EESC6390 Introduction to Wireless Communications Systems

Dept. of Electrical Engineering
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PROJECT I: Path loss Measurement Campaign

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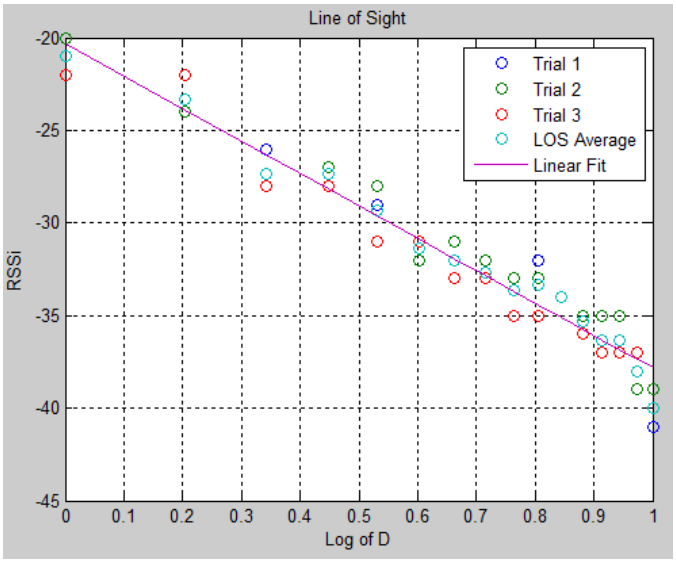
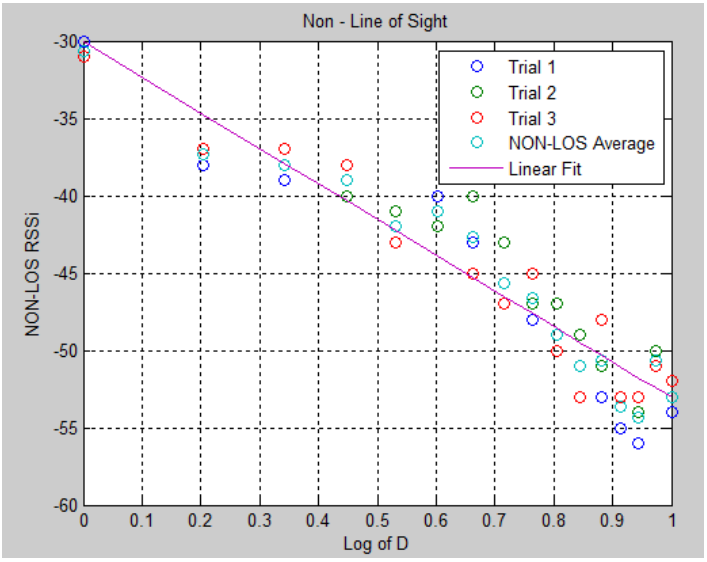
Aim: To measure path loss for Line-of-Sight and Non Line-of-Sight measurements of Wifi Signal strengths, estimate the path loss parameters obtained from the measurements and to predict the path loss at a given distance.

Tools:
a. Laptop running Windows with Wifi Card
b. inSSIDer software for measuring Wifi RSS (Received Signal Strength in dBm),
c. Wifi Access Point

Question 1 & 2: Plot the measured RSS vs Distances with the Wifi Access Point in Line-of-sight & Non-Line-of-Sight with the receiver.





In the above plots, the distances are given in $\log_{10}$d, where d is in meters ranging from 1m to 10m. Three trails were performed and they are plotted together with their average and the linear fit curve.

Measurement data

a. LOS

Log (d in m)	0	0.2	0.34	0.44	0.53	0.6	0.66	0.71	0.76	0.8	0.84	0.88	0.91	0.94	0.97	1
Trial 1 (dBm)	-21	-24	-26	-27	-29	-31	-32	-33	-33	-32	-34	-35	-37	-37	-38	-41
Trial 2 (dBm)	-20	-24	-28	-27	-28	-32	-31	-32	-33	-33	-34	-35	-35	-35	-39	-39
Trial 3 (dBm)	-22	-22	-28	-28	-31	-31	-33	-33	-35	-35	-34	-36	-37	-37	-37	-40

b. Non-LOS

Log(d in m)	0	0.2	0.34	0.44	0.53	0.6	0.66	0.71	0.76	0.8	0.84	0.88	0.91	0.94	0.97	1
Trial 1 (dBm)	-30	-38	-39	-39	-42	-40	-43	-47	-48	-50	-51	-53	-55	-56	-51	-54
Trial 2 (dBm)	-31	-37	-38	-40	-41	-42	-40	-43	-47	-47	-49	-51	-53	-54	-50	-53
Trial 3 (dBm)	-31	-37	-37	-38	-43	-41	-45	-47	-45	-50	-53	-48	-53	-53	-51	-52

Question 3: Attenuation caused by the wall

Clearly, an attenuation of -9.67 dB can be observed from the first set of readings of the LOS and Non-LOS plots shown above, caused by the thick wall in between.

