In [1]:
```
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# Student ID: 801197095
# Homework 3: Naïve Bayesian
# Date: 10/25/2022
```

In [2]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import recall_score
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import metrics
import warnings
warnings.filterwarnings('ignore')
```

In [3]:
```
# gathering cancer data
from sklearn.datasets import load_breast_cancer
breast = load_breast_cancer()
breast_data = breast.data
breast_data
```

Out[3]:
```
array([[1.799e+01, 1.038e+01, 1.228e+02, ..., 2.654e-01, 4.601e-01,
        1.189e-01],
       [2.057e+01, 1.777e+01, 1.329e+02, ..., 1.860e-01, 2.750e-01,
        8.902e-02],
       [1.969e+01, 2.125e+01, 1.300e+02, ..., 2.430e-01, 3.613e-01,
        8.758e-02],
       ...,
       [1.660e+01, 2.808e+01, 1.083e+02, ..., 1.418e-01, 2.218e-01,
        7.820e-02],
       [2.060e+01, 2.933e+01, 1.401e+02, ..., 2.650e-01, 4.087e-01,
        1.240e-01],
       [7.760e+00, 2.454e+01, 4.792e+01, ..., 0.000e+00, 2.871e-01,
        7.039e-02]])
```

In [4]:
```
breast_input = pd.DataFrame(breast_data)
```

In [5]:
```
breast_labels = breast.target
```

In [6]:
```
labels = np.reshape(breast_labels,(569,1))
final_breast_data = np.concatenate([breast_data,labels],axis=1)
breast_dataset = pd.DataFrame(final_breast_data)

features = breast.feature_names
breast_dataset.columns = np.append(features,'label')
breast_dataset['label'].replace(0, 'Benign',inplace=True)
breast_dataset['label'].replace(1, 'Malignant',inplace=True)
```

In [7]:
```
# Setting the label column to ones and zeros.
varList = ['label']
def binaryMap(x):
    return x.map({'Malignant': 1, 'Benign': 0})
```

```
breast_dataset[varList] = breast_dataset[varList].apply(binaryMap)
data = breast_dataset
breast_dataset
```

Out[7]:

	mean radius	mean texture	mean perimeter	mean area	mean smoothness	mean compactness	mean concavity	mean concave points	mean symmetry	d
0	17.99	10.38	122.80	1001.0	0.11840	0.27760	0.30010	0.14710	0.2419	
1	20.57	17.77	132.90	1326.0	0.08474	0.07864	0.08690	0.07017	0.1812	
2	19.69	21.25	130.00	1203.0	0.10960	0.15990	0.19740	0.12790	0.2069	
3	11.42	20.38	77.58	386.1	0.14250	0.28390	0.24140	0.10520	0.2597	
4	20.29	14.34	135.10	1297.0	0.10030	0.13280	0.19800	0.10430	0.1809	
...	...	...	...	...	...	...	...	...	...	
564	21.56	22.39	142.00	1479.0	0.11100	0.11590	0.24390	0.13890	0.1726	
565	20.13	28.25	131.20	1261.0	0.09780	0.10340	0.14400	0.09791	0.1752	
566	16.60	28.08	108.30	858.1	0.08455	0.10230	0.09251	0.05302	0.1590	
567	20.60	29.33	140.10	1265.0	0.11780	0.27700	0.35140	0.15200	0.2397	
568	7.76	24.54	47.92	181.0	0.05263	0.04362	0.00000	0.00000	0.1587	

569 rows × 31 columns

In [8]:
```
#getting x and y values
x = breast_dataset.iloc[:,0:29].values
y = breast_dataset.iloc[:, [30]]
#print(y)

