Mobile Communication
Exercise Sheet # 1

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May 11, 2020

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Exercise 1: Free Space and Two-Ray Ground propagation

The Free Space Propagation Model (FSP) and the Two-Ray Ground Propagation Model (TRG):

$$FSP : P_r = \frac{P_t \cdot \lambda^2}{d^2 \cdot (4\pi)^2} \quad (1)$$

$$TRG : P_r = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^4} \quad (2)$$

1. Path loss:

$$PL[db] = 10 \cdot log_{10} \frac{P_t}{P_r}$$

$$PL_{FSP} = 10 \cdot log_{10} \frac{P_t}{P_r} = 10 \cdot log_{10} \frac{P_t \cdot d^2 \cdot (4\pi)^2}{P_t \cdot \lambda^2} = 10 \cdot log_{10} \frac{d^2 \cdot (4\pi)^2}{\lambda^2}$$

$$PL_{TRG} = 10 \cdot log_{10} \frac{P_t}{P_r} = 10 \cdot log_{10} \frac{P_t \cdot d^4}{P_t \cdot h_t^2 \cdot h_r^2} = 10 \cdot log_{10} \frac{d^4}{h_t^2 \cdot h_r^2}$$

2. TRG does not provide meaningful results for small distances. Therefore it is a common practice to define a *crossover distance* d_c and use FSP for distances $d \leq d_c$, TRG for $d > d_c$. For this exercise sheet, we assume:

$$d_c = \frac{4\pi \cdot h_t \cdot h_r}{\lambda} \quad (3)$$

Prove that there is a smooth transition between the two models at the crossover distance, i.e. prove that both models yield equal results at d_c.

Proof:

We need to prove that $P_r(FSP) = P_r(TRG)$ when $d = d_c$. From equation (3) we can write λ as:

$$\lambda = \frac{4\pi \cdot h_t \cdot h_r}{d_c}$$

Then replacing the value of λin equation (1):

$$P_r(FSP) = \frac{P_t \cdot \lambda^2}{d^2 \cdot (4\pi)^2} = \frac{P_t \cdot (4\pi \cdot h_t \cdot h_r)^2}{d^2 \cdot (4\pi)^2 \cdot d_c^2} = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^2 \cdot d_c^2} = \frac{P_t \cdot h_t^2 \cdot h_r^2}{d^4} = P_r(TRG)$$

