

```

import numpy as np

from sklearn.metrics.pairwise import rbf_kernel


def predict_binary_classifier(X):
    """
    X: num test data by 13 features
    """

    # Get params
    params = binary_classifier()

    # compute kernel for all data points
    K = rbf_kernel(params['support_vec'], X, gamma=params['gamma'])

    # Prediction = sign((sum_{i=1}^n y_i*alpha*K(x_i,x)) + rho)
    predictions = np.zeros(X.shape[0])
    for i in range(X.shape[0]):
        predictions[i] = np.sign(np.sum(params['dual_coef']*K[:, i]) + params['intercept'])

    return predictions


def predict_multiclass_classifier(X):
    """
    X: num test data by 10 features
    """

    # Get params
    params = multiclass_classifier()

```

```
K = rbf_kernel(params['support_vec'], X, gamma=params['gamma'])
```

```
# define the start and end index for support vectors for each class
```

```
nv = params['num_support_vec']
```

```
start = [sum(nv[:i]) for i in range(len(nv))]
```

```
end = [start[i] + nv[i] for i in range(len(nv))]
```

```
# calculate:  $\sum(a_p * k(x_p, x))$  between every 2 classes
```

```
dual_coef = params['dual_coef'].T
```

```
predictions_0_1 = np.zeros(X.shape[0])
```

```
for i in range(X.shape[0]):
```

```
    temp_prediction = np.sum(dual_coef[start[0]:end[0], 0] * K[start[0]:end[0], i]) + \
        np.sum(dual_coef[start[1]:end[1], 0] * K[start[1]:end[1], i]) + params['intercept'][0]
```

```
    predictions_0_1[i] = 0 if temp_prediction > 0 else 1
```

```
predictions_0_2 = np.zeros(X.shape[0])
```

```
for i in range(X.shape[0]):
```

```
    temp_prediction = np.sum(dual_coef[start[0]:end[0], 1] * K[start[0]:end[0], i]) + \
        np.sum(dual_coef[start[2]:end[2], 0] * K[start[2]:end[2], i]) + params['intercept'][1]
```

```
    predictions_0_2[i] = 0 if temp_prediction > 0 else 2
```

```
predictions_1_2 = np.zeros(X.shape[0])
```

```
for i in range(X.shape[0]):
```

```
    temp_prediction = np.sum(dual_coef[start[1]:end[1], 1] * K[start[1]:end[1], i]) + \
        np.sum(dual_coef[start[2]:end[2], 1] * K[start[2]:end[2], i]) + params['intercept'][2]
```

```
    predictions_1_2[i] = 1 if temp_prediction > 0 else 2
```

```
decision_function = np.vstack([predictions_0_1, predictions_0_2, predictions_1_2]).T
```



```
7.92366387e+02, 3.00553142e+02, 2.22950860e-01,  
1.00000000e+03, 1.00000000e+03, 5.58636056e+02,  
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2.61920652e+00, 9.96570403e+02, 1.00000000e+03,  
1.00000000e+03, 1.00000000e+03, 1.00000000e+03,  
1.00000000e+03, 1.00000000e+03, 1.02270060e+02,  
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1.00000000e+03, 1.00000000e+03, 1.00000000e+03,  
2.66900636e+02, 1.00000000e+03, 6.54763900e+02,  
3.38216549e+02, 6.86434772e+01, 2.78998678e+02,  
6.97557950e+02, 1.00000000e+03]]))
```

```
# intercept = rho
```

```
intercept = np.array([-2.63232929])
```

```
# support vectors = x_i
```

```
support_vec = np.array([[0.02809756, 0.0455, 0.025, 0.00866667, 0.03799132, -0.00799413,  
0.01061208, 0.016263, 0.00671743, 0.00572262, 0.00578504, 0.00542415, 0.00318195],  
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[1.18829268e-01, 1.00000000e-03, 4.00000000e-03, 1.17948718e-03, 1.18657803e-01, -3.33958979e-04, 3.55599268e-04, 1.41420000e-03, 1.41420000e-03, 2.60312573e-11, 6.32455532e-04, 5.32284214e-04, 7.07110000e-04],

[0.09217073, 0.0085, 0.007, 0.00258974, 0.07952256, -0.00104703, 0.00138337, 0.006364, 0.00466692, 0.00203719, 0.00509166, 0.01307342, 0.021213],

[0.06936585, 0.0095, 0.015, 0.00394872, 0.06837444, -0.00205373, 0.00205373, 0.0084853, 0.00296984, 0.0030984, 0.00234521, 0.00419839, 0.0017678],

[5.05807317, 0.049, 0.082, 0.02402564, 5.06327737, -0.01120311, 0.01120311, 0.031113, 0.0239, 0.01338272, 0.01117139, 0.04351642, 0.020506],

[0.26421951, 0.04, 0.068, 0.00902564, 0.2587529, -0.01040894, 0.01040894, 0.025456, 0.01060666, 0.00890233, 0.01111643, 0.04563416, 0.011314],

[3.59336585, 0.0575, 0.054, 0.02094872, 3.58195886, -0.01804095, 0.01838506, 0.043134, 0.0336584, 0.01240579, 0.01683523, 0.04717173, 0.038184],

[1.29187805, 0.026, 0.016, 0.00689744, 1.27916244, -0.00322078, 0.00490015, 0.025456, 0.01032378, 0.00861112, 0.01863263, 0.0636921, 0.038537],

[6.28670732, 0.1245, 0.127, 0.03102564, 6.35501978, -0.01747513, 0.02813757, 0.084146, 0.04690465, 0.0254467, 0.06541464, 0.18275149, 0.15008],

[10.64578049, 0.079, 0.284, 0.04564103, 10.64447668, -0.01946271, 0.01947497, 0.10889, 0.04186, 0.05739752, 0.06891299, 0.05417812, 0.050205],

