1 Free Space and Two-Ray Ground propagation

We know, by definition

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

$$TRG : P_r = \frac{P_t.h_t^2.h_r^2}{d^4}$$

where, FSP = Free Space propagation model TRG = Two-Ray Ground propagation model

Therefore,

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

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

Hereby, We come to know that path loss for both FSP and TRG are independently specific for P_t and P_r values.

From the definition of the FSP and TRG for Received power P_r we can write

$$\frac{P_t.\lambda^2}{d^2.(4\pi)^2} = \frac{P_t.h_t^2.h_r^2}{d^4} \Rightarrow \frac{P_t.\lambda^2}{P_t.h_t^2.h_r^2} = \frac{d^2.(4\pi)^2}{d^4} \Rightarrow \frac{\lambda^2}{h_t^2.h_r^2} = \frac{(4\pi)^2}{d^2}$$

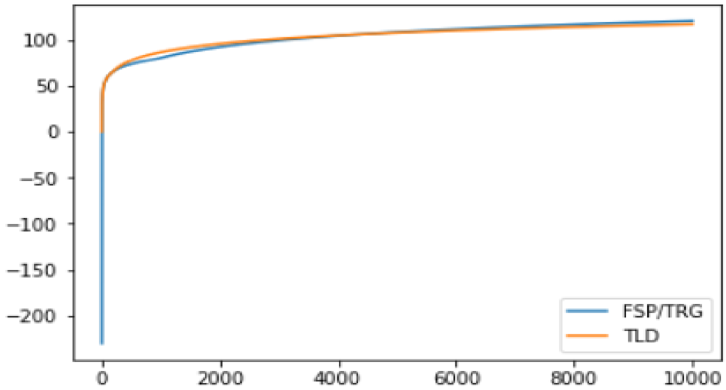
Now considering crossover distance,

$$\frac{\lambda^2}{h_t^2.h_r^2} = \frac{(4\pi)^2}{\frac{4\pi.h_t.h_r}{\lambda}} \Rightarrow \frac{\lambda^2}{h_t^2.h_r^2} = \frac{(4\pi.)}{h_t.h_r} \Rightarrow \frac{\lambda}{h_t.h_r} = 4\pi \Rightarrow \frac{4\pi.h_t.h_r}{\lambda} = 0$$

2 Comparing two path loss models

According to our Path loss formula, we made some functions which calculate path loss for specific distance.

Using the functions, we measured path loss from 0 meter to 1000 meters and plot those data like below:



We have checked our implemented function with some specific distance also (e.g. 1000,5000,10000)
Here is our measured data:

	Distance	FSP/TRG	TLD
0	1000	80.0000	86.3667
1	5000	107.9588	107.3358
2	10000	120.0000	116.3667

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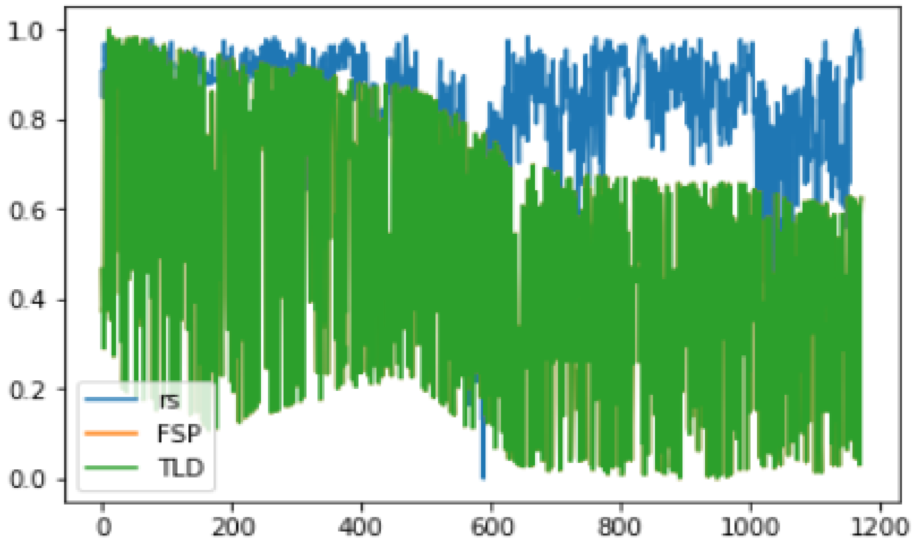
From our measured data and plot, we can see that the combination of FSP and TRG gives almost same path loss as TLD. Though FSP works with lower distance and TRG works with high distance, combination of these two gives better result if we can apply crossover distance value properly.
Besides of FSP and TRG, TLD works for all distance and gives similar path loss from other two. So, we can consider TLD as a complete method.

3 Reality check

We have converted the geographic coordinates data into latitude, longitude and distance and pass those distance into path loss function.

We have computed path loss from those distances and normalize those values from 0 to 1. And noticed that FSP/TRG and TLD almost overlaps with each other in normalized form. Besides relative signal works almost inversely with FSP/TRG and TLD. To see the better comparison with conducted relative signal we have inverted this signal and make a plot. We found the plot like below:



This model does not represent the real world signal propagation. When relative strength is high, path loss supposed to be low. Here we inverse our relative strength data but till we see that the path loss data is not relative.