CSDS 440: Assignment 8

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Problem 34

With $wx + b = 0$, we know that w is perpendicular decision plane as we may select two points on w, we have $w(u - v) = wu - wv = -b - (-b) = 0$. Known that the plus and minus plane are parallel to the decision plane, w is perpendicular to both the plus and minus plane.

Say we have x^+ on plus plane, let x^- to be a point on minus plane with shortest distance to x^+. We know that there must be $x^+ - x^- = \lambda w$ since the shortest distance between two paralleled planes are on their norm. Thus, we have:

$$\begin{aligned} 1 &= w(x^- + \lambda w) + b \\ &= wx^- + \lambda w \cdot w + b \\ \lambda ||w||^2 &= 2 \end{aligned}$$

Since we know the margin is defined as $M = \lambda ||w||$, we have $M = \frac{2}{||w||}$ which is independent of b.

Known that the 95% CI are $[x_B, y_B]$ and $[x_N, y_N]$ respectively for two datasets, we may deduce the error rates to be $e_B = \frac{x_B + y_B}{2}$ and $e_N = \frac{x_N + y_N}{2}$ for their respective dataset.

Assume Prof. Bob's dataset has n_B examples and Prof. Nan has n_N examples, Prof. Scoop may simply derive his version of error rate to be a combination of the both, which is $e_S = \frac{n_B e_B + n_N e_N}{n_B + n_N}$. This implies $n_S = n_B + n_N$, we may get this n_S (and also n_B, n_N) by doing:

$$
\begin{aligned}
x_B &= e_B - 2\sigma_B \\
2\sqrt{\frac{e_B(1-e_B)}{n_B}} &= e_B - x_B \\
\frac{4e_B(1-e_B)}{n_B} &= (e_B - x_B)^2 \\
\implies n_B &= \frac{4e_B(1-e_B)}{(e_B - x_B)^2}
\end{aligned}
$$

By doing the same calculation for n_N we have:

$$
\begin{aligned}
n_N &= \frac{4e_N(1-e_N)}{(e_N - x_N)^2} \\
\implies n_S &= \frac{4e_B(1-e_B)}{(e_B - x_B)^2} + \frac{4e_N(1-e_N)}{(e_N - x_N)^2}
\end{aligned}
$$

Since e_B, n_B, e_N, n_N, n_S are now all known, we can calculate e_S accordingly. Now, assume Prof. Scoop will land with a 95% CI of $[x_S, y_S]$, then there must be:

$$
\begin{aligned}
x_S &= e_S - 2\sigma_S \\
&= e_S - 2\sqrt{\frac{e_S(1-e_S)}{n_S}} \\
y_S &= e_S + 2\sigma_S \\
&= e_S + 2\sqrt{\frac{e_S(1-e_S)}{n_S}}
\end{aligned}
$$

The above two equations suggest we may derive x_S and y_S with just e_S and n_S, which are two known value to us and also to Prof. Scoop. So Prof. Scoop – while not doing any experiment – may derive his 95% CI base on Prof. Bob and Prof. Nan's results at the cost of his academic integrity.