CMPE 257 HW1
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Note: *Problems 4, 5, and 7 are submitted as .ipynb files. And for problem 7 converted the .traning and .test file to .csv format so its easier for me to process the data inside it.therefore they are naming differently from the original data files*

1. (5 points) What types of Machine Learning, if any, best describe the following scenarios:

A . **Supervised Learning**: because the developer has the exact coin specification and knows what output the system wants to do

B. **supervised Learning**: because the developer has the exact coin specification and knows what output the system wants to do

C. **Supervised Learning**: because we have the data and know what kind of result want to get

D. **Unsupervised Learning**: because the computer is learning by the data And want the system to identify different types of tissue but there's nothing about what output should be

E. **reinforces learning**. Because the computer will improve the result based on the rewards or punishments it gets to learn.

2.

a. Show that $y(t)w^t(t)x(t) < 0$

Lets say x(t) is misclassified and to prove $y(t)w^t(t)x(t) < 0$

If $y(t) = +1$ and x(t) is misclassified

$sign(w^t(t)x(t)) = -1 \Rightarrow w^t(t)x(t) < 0$

Therefore we $y(t)w^t(t)x(t) < 0$

If $y(t) = -1$ and x(t) is misclassified

$sign(w^t(t)x(t)) = +1 \Rightarrow w^t(t)x(t) > 0$

Therefore $y(t)w^t(t)x(t) < 0$

b. Show that $y(t)w^t(t+1)x(t) \; > \; y(t)w^t(t+1)x(t)$

If $y(t) \; = \; +1$ and x(t) is misclassified

and $\qquad sign(w^t(t)x(t)) \; = \; -1 \Rightarrow \; w^t(t)x(t) \; < \; 0$

And w(t+1) classified x(t) correctly so

$sign(w^t(t+1)x(t)) \; = \; +1 \Rightarrow \; w^t(t+1)x(t) \; > \; 0$

Then $y(t)w^t(t+1)x(t) \; > \; y(t)w^t(t)x(t)$

If $y(t) \; = \; -1$ and x(t) is misclassified

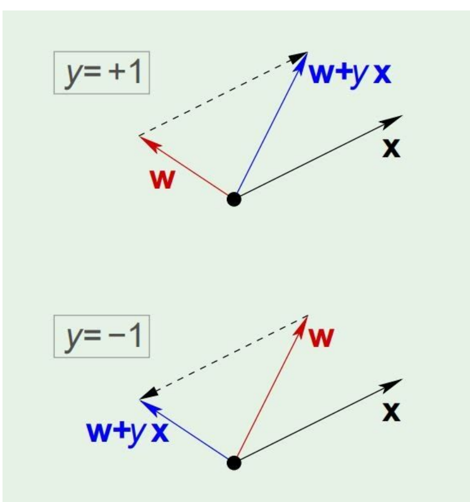
and $\qquad sign(w^t(t)x(t)) \; = \; +1 \Rightarrow \; w^t(t)x(t) \; > \; 0$

And w(t+1) classified x(t) correctly so

$sign(w^t(t+1)x(t)) \; = \; -1 \Rightarrow \; w^t(t+1)x(t) \; < \; 0$

Then $y(t)w^t(t+1)x(t) \; > \; y(t)w^t(t)x(t)$

c. As far as classifying x(t) is concerned argure that the move from w(t) to w(t+1) is a move 'in the right direction'



$A \cdot B = |A| \cdot |B| cos\theta$ and by this formula, theta is the degree between A and B, by this formula, we can get the direction of the w(t) to w(t+1) and verify if its in the right direction

