Student ID:_____ Name:_____

MA2007 Random Processes
Propagation Modeling and Estimation

Due date: By Monday May 10th, 2021

Protocol:

In this project, you are going to study and compare different propagation models to propagation measurements. You will also perform statistical analysis of the data and perform some comparison by generating some random numbers of your own. You need to turn in a formal ***TEAMWORK*** report of your project.

You need:

- Software (e.g., NetSpot) or an App (Airport) to measure power in dBs
- Computer software (Matlab) to plot colored surfaces and compare models

1. Consider the interior area of your house, where you can have measurements at different distances from your WiFi modem. Define the height at which you will place the receiver. Measure the height at which your modem is. Also, all your measurements must be conducted in a similar way, e.g., do not stand next to the receiver so that your body "blocks" the reception. Stay in a position while you get the measurements.
2. Prepare an area or room by generating a grid as a reference where you will take some measurements, i.e., define a grid that covers what is of interest to you such as height, depth, etc. You need to define a coordinate system for the entire house.
3. Determine the points on which measurements will take place. Recall that you need to do a 3D map of the room. Take a note on the materials in the room, e.g., wall, window, etc. To later discuss about the effects of materials or walls or floors or windows. Choose different heights in the same room, but when you take a set of measurements, only consider one height, e.g., the height of a chair, the height of your hands carrying the laptop, etc.
4. With the software determine the frequency at which the modem is transmitting.
5. Then considering those parameters (make a note of these), take measurements at different points in the room. Obtain a table where you have the points of measurements in the room (coordinates) and the receive power in dBm for the frequency of interest. You will need to run the program for each measurement. For each point of your grid, consider the power received as the average of 10 or 20 readings from the software.
6. Repeat measurements for all the points of your scenario grid and all the rooms considered. Try not to block the link with your body as much as you can.
7. For every measurement you will write a table with coordinates, and power received.
8. You **MUST** include a measurement at 1m of distance in a LOS link from the modem, please do so (this is without moving the transmitter and with as much LOS as you can). This is the measurement of the receive power at a distance d_0=1m because it will be your reference distance for your models. You can get several measurements at 1m and then average them.
9. Recall not to move the transmitter or its configuration. Recall that if you get more measurements you will get a better model for your area, and also if your area is larger it will be better. Try to get a minimum of 100 measurements around the transmitter's position.
10. Obtain a table where you have coordinates, distance in meters, and received power in dBm.

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11. At the same time that you make your measurements, try to see how the radiation pattern of the antenna looks like, i.e., you can measure at several points that are at the same distance from the transmit antenna in a circle. Do not forget to make measurements in a 3D space, i.e., at different heights.

Statistical Modeling and Analysis

1. Provide a dBm received power 3D map (surface) detected, use interpolation to generate received power at more points than those measured.
2. Discuss the surface in terms of behavior.
3. For the antenna, with your data obtained, provide a 2D plot of distance in meters vs. power received in dBm. Consider the average of dBms when you have several measurements at the same distances. This plot is distance dependent, not location dependent.
4. In the same plots as in the previous point, you should use the free-space Friis model to estimate power received and path loss and plot them as a function of distance.
5. Repeat part 4 for the 2-ray model
6. Now with your data from measurements, estimate the path loss exponent *n* using linear regression and plot the line corresponding to this exponent (slope) for both, i.e., power received and path loss.
7. Now estimate the path loss exponent using the statistical method of maximum likelihood (ML). Use the simplified model with this exponent estimate and plot its line in the same figures. So far you have free space, 2-ray, linear regression, and data points in your plot.
8. Compare exponents obtained by the methods (ML and linear regression) and discuss its similarities or differences.
9. Discuss which model, of all those that you used, approximates the better your measurements, and justify your answer.
10. Now draw a propagation map of the power received in the rooms by coloring the area according to the power received measured, **use the model that achieved the best fit**. You will need a color-coded map. This map will be a smooth surface since it comes only from your model which is based on averages.
11. Now with the data obtained, estimate the σ of the environment using statistical method ML.
12. Also estimate the standard deviation of your data by using statistical tools (averages)
13. Take your best model and in the plot of distance vs. power received of your data from part 3, now superimpose the result of adding such best model and the Gaussian random numbers (in dB) that simulate fading effects. You will add to each point a Gaussian random variable with zero mean and standard deviation σ. Generate the plots for the statistical method.
14. With your best model and the measurements provide two dBm received power 3D maps, one which is given by the measurements and the other by your best model with a log-normal random variable of the standard deviation that best approximates the measurements.
15. Discuss the results and compare how the random variable plays a role in the power received by comparing the map from measurements and the map obtained from your best model and the Gaussian random variables obtained in part 13.
16. Make your own conclusions, establish a methodology to be followed in order to achieve a propagation study for a network, give the procedure as steps to be followed.
17. Now estimate coverage by calculating the outage probability with your best model. You have to define a value in dB for a threshold where the signal has to be received above it (say a value of γ in dB), provide the color map where the areas that do not satisfy the criterion of outage will be colored in black. Discuss what you experience and what you are predicting with the models.