DS4023_assignment3

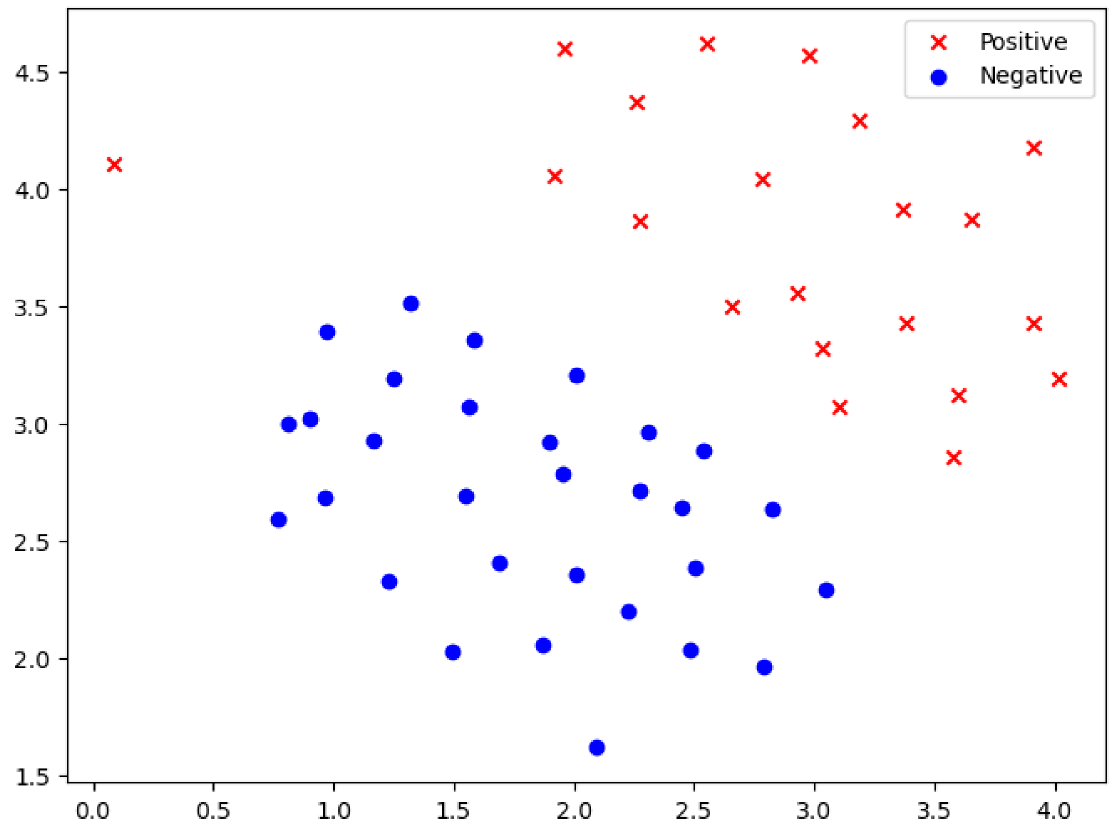
November 5, 2025

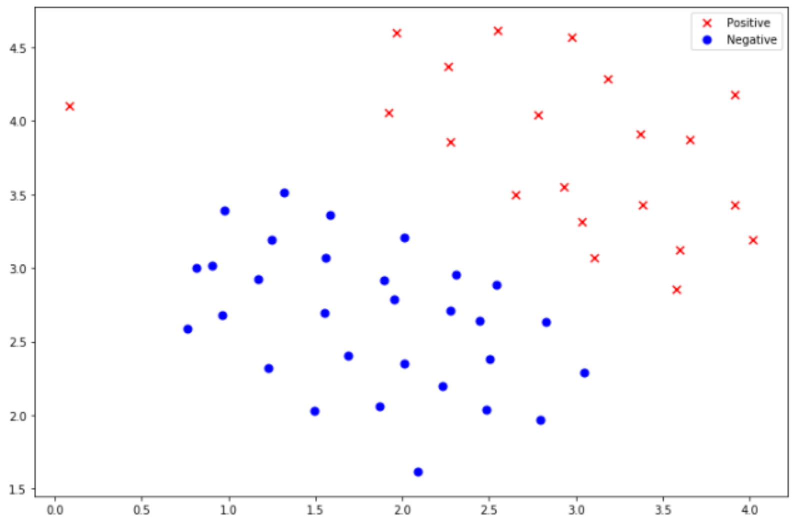
1 DS4023 Assignment 3: SVM and Ensemble Learning(45 pts)

1.0.1 Q1: Soft-margin SVM (9 pts)

You are given a dataset (svm_soft.mat) containing 2D points ['X'] from two classes with corresponding label (0 or 1) in column ['y']. Please visualize the datapoints and classify them using linear SVM with soft margin. You may assume that the penalty term C is set to 1 in $min_{w,b}\frac{1}{2}||w||^2 + C\sum_i \epsilon_i$.

