Homework3 Report

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1 Hard Margin SVM

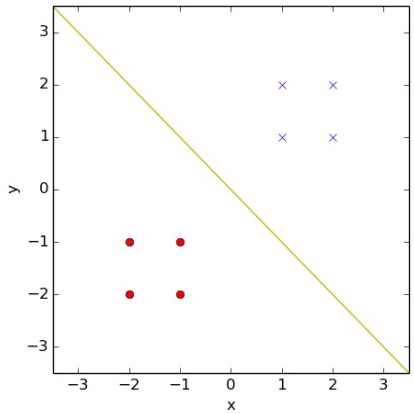
1.1 Perpendicular

The boundary is a hyperplane $w^T x + b = 0$. For any two points x_1, x_2 in this hyperplane, we have $w^T x_1 + b = 0$ and $w^T x_2 + b = 0$. This implies $w^T(x_2 - x_1) = 0$ which means w is perpendicular to the vector $\overrightarrow{x_1 x_2}$. Due to x_1 and x_2 can be chosen arbitrarily, w is perpendicular to any vector in the hyperplane. Thus w is perpendicular to the hyperplane which is the boundary.

1.2 Support Vectors

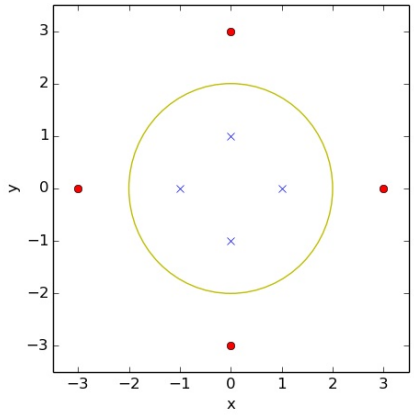
Due to x is the support vector of the positive class, we have $w^T x + b = 1$, then $b = 1 - w^T x$. By the same method, $b = -1 - w^T y$ if y is the support vector of the negative class.

1.3 Linear Boundary



The boundary is shown as the yellow line in the above figure. The two support vectors are $(-1, -1)$ and $(1, 1)$.

1.4 Circular Boundary



The boundary is shown as the yellow circle in the above figure. We use the transform $\phi(x) = |x|$ thus kernel is $K(x, x') = |x||x'|$. For all positive samples, $\phi(x) = 3$. For all negative samples, $\phi(x) = 1$. Therefore the boundary is $\phi(x) = 2$ which is just the yellow circle.

2 Soft Margin SVM