SNLP Assignment 3

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1. Naïve Bayes classification

Using $\alpha = 1$ and $c_s := \text{spam}, c_n := \text{normal}$.

$$P(c_s) = \frac{\#docs_{c_s}}{\#docs} = \frac{2}{3},\ P(c_n) = \frac{\#docs_{c_n}}{\#docs} = \frac{1}{3}$$

1.1. Equal weights

$$\begin{aligned}
\hat{P}(\text{free}|c_s) &= \frac{2+\alpha}{11+\alpha|V|} = \frac{3}{19} & \hat{P}(\text{free}|c_n) &= \frac{0+\alpha}{4+\alpha|V|} = \frac{1}{12} \\
\hat{P}(\text{bitcoins}|c_s) &= \frac{4}{19} & \hat{P}(\text{bitcoins}|c_n) &= \frac{1}{12} \\
\hat{P}(\text{bank}|c_s) &= \frac{2}{19} & \hat{P}(\text{bank}|c_n) &= \frac{1}{12} \\
\hat{P}(\text{account}|c_s) &= \frac{2}{19} & \hat{P}(\text{account}|c_n) &= \frac{1}{12} \\
\hat{P}(\text{credit}|c_s) &= \frac{3}{19} & \hat{P}(\text{credit}|c_n) &= \frac{2}{12} \\
\hat{P}(\text{card}|c_s) &= \frac{2}{19} & \hat{P}(\text{card}|c_n) &= \frac{2}{12} \\
\hat{P}(\text{wallet}|c_s) &= \frac{2}{19} & \hat{P}(\text{wallet}|c_n) &= \frac{2}{12} \\
\hat{P}(\text{wood}|c_s) &= \frac{1}{19} & \hat{P}(\text{wood}|c_n) &= \frac{2}{12} \\
\hat{P}(c_s|d_4) &= \frac{2\cdot 4\cdot 2\cdot 3\cdot 1}{3\cdot 19^4} \approx 0.000123 & \hat{P}(c_n|d_4) &= \frac{1\cdot 1\cdot 2\cdot 1\cdot 2}{3\cdot 12^4} \approx 0.000064 \\
\hat{P}(c_s|d_5) &= \frac{2\cdot 2\cdot 3\cdot 3\cdot 2}{3\cdot 19^4} \approx 0.000184 & \hat{P}(c_n|d_5) &= \frac{1\cdot 2\cdot 1\cdot 2\cdot 2}{3\cdot 12^4} \approx 0.000129
\end{aligned}$$

$$\implies c_{d_4} = c_s = \text{spam},\ c_{d_5} = c_s = \text{spam}$$

1.2. Different weights

It was unclear to me what exactly was meant by tripling the weight. I chose to triple the title weight by counting each title word thrice. A word appearing in the title of a training sample thus has the same higher weight in the title and the text of test samples:

$$\begin{aligned}
\hat{P}(\text{free}|c_s) &= \frac{\overbrace{3\cdot 1}^{\text{title}} + \overbrace{1}^{\text{text}} + \alpha}{3\cdot 4+7+\alpha|V|} = \frac{5}{27} & \hat{P}(\text{free}|c_n) &= \frac{\overbrace{3\cdot 0}^{\text{title}} + \overbrace{0}^{\text{text}} + \alpha}{3\cdot 2+2+\alpha|V|} = \frac{1}{16} \\
\hat{P}(\text{bitcoins}|c_s) &= \frac{6}{27} & \hat{P}(\text{bitcoins}|c_n) &= \frac{1}{16} \\
\hat{P}(\text{bank}|c_s) &= \frac{2}{27} & \hat{P}(\text{bank}|c_n) &= \frac{1}{16} \\
\hat{P}(\text{account}|c_s) &= \frac{2}{27} & \hat{P}(\text{account}|c_n) &= \frac{1}{16} \\
\hat{P}(\text{credit}|c_s) &= \frac{5}{27} & \hat{P}(\text{credit}|c_n) &= \frac{2}{16} \\
\hat{P}(\text{card}|c_s) &= \frac{4}{27} & \hat{P}(\text{card}|c_n) &= \frac{2}{16} \\
\hat{P}(\text{wallet}|c_s) &= \frac{2}{27} & \hat{P}(\text{wallet}|c_n) &= \frac{4}{16} \\
\hat{P}(\text{wood}|c_s) &= \frac{1}{27} & \hat{P}(\text{wood}|c_n) &= \frac{4}{16} \\
\hat{P}(c_s|d_4) &= \frac{2\cdot 6\cdot 2\cdot 5\cdot 1}{3\cdot 27^4} \approx 0.000075 & \hat{P}(c_n|d_4) &= \frac{1\cdot 1\cdot 4\cdot 1\cdot 4}{3\cdot 16^4} \approx 0.000081 \\
\hat{P}(c_s|d_5) &= \frac{2\cdot 2\cdot 5\cdot 5\cdot 4}{3\cdot 27^4} \approx 0.000251 & \hat{P}(c_n|d_5) &= \frac{1\cdot 4\cdot 1\cdot 2\cdot 2}{3\cdot 16^4} \approx 0.000081
\end{aligned}$$

$$\implies c_{d_4} = c_n = \text{normal},\ c_{d_5} = c_s = \text{spam}$$