[1]:
```
"""
Part 1: Visualize the datapoints. Your plot should look similar to the sample␣
↪one.
"""

import pandas as pd
import matplotlib.pyplot as plt
from scipy.io import loadmat


def plot_svm_soft(boundary=False, svc=None):
    raw_data = loadmat('data/svm_soft.mat')

    data = pd.DataFrame(raw_data['X'], columns=['X1', 'X2'])
    data['y'] = raw_data['y']

    pos = data['y'] == 1
    neg = data['y'] == 0

    plt.figure(figsize=(8, 6))
    plt.scatter(data.loc[pos, 'X1'], data.loc[pos, 'X2'],
                marker='x', color='red',   label='Positive')
    plt.scatter(data.loc[neg, 'X1'], data.loc[neg, 'X2'],
                marker='o', color='blue',  label='Negative')

    if boundary:
        X = data[['X1', 'X2']].values
        y = data['y'].values

        x_min, x_max = X[:, 0].min()-0.5, X[:, 0].max()+0.5
        y_min, y_max = X[:, 1].min()-0.5, X[:, 1].max()+0.5
        xx, yy = np.meshgrid(
            np.linspace(x_min, x_max, 300),
            np.linspace(y_min, y_max, 300)
        )

        Z = svc.decision_function(
            np.c_[xx.ravel(), yy.ravel()]).reshape(xx.shape)

        plt.contour(xx, yy, Z, levels=[0],
                    linestyles=['-'], colors='lightblue')

    plt.legend()
    plt.show()


plot_svm_soft()
```