# Spliting data into 80% training and 20% testing
np.random.seed(0)
xTrain, xTest, yTrain, yTest = train_test_split(x, y, train_size = 0.80, test_size = 0
```

In [9]:
```
# standardizing data set
sc_X = StandardScaler()
xTrain = sc_X.fit_transform(xTrain)
xTest = sc_X.transform(xTest)
```

In [10]:
```
##############
# Problem 1
##############
```

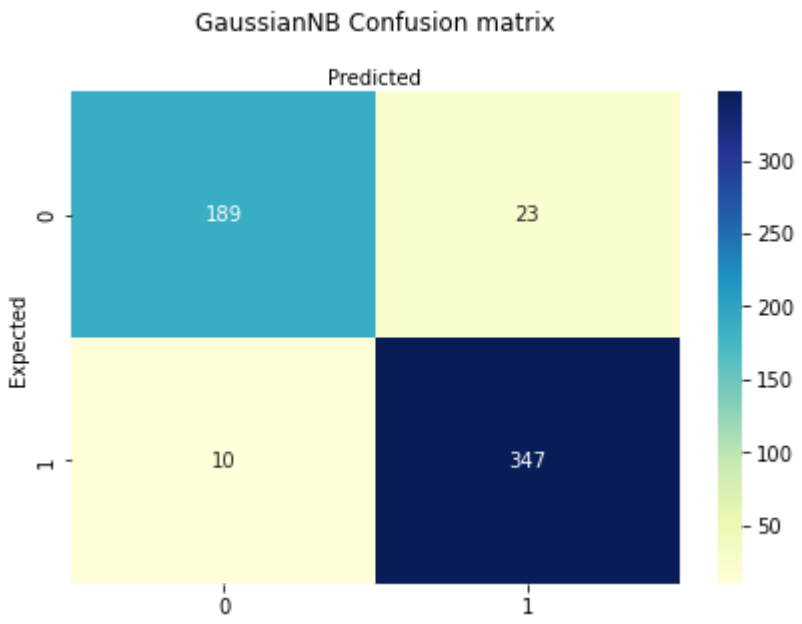
In [11]:
```
# Naive bayes model
from sklearn.naive_bayes import GaussianNB
model = GaussianNB()

model.fit(breast.data, breast.target)
print(model)
expected = breast.target
predicted = model.predict(breast.data)
```

```
print(metrics.classification_report(expected,predicted))
print(metrics.confusion_matrix(expected,predicted))
matrix = confusion_matrix(expected, predicted)
```

```
GaussianNB()
              precision    recall  f1-score   support

           0       0.95      0.89      0.92       212
           1       0.94      0.97      0.95       357

    accuracy                           0.94       569
   macro avg       0.94      0.93      0.94       569
weighted avg       0.94      0.94      0.94       569

[[189  23]
 [ 10 347]]
```

In [12]:
```
# Plotting the confusion matrix: prediction vs values
fig, ax = plt.subplots()
plt.tight_layout()
# create heatmap
sns.heatmap(pd.DataFrame(matrix),annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.title('GaussianNB Confusion matrix', y=1.1)
plt.ylabel('Expected')
plt.xlabel('Predicted')
```

Out[12]:
```
Text(0.5, 6.799999999999997, 'Predicted')
```



In [13]:
```
#############
# Problem 2
#############
```

In [14]:
```
from sklearn.decomposition import PCA
for i in range (12):
    n=i+1
    pca = PCA(n)
    breast2 = breast_dataset
    breast2 = pca.fit_transform(breast2)
    xTrain, xTest, yTrain, yTest = train_test_split(breast2, breast_labels, train_size
```

```
    Classifier = LogisticRegression()
    Classifier.fit(xTrain, yTrain)
    prediction =  Classifier.predict(xTrain)
    model = GaussianNB()
    model.fit(xTrain,yTrain)
    print("K:",n)
    print('Accuracy =', metrics.accuracy_score(yTrain,prediction))
    print('Recall =', metrics.recall_score(yTrain,prediction))
    print('precision =', metrics.precision_score(yTrain,prediction))
    print("")
```

```
K: 1
Accuracy = 0.9032967032967033
Recall = 0.9620689655172414
precision = 0.8942307692307693

K: 2
Accuracy = 0.9274725274725275
Recall = 0.9655172413793104
precision = 0.9240924092409241

