Skills Network

SVM (Support Vector Machines)

Estimated time needed: **15** minutes

Objectives

After completing this lab you will be able to:

- Use scikit-learn to Support Vector Machine to classify

In this notebook, you will use SVM (Support Vector Machines) to build and train a model using human cell records, and classify cells to whether the samples are benign or malignant.

SVM works by mapping data to a high-dimensional feature space so that data points can be categorized, even when the data are not otherwise linearly separable. A separator between the categories is found, then the data is transformed in such a way that the separator could be drawn as a hyperplane. Following this, characteristics of new data can be used to predict the group to which a new record should belong.

Table of contents

In [1]:
```
!pip install scikit-learn==0.23.1
```

```
Requirement already satisfied: scikit-learn==0.23.1 in /home/jupyterlab/conda/envs/pytho
n/lib/python3.7/site-packages (0.23.1)
Requirement already satisfied: numpy>=1.13.3 in /home/jupyterlab/conda/envs/python/lib/p
ython3.7/site-packages (from scikit-learn==0.23.1) (1.21.6)
Requirement already satisfied: scipy>=0.19.1 in /home/jupyterlab/conda/envs/python/lib/p
ython3.7/site-packages (from scikit-learn==0.23.1) (1.7.3)
Requirement already satisfied: joblib>=0.11 in /home/jupyterlab/conda/envs/python/lib/py
thon3.7/site-packages (from scikit-learn==0.23.1) (1.3.2)
```

```
Requirement already satisfied: threadpoolctl>=2.0.0 in /home/jupyterlab/conda/envs/pytho
n/lib/python3.7/site-packages (from scikit-learn==0.23.1) (3.1.0)
```

In [2]:

```
import pandas as pd
import pylab as pl
import numpy as np
import scipy.optimize as opt
from sklearn import preprocessing
from sklearn.model_selection import train_test_split
%matplotlib inline
import matplotlib.pyplot as plt
```

Load the Cancer data

The example is based on a dataset that is publicly available from the UCI Machine Learning Repository (Asuncion and Newman, 2007)[http://mlearn.ics.uci.edu/MLRepository.html]. The dataset consists of several hundred human cell sample records, each of which contains the values of a set of cell characteristics. The fields in each record are:

Field name	Description
ID	Clump thickness
Clump	Clump thickness
UnifSize	Uniformity of cell size
UnifShape	Uniformity of cell shape
MargAdh	Marginal adhesion
SingEpiSize	Single epithelial cell size
BareNuc	Bare nuclei
BlandChrom	Bland chromatin
NormNucl	Normal nucleoli
Mit	Mitoses
Class	Benign or malignant

For the purposes of this example, we're using a dataset that has a relatively small number of predictors in each record. To download the data, we will use `!wget` to download it from IBM Object Storage.

In [3]:

```
#Click here and press Shift+Enter
!wget -O cell_samples.csv https://cf-courses-data.s3.us.cloud-object-storage.appdomain.
```

```
--2024-09-17 02:52:43--  https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cl
oud/IBMDeveloperSkillsNetwork-ML0101EN-SkillsNetwork/labs/Module%203/data/cell_samples.c
sv
```

```
Resolving cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud (cf-courses-data.s
3.us.cloud-object-storage.appdomain.cloud)... 169.63.118.104, 169.63.118.104
Connecting to cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud (cf-courses-dat
a.s3.us.cloud-object-storage.appdomain.cloud)|169.63.118.104|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 19975 (20K) [text/csv]
Saving to: 'cell_samples.csv'

cell_samples.csv    100%[===================>]  19.51K  --.-KB/s    in 0.001s

2024-09-17 02:52:43 (28.4 MB/s) - 'cell_samples.csv' saved [19975/19975]
```

Load Data From CSV File

In [4]:

```
cell_df = pd.read_csv("cell_samples.csv")
cell_df.head()
```

Out[4]:

	ID	Clump	UnifSize	UnifShape	MargAdh	SingEpiSize	BareNuc	BlandChrom	NormNucl	Mit
0	1000025	5	1	1	1	2	1	3	1	1
1	1002945	5	4	4	5	7	10	3	2	1
2	1015425	3	1	1	1	2	2	3	1	1
3	1016277	6	8	8	1	3	4	3	7	1
4	1017023	4	1	1	3	2	1	3	1	1