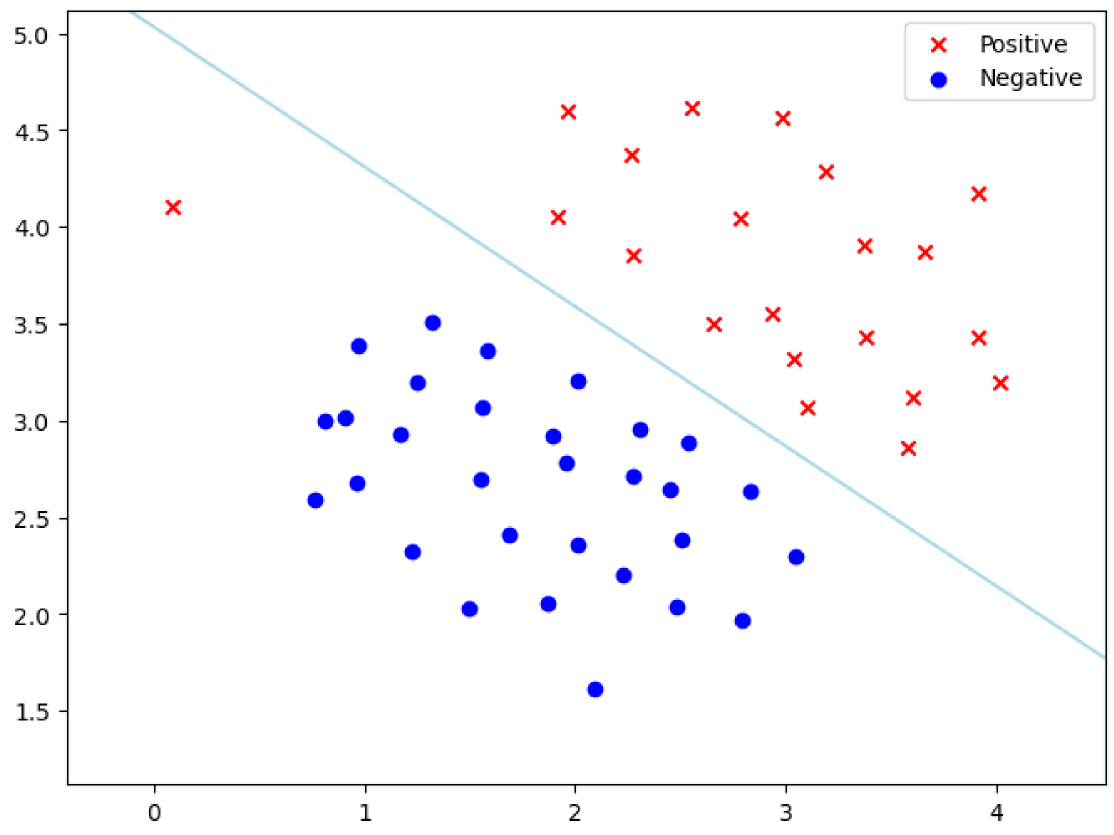


[2]:
```
"""
Part 2: Classify the datapoints and visualize the decision boundary.
        You should print out the coefficients and the interception for the␣
 ↪linear classifier.
        Your plot should look like the sample one.
"""
from sklearn import svm
import numpy as np


def classify_svm_soft():
    raw_data = loadmat('data/svm_soft.mat')
    data = pd.DataFrame(raw_data['X'], columns=['X1', 'X2'])
    data['y'] = raw_data['y']

    svc = svm.LinearSVC(C=1, loss='hinge', max_iter=1_000_000)
    svc.fit(data[['X1', 'X2']], data['y'])

    print('Coefficients (w):', svc.coef_[0])
    print('Intercept (b):', svc.intercept_[0])

    plot_svm_soft(boundary=True, svc=svc)

    return svc


classify_svm_soft()
```

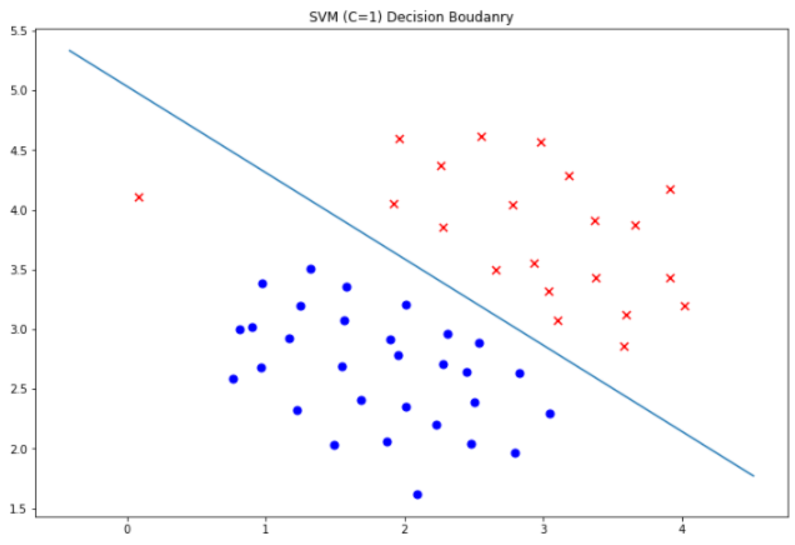
```
Coefficients (w): [0.59153686 0.81825054]
Intercept (b): -4.11954105475478
```

```
/opt/homebrew/anaconda3/lib/python3.11/site-
```

```
packages/sklearn/utils/validation.py:2749: UserWarning: X does not have valid
feature names, but LinearSVC was fitted with feature names
  warnings.warn(
```



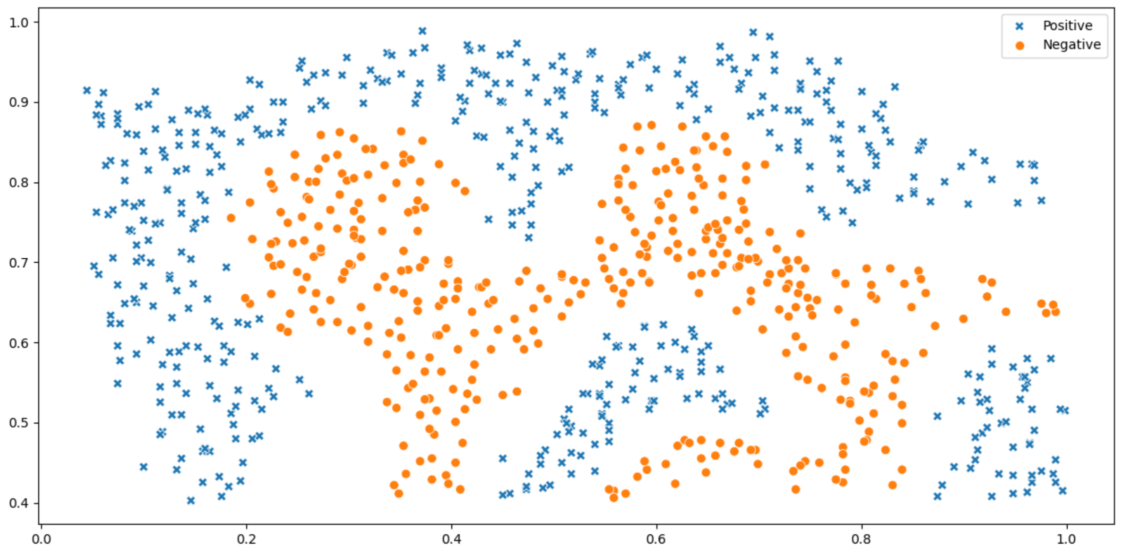
```
[2]: LinearSVC(C=1, loss='hinge', max_iter=1000000)
```

