A REVIEW ON PATH LOSS MODELS FOR SUBURBAN REGIONS USING FUZZY LOGIC

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ABSTRACT

Path loss is a reduction in power density of electromagnetic wave as it propagates through space. In this paper path loss is estimated with help of different path loss models and implementing it using fuzzy logic tool. The propagation medium is classified into several propagation environments such as free space, flat area terrain, light structure terrain, heavy structure terrain, and village terrain. A mean path loss exponent (n) is assigned to each propagation environment .the fuzzy logic tool is to determine 'n' number of unknown environment which will be obtained using set of fuzzy logic rule set. HATA model COST 231 HATA and ECC-33 model is used in this analysis.

KEYWORDS: *Path loss data, Path loss prediction, Fuzzy logic, HATA Model, COST 231, ECC-33 Model.*

1. INTRODUCTION

There are different mechanisms behind electromagnetic wave propagation defined by reflection, refraction, path loss, fading, scattering and shadowing. Path loss is a loss of signal that signals suffers when it propagates from transmitter to receiver. Path loss increases not only to the frequency but also to distance [1].

$P_L \propto D^{-n}$

Electromagnetic wave propagation is affected by vegetation mass, structural mass and atmosphere. There are different types of outdoor propagation model which are helpful in determining the path loss in such terrain. The signal strength predicted by these outdoor propagation models at a receiving point or in a particular area. These models are used in the environment other than for which they are made.

Theoretically measured propagation model shows that average signal power received decreases logarithmically with distance. The average path loss for an transmitter and receiver separation is