```
[3.32470732, 0.092, 0.046, 0.01687179, 3.32977984, -0.02794509, 0.02794509,  
0.072125, 0.0288498, 0.02428699, 0.06277798, 0.10343739, 0.061518],
```

```
[0.07358537, 0.001, 0.004, 0.00153846, 0.0735262, -0.00027514, 0.00027514,  
0.0014142, 0.0009428, 0.00073029, 0.00075277, 0.00053228, 0.00070711]])
```

```
return {'dual_coef': dual_coef,  
        'support_vec': support_vec,  
        'intercept': intercept,  
        'gamma': gamma}
```

```
def multiclass_classifier():
```

```
    gamma = 0.1
```

```
    # dual_coef =  $y_i \cdot \alpha_i$ 
```

```
    dual_coef = np.array([[1.00000000e+02, 0.00000000e+00, 0.00000000e+00, 1.00000000e+02,  
2.19164051e-01,  
1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 0.00000000e+00, 1.00000000e+02,  
2.73972798e+00, 1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02,  
1.00000000e+02, 0.00000000e+00, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02,  
1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 5.78184818e+01,  
1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02,  
1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,  
0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 4.43824790e+01,  
0.00000000e+00, 0.00000000e+00, 8.90021137e+01, 1.00000000e+02, 3.38829336e+01,  
1.00000000e+02, 7.35308055e+01, 5.00832282e+01, 1.00000000e+02, 1.00000000e+02,  
1.00000000e+02, 9.04295253e+01, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,  
1.00000000e+02, 1.00000000e+02, 7.37255035e+01, 1.00000000e+02, 0.00000000e+00,  
1.00000000e+02, -1.00000000e+02, -4.59726588e+01, -9.10060871e+01, -  
0.00000000e+00,
```

-1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -
0.00000000e+00,

-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
0.00000000e+00,

-1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -
0.00000000e+00,

-0.00000000e+00, -1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -
1.00000000e+02,

-1.00000000e+02, -1.00000000e+02, -2.32473120e-01, -1.00000000e+02, -
0.00000000e+00,

-0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -
1.00000000e+02,

-0.00000000e+00, -0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -
0.00000000e+00,

-2.01478019e-01, -1.00000000e+02, -5.32795432e+01, -0.00000000e+00, -
0.00000000e+00,

-1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -0.00000000e+00, -
0.00000000e+00,

-1.00000000e+02, -2.05233000e+01, -0.00000000e+00, -9.58435547e-02, -
0.00000000e+00,

-0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,

-1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -0.00000000e+00, -
0.00000000e+00,

-1.00000000e+02, -0.00000000e+00, -1.14900102e+01, -7.73085905e+01, -
1.00000000e+02,

-0.00000000e+00, -1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -
0.00000000e+00,

-0.00000000e+00, -8.64770605e+01, -1.00000000e+02, -1.18090663e-01, -
1.00000000e+02,

-1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -
0.00000000e+00,

-0.00000000e+00, -6.27523608e+01, -0.00000000e+00, -4.38003436e+01, -
0.00000000e+00,

-0.00000000e+00, -5.36807440e-02, -0.00000000e+00, -0.00000000e+00, -
1.00000000e+02,

-0.00000000e+00, -1.51862509e-01, -2.23505792e+01, -0.00000000e+00, -
1.71549400e+00,

-0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -
0.00000000e+00,

-1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -
0.00000000e+00,

-6.48908553e+01, -5.45079781e+01, -0.00000000e+00, -1.00000000e+02, -
1.00000000e+02,

-1.00000000e+02, -4.15526000e+01, -1.00000000e+02, -0.00000000e+00, -
0.00000000e+00,

-3.97322757e+01, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,

-1.00000000e+02, -8.51452564e+01, -1.00000000e+02, -0.00000000e+00, -
0.00000000e+00,

