Path Loss Models for Suburban Areas of Dehradun using Anfisedit Tool

Ujjawal Bahuguna
Post Grad. Scholar
DIT-U, Dehradun
Ujjawal.bahuguna@yahoo.com

Bhagirathi Pradhan
Assistant Professor
DIT-U, Dehradun
mail2bhagirathi@gmail.com

Govind Sati
Post grad. Scholar
DIT-U, Dehradun
satigovind@gmail.com

ABSTRACT

Path loss is the reduction in power density of electromagnetic wave as it propagates through the space. The purpose of this paper is to propose the path loss with the field measurement model and represent them in a convenient form of fuzzy logic modeling. This paper proposes method to predict path loss of base station in cellular mobile communication system using fuzzy logic. The propagation medium is classified in to several well-established propagation environments defined as a fuzzy set such as free space, flat area terrain, light structures terrain, heavy structures terrain, and village terrain. A unique mean path loss exponent (n) is assigned to each propagation environment, which is established by means of the experimental. Fuzzy logic is used to determine "n" number for an unknown environment, which will be obtained using linguistic rules that provide a fine-tuning of the known propagation environments. HATA model is been used for the present analysis.

Keywords: *Path loss data, Path loss prediction, Fuzzy logic, HATA Model.*

1. INTRODUCTION

The mechanisms behind electromagnetic wave propagation are diverse, but they are characterized by reflection, refraction, path loss, fading, scattering and shadowing. Path loss is an attenuation that signal suffers when propagate from transmitter to the receiver. Propagation path loss increased not only with frequency but also with distance [5].

$P_L \alpha R^{-\alpha}$

Efficient path loss prediction is important for proper design of wireless network. Efficient path loss prediction depends upon Vegetation Density, Buildings, and Atmosphere etc. Various outdoor propagation models are available to determine path loss over irregular terrain. While all these models aim to predict signal strength at a particular receiving point or in a specific local area (called zone/sector), the methods vary widely in their approach, complexity and accuracy. However accuracy of these models suffers when they are used in the environment other than for which they have been designed. Performing ON SITE calculations and considering link loss in the practical environment and their result may be applied to existing models for correction [1]. Both theoretical measurement based propagation models indicate that average received signal power decreases logarithmically with distance, whether in outdoor or indoor radio channels. The average large-scale path loss for an arbitrary T-R separation is expressed as a function of distance by using a path loss exponent "n".

$$P_L(dB) = P_L(d_0) + 10n\log(d/d_0) \quad \text{.................. (1)}$$

Where n is the path loss exponent, which indicates the rate at which the path loss increases with distance, d0 is reference distance and d is the T-R separation distance [6]. n depends on specific propagation environment for free space n=2 and when obstruction are present n will have a larger value. The reference distance should always be in the far field of the antenna so that near field effects do not alter the reference path loss.

In this paper an empirical path loss model for a typical suburban city of India has been proposed. (Sahastradhara Road Dehradun, Uttarakhand). The field measurements were carried out in the suburban city of Sahastradhara road, Dehradun of its GSM based System.

2. Description of selected outdoor propagation models

2.1 Hata model

HATA model is also known as Okumura-Hata model for being a revised version of Okumura model. It is valid in frequency range of 150 MHz to 1500 MHz. Hata model provides the formulation for path loss calculation in urban, suburban and rural areas [3, 4].

Path loss (dB) is given by:

$$PL_{dB} = A + B\log d - C \quad \text{............ (2)}$$

Where

$$A = 69.55 + 26.16\log_{10}(f_c) - 13.82\log_{10} h_t(m) - a[h_r(m)]$$

$$B = [44.9 - 6.55\log_{10} h_r(m)]\, log_{10}\, d(km)$$

$$C = 5.4 + 2[\log_{10} f_c\ (MHz)/28]^2$$

$$\alpha[h_r(m)] = 3.2[log_{10}\ 11.75\, h_r(m)]^2 - 4.97,\ f > 400\, MHz$$

f_c= carrier frequency

h_t = transmitter antenna height in meter

h_r= receiver height in meter

d= transmitter-receiver distance in km

$a[h_r(m)]$ =mobile station antenna height correction factor

2.2 Cost 231 hata model

Cost 231 Hata model is the improved version of Hata model. It is also called the Hata Model PCS Extension. It is applicable for frequency range between 500MHz to 2000MHz [10].