K: 3
Accuracy = 0.9296703296703297
Recall = 0.9620689655172414
precision = 0.93

K: 4
Accuracy = 0.9582417582417583
Recall = 0.9758620689655172
precision = 0.9593220338983051

K: 5
Accuracy = 0.9560439560439561
Recall = 0.9724137931034482
precision = 0.9591836734693877

K: 6
Accuracy = 0.9582417582417583
Recall = 0.9724137931034482
precision = 0.962457337883959

K: 7
Accuracy = 0.9560439560439561
Recall = 0.9689655172413794
precision = 0.9623287671232876

K: 8
Accuracy = 0.9560439560439561
Recall = 0.9689655172413794
precision = 0.9623287671232876

K: 9
Accuracy = 0.9560439560439561
Recall = 0.9689655172413794
precision = 0.9623287671232876

K: 10
Accuracy = 0.9956043956043956
Recall = 1.0
precision = 0.9931506849315068

K: 11
Accuracy = 0.9978021978021978
Recall = 1.0
precision = 0.9965635738831615

K: 12
Accuracy = 0.9978021978021978
Recall = 1.0
precision = 0.9965635738831615
```

In [15]:
```
#############
# Problem 3
#############
```

In [16]:
```
from sklearn.decomposition import PCA

acc = [None]*12
precision = [None]*12
recall = [None]*12
for i in range (12):
    n=i+1
    pca = PCA(n)
    breast3 = breast_dataset
    breast3 = pca.fit_transform(breast3)
    xTrain, xTest, yTrain, yTest = train_test_split(breast3, breast_labels, train_size
    Classifier = LogisticRegression()
    Classifier.fit(xTrain, yTrain)
    prediction =  Classifier.predict(xTest)
    matrix = confusion_matrix(yTest, prediction)
    print("K:",n)
    print('Accuracy =', metrics.accuracy_score(yTest,prediction))
    print('Recall =', metrics.recall_score(yTest,prediction))
    print('precision =', metrics.precision_score(yTest,prediction))
    print('matrix :')
    print(matrix)
    print("")
```

```
K: 1
Accuracy = 0.9122807017543859
Recall = 0.9552238805970149
precision = 0.9014084507042254
matrix :
[[40  7]
 [ 3 64]]

K: 2
Accuracy = 0.9473684210526315
Recall = 0.9701492537313433
precision = 0.9420289855072463
matrix :
[[43  4]
 [ 2 65]]

K: 3
Accuracy = 0.9385964912280702
Recall = 0.9552238805970149
precision = 0.9411764705882353
matrix :
[[43  4]
 [ 3 64]]

K: 4
Accuracy = 0.9385964912280702
Recall = 0.9253731343283582
precision = 0.96875
matrix :
[[45  2]
 [ 5 62]]

K: 5
Accuracy = 0.9385964912280702
Recall = 0.9253731343283582
precision = 0.96875
matrix :
[[45  2]
 [ 5 62]]

K: 6
Accuracy = 0.9473684210526315
Recall = 0.9253731343283582
precision = 0.9841269841269841
matrix :
[[46  1]
 [ 5 62]]

K: 7
Accuracy = 0.9473684210526315
Recall = 0.9253731343283582
precision = 0.9841269841269841
matrix :
[[46  1]
 [ 5 62]]

K: 8
Accuracy = 0.9473684210526315
Recall = 0.9253731343283582
precision = 0.9841269841269841
```

```
matrix :
[[46  1]
 [ 5 62]]

K: 9
Accuracy = 0.9473684210526315
Recall = 0.9253731343283582
precision = 0.9841269841269841
matrix :
[[46  1]
 [ 5 62]]

K: 10
Accuracy = 0.9912280701754386
Recall = 0.9850746268656716
precision = 1.0
matrix :
[[47  0]
 [ 1 66]]

K: 11
Accuracy = 1.0
Recall = 1.0
precision = 1.0
matrix :
[[47  0]
 [ 0 67]]

K: 12
Accuracy = 1.0
Recall = 1.0
precision = 1.0
matrix :
[[47  0]
 [ 0 67]]
```