```
% load data
wdbc_data_orig = readtable("wdbc.data.txt");
[nrows, ncols] = size(wdbc_data_orig)
```

```
nrows = 569
ncols = 32
```

```
wdbc_data = wdbc_data_orig(:, 3:ncols);
wdbc_data = table2array(wdbc_data)
```

```
wdbc_data = 569×30
10^3 ×
    0.0180    0.0104    0.1228    1.0010    0.0001    0.0003    0.0003    0.0001 ···
    0.0206    0.0178    0.1329    1.3260    0.0001    0.0001    0.0001    0.0001
    0.0197    0.0213    0.1300    1.2030    0.0001    0.0002    0.0002    0.0001
    0.0114    0.0204    0.0776    0.3861    0.0001    0.0003    0.0002    0.0001
    0.0203    0.0143    0.1351    1.2970    0.0001    0.0001    0.0002    0.0001
    0.0124    0.0157    0.0826    0.4771    0.0001    0.0002    0.0002    0.0001
    0.0182    0.0200    0.1196    1.0400    0.0001    0.0001    0.0001    0.0001
    0.0137    0.0208    0.0902    0.5779    0.0001    0.0002    0.0001    0.0001
    0.0130    0.0218    0.0875    0.5198    0.0001    0.0002    0.0002    0.0001
    0.0125    0.0240    0.0840    0.4759    0.0001    0.0002    0.0002    0.0001
     ⋮
```

```
wdbc_group = wdbc_data_orig.Var2;
```

```
M = wdbc_data(wdbc_group(1:500) == "M", :); % Malicious
B = wdbc_data(wdbc_group(1:500) == "B", :); % Benign

[mcnt, num_features] = size(M);
[bcnt, ~           ] = size(B);
```

```
% quadraic programming
tau = 1000;
quadratic = diag([ones(num_features, 1); zeros(1 + mcnt + bcnt, 1)]);
linear = [zeros(num_features + 1, 1); tau * ones(mcnt + bcnt, 1)];
% malicious
malicious_lhs = [-M ones(mcnt, 1) -eye(mcnt) zeros(mcnt, bcnt)];
benigh_lhs = [B -ones(bcnt, 1) zeros(bcnt, mcnt) -eye(bcnt)];
mb_rhs = -ones(mcnt + bcnt, 1);

% solve
[xstar, fstar] = quadprog(quadratic, linear, ...
                          [malicious_lhs;benigh_lhs], mb_rhs, ...
                          [], [], ...
                          [-inf*ones(num_features + 1, 1); ...
                            zeros(mcnt + bcnt, 1)] ...
                         );
```

```
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
```

```
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
fstar
```

```
fstar = 1.9427e+04
```

```
alpha = xstar(1:30)
```

```
alpha = 30×1
   -7.0337
   -0.0094
    0.6434
    0.0328
    2.4662
  -14.3500
   -6.4099
   11.4022
    7.6009
    2.3617
     ⋮
```

```
bias = xstar(31)
```

```
bias = 25.8190
```

```
plane = @(x) x * alpha - bias
```

```
plane = function_handle with value:
    @(x)x*alpha-bias
```

```
sum(plane(M) >= 1) / mcnt, sum(plane(B) <= -1) / bcnt
```

```
ans = 0.9436
ans = 0.9672
```

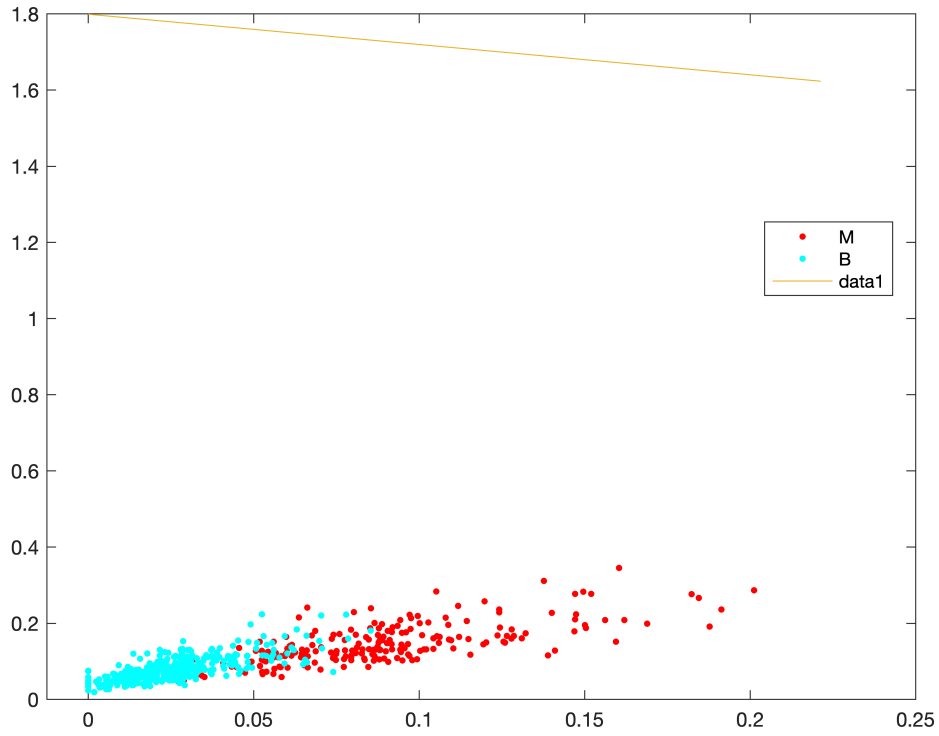
```
xidx = 8;
yidx = 6;

gscatter(wdbc_data(:, xidx), wdbc_data(:, yidx), wdbc_group);
hold on

px = linspace(0.9 * min(wdbc_data(:, xidx)), ...
              1.1 * max(wdbc_data(:, xidx)));
py = (alpha(xidx) * px - bias) / alpha(yidx);

plot(px, py)

hold off
```