Path loss for COST-Hata-Model is formulated as,

PL_{dB}=$46.3 + 33.9\log_{10} f_c - 13.82\log_{10}(h_t) - a(h_r) + [44.9 - 6.55\log_{10}h_t]\log_{10} d + C$ ……… (3)

C= 0 db, for suburban areas and medium cities

$a(h_r) = (1.11\log_{10} f_c - 0.7)h_r - (1.5\log_{10} f_c - 0.8)$,for suburban enviourment

$a(h_r)$= mobile station antenna height correction factor

f_c = carrier frequency in MHz

d= transmitter-receiver separation distance in km

h_t= transmitter anteena height in meter

h_r= receiver height in meter

2.3 ECC-33 model or Hata – Okumura Extended model

ECC-33 model was developed by Electronics Communication Committee (ECC), it is formulated by original measurements by Okumura model. The model is most widely used in suburban areas but not much tall density structure. The range of the model is upto 3000MHz and distance upto 1to 100 km [10].

The model is expressed as:-

$PL_{dB} = A_{fs} + A_{bm} - G_b - G_r$ ..... (4)

Where,

A_{fs} [dB]= free space attenuation

A_{bm} [dB] =basic median path loss

G_b =Transmitter antenna height gain factor

G_r =Receiver antenna height gain factor

Further expressed as,

$$A_{fs} = 92.4 + 20log_{10}(d) + 20log_{10}(f_c)$$

$$A_{bm} = 20.41 + 9.83 \log_{10}(d) + 7.894\log_{10}(f_c) + 9.56 [\log_{10}(f_c)]^2$$

$$G_b = \log_{10}(h_b/200) \{ 13.958 + 5.8 [\log_{10}(d)]^2\}$$

$$G_r = [42.57 + 13.7 \log_{10}(f_c)][\log_{10}(d_r) - 0.585]$$

3. Field data calculation based path loss model

Field measurement is for suburban areas of Dehradun, Uttarakhand, India for GSM based system. All the data is taken by mobile device by using TEMS 10.0.5 kit. Measurement will be taken in three zones/sectors. For macro cellular system, the reference distance is taken as d_0 = 1km. as the maximum coverage of GSM based mobile is 3 km to 5 km ,so measurements will performed upto 5 km from the transmitter. Average value of received power must be taken at each interval from different sectors.

Table-1 Received power using TEMS 10.0.5

Distance from transmitter d(km)	**Received power in different zones, (dBm)**			**Average value (dBm)**
	X	Y	Z	
1.0	74	72	76	74
2.0	76	74	78	76
3.0	78	76	80	78
4.0	80	78	82	80
5.0	82	80	84	82

As the value of the received power varies at the same distance so the average value of the received power is taken. The path loss exponent n is calculated by linear regression such that difference between measured and estimated path loss is minimized in mean square sense.

$E(n) = \sum_{i=1}^{k}\{L_p(d_i) - \acute{L}_p(d_i)\}^2$ ………… (5)

$L_p(d_i)$ = measured path loss at distance di

$\acute{L}_p(di)$ = Estimated path loss using equation (1)

The value of n is calculated by equating equation to zero,

$dE(n)/dn = 0$

Model	**Path Loss Exponent**
HATA	2.3
COST 231 HATA	2.8
ECC-33	2.9

4. Fuzzy Logic Path Loss Analysis

Fuzzy logic is the branch of science, which rationalizes uncertain events. Fuzzy logic is extensively used in many fields where a accurate mathematical model is not available [5, 6].

FL was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. It is very robust and forgiving of operator and data input and often works when first implemented with little or no tuning. The concept is shown in fig.1 where propagation medium is classified into environmental mass as input fuzzy set X1= structural density and X2= vegetation density. The input crisp value is implemented using fuzzy rule base. De-fuzzification is done to regenerate the output into crisp value.

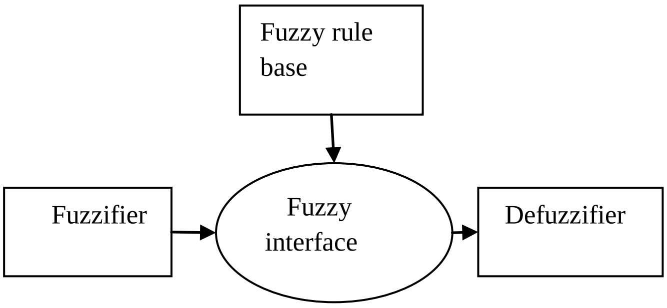
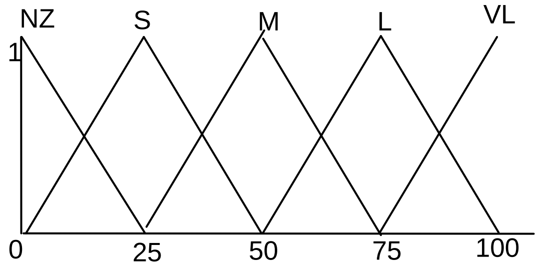
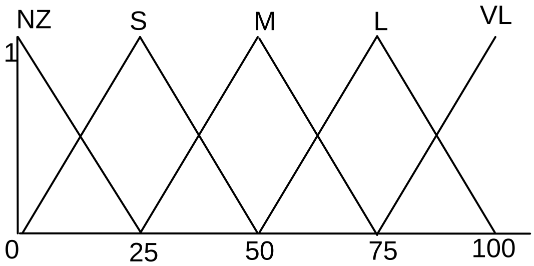


Fig.1 Fuzzy Prediction Model

We use triangular membership function and define it in 5 levels as: NZ: nearly zero, S: small, M: medium, L: large, and VL: very large.