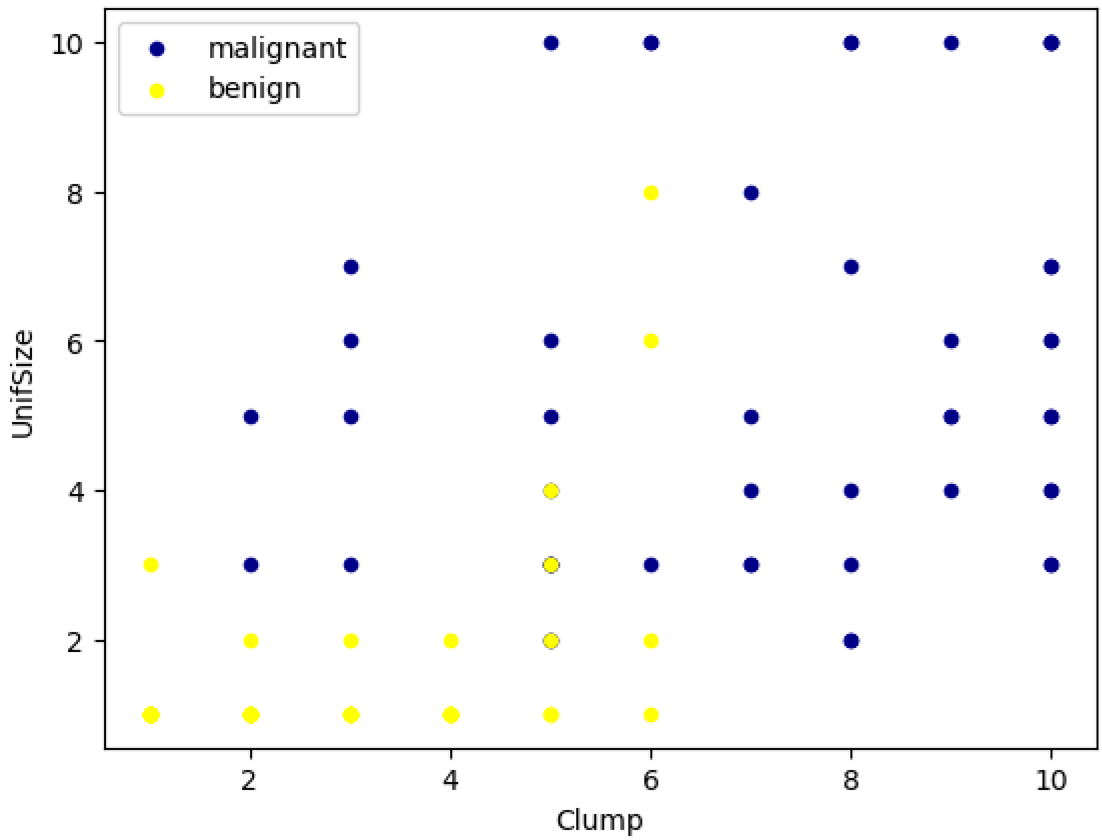
The ID field contains the patient identifiers. The characteristics of the cell samples from each patient are contained in fields Clump to Mit. The values are graded from 1 to 10, with 1 being the closest to benign.

The Class field contains the diagnosis, as confirmed by separate medical procedures, as to whether the samples are benign (value = 2) or malignant (value = 4).

Let's look at the distribution of the classes based on Clump thickness and Uniformity of cell size:

In [6]:

```
ax = cell_df[cell_df['Class'] == 4][0:50].plot(kind='scatter', x='Clump', y='UnifSize',
cell_df[cell_df['Class'] == 2][0:50].plot(kind='scatter', x='Clump', y='UnifSize', colo
plt.show()
```



Data pre-processing and selection

Let's first look at columns data types:

In [7]:

```
cell_df.dtypes
```

Out[7]:

```
ID              int64
Clump           int64
UnifSize        int64
UnifShape       int64
MargAdh         int64
SingEpiSize     int64
BareNuc        object
BlandChrom      int64
NormNucl        int64
Mit             int64
Class           int64
dtype: object
```

