Machine Learning Assignments
Assignment 2.

1. (5 points) A Neural Network has 10 input units (the constant $x_0^{(0)}$ is counted here as a unit), one output unit, and 36 hidden units (each $x_0^{(l)}$ is also counted as a unit). The hidden units can be arranged in any number of layers $l = 1, ..., L-1$, and each layer is fully connected to the layer above it.
What is the minimum possible number of weights that such a network can have?

[a] 46
[b] 47
[c] 56
[d] 57
[e] 58

2. (10 points) Consider the dataset in Fig 1, with points belonging to two classes, blue squares and red circles.

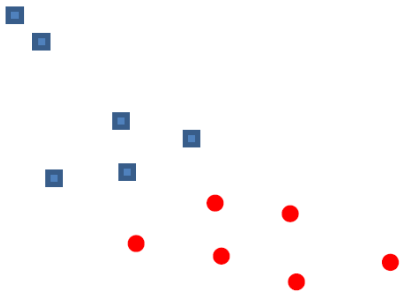

Fig. 1

(a) [2 pt] Draw (approximately) the hard-margin SVM line separator and two corresponding margin boundaries.
(b) [1 pt] Suppose we find $(1/2)*\mathbf{w}^2$ to be 2 in the SVM optimization. What is the margin, i.e. the distance of the closest points to the line?

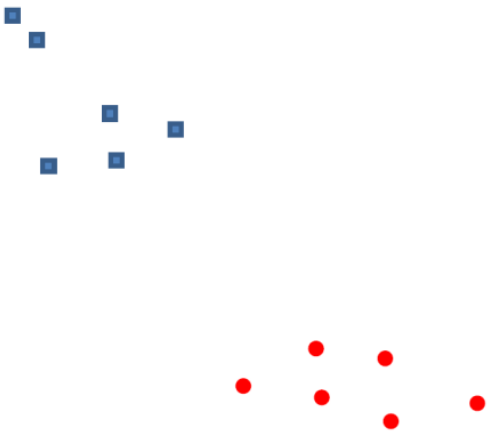

Fig. 2

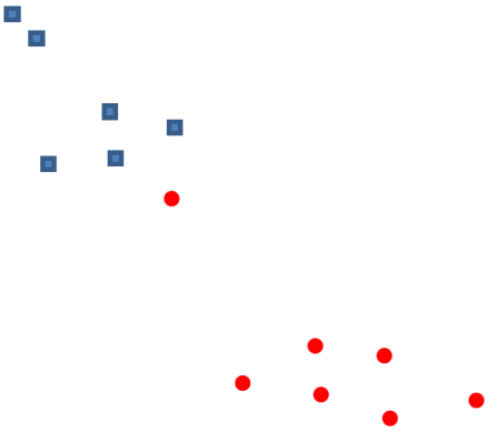

Fig. 3

(c) [1 pt] Now consider the dataset in Fig 2 (the red points are shifted below). Will $(1/2)*\mathbf{w}^2$ be smaller or greater than previously? Explain.

(d) [2 pt] Using a ruler, and the fact that $(1/2)*\mathbf{w}^2$ was 2 previously, find (approximately) the magnitude of the new line coefficient vector, $\mathbf{w}'$, i.e. $||\mathbf{w}'||$.

(e) [3 pt] Consider the dataset in Fig 3 (with one additional red circle quite close to the blue squares). Assuming soft-margin SVM and C=1, draw a line that does not perfectly separate the points, but which is nonetheless better than the line that perfectly separates the points. (Draw it in the figure, and explain why).

(f) [1 pt] Why would we rather prefer the line in (e) to the line that perfectly separates the points?

3. (8 points) You are given the data points (x, y) in 1 dimensional space $\mathcal{X}$ as :

$(-1, 0), (\rho, 1), (1, 0),$ where $\rho \geq 0$;

and a choice between two models: constant $h_0(x) = c$ and linear $h_1(x) = ax + b$.

For which value of ρ would the two models perform the same using leave-one-out cross-validation with the squared error measure?

[a] $\sqrt{\sqrt{3}+4}$

[b] $\sqrt{\sqrt{3}-1}$

[c] $\sqrt{9+4\sqrt{6}}$

[d] $\sqrt{9-\sqrt{6}}$

[e] none of the above