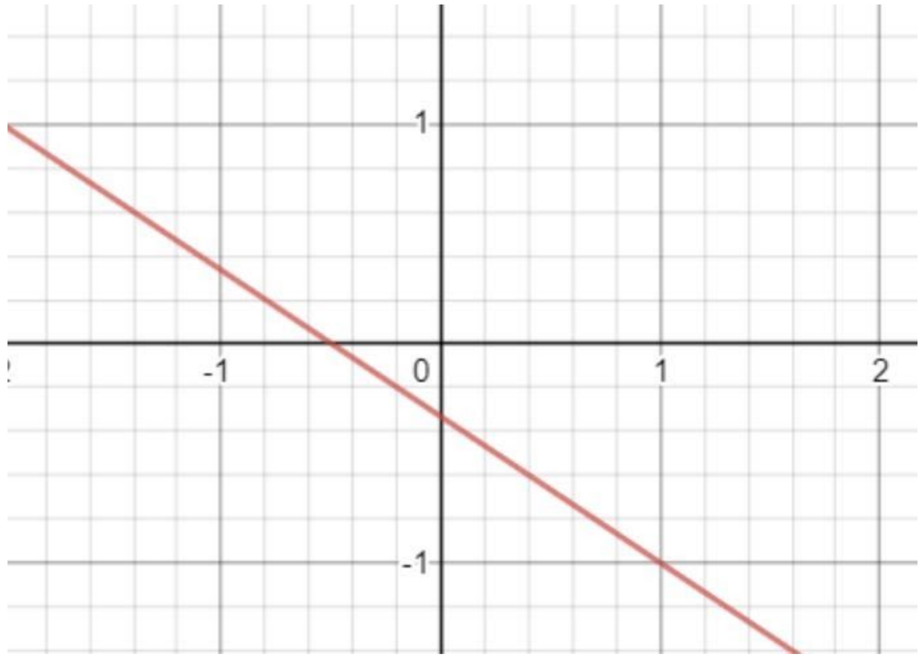
3. Consider the perceptron in two dimensions: $h(x) = sign(w^t x)$ where $w = [w_0, w_1, w_2]^T$ and $x = [1, x_1, x_2]^T$. Technically, x has three coordinates, but we call this perceptron two dimensional because the first coordinate is fixed at 1.

a. Show that the regions on the plane where $h(x) = +1$ and $h(x) = -1$ are separated by a line. If we express this line by the equation $x_2 = ax_1 + b$, what are the slope and intercept b in terms of w_0, w_1, w_2 ?
If $h(x) = +1$ $w^T x > 0$ and $h(x) = -1$ $w^T x < 0$ and there should be a line to separate the two region

$w^T x = w_0 + w_1 x_1 + w_2 x_2 = 0$
Also, it could be the format of $x_2 = ax_1 + b$
$w_2 x_2 = -w_1 x_1 + (-w_0)$
$x_2 = \frac{-w_1}{w_2} x_1 + (-\frac{w_0}{w_2})$
From the equation above we can get the slope is $-\frac{w_1}{w_2}$ and b is $-\frac{w_0}{w_2}$

b. Draw a picture for the cases $w = [1, 2, 3]^T$ and $w = -[1, 2, 3]^T$
for $w = [1, 2, 3]^T$
$w_0 + w_1 x_1 + w_2 x_2 = 0$
$1 + 2x_1 + 3x_2 = 0$
$2x_1 + 3x_2 = -1$
$3x_2 = -1 - 2x_1$
$x_2 = -\frac{1}{3} - \frac{2}{3} x_1$

The graph is :



for $w =- [1, 2, 3]^T$

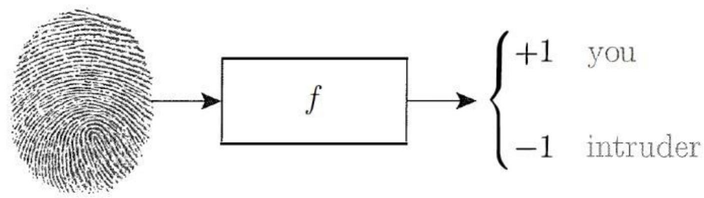
$$
\begin{aligned}
-w_0 - w_1x_1 - w_2x_2 &= 0 \\
-1 - 2x_1 - 3x_2 &= 0 \\
-2x_1 - 3x_2 &= 1 \\
3x_2 &= -1 - 2x_1 \\
x_2 &= -\tfrac{1}{3} - \tfrac{2}{3}x_1
\end{aligned}
$$

And for this one, the graph is the same as the last one

6.

First of all, we have the formula of in-sample error

$E_{in}(h) = \frac{1}{N}\sum_{n=1}^{N} err(h(x_n), f(x_n))$ (from Hsuan-Tien Lin's learning from data slides)



Supermarket

		f: +1	f: −1
h	+1	0	1
	−1	10	0

CIA

		f: +1	f: −1
h	+1	0	1000
	−1	1	0

And we know the risk or loss matrix for both supermarket and CIA

For the supermarket

$$E_{in}(h) = \frac{1}{N}\sum_{n=1}^{N} err(h(x_n), f(x_n))$$

$$E_{in}(h) = \frac{1}{N}\Big[\sum_{y_n=1}^{N} err(h(x_n), f(x_n)) + \sum_{y_n=-1}^{N} err(h(x_n), f(x_n))\Big]$$

$$E_{in}(h) = \frac{1}{N}\Big[\sum_{y_n=1}^{N} 10(h(x_n) \neq 1) + \sum_{y_n=-1}^{N} err(h(x_n) \neq -1)\Big]$$