-0.00000000e+00, -0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -
1.00000000e+02,

-1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -
1.00000000e+02,

-1.00000000e+02, -1.36707150e+01, -2.28944671e+00, -1.00000000e+02, -
1.00000000e+02,

-0.00000000e+00, -1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -
9.70237576e+01,

-0.00000000e+00, -1.00000000e+02, -8.98901380e+00, -1.00000000e+02, -
0.00000000e+00,

-1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -
1.00000000e+02,

-0.00000000e+00, -0.00000000e+00, -0.00000000e+00, -2.31872364e+00, -
0.00000000e+00,

-1.00000000e+02, -1.00000000e+02, -6.81207558e+01, -0.00000000e+00, -
1.00000000e+02,

-1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -
1.00000000e+02,

-1.25804913e+01, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,
-0.00000000e+00, -0.00000000e+00, -5.79636185e+01, -0.00000000e+00, -
3.60349193e+01,
-1.00000000e+02, -1.00000000e+02],
[1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 0.00000000e+00,
1.00000000e+02, 0.00000000e+00, 1.22133880e+01, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 1.00000000e+02,
0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 5.45699567e+01, 0.00000000e+00,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 0.00000000e+00,
1.00000000e+02, 1.00000000e+02, 5.30198194e+01, 1.00000000e+02, 0.00000000e+00,
8.10028022e+01, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 8.57299348e+01,
0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 0.00000000e+00, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 6.98226850e+00, 1.00000000e+02,
1.00000000e+02, 2.28942244e+00, 1.00000000e+02, 0.00000000e+00, 3.10951756e+00,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 2.43965458e+01,
5.54247795e+01, 4.89715327e+01, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 8.77648862e-01,
1.41352297e+00, 1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 5.87399500e+01,
1.00000000e+02, 7.89673831e+01, 7.17216921e-01, 7.08622898e+01, 1.00000000e+02,
1.00000000e+02, 0.00000000e+00, 1.00000000e+02, 0.00000000e+00, 7.08652210e+01,
1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 2.28740165e+00, 1.00000000e+02,

1.00000000e+02, 1.00000000e+02, 6.26644343e+01, 1.51915932e+01, 9.33156003e+01,
1.00000000e+02, 5.73480226e-01, 0.00000000e+00, 0.00000000e+00, 1.00000000e+02,
6.51947143e+01, 0.00000000e+00, 1.00000000e+02, 3.61854680e+01, 1.50700439e+00,
3.93114839e+01, 1.00000000e+02, 1.00000000e+02, 0.00000000e+00, 0.00000000e+00,
1.00000000e+02, 1.62942145e+01, 1.00000000e+02, 1.00000000e+02, 3.65697187e+01,
3.32328741e+01, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02, 1.00000000e+02,
1.00000000e+02, 0.00000000e+00, 3.84017861e-02, 3.27497129e+00, 1.00000000e+02,
1.00000000e+02, 0.00000000e+00, 1.00000000e+02, -1.00000000e+02, -
1.00000000e+02,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
7.87287696e+01,
-1.00000000e+02, -2.17133274e+01, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -
1.00000000e+02,
-1.00000000e+02, -4.03561653e+01, -1.00000000e+02, -1.00000000e+02, -
0.00000000e+00,
-1.00000000e+02, -0.00000000e+00, -0.00000000e+00, -8.73885349e+01, -
1.00000000e+02,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -
1.00000000e+02,
-0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -
0.00000000e+00,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -
1.00000000e+02,
-1.00000000e+02, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -
0.00000000e+00,
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -0.00000000e+00, -
1.00000000e+02,
-0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -7.69821289e+01, -
0.00000000e+00,