It looks like the **BareNuc** column includes some values that are not numerical. We can drop those rows:

In [8]:

```
cell_df = cell_df[pd.to_numeric(cell_df['BareNuc'], errors='coerce').notnull()]
cell_df['BareNuc'] = cell_df['BareNuc'].astype('int')
cell_df.dtypes
```

Out[8]:

```
ID             int64
Clump          int64
UnifSize       int64
UnifShape      int64
```

```
MargAdh        int64
SingEpiSize    int64
BareNuc        int64
BlandChrom     int64
NormNucl       int64
Mit            int64
Class          int64
dtype: object
```

In [9]:

```
feature_df = cell_df[['Clump', 'UnifSize', 'UnifShape', 'MargAdh', 'SingEpiSize', 'Bare
X = np.asarray(feature_df)
X[0:5]
```

Out[9]:

```
array([[ 5,  1,  1,  1,  2,  1,  3,  1,  1],
       [ 5,  4,  4,  5,  7, 10,  3,  2,  1],
       [ 3,  1,  1,  1,  2,  2,  3,  1,  1],
       [ 6,  8,  8,  1,  3,  4,  3,  7,  1],
       [ 4,  1,  1,  3,  2,  1,  3,  1,  1]])
```

We want the model to predict the value of Class (that is, benign (=2) or malignant (=4)).

In [10]:

```
y = np.asarray(cell_df['Class'])
y [0:5]
```

Out[10]:

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

Train/Test dataset

We split our dataset into train and test set:

In [11]:

```
X_train, X_test, y_train, y_test = train_test_split( X, y, test_size=0.2, random_state=
print ('Train set:', X_train.shape,  y_train.shape)
print ('Test set:', X_test.shape,  y_test.shape)
```

```
Train set: (546, 9) (546,)
Test set: (137, 9) (137,)
```

Modeling (SVM with Scikit-learn)

The SVM algorithm offers a choice of kernel functions for performing its processing. Basically, mapping data into a higher dimensional space is called kernelling. The mathematical function used for the transformation is known as the kernel function, and can be of different types, such as:

```
1.Linear
2.Polynomial
3.Radial basis function (RBF)
4.Sigmoid
```

Each of these functions has its characteristics, its pros and cons, and its equation, but as there's no easy way of knowing which function performs best with any given dataset. We usually choose different functions in turn and compare the results. Let's just use the default, RBF (Radial Basis Function) for this lab.

In [12]:
```
from sklearn import svm
clf = svm.SVC(kernel='rbf')
clf.fit(X_train, y_train)
```

Out[12]: SVC()

After being fitted, the model can then be used to predict new values:

In [13]:
```
yhat = clf.predict(X_test)
yhat [0:5]
```

Out[13]: array([2, 4, 2, 4, 2])