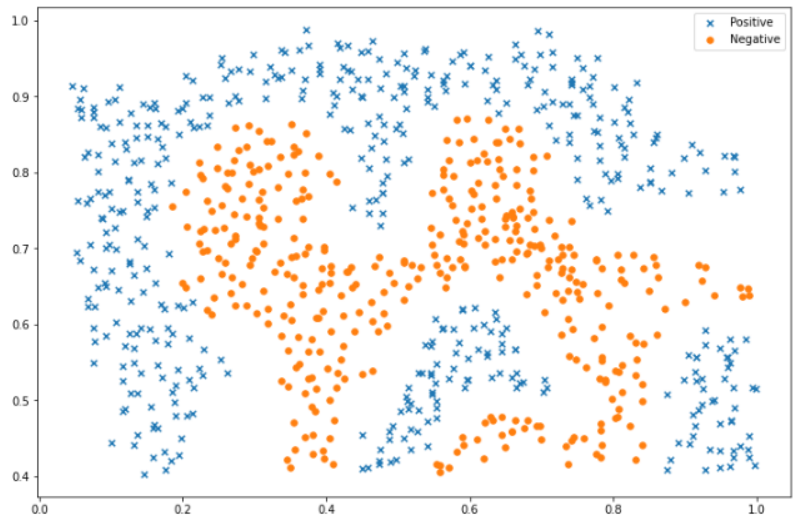


1.0.2 Q2: Kernel SVM (9 pts)

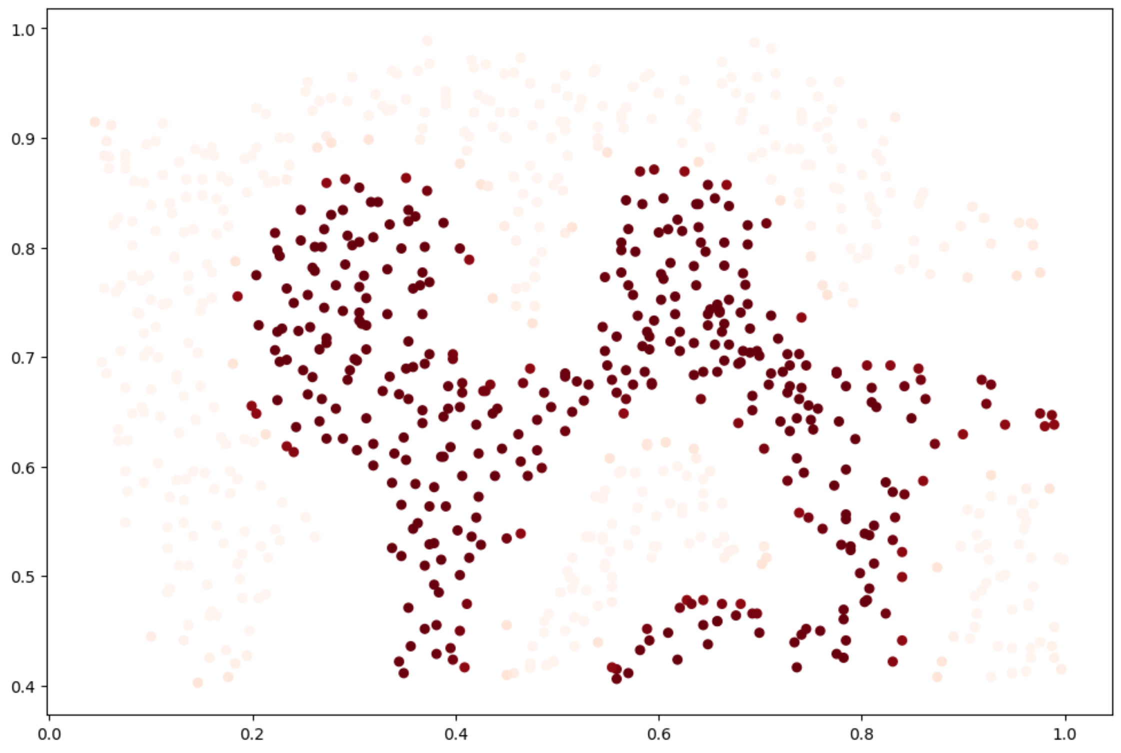
You are given a dataset (svm_kernel.mat) containing 2D points [‘X’] from two classes with corresponding label (0 or 1) in column [‘y’]. Please visualize the datapoints and classify them using linear SVM with Gaussian kernel.

