Machine Learning for Computer Vision
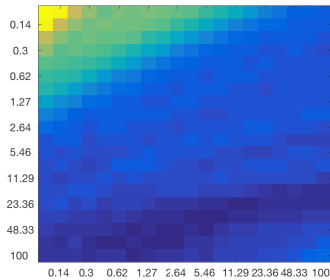
[MVA 2015/2016]

## Programming Assignment 2

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1 Support Vector Machine classifiers

We use LibSVM library to train a C-SVM with rbf kernel. To choose the best couple of parameters C (regularization) and γ (rbf kernel parameter $K(x,y) = exp(-\gamma\|x - y\|^2)$) we consider a 10-folds cross-validation.

Best perfromance achieved with $(\gamma, C) = (33.5982, 5.4556)$

After training on the full set we obtain the boundary decision shown below with the support vectors.
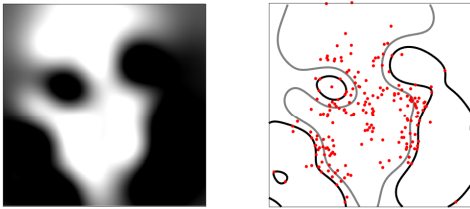
Decision boundary (svm probabilities on a grid) and support vectors

With this model we achieved an error rate of 17.80% (89/500)

2 Adaboost

We implemented the Adaboost algorithm where at each round t we fit a weak learner $h_t(x)$ to the training data $\mathcal{X} = (x_n, y_n)_{1 \le n \le N}$ by minimizing:

$$L_t = \sum_{n=1}^{N} w_n^{(t)} \mathbb{1}[h_t(x_n) \neq y_n]$$

We initialize the weights at $w_i^{(0)} = \frac{1}{N}$, $\forall i$ and update at each round as follows:

$$\epsilon_t = \frac{\sum_{n=1}^{N} w_n^{(t)} \mathbb{1}[h_t(x_n) \neq y_n]}{\sum_{n=1}^{N} w_n^{(t)}}$$

$$\alpha_t = \log\left(\frac{1 - \epsilon_t}{\epsilon_t}\right)$$

$$w_n^{(t+1)} = \frac{1}{Z_t} w_n^{(t)} \exp\left(-\alpha_t h_t(x_n) y_n\right)$$

where Z_t is a scaling factor so that the weights sum to 1. The final strong model makes predictions given by:
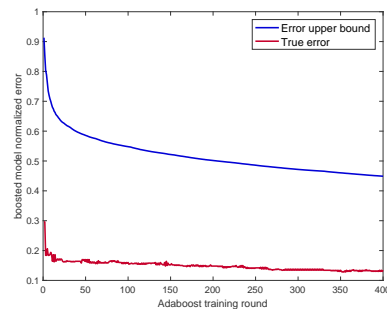
$$H_T(x) = \sum_{t=1}^{T} \alpha_t h_t(x)$$

The error of the boosted model is estimated as:

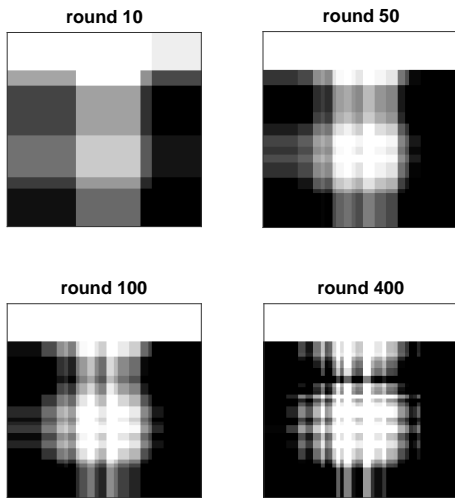$$E_T = \frac{1}{N} \sum_{n=1}^{N} \mathbb{1}[sign(H_T(x_n)) \neq y_n]$$

We can estimate an upper bound of E_T with:

$$\widetilde{E}_T = \sum_{n=1}^{N} \exp\left(-y_n H_T(x_n)\right) = \prod_{t=1}^{T} Z_t$$
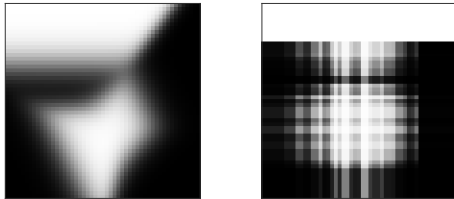
On the right figure we report the error defined as the number of misclassified samples from the training set while on the left one we plot the normalized errors E_T and $\widetilde{E}_T$.

Error of the strong model $f = \text{sign } H_t$ at each round

round 10   round 50
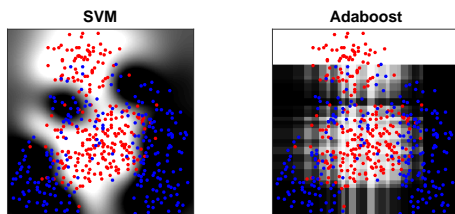
round 100   round 400

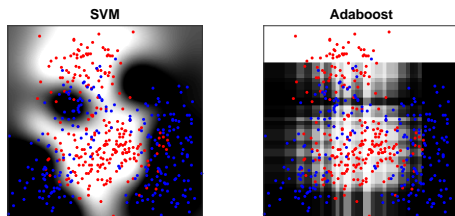*Strong models $H_{10}, H_{50}, H_{100}, H_{400}$*

Left: true class posterior - Right: Final adaboost classifier

2.1   SVM vs. Adaboost

We measure the Adaboost performance on the same test set as the SVM above. The decision boundaries are shown below with the test set samples scattered to visualize the quality of each model. The test error rate of the Adaboost classifier is 21.40% vs 17.80% for the SVM while on the training set Adaboost misclassified 67/500 and the SVM 69/500. Visually the probability distribution obtained with the SVM is much closer to the ground truth prior.

SVM   Adaboost

(a) *Train*

SVM   Adaboost

(b) *Test*

SVM vs Adaboost