CS425A: Assignment 1

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1 Finding the Path Loss Exponent

WiFi Analyzer app was used to take the following samples of WiFi router from 4 different orientations.

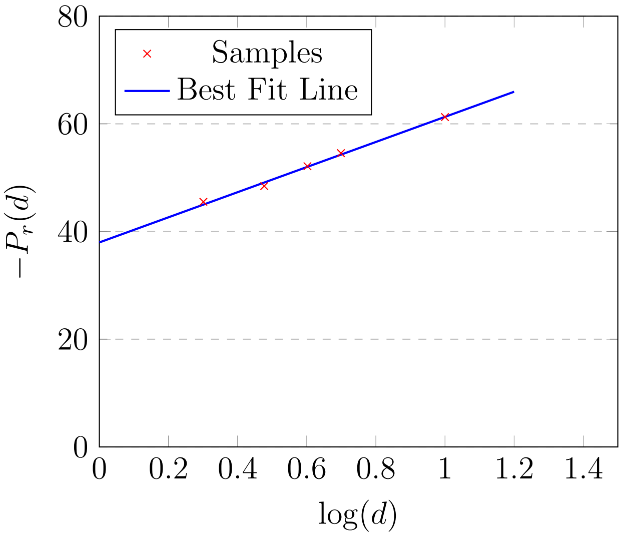
Distance	Orientation 1	Orientation 2	Orientation 3	Orientation 4	Avg. RSSI
2	44	45	46	46	45.25
3	48	48	49	49	48.5
4	52	53	51	52	52
5	53	56	54	55	54.5
10	61	63	59	62	61.25

The measurements are presented in meters for distances and in dBm for signal strengths, with the latter's negative values being inverted to positive for clarity. When plotting the relationship between the logarithm of the distance to the WiFi Access Point as the independent variable (x) and the negated Received Signal Strength Indicator (RSSI) as the dependent variable (y), the resulting linear regression equation is given by $y = 23.3x + 37.9$.

We denote the best-fit line by $y = mx + c$ for the set of data points $\{(x_i, y_i)\}_{i=1}^{k}$. The calculations for the slope m and the y-intercept c are as follows, with m being approximately 23.3 and c about 37.9.

$$m = \frac{k \cdot \sum_{i=1}^{k} y_i x_i - (\sum_{i=1}^{k} y_i)(\sum_{i=1}^{k} x_i)}{k \cdot \sum_{i=1}^{k} x_i^2 - (\sum_{i=1}^{k} x_i)^2} \approx 23.3$$

$$c = \frac{k \cdot (\sum_{i=1}^{k} y_i)(\sum_{i=1}^{k} x_i^2) - (\sum_{i=1}^{k} x_i)(\sum_{i=1}^{k} y_i x_i)}{k \cdot \sum_{i=1}^{k} x_i^2 - (\sum_{i=1}^{k} x_i)^2} \approx 37.9$$



Variance = 0.148

To determine the variance σ^2 in relation to the best-fit line, we first compute the mean μ of the residuals. Subsequently, we apply the variance formula to obtain an approximate value of 0.148.

$$\mu = \frac{\sum_{i=1}^{k}(y_i - mx_i - c)}{k} \approx -0.004$$

$$\sigma^2 = \frac{\sum_{i=1}^{k}(y_i - mx_i - c - \mu)^2}{k} \approx 0.148$$

Path Loss Exponent (n) = 2.33

The power exponent n is derived by dividing the slope m by 10, which results in an approximate value of 2.33. It is important to note that we divide by positive 10 because the formula has been adjusted to account for the originally negative RSSI values.

$$n = \frac{m}{10} = 2.33$$

2 Range Estimation

The reference signal power, $P_r(d_0)$ where $d_0 = 1m$, is determined to be -37.9 dBm based on the best-fit line equation, which uses the negative of the RSSI values. Subsequent signal strength readings were collected at various distances:

Actual Distance	Avg. RSSI	Calculated Distance	Error Distance
4	51.25	3.74	0.26
5	55	5.42	0.42
9.5	60.75	9.57	0.07
12.5	63.5	12.55	0.05
17	66.25	16.64	0.36

The measurements are presented in meters for distances and in dBm for signal strengths, with the latter's negative values being inverted to positive for clarity.

Average Error = 0.23 m

The distance equation employed to calculate the distance d is based on the reference distance d_0 and the measured RSSI values, with $P_r(d)$ representing the RSSI value after negation.

$$P_r(d)[\text{dBm}] = P_t(d)[\text{dBm}] - [P_L(d_0)]\text{dB} - 10n\log_{10}\left(\frac{d}{d_0}\right) = P_r(d_0)[\text{dBm}] - 10n\log_{10}\left(\frac{d}{d_0}\right)$$

After negating $P_r(d)$ and $P_r(d_0)$,

$$d = d_0 \cdot 10^{(P_r(d) - P_r(d_0))/10n} = 10^{(P_r(d)-c)/m}$$