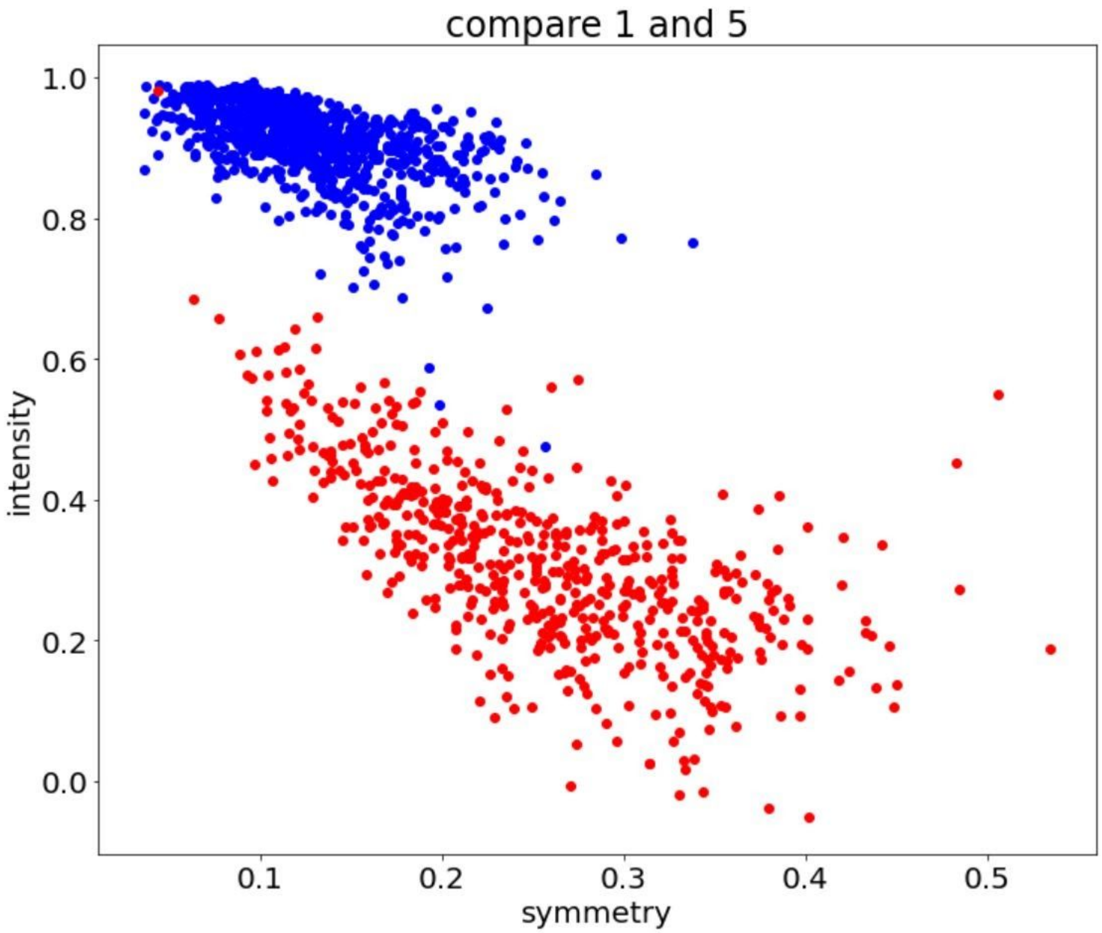
For the CIA

$$E_{in}(h) = \frac{1}{N}\sum_{n=1}^{N} err(h(x_n), f(x_n))$$

$$E_{in}(h) = \frac{1}{N}\Big[\sum_{y_n=1}^{N} err(h(x_n), f(x_n)) + \sum_{y_n=-1}^{N} err(h(x_n), f(x_n))\Big]$$

$$E_{in}(h) = \frac{1}{N}\Big[\sum_{y_n=1}^{N} (h(x_n) \neq 1) + \sum_{y_n=-1}^{N} 1000(h(x_n) \neq -1)\Big]$$

7. Graph ploted



Reference:

- https://github.com/kgourgou/Linear-Perceptron/blob/master/Perceptron-Algorithm.ipynb
- https://www.youtube.com/watch?v=OVHc-7GYRo4
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- https://www.youtube.com/watch?v=WW5k_3JhxAY
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- http://book.caltech.edu/bookforum/
- https://medium.com/@thomascountz/19-line-line-by-line-python-perceptron-b6f113b161f3
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- http://book.caltech.edu/bookforum/

- *And I discussed Hw with two classmates. I know one's name is Ruichun Chen and another one I only know his WeChat name is wanyuan Tom.*