Membership Function: Structural Density



Membership Function: Vegetation Density

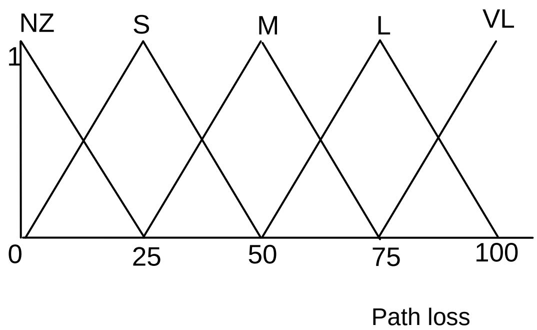


Fig.2 Membership Function of Fuzzy Input and Output

Weighted average method is used for de-fuzzification for the present analysis is expressed as:

$$f(y) = \frac{\sum \mu(y).\ y}{\sum \mu(y)}$$

After applying weighted average method,

$$f(y) = \frac{\sum_{m=1}^{n} E^m\ D^m}{\sum_{m=1}^{n} D^m}$$

Where, f(y) is the crisp output value; E^m is the crisp weighting for the linguistic value LV^m,D^m is the membership value of y with relation to linguistic value LV^m.

5. Conclusion

This study has given us a brief introduction about path loss models especially HATA, COST 231, ECC-31 model. All the three path loss models are compared to each other by path loss exponent "n" .as we see that the path loss exponents for Hata, Cost 231 Hata and ECC-33 is quite low as compared to theoretical value path loss exponent whom lies between 3 to 5 for suburban areas. Also, as compared to Japanese city it is quite low. But according to Indian cities it is quite good because of open envioournment. And as compared between Hata, Cost 231 Hata, ECC-33 model, Hata model is good for Indian cities.

The fuzzy logic method used for path loss prediction puts a different method for communication analysis, which RF propagation is chaotic in multipath environment owing to various RF barriers and scattering phenomena from several objects in the environment. Thus we made a conclusion that theoretical analysis is totally different than practical analysis. Therefore, to find a result we have to use combination of both.

References

[1] Faruque, Saleh, "Propagation Prediction Based on Environmental Classification and Fuzzy Logic Approximation", Proc. IEEE ICC'96, 1996 Pp272-276.

[2] G L Stuber, "Principles of Mobile Communications", Kluwer Academic Publishers, 1996, Pp: 162-198

[3] M. M. Peritsky, "Statistical estimation of mean signal in a Rayleigh-fading environment", IEEE Trans. Veh. Technology., vol. VT-22, pp. 123-129, Nov. 1973

[4] R. A. Valenzuela, O. Landron, and D. L. Jacobs, "Estimating Local Mean Signal Strength of Indoor Multipath Propagation", IEEE Transaction on vehicular technology, Vol.46, No.1, February, 1997

[5] T. S. Rappaport, S. Y. Seidel, and K. R. Schaubach, " Site-specific propagation prediction for PCS system design", in Virginia Tech's Second Symp Wireless Personal Comm., Blacksburg, VA, June 17 – 19, 1992, pp. 16.1 – 16.27

[6] T. S. Rappaport., "Characterization of UHF multipath radio channels in factory buildings", IEEE Trans. Antennas Propagation., vol. 37, pp. 1058-1069, Aug, 1989

[7] T S Rappaport, "Wireless Communication Principles and Practice", Pearson Education Pvt. Ltd, 2002.

[8] Vishal Gupta, Sandip Vijay and S.C.Sharma, "Efficient Path Loss Prediction in Mobile Wireless Communication Network", ISN2008, Feb. 22-24, 2008, Pg-271.

[9] Dharm Prakash Agarwal and Qing-An Zeng, "Introduction to Wireless and Mobile Systems", Thomson and Brooks/Cole, 2003, Pp: 63-87.

[10] V.S Abhaywardhana, I.J Wassell, D. Crosby, M.P Sellars, M.G Brown,'Comparison of empirical propagation path loss models for fixed wireless access systems' IEEE Conference, 2005.