```
-1.00000000e+02, -8.28241499e+01, -1.00000000e+02, -6.27852100e+00, -  
8.74723914e+01,
```

```
-0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -  
1.00000000e+02,
```

```
-0.00000000e+00, -0.00000000e+00, -1.00000000e+02, -1.00000000e+02, -  
0.00000000e+00,
```

```
-1.00000000e+02, -1.00000000e+02, -1.00000000e+02, -2.15412985e+01, -  
0.00000000e+00,
```

```
-2.97074994e+01, -9.62658735e+01, -1.00000000e+02, -1.00000000e+02, -  
1.00000000e+02,
```

```
-1.00000000e+02, -0.00000000e+00]]))
```

```
# intercept = rho
```

```
intercept = np.array([-0.62674907, 1.31994877, 0.67252991])
```

```
# support vectors = x_i
```

```
support_vec = np.array([[5.49570019e-07, -2.58632551e-07, 3.16229206e-02, 0.00000000e+00,  
0.00000000e+00, 7.07110000e-02, 0.00000000e+00, 0.00000000e+00, 5.49570019e-07, -1.79132036e-  
08],
```

```
[0.01061208, -0.00799413, 0.00572262, 0.025, 0.02809756, 0.016263, 0.058,  
0.00866667, 0.01061208, 0.03799132],
```

```
[0.0005069, -0.0005069, 0.0031833, 0.007, 0.00060976, 0.0070711, 0.014, 0.00087179,  
0.00039282, 0.00024191],
```

```
[0.02659884, -0.02236652, 0.01818914, 0.054, 3.49731707, 0.062225, 0.063,  
0.01923077, 0.02659884, 3.53815367],
```

```
[0.1959552, -0.19377234, 0.49935644, 2.567, 0.212, 1.2473, 4.086, 0.27730769,  
0.1959552, 0.21128449],
```

```
[0.01296803, -0.01070662, 0.01579683, 0.055, 2.52643902, 0.043134, 0.057, 0.0114359,  
0.01296803, 2.54031008],
```

```
[0.04634941, -0.03616377, 0.03342396, 0.285, 1.25278049, 0.11031, 0.285, 0.05482051,  
0.04634941, 1.24439126],
```