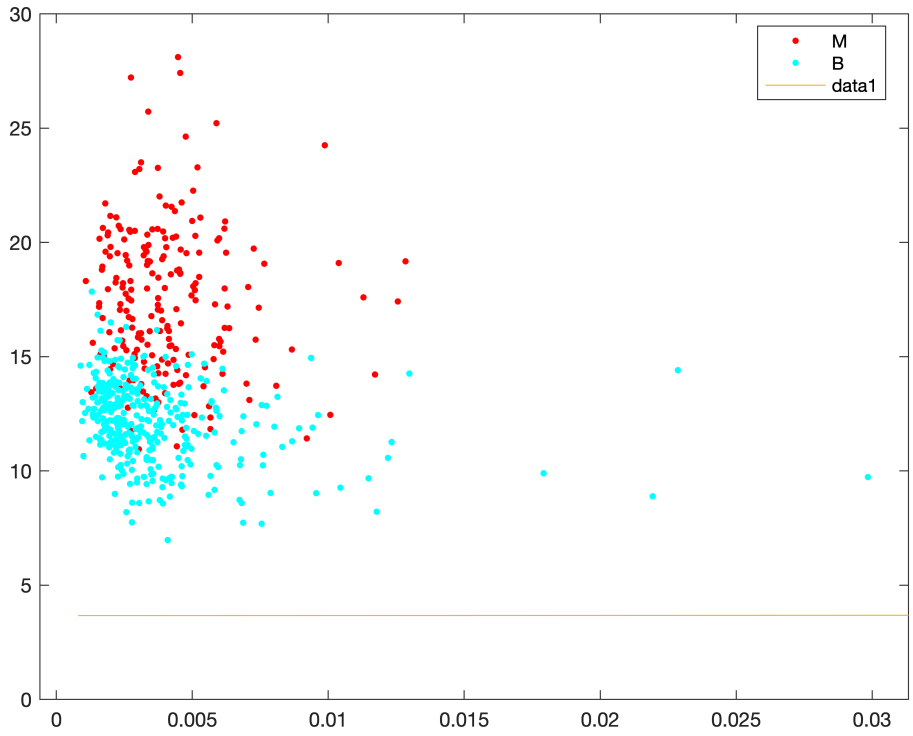

```
xidx = 20;
yidx = 1;

gscatter(wdbc_data(:, xidx), wdbc_data(:, yidx), wdbc_group);
hold on

px = linspace(0.9 * min(wdbc_data(:, xidx)), ...
              1.1 * max(wdbc_data(:, xidx)));
py = (alpha(xidx) * px - bias) / alpha(yidx);

plot(px, py)

hold off
```




```
% determine whether the data is indeed separable

u = xstar(32:31+mcnt)
```

```
u = 195×1
    0.3115
    0.3116
    0.3117
    0.3117
    0.3116
    0.3120
    0.3117
    0.3118
    0.3117
    0.3117
     ⋮
```

```
v = xstar(31+mcnt+1:31+mcnt+bcnt)
```

```
v = 305×1
    0.0000
    0.0000
    0.0000
    0.0000
    0.0000
    0.0000
    0.6769
    0.0000
    0.0000
    0.0000
```

⋮

```
sum(abs(u) <= eps(max(u))), sum(abs(v) <= eps(max(v)))
```

```
ans = 189
ans = 299
```

```
slack = [u;v]; eps(max(slack))
```

```
ans = 8.8818e-16
```

```
sum(abs(slack) <= eps(max(slack)))
```

```
ans = 488
```

```
% test SVM with the remaining part of the data
wdbc_test = wdbc_data(501:nrows, :);
wdbc_test_group = wdbc_group(501:nrows, :);
M_test = wdbc_test(wdbc_test_group == "M", :);
B_test = wdbc_test(wdbc_test_group == "B", :);

[mtestcnt, ~] = size(M_test)
```

```
mtestcnt = 17
```

```
[btestcnt, ~] = size(B_test)
```

```
btestcnt = 52
```

```
sum(plane(M_test) >= 1) / mtestcnt
```

```
ans = 1
```

```
sum(plane(B_test) <= -1) / btestcnt
```

```
ans = 0.9423
```

```
sum(plane(M_test) <= -1) / mtestcnt
```

```
ans = 0
```

```
sum(plane(B_test) >= 1) / btestcnt
```

```
ans = 0.0192
```

```
sum(plane(M_test) < 1 & plane(M_test) > -1) / mtestcnt
```

```
ans = 0
```

```
sum(plane(B_test) < 1 & plane(B_test) > -1) / btestcnt
```

```
ans = 0.0385
```