Evaluation

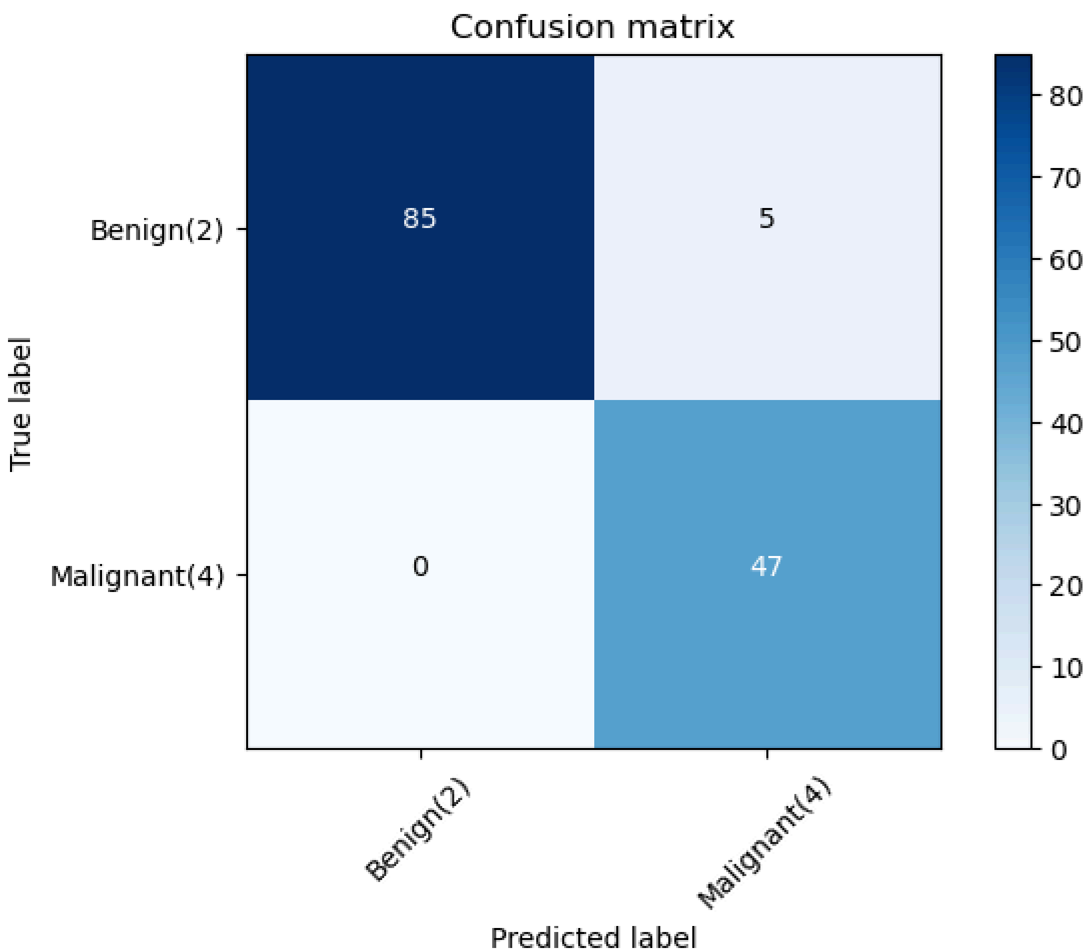
In [14]:
```
from sklearn.metrics import classification_report, confusion_matrix
import itertools
```

In [15]:
```
def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    print(cm)

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

In [16]:

```
# Compute confusion matrix
cnf_matrix = confusion_matrix(y_test, yhat, labels=[2,4])
np.set_printoptions(precision=2)

print (classification_report(y_test, yhat))

# Plot non-normalized confusion matrix
plt.figure()
plot_confusion_matrix(cnf_matrix, classes=['Benign(2)','Malignant(4)'],normalize= False
```

```
              precision    recall  f1-score   support

           2       1.00      0.94      0.97        90
           4       0.90      1.00      0.95        47

    accuracy                           0.96       137
   macro avg       0.95      0.97      0.96       137
weighted avg       0.97      0.96      0.96       137

Confusion matrix, without normalization
[[85  5]
 [ 0 47]]
```



You can also easily use the **f1_score** from sklearn library:

In [17]:

```
from sklearn.metrics import f1_score
f1_score(y_test, yhat, average='weighted')
```

Out[17]: 0.9639038982104676

Let's try the jaccard index for accuracy:

In [18]:
```
from sklearn.metrics import jaccard_score
jaccard_score(y_test, yhat,pos_label=2)
```

Out[18]: 0.9444444444444444

Practice

Can you rebuild the model, but this time with a **linear** kernel? You can use **kernel='linear'** option, when you define the svm. How the accuracy changes with the new kernel function?

In [19]:
```
clf2 = svm.SVC(kernel='linear')
clf2.fit(X_train, y_train)
yhat2 = clf2.predict(X_test)
print("Avg F1-score: %.4f" % f1_score(y_test, yhat2, average='weighted'))
print("Jaccard score: %.4f" % jaccard_score(y_test, yhat2,pos_label=2))
```

```
Avg F1-score: 0.9639
Jaccard score: 0.9444
```

▶ Click here for the solution

Thank you for completing this lab!

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Other Contributors

Joseph Santarcangelo

<!--

Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2021-01-21	2.2	Lakshmi	Updated sklearn library
2020-11-03	2.1	Lakshmi	Updated URL of csv
2020-08-27	2.0	Lavanya	Moved lab to course repo in GitLab

Date (YYYY-MM-DD)	Version	Changed By	Change Description

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