```
[0.01161685, -0.01161685, 0.01472225, 0.061, 0.00495122, 0.036062, 0.131,  
0.00758974, 0.00936955, 0.00494698],
```

[3.36047450e-17, -2.42947453e-17, 0.00000000e+00, 0.00000000e+00,
0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 3.36047450e-17,-2.74622599e-
18],

[0.05403825, -0.04130143, 0.01255584, 0.27, 3.89758537,0.047376, 0.27, 0.06717949,
0.05403825, 3.87923565],

[0.06322635, -0.0450853, 0.0069893, 0.107, 0.52617073,0.019799, 0.166, 0.01469231,
0.06322635, 0.51547654],

[0.02740927, -0.02740927, 0.01595008, 0.106, 0.93326829,0.043841, 0.106,
0.01169231, 0.01663183, 0.92669874],

[0.02181645, -0.02181645, 0.00031623, 0.045, 0.04685366,0.00070711, 0.045,
0.00605128, 0.01964941, 0.05939633],

[0.03168223, -0.03168223, 0.03369301, 0.13, 4.64253659,0.10182, 0.13, 0.03661538,
0.02589546, 4.63806066],

[0.00648365, -0.00648365, 0.00126494, 0.039, 0.29312195,0.0056569, 0.039,
0.00682051, 0.0043318, 0.28575076],

[0.02260403, -0.02260403, 0.01570345, 0.123, 3.08187805,0.053033, 0.123,
0.03435897, 0.01139526, 3.11862292],

[7.19856842e-05, -7.19856842e-05, 0.00000000e+00, 1.00000000e-03, 2.43902439e-05,
0.00000000e+00, 2.00000000e-03, 1.02564103e-04, 5.59639155e-05, 2.43769719e-05],

[5.77955577e-09, -2.77557303e-09, 2.88676449e-04, 0.00000000e+00,
0.00000000e+00, 7.07110000e-04, 0.00000000e+00, 0.00000000e+00, 5.77955577e-09,-4.05052739e-
10],

[0.0168393, -0.0168393, 0.04987211, 0.172, 0.83290244,0.13011, 0.287, 0.02610256,
0.01063438, 0.82408369],

[0.00670974, -0.00670974, 0.00420523, 0.009, 0.92597561,0.012021, 0.012,
0.00369231, 0.00394705, 0.92583814],

[0.04881422, -0.04881422, 0.06039519, 0.128, 0.84173171,0.15274, 0.166, 0.0145641,
0.02705203, 0.83114509],

[5.56411248e-04, -5.56411248e-04, 4.25246049e-03, 1.00000000e-03, 2.43902439e-05,
9.19240000e-03, 1.00000000e-03, 2.56410256e-05, 4.16114259e-04, 2.18000765e-04],

[0.00461828, -0.00346772, 0.00394135, 0.022, 0.88760976,0.011314, 0.022,
0.00489744, 0.00461828, 0.88799505],

[0.02181738, -0.02181738, 0.06135461, 0.472, 9.21263415,0.16688, 0.472, 0.0695641,
0.01361679, 9.19153391],

[0.18064104, -0.18064104, 0.02243327, 0.141, 1.74753659,0.065761, 0.141,
0.02587179, 0.08614869, 1.89288442],

[0.04502684, -0.04502684, 0.03092595, 0.075, 0.66726829,0.070004, 0.075,
0.01507692, 0.02703687, 0.6524218],

[0.00350864, -0.00337375, 0.00472601, 0.026, 0.48378049,0.016971, 0.038,
0.00794872, 0.00350864, 0.48333175],

[4.22507597e-120, -2.00921455e-120, 0.00000000e+000, 0.00000000e+000,
0.00000000e+000, 0.00000000e+000, 0.00000000e+000, 0.00000000e+000, 4.22507597e-120,
9.65026603e-122],

[0.0511954, -0.0511954, 0.00917865, 0.032, 1.50741463,0.028284, 0.056, 0.00958974,
0.01612377, 1.43087637],

[0.0504243, -0.03682241, 0.03693438, 0.147, 3.4434878,0.086267, 0.147, 0.02051282,
0.0504243, 3.49633275],

[0.00556735, -0.00442938, 0.00870258, 0.033, 0.10897561,0.025456, 0.033,
0.00553846, 0.00556735, 0.12761266],

[2.34438020e-08, -2.34438020e-08, 0.00000000e+00, 0.00000000e+00,
0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 1.15475168e-08,-1.38812548e-
09],

[0.01361869, -0.01361869, 0.00208565, 0.05, 0.66663415,0.0049497, 0.05, 0.00510256,
0.0087315, 0.66182973],

[0.00526982, -0.00287197, 0.016589, 0.06, 0.02595122,0.042426, 0.06, 0.00515385,
0.00526982, 0.02530658],

[1.65194036e-02, -1.65194036e-02, 3.87787571e-04, 7.00000000e-02, 3.74146341e+00,
2.33350000e-02, 1.06000000e-01, 2.41025641e-02, 1.58008422e-02, 3.72790310e+00],

[7.19856850e-05, -7.19856850e-05, 2.88676449e-04, 1.00000000e-03, 2.43902439e-05,
7.07110000e-04, 2.00000000e-03, 1.02564103e-04, 5.59639159e-05, 2.44149661e-05],

[4.35202063e-02, -4.35202063e-02, 5.32593935e-03, 3.24000000e-01, 1.14713659e+01,