From a), measurement at $\log_{10}d = 0$, RSS = -21 dBm
From b), measurement at $\log_{10}d = 0$, RSS = -30.67 dBm Attenuation due to wall = -9.67 dB

Question 4: Parameters for the Simplified Path Loss model:

For Line-of-sight measurements:

K_{dB} = -20.32 dB, n = 1.75, Variance = 0.67 dB

For Non Line-of-sight measurements:

K_{dB} = -30.06 dB, n = 2.3, Variance = 2.8 dB

Question 5: Estimated path loss at d = 30m ($\log_{10}d = 1.477$) is -76.72 dB from the Non-LOS plot as shown below.

Path loss at a distance d = 30m from the Wifi Access Point is calculated as follows:
Estimated Path Loss @ 30m = $P_r/P_t = K_{dB} - 10n \log_{10} d$

K_{dB} (*from y-intercept for Non-LOS*) = - 30.06 dB
n (*slope from Non-LOS*) = 2.3

Therefore, Estimated Path Loss = -30.06 – 10*2.3*1.477 = -64 dB

Question 6: The measured signal strength at d = 30m ($\log_{10}d = 1.477$) is -69 dB

Appendix:

1. MATLAB Code:

```
%Program for Pathloss prediction at a distance d calculated using LogNormal
%shadowing and simplified path loss model


% X-axis of the plot (log of D)
d = 1:0.6:10;
Log_Of_D = log10(d);

    %LOS trial data
    los_trial1 = [-21,   -24,   -26,   -27,   -29,   -31,   -32,   -33,   -33,   -32,   -34,   -35,   -37,   -37,   -38,   -41];
    los_trial2 = [-20,   -24,   -28,   -27,   -28,   -32,   -31,   -32,   -33,   -33,   -34,   -35,   -35,   -35,   -39,   -39];
    los_trial3 = [-22,   -22,   -28,   -28,   -31,   -31,   -33,   -33,   -35,   -35,   -34,   -36,   -37,   -37,   -37,   -40];


    %LOS average
    los_avg = (los_trial1 + los_trial2 + los_trial3)/3;

    %LOS curve fitting
    los_fit = polyfit(Log_Of_D,los_avg,1);
    los_fit_plot = polyval(los_fit,Log_Of_D);

    %LOS Slope and intercept
    temp = diff(los_fit_plot)./diff(Log_Of_D);
    Slope_Of_LOS = temp(1)/(-10)
    LOS_y_intercept = los_fit_plot(1)

    %LOS Variance
    MSSE = (los_fit_plot - los_avg).^2;
    Variance_Of_LOS = sum(MSSE)/16

    %LOS Plotting
    figure;
    plot(Log_Of_D, los_trial1, 'o', Log_Of_D, los_trial2,'o', Log_Of_D, los_trial3,'o', Log_Of_D, los_avg, 'o', Log_Of_D, los_fit_plot);
    legend('Trial 1','Trial 2','Trial 3','LOS Average', 'Linear Fit');
    grid on;
    title('Line of Sight');
    ylabel('RSSi');xlabel('Log of D');


    %Non-LOS data
    nonlos_trial1 = [-30,   -38,   -39,   -39,   -42,   -40,   -43,   -47,   -48,   -50,   -51,   -53,   -55,   -56,   -51,   -54];
    nonlos_trial2 = [-31,   -37,   -38,   -40,   -41,   -42,   -40,   -43,   -47,   -47,   -49,   -51,   -53,   -54,   -50,   -53];
    nonlos_trial3 = [-31,   -37,   -37,   -38,   -43,   -41,   -45,   -47,   -45,   -50,   -53,   -48,   -53,   -53,   -51,   -52];
```

```
46.
47.      %Non-LOS average
48.      nonlos_avg = (nonlos_trial1 + nonlos_trial2 + nonlos_trial3)/3;
49.
50.      %Non-LOS curve fitting
51.      nonlos_fit = polyfit(Log_Of_D,nonlos_avg,1);
52.      nonlos_fit_plot = polyval(nonlos_fit,Log_Of_D);
53.
54.      %Non-LOS plotting
55.      figure;
56.      plot(Log_Of_D, nonlos_trial1, 'o', Log_Of_D, nonlos_trial2,'o',
   Log_Of_D, nonlos_trial3,'o', Log_Of_D, nonlos_avg, 'o', Log_Of_D,
   nonlos_fit_plot);
57.      legend('Trial 1','Trial 2','Trial 3','NON-LOS Average', 'Linear Fit');
58.      grid on;
59.      title('Non - Line of Sight');
60.      ylabel('NON-LOS RSSi');xlabel('Log of D');
61.
63.      %Non-LOS Slope and intercept
64.      temp = diff(nonlos_fit_plot)./diff(Log_Of_D);
65.      Slope_Of_NonLOS = temp(1)/(-10)
66.      NonLOS_y_intercept = nonlos_fit_plot(1)
67.
68.      %Non-LOS Variance
69.      MSSE = (nonlos_fit_plot - nonlos_avg).^2;
70.      Variance_Of_NonLOS = sum(MSSE)/16
71.
72.      %Pathloss prediction
73.      % At d = 30m, Log of d = 1.477
74.      NonLOS_PathLoss_at_d = -10*Slope_Of_NonLOS(1)*(log10(30)) +
   NonLOS_y_intercept(1)
75.
76.      %Attenuation due to wall
77.      Attenuation_due_to_wall = abs(nonlos_avg(1) - los_avg(1))
78.
```