CSI 747 / MATH 689

Final Exam. Computational part. Due December 17 , 2012. 10 am.

Solve a hand written digits recognition problem using the support vector machine and Nonlinear Rescaling-Augmented Lagrangian method.

1) Use the discretized hand written digits data for the midterm project.
2) Model the dual SVM optimization problem in MATLAB to be solved by the NRAL code made earlier in the class:

$$\max_{\alpha} \sum_{i=1}^{l} \alpha_i - 0.5 \sum_{i,j}^{l} \alpha_i \alpha_j y_i y_j K(x_i, x_j)$$

s.t.

$$\sum_{i=1}^{l} \alpha_i y_i = 0, \quad 0 \le \alpha_i \le C, \quad i = 1,2,...,l$$

3) Train the dual polynomial kernel machine with $\alpha = 0.0156$, $\beta = 0$, $d = 3$ to detect 3s and 6s only. Calculate the error rate for testing examples.
4) Train the dual radial basis function machine $\gamma = 0.0521$ to detect 3s and 6s again. Calculate the error rate for testing examples.
5) Chose the machine with the better error rate for the main experiment.
6) Run 10 SVMs to train to detect a particular digit (e.g. 2) against the rest digits (e.g. 0, 1, 3, 4, 5, 6, 7, 8, 9). In the training use the value y = +1 for a particular digit and y = -1 for the rest of them. Obtain 10 different separating hyperplanes $h_0,\ldots,h_9$ that separate each 0,1,…,9 from the rest digits.
7) While testing the digits you may find out that a particular digit may be classified not uniquely. For example, some tested digit can be on the positive side of h_3, h_5 and h_8, meaning that this digit can be classified as 3, 5 or 8. To resolve the ambiguity classify this digit as the one that corresponds to the hyperplane with the maximum classification number

$$\sum_{i=1}^{l} y_i \alpha_i^* K(x_i, x) - b$$

8) Use C = 100 as the penalty parameter. Increase if necessary.
9) Use k=100 for the NRAL method. Change if necessary.
10) Document all the experiments you are doing. For each solved optimization problem, for each iteration of the NRAL method display
    a) NRAL iteration number
    b) $\|\nabla_{\alpha} L(\cdot)\|$
    c) Equality constraints infeasibility $\|g(\cdot)\|$
    d) Inequality constraints infeasibility $\max\{0, -c_i(\cdot), i = 1,...m\}$
    e) Complementarity $\max\{|c_i(\cdot) y_i|, i = 1,...m\}$
    f) Number of Newton steps within this NRAL iteration.
11) After each newton step display $\|\nabla_{\alpha} \Phi(\cdot)\|$
12) Calculate the total SVM error.
13) Submit the graded Midterm project together with the final exam.