This is the report of one vs one classifier.

```
trainX = rescale(clean_data(trainX));
testX = rescale(clean_data(testX));
col1 = ones([60000,1]);%add a column of one to the matrix
trainX = [trainX col1];
```

Get recognize y by voting i or j

```
%find trainY after it goes through the binary classi
trainY_i_j = [];
for j = 0:9
    for i = 0:9
        if i<j
            trainY_i_j = [trainY_i_j;bi_clasi_ovo(trainY,i,j)];
        end
    end
end
```

calculate matrix of beta and alpha

```
result_i_j = [];
for h = 1:45
    result_i_j = [result_i_j lsqlin(double(trainX),double(trainY_i_j(h,:)))];
end
```

Calculate result using one_v_one function which count the votes for each digit in each class

```
%one vs all alpha beta values
alpha_i_j = result_i_j(end,:);
alpha_i_j
```

alpha_i_j = 1×45
   -0.0834   0.1027   0.1862   0.1339   0.2174   0.0312   -0.0496   0.0338 ···

```
beta_i_j = result_i_j(1:end-1,:);
beta_i_j
```

beta_i_j = 493×45
    0.0006   0.1090   0.1084   -0.0453   -0.0459   -0.1543   0.2117   0.2112 ···
   -0.0248   0.0788   0.1036   -0.0333   -0.0085   -0.1121   0.0321   0.0569
    0.0178   0.0585   0.0407   -0.0483   -0.0661   -0.1068   0.0682   0.0504
   -0.0017   0.0400   0.0417   -0.0122   -0.0105   -0.0522   0.0304   0.0321
   -0.0354   0.0179   0.0534   -0.0819   -0.0464   -0.0998   0.0138   0.0493
   -0.0101   0.0506   0.0607   -0.0581   -0.0480   -0.1087   0.0190   0.0291
    0.0060   0.0321   0.0262   -0.0253   -0.0313   -0.0575   0.0216   0.0157
   -0.0292   0.0275   0.0566   -0.0921   -0.0630   -0.1196   -0.0097   0.0195
   -0.0228   -0.0548   -0.0320   -0.0046   0.0181   0.0502   0.0408   0.0636
    0.0335   -0.0340   -0.0675   -0.0026   -0.0361   0.0314   0.0660   0.0325
      :
      :

1

```
trainX(:,end)=[];
result_ovo = [];
for i = 1:60000
    a_i_j = trainX(i,:);
    b_i_j = a_i_j*beta_i_j+alpha_i_j;
    result_ovo = [result_ovo one_v_one(b_i_j)];
end
```

Get error rate.

```
count_i_j = 0;
for j = 1:60000
    if trainY(j) == result_ovo(j)
        count_i_j = count_i_j + 1;
    end
end
ovo_error = 1-(count_i_j/60000);
ovo_error
```

ovo_error = 0.2609

Get confusion matrix.

```
cof_matrix_i_j = zeros(10);
for i = 1:10
    for j = 1:10
        for k = 1:60000
            if trainY(k) == i-1 && result_ovo(k) == j-1
                cof_matrix_i_j(i,j) = cof_matrix_i_j(i,j)+1;
            end
        end
    end
end

sum_col_i_j = [];
for i = 1:10
    sum_col_i_j(i) = sum(cof_matrix_i_j(i,:));
end

cof_matrix_i_j = [cof_matrix_i_j (sum_col_i_j).'];

sum_row_i_j = [];
for i = 1:11
    sum_row_i_j(i) = sum(cof_matrix_i_j(:,i));
end
cof_matrix_i_j = [cof_matrix_i_j;(sum_row_i_j)];
cof_matrix_i_j
```

```
cof_matrix_i_j = 11×11
      5827          12          21          14          18          13 ···
        10        6615          58          14          21          20
       171         361        5022         174         100          10
        97         260         237        5352          36          73
        49         179          75          14        5418          63
       489         192          63         645         103        3763
       444         234         159           5          93          79
       429         466         148         264         330          17
       538        1497         332         696         243         481
       406         494         161         430        2402         137
     :
     :
     :
```

To compare the result of one vs all and one vs one classifier. The one vs one classifier has higher error rate than one vs all classifier. Thus from my experiment result, one vs one performs worse than one vs all.