M4-L1-P2

October 1, 2023

1 Problem 2 (5 points)

The UCI Machine Learning Repository (https://archive.ics.uci.edu/ml/index.php) contains hundreds of public datasets donated by researchers to test machine learning/statistical methods. Here we will look at a curated version of one of these datasets and try to perform classification using SVM.

Tsanas and Xifara, cited below, performed simulations of buildings using a program called Ecotect. They modified 8 building features, and measured energy efficiency with 2 metrics: heating load requirement and cooling load requirement. For the purpose of demonstration, we have truncated the dataset to only look at a subset of the data points and building attributes.

You will be training an SVM (with sklearn) to use “relative compactness” and “wall area” to classify whether “heating load” is high (>20) or low (<=20).

```
Dataset source:
A. Tsanas, A. Xifara: 'Accurate quantitative estimation of energy performance of residential bu
```

Run the following cell to perform the necessary imports and load the data:

```
[ ]: import numpy as np
     import pandas as pd
     import matplotlib.pyplot as plt
     from sklearn.svm import SVC
     from matplotlib.colors import ListedColormap

     def plot_data(x,y,e=0.1):
         x1min, x1max = min(x[:,0]), max(x[:,0])
         x2min, x2max = min(x[:,1]), max(x[:,1])

         xb = np.linspace(x1min,x1max)

         cmap = ListedColormap(["blue","red"])


         plt.scatter(x[:,0],x[:,1],c=y,cmap=cmap)
         plt.colorbar()

         plt.xlabel('$x_1$')
         plt.ylabel('$x_2$')
```

```
    plt.axis((x1min-e,x1max+e,x2min-e,x2max+e))


def plot_SV_decision_boundary(svm, extend=True):
    ax = plt.gca()
    xlim = ax.get_xlim()
    ylim = ax.get_ylim()

    xrange = xlim[1] - xlim[0]
    yrange = ylim[1] - ylim[0]

    x = np.linspace(xlim[0] - extend*xrange, xlim[1] + extend*xrange, 100)
    y = np.linspace(ylim[0] - extend*yrange, ylim[1] + extend*yrange, 100)

    X,Y = np.meshgrid(x,y)
    xy = np.vstack([X.ravel(), Y.ravel()]).T
    P = svm.decision_function(xy)

    P = P.reshape(X.shape)
    ax.contour(X, Y, P, colors='k',levels=[0],linestyles=['-'])
    ax.contour(X, Y, P, colors='k',levels=[-1, 1], alpha=0.6,linestyles=['--'])

    plt.xlim(xlim)
    plt.ylim(ylim)

relative_compactness = np.array([0.98, 0.9 , 0.86, 0.82, 0.79, 0.76, 0.74, 0.
 ↪71, 0.69, 0.66, 0.64,
       0.62])
wall_area = np.array([294. , 318.5, 294. , 318.5, 343. , 416.5, 245. , 269.5,␣
 ↪294. ,
       318.5, 343. , 367.5])
heating_load = np.array([24.58, 29.03, 26.28, 23.53, 35.56, 32.96, 10.36, 10.
 ↪71, 11.11,
       11.68, 15.41, 12.96])
```

1.1 Train an SVM in sklearn

Perform the following steps: - Combine `relative_compactness` and `wall_area` into one 2-column input feature array - Transform `heating_load` into an array of classes with -1 where `heating_load` entries are less than 20, and +1 otherwise. - Create a Support Vector Classification model in sklearn. Make sure to use a "linear" kernel! Also set the argument "C" to a large number, like `1e5`. - Fit the SVC to your data

```
[ ]: X = np.concatenate([relative_compactness.reshape(-1,1), wall_area.
      ↪reshape(-1,1)], axis=1)
     y = np.ones_like(heating_load)
     y[np.where(heating_load < 20)] = -1
```

```
print(X)

model = SVC(kernel='linear', C=1e5)
model.fit(X, y)
```

```
[[  0.98 294.  ]
 [  0.9  318.5 ]
 [  0.86 294.  ]
 [  0.82 318.5 ]
 [  0.79 343.  ]
 [  0.76 416.5 ]
 [  0.74 245.  ]
 [  0.71 269.5 ]
 [  0.69 294.  ]
 [  0.66 318.5 ]
 [  0.64 343.  ]
 [  0.62 367.5 ]]
```

```
[ ]: SVC(C=100000.0, kernel='linear')
```

1.2 Plotting results

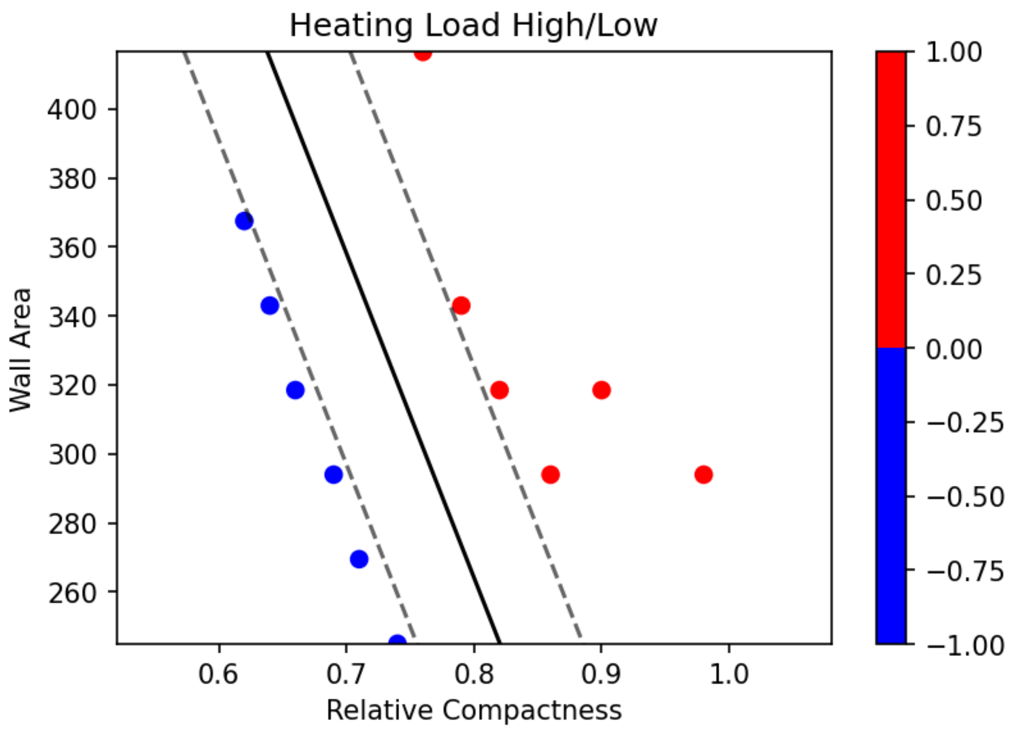
You can make predictions on any X data using the `.predict(X)` method of your SVC model. The `.decision_function()` method will return a continuous class evaluation, 0 at the boundary and 1 or -1 at the margin edges.

Now use the provided function `plot_SV_decision_boundary()`, which takes an sklearn model as its input, to plot the decision boundary.

```
[ ]: plt.figure(figsize=(6,4),dpi=150)
     plot_data(X,y)

     plot_SV_decision_boundary(model)

     plt.xlabel("Relative Compactness")
     plt.ylabel("Wall Area")
     plt.title("Heating Load High/Low")
     plt.show()
```


Heating Load High/Low
Wall Area
Relative Compactness
400
380
360
340
320
300
280
260
0.6
0.7
0.8
0.9
1.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00