusion Matrix:
[[ 7  7]
 [ 2 11]]
Accuracy: 0.6666666666666666
Classification Report
              precision    recall  f1-score   support

           0       0.78      0.50      0.61        14
           1       0.61      0.85      0.71        13

    accuracy                           0.67        27
   macro avg       0.69      0.67      0.66        27
weighted avg       0.70      0.67      0.66        27
```

Stacking

In [84]:

```
from xgboost import XGBClassifier
from vecstack import stacking

models = [
    KNeighborsClassifier(n_neighbors=5,
                         n_jobs=-1),

    RandomForestClassifier(random_state=0, n_jobs=-1,
                           n_estimators=100, max_depth=3),

    XGBClassifier(random_state=0, n_jobs=-1, learning_rate=0.1,
                  n_estimators=100, max_depth=3)
]
```

In [85]:

```
S_train, S_test = stacking(models,
                           xtrain, ytrain, xtest,
                           regression=False,

                           mode='oof_pred_bag',

                           needs_proba=False,

                           save_dir=None,

                           metric=accuracy_score,

                           n_folds=4,

                           stratified=True,

                           shuffle=True,

                           random_state=0,

                           verbose=2)
```

```
task:         [classification]
n_classes:    [2]
metric:       [accuracy_score]
mode:         [oof_pred_bag]
n_models:     [3]

model  0:     [KNeighborsClassifier]
    fold  0:  [0.81250000]
    fold  1:  [0.81250000]
    fold  2:  [0.87500000]
    fold  3:  [0.80000000]
    ----
    MEAN:     [0.82500000] + [0.02931510]
    FULL:     [0.82539683]

model  1:     [RandomForestClassifier]
    fold  0:  [0.87500000]
    fold  1:  [0.81250000]
    fold  2:  [0.87500000]
    fold  3:  [0.80000000]
    ----
    MEAN:     [0.84062500] + [0.03465793]
    FULL:     [0.84126984]

model  2:     [XGBClassifier]
    fold  0:  [0.81250000]
    fold  1:  [0.81250000]
    fold  2:  [0.87500000]
    fold  3:  [0.73333333]
    ----
    MEAN:     [0.80833333] + [0.05025974]
    FULL:     [0.80952381]
```