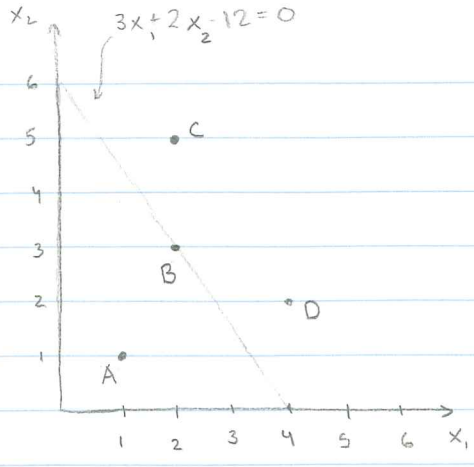

3. distance of point x to hyperplane (w, b)

$$= \frac{|w^T x + b|}{\|w\|_2}$$

$$\text{distance} = \frac{|3(2) + 2(5) - 12|}{\sqrt{3^2 + 2^2}}$$

$$= \boxed{\frac{4}{\sqrt{13}}}$$

4. the hyperplane linearly separates the data if $y_i (w^T x_i + b) > 0 \quad \forall i$

(y_i: label, x_i: data point)

B: $-1 (3(2) + 2(3) - 12) > 0$

$-1 \cdot (12 - 12) > 0$

$0 > 0$ false $\Rightarrow$ this hyperplane does not linearly separate the data

5. $x_- = \underset{x}{\text{argmin}} \|x - x'\|_2$ $\quad x \in$ convex hull of $\ominus$ class, $x' \in$ convex hull of $\oplus$ class

since both convex hulls are line segments, we can graphically see that point B is closest to the line segment $\overline{CD}$.

$\therefore x_- =$ Point B $= (2, 3)$

$x_+ = \underset{x}{\text{argmin}} \|x - x'\|_2$ $\quad x \in$ convex hull of $\oplus$ class, $x' \in$ convex hull of $\ominus$ class

find slope of $\overline{CD}$: $m = \frac{(5-2)}{(2-4)} = -\frac{3}{2}$ $\quad \underbrace{y - 5 = -\frac{3}{2}(x - 2)}_{\text{line through } \oplus \text{ class convex hull}}$

find $\perp$ line to $\overline{CD}$ through point B:

$m = +\frac{3}{2}$ $\quad \underbrace{y - 3 = \frac{2}{3}(x - 2)}_{\text{line through B } \perp \text{ to } \overline{CD}}$

find intersection of 2 perpendicular lines.

$y - 5 = -\frac{3}{2}(x-2)$

$y = -\frac{3}{2}(x-2) + 5$

$y - 3 = \frac{2}{3}(x-2)$

$-\frac{3}{2}(x-2) + 5 - 3 = \frac{2}{3}(x-2)$

$\Rightarrow y = -\frac{3}{2}(2.923 - 2) + 5$

$-\frac{3}{2}x + 3 + 5 - 3 = \frac{2}{3}x - \frac{4}{3}$

$y = 3.615$

$-\frac{3}{2}x + 5 = \frac{2}{3}x - \frac{4}{3}$

$\frac{19}{3} = \frac{13}{6}x$

$\therefore x_+ = (2.923, 3.615)$

$\frac{2 \cdot 19}{13} = x$

$x = 2.923$

$$\underbrace{\gamma(x^+ - x^-)^T}_{w} \underbrace{\left(\frac{x_+ + x_-}{2}\right)}_{\text{midpoint}} + b_{svm} = 0$$

$$\Rightarrow b_{svm} = -\gamma(x_+ - x_-)^T\left(\frac{x_+ + x_-}{2}\right) = -\gamma(0.923, 0.615)\begin{pmatrix}2.4615\\3.3075\end{pmatrix}$$

$= -\gamma(4.306)$

$= -4.306\gamma$

$$\Rightarrow w_{svm} = \gamma(x_+ - x_-) = \gamma\begin{bmatrix}0.923\\0.615\end{bmatrix}$$

$$\gamma\left\{(x_+ - x_-)^T x_+ - (x_+ - x_-)^T\left(\frac{x_+ + x_-}{2}\right)\right\} = 1$$

solve for gamma to get canonical form

$$\gamma\left[(0.923,\ 0.615)\begin{pmatrix}2.923\\3.615\end{pmatrix} - (0.923, 0.615)\begin{pmatrix}2.4615\\3.3075\end{pmatrix}\right] = 1$$

$$\gamma\left[\ 4.921 - 4.306\right] = 1$$

$$\gamma(0.615) = 1$$

$$\gamma = 1.626$$

$$b_{svm} = -(-4.306)(1.626) = +7.00$$

$$w_{svm} = 1.626\begin{bmatrix}0.923\\0.615\end{bmatrix} = \begin{bmatrix}1.50\\1.00\end{bmatrix}$$

6. None, $y_j(wx+b) > 0 \quad \forall j$ in data set.