1.20920000e-01, 3.24000000e-01, 8.83589744e-02, 3.31111507e-02, 1.13977278e+01],

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[0.04266586, -0.04266586, 0.0106888, 0.126, 3.67914634, 0.041719, 0.132, 0.02676923, 0.03469959, 3.67052968],

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[0.01877031, -0.00838677, 0.02480503, 0.068, 2.56031707, 0.077075, 0.068, 0.02294872, 0.01877031, 2.4790144],

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[0.00190969, -0.00179795, 0.00162791, 0.01, 0.06846341, 0.0056569, 0.01, 0.00307692, 0.00190969, 0.06774886],

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[1.59897956e-02, -1.15451745e-02, 1.01170444e-02, 3.20000000e-01, 1.16454634e+01, 1.37890000e-01, 3.47000000e-01, 8.94615385e-02, 1.59897956e-02, 1.15869935e+01],

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[0.02835417, -0.02835417, 0.0188188, 0.111, 3.12563415, 0.054447, 0.111, 0.02897436, 0.01213407, 3.17337638],

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[0.00684639, -0.0053288, 0.01423898, 0.121, 0.82373171,0.041012, 0.121, 0.01853846, 0.00684639, 0.82149219],

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[0.01601326, -0.01601326, 0.00953142, 0.044, 4.34658537,0.029698, 0.082, 0.02784615, 0.0152717, 4.34824852],

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[0.01692731, -0.01692731, 0.00934515, 0.17, 2.76797561,0.04879, 0.17, 0.03212821, 0.00804809, 2.84223399],

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[0.0025624, -0.0017206, 0.00242901, 0.013, 0.22082927,0.0084853, 0.015, 0.00476923, 0.0025624, 0.21293887],

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[0.03710778, -0.03710778, 0.00465324, 0.076, 4.443, 0.03182, 0.086, 0.02310256, 0.03407041, 4.40858239],

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[0.00241135, -0.00186458, 0.0089488, 0.059, 1.06817073, 0.02192, 0.059, 0.00302564, 0.00241135, 1.06816635],

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[0.02311331, -0.02311331, 0.01137534, 0.062, 4.10326829, 0.048083, 0.076, 0.02253846, 0.02280474, 4.08634796],

[0.00020308, -0.00020308, 0.00116188, 0.006, 0.08992683, 0.0021213, 0.006, 0.00030769, 0.0001032, 0.09000535],

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[0.02995729, -0.02995729, 0.02248653, 0.065, 3.89078049, 0.067175, 0.072, 0.02235897, 0.02419343, 3.84855841],

[0.03168889, -0.01073342, 0.02388286, 0.091, 4.27865854, 0.08061, 0.091, 0.02253846, 0.03168889, 4.27815091],

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[0.00033805, -0.00023428, 0.00154918, 0.005, 0.06904878, 0.0035355, 0.005, 0.00117949, 0.00033805, 0.06819891],

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[0.00860053, -0.00687122, 0.00984125, 0.028, 1.9362439, 0.032527, 0.028, 0.01158974, 0.00860053, 1.85928806],

[1.62829923e-02, -1.27782612e-02, 5.03488484e-03, 2.93000000e-01, 1.10292927e+01, 9.19240000e-03, 2.93000000e-01, 4.98717949e-02, 1.62829923e-02, 1.10624738e+01],

[5.11402880e-02, -5.11402880e-02, 0.00000000e+00, 4.40000000e-02, 2.07410488e+01, 1.55560000e-02, 4.40000000e-02, 1.24102564e-02, 2.17468552e-02, 2.07288498e+01],

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[8.49163246e-03, -7.36645573e-03, 1.26472005e-03, 4.00000000e-02, 4.19334146e+00, 2.82840000e-02, 8.00000000e-02, 2.64615385e-02, 8.49163246e-03, 4.21478989e+00],

[0.04132153, -0.04132153, 0.08233984, 0.491,13.82968293, 0.1789, 0.491, 0.09758974, 0.02614823, 13.93101321],

[0.00138337, -0.00104703, 0.00203719, 0.007, 0.09217073,0.006364, 0.007, 0.00258974, 0.00138337, 0.07952256],

[0.02013966, -0.02013966, 0.06794402, 0.35,11.46958537, 0.12728, 0.35, 0.09010256, 0.01988961, 11.45768721],

