# 1 Classification and Linear Programming

So I'm not sure if this is right, but since I'm already past due I mind as well take a shot.

Since they both share $x$ I'm going to rename them. The $x$ for linear programming, I will call $x^{lp}$ and the $x$ for SVM will just remain $x$.

So first we need to change $z = \xi$ into a vector so it fits the form of the linear programming problem. So we can do $c = [1, 1, \ldots 1]$ of $n$ length and let $x^{lp} = [\xi/n, \xi/n, \ldots \xi/n]$ on $n$ length. Will also have to add constraint that all elements of $x^{lp}$ are the same value, i.e. $x^{lp}[i] = x^{lp}[j] \quad \forall i \in \{1..n\}, \quad \forall j \in \{1..n\}$.

Finally we must convert our constraints. Constraint (3) is simple, to keep $\xi \geq 0$ we can impose that $x^{lp}[i] \geq 0 \quad \forall i \in \{1..n\}$

Lets rearrange constraint 2 so we can get something in the form of $Ax \geq b$.

$$
\begin{aligned}
y_i(\vec{w}^T \vec{x_i} + \theta) &\geq 1 - \xi \quad \forall(\vec{x_i}, y_i) \in S \\
y_i - \frac{1}{(\vec{w}^T \vec{x_i} + \theta)} &\geq \frac{-\xi}{(\vec{w}^T \vec{x_i} + \theta)} \quad \forall(\vec{x_i}, y_i) \in S \\
-y_i + \frac{1}{(\vec{w}^T \vec{x_i} + \theta)} &\leq \frac{1}{(\vec{w}^T \vec{x_i} + \theta)}\xi \quad \forall(\vec{x_i}, y_i) \in S
\end{aligned}
$$

So now the LHS (left hand side) of the equation can be converted to $\vec{b}$ and the RHS (right hand side) can be converted to $\boldsymbol{A}\vec{x}$

To convert the LHS, you just need to run the math for each index to convert it into an array. i.e.

$$b[i] = -y_i + \frac{1}{(\vec{w}^T \vec{x_i} + \theta)} \quad \forall i \in \{1..n\}$$

To convert the RHS, we need a matrix and an vector for $\xi$. Well we already established we we should need to use $x^{lp} = [\xi/n, \xi/n, \ldots \xi/n]$, so now we need the matrix.

Let $\vec{A_i}$ be the $i$th row of $\boldsymbol{A}$. To the RHS we need:

$$\vec{A_i} x^{lp} = \vec{A_i}[\xi/n, \xi/n, \ldots \xi/n] = \frac{1}{(\vec{w}^T \vec{x_i} + \theta)}\xi$$

The simple solution is to set

$$\vec{A_i}[j] = \frac{1}{(\vec{w}^T \vec{x_i} + \theta)} \quad \forall j \in 1..m$$

Then we just need to gather everything together, and form everything into the form of $\boldsymbol{A}\vec{x} \geq \vec{b}$. Writing it out would be messy, but all the part are here to do so.