Exercise 2: Comparing two path loss models

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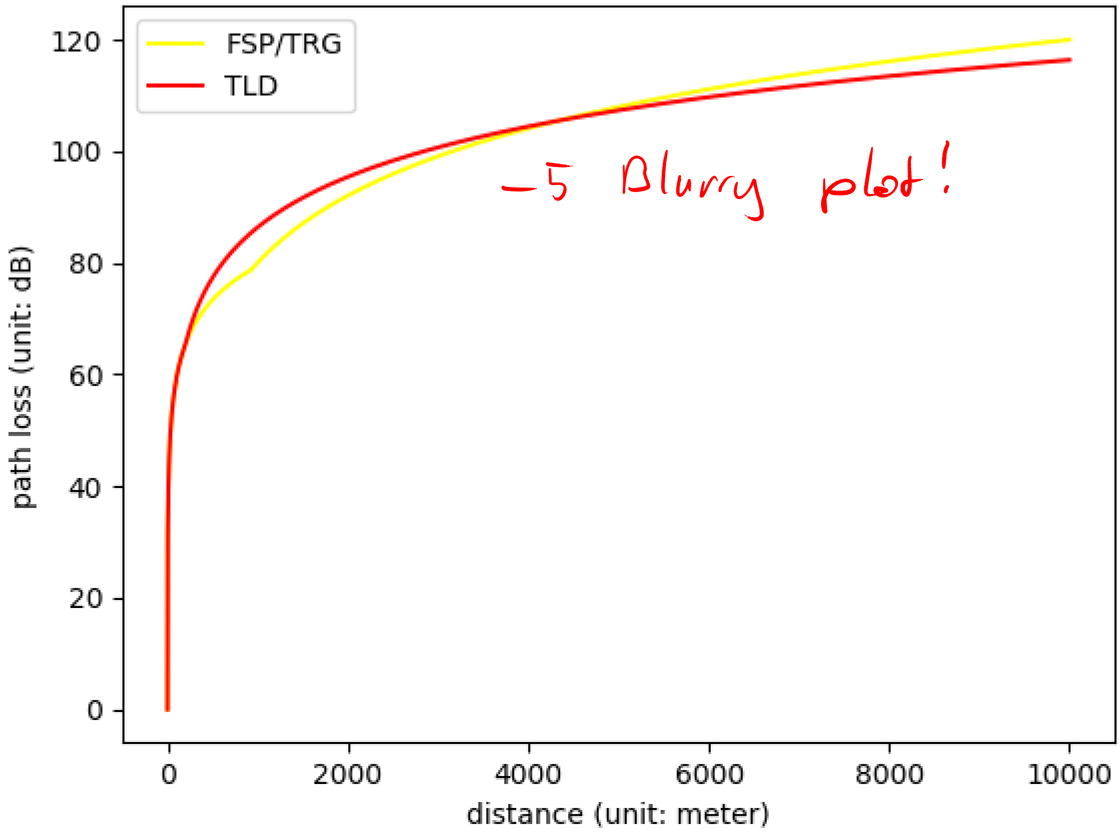
distance: 1000, FSP-TRG: 80.0 , TLD: 86.36670004336018
distance: 5000, FSP-TRG: 107.95880017344075 , TLD: 107.33580017344075
distance: 10.000, FSP-TRG: 120.0 , TLD: 116.36670004336018
```



In the code, we calculated FSP and TRG from the first task and calculated TLD as given properties. Then we calculated FSP-TRG and TLD values for distances 1000, 5000 and 10.000. Path loss for TLD is a bit better than FSP-TRG values as seen in the diagram for 10.000 distance values.

Exercise 3: Reality check

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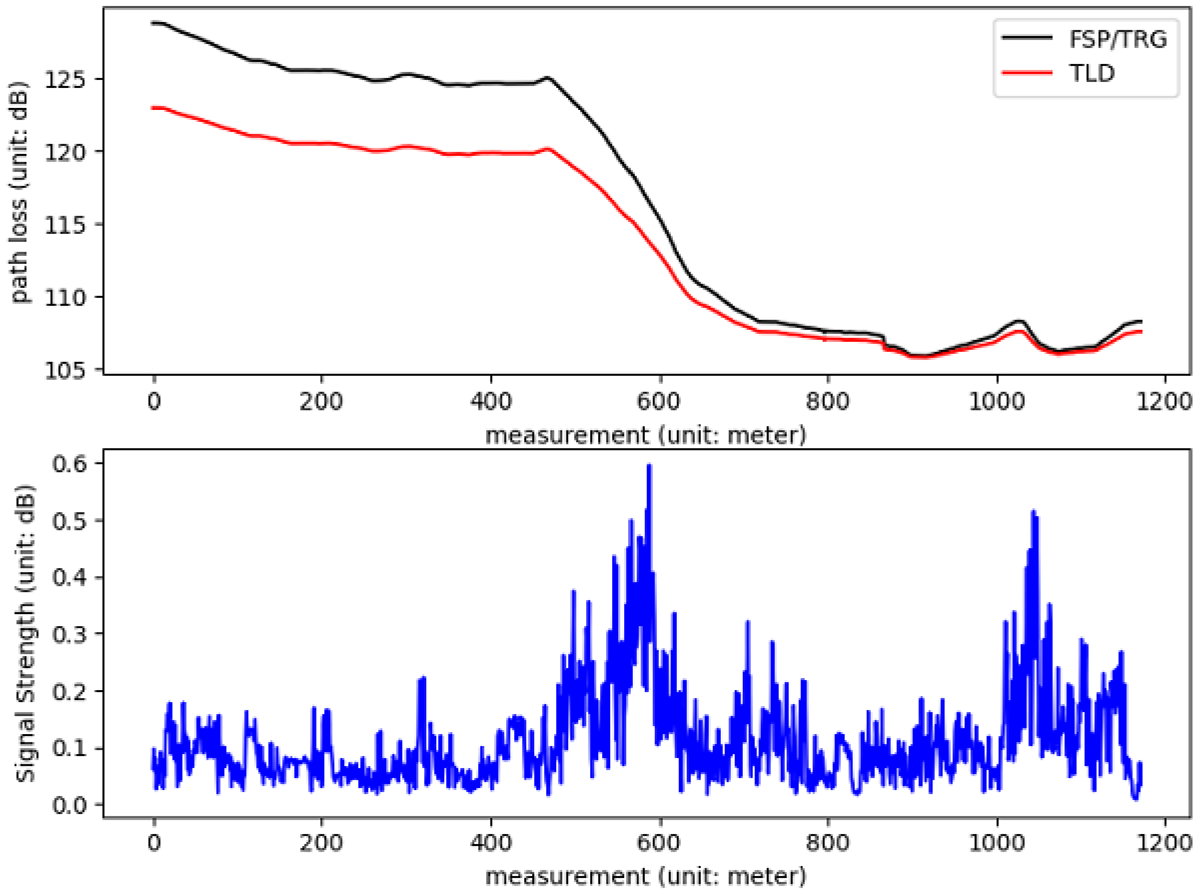

We have used the data from the ex1.csv provided as part of the exercise.

Q1. Extend your program so that it can calculate the path loss based on two geographic coordinates.

1. We used Geopy geocoding web services. It is used to locate the coordinates of addresses across the globe using third-party geocoders and other data sources.

2. We use a method in our code to deal with path loss based on two geographic coordinates using Geopy.

Q2. Compute the expected path loss for the moving car using both of the models defined before. Produce a plot which shows the expected path loss for both models in comparison to the conducted measurements.

1. As shown in the above plots, there is the expected path loss for both models in comparison to the conducted measurements. As you can see in above models, the car is moving towards the transmitter antenna. As you can see the Free space propagation model's path loss is decreasing and its signal strength at 400-600 is at high peak, when it is passing or reaching the transmitter and then at 1000-1200 we see a decrement in that. This is a simple model of the real case. Doppler shift may have cause the less path loss at the end.

Q3. Do the path loss models correctly represent the real world signal propagation? Give reasons why this might (not) be the case.

1. Those objects causing shadowing, reflection and attenuation are not considered, that is why, in real world the case might be different.