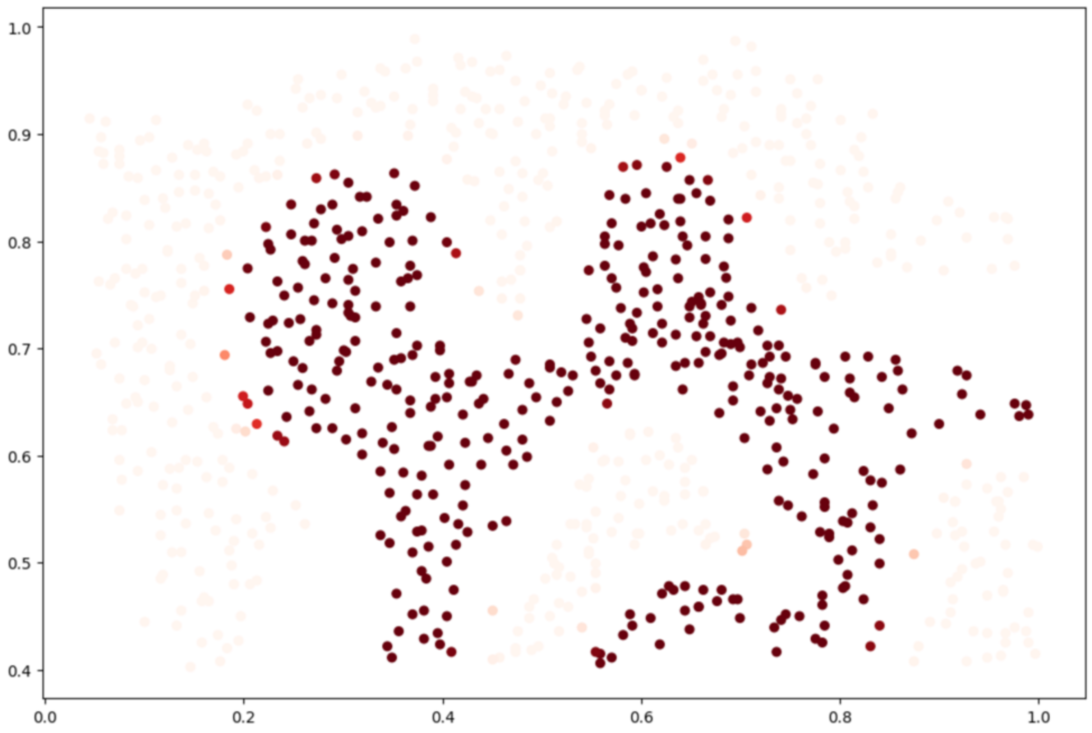
[8]:
```
"""
Part 1: Visualize the datapoints. Your plot should look similar to the sample␣
 ↪one.
"""

import pandas as pd
import matplotlib.pyplot as plt
from scipy.io import loadmat
import seaborn as sb

def plot_svm_kernel():
    global data_svm_kernel

    data_svm_kernel = loadmat('data/svm_kernel.mat')
    X2 = data_svm_kernel['X']
    y2 = data_svm_kernel['y'].ravel()

    data = pd.DataFrame(data_svm_kernel['X'], columns=['X1', 'X2'])
    data['y'] = data_svm_kernel['y']

    plt.figure(figsize=(12, 6))
    sb.scatterplot(
        data=data,
        x='X1', y='X2',
        hue='y',
        style='y',
        palette={1: '#1f77b4', 0: '#ff7f0e'},
        markers={1: 'X', 0: 'o'},
        s=50,
    )
    plt.xlabel('')
    plt.ylabel('')
    plt.legend(labels=['Positive', 'Negative'])
    plt.tight_layout()
    plt.show()


plot_svm_kernel()
```