[0.00205373, -0.00205373, 0.0030984, 0.015, 0.06936585,0.0084853, 0.017, 0.00394872, 0.00152146, 0.06837444],

[0.01040894, -0.01040894, 0.00890233, 0.068, 0.26421951,0.025456, 0.068, 0.00902564, 0.00546137, 0.2587529],

[8.19684883e-03, -8.19684883e-03, 2.09202670e-02, 6.30000000e-02, 6.51109756e+00, 4.45480000e-02, 6.30000000e-02, 1.66153846e-02, 5.80672162e-03, 6.50965345e+00],

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[0.00490015, -0.00322078, 0.00861112, 0.016, 1.29187805,0.025456, 0.016, 0.00689744, 0.00490015, 1.27916244],

[0.0134886, -0.00766548, 0.0189313, 0.109, 6.21553659,0.041012, 0.109, 0.03533333, 0.0134886, 6.22416714],

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[0.02813757, -0.01747513, 0.0254467, 0.127, 6.28670732, 0.084146, 0.127, 0.03102564,
0.02813757, 6.35501978],
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[0.02044022, -0.02044022, 0.03488198, 0.176, 8.10602439, 0.065761, 0.176,
0.04466667, 0.01777938, 8.12759058],
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[0.01947497, -0.01946271, 0.05739752, 0.284, 10.64578049, 0.10889, 0.296,
0.04564103, 0.01947497, 10.64447668],
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[0.01922614, -0.01922614, 0.02849813, 0.097, 4.29178049, 0.08061, 0.097, 0.02720513,
0.01556252, 4.30987745],
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```
[0.00027514, -0.00027514, 0.00073029, 0.004, 0.07358537, 0.0014142, 0.004,
0.00153846, 0.0002546, 0.0735262]])
```

```
num_support_vec = [61, 97, 89]
```

```
return {'dual_coef': dual_coef,
        'support_vec': support_vec,
        'intercept': intercept,
        'gamma': gamma,
        'num_support_vec': num_support_vec}
```

```
if __name__ == '__main__':
```

```
binary_test_data = np.array([
    [0., 0., 0., 0., 0., 0., 0., 0.14212846, 0.02368808, 0.0580237, 0.06960633, 0.04921911, 0.],
    [0.21073171, 0.794, 0.922, 0.14076923, 0.20974742, -0.32312654, 0.32312654, 0.88741901,
0.17300546, 0.3544437, 0.39891235, 0.5271785, 0.0076014],
    [0.04058537, 0.009, 0.008, 0.00225641, 0.03362015, -0.00420592, 0.00420592, 0.00565685,
0.00235702, 0.00193218, 0.00581951, 0.00861878, 0.00671751],
    [0.07887805, 0.0035, 0.007, 0.00179487, 0.07598638, -0.00096018, 0.00113304, 0.00494975,
0.00235702, 0.00177012, 0.00098742, 0.00128452, 0.00335876],
    [0.10126829, 0.0015, 0.004, 0.00174359, 0.09954269, -0.00034342, 0.00034342, 0.00212132,
0.00153206, 0.00028868, 0.00075829, 0.00064872, 0.00212132]
```

```

])

binary_predictions = predict_binary_classifier(binary_test_data)

import pickle

f2 = open('/Users/sarataylor/Dev/eda-explorer-public/SVMBinary.p', 'rb')
s2 = f2.read()
clf = pickle.loads(s2)

assert(len([1 for i in range(5) if binary_predictions[i] != clf.predict(binary_test_data)[i]]) == 0)

# Test multiclass

test_data = np.array([[3.11141105e-02, -3.11136868e-02, 2.42079822e-02, 7.49220000e-02,
1.15335178e+01, 8.37681119e-02, 7.49220000e-02, 1.03606795e-02, 3.11141105e-02,
1.15205823e+01],

[0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],

[0.10255266, -0.10255266, 0.03827904, 0.328471, 6.61645195, 0.26352986, 0.406695,
0.02494941, 0.05696297, 7.64941098],

[0.1095642, -0.1095642, 0.08589464, 0.113983, 11.49373772, 0.26352986, 0.113983,
0.01375942, 0.03753318, 11.51816541],

[0.15404637, -0.08878016, 0.1020834, 0.768917, 11.40673696, 0.28606288, 0.768917,
0.08697605, 0.15404637, 11.46339086]])

multi_predictions = predict_multiclass_classifier(test_data)

f2 = open('/Users/sarataylor/Dev/eda-explorer-public/SVMMMulticlass.p', 'rb')
s2 = f2.read()
clf = pickle.loads(s2)

assert (len([1 for i in range(5) if multi_predictions[i] != clf.predict(test_data)[i]]) == 0)

```