[6]:
```
"""
Part 2. Classify the data points using Gaussian kernel.
        Visualize the probabilities of the classification results.
        If your classification is correct, your plot should look similar to the␣
 ↪sample one.
"""



def classify_svm_kernel():
    global data_svm_kernel
    data = loadmat('data/svm_kernel.mat')
    X = data['X']
    y = data['y'].flatten()
    data_svm_kernel = {
        'X1': X[:, 0],
        'X2': X[:, 1]
    }
    svc = svm.SVC(kernel='rbf', C=1000, gamma=100, probability=True)
    svc.fit(X, y)
    probabilities = svc.predict_proba(X)[:, 0]
    return probabilities


probabilities = classify_svm_kernel()

fig, ax = plt.subplots(figsize=(12, 8))
ax.scatter(data_svm_kernel['X1'], data_svm_kernel['X2'],
           s=30, c=probabilities, cmap='Reds')
plt.show()
```





1.0.3 Q3: SVM in Email Spam Detection (9 pts)

Many email services today provide spam filters that are able to classify emails into spam and non-spam email with high accuracy. Please write an SVM classifier to detect spam emails. There are two data files that you need to load, one for training, i.e., "email_train.mat", and the other for testing, i.e., "email_test.mat". Your model should train on the training dataset and be applied to the test dataset to obtain the spam detection accuracy. **Your classifier should have an accuracy higher than 90% in both training and testing. Otherwise, every 10% of accuracy decrease leads to a 2 pts deduction in marks. For example, an accuracy of [80%, 90%) will get deducted for 2 pts overall, and [70%, 80%) will get deducted for 4 pts.**

[ ]:
```python
from scipy.io import loadmat


def spam_detector_svm():
    train_data = loadmat('data/email_train.mat')
    X = train_data['X']
    y = train_data['y'].flatten()

    test_data = loadmat('data/email_test.mat')
    Xtest = test_data['Xtest']
    ytest = test_data['ytest'].flatten()

    svc = svm.SVC(kernel='rbf', C=1000, gamma='scale')
    svc.fit(X, y)
    # Do not remove.
    print('Training accuracy = {0}%'.format(
        np.round(svc.score(X, y) * 100, 2)))
    print('Test accuracy = {0}%'.format(
        np.round(svc.score(Xtest, ytest) * 100, 2)))


spam_detector_svm()
```

```
Training accuracy = 100.0%
Test accuracy = 98.0%
```

1.0.4 Q4: Bagging (9 pts)

You are given a tumor dataset `tumor.csv`. The dataset contains instances with 9 features. Each instance is labeled in either benign or malignant classes (0 for benign, 1 for malignant in last column). The dataset only contains numeric values and has been normalized. Use `RandomForestClassifier` to calculate the mean accuracy by using 8-folds cross-validation. Number of trees set to 50.

[ ]:
```
import numpy as np
import pandas as pd
from sklearn import model_selection
from sklearn.ensemble import RandomForestClassifier


def classify_bagging():
    rand_seed = 50  # Do not change

    df = pd.read_csv('data/tumor.csv')

    X = df.iloc[:, :-1].values
    y = df.iloc[:, -1].values

    rf = RandomForestClassifier(n_estimators=50, random_state=rand_seed)
    results = model_selection.cross_val_score(rf, X, y, cv=8)

    # Do not remove.
    print("Performance of random forest:%f" % (results.mean()))


classify_bagging()
```

```
Performance of random forest:0.965713
```

1.0.5 Q5: AdaBoost (9 pts)

Use AdaBoostClassifier to classify the same dataset `tumor.csv`. Compute the mean accuracy by using 8-folds cross-validation and 50 estimators.

[ ]:
```python
from sklearn.ensemble import AdaBoostClassifier


def classify_adaboost():
    rand_seed = 50  # Do not change

    df = pd.read_csv('data/tumor.csv')
    X = df.iloc[:, :-1].values
    y = df.iloc[:, -1].values

    ada = AdaBoostClassifier(n_estimators=50, random_state=rand_seed)
    cv = StratifiedKFold(n_splits=8, shuffle=True, random_state=rand_seed)
    results = cross_val_score(
        ada, X, y, cv=cv, scoring='accuracy', n_jobs=-1)

    # Do not remove.
    print("Performance of adaboost:%f" % (results.mean()))


classify_adaboost()
```

```
Performance of adaboost:0.954219
```

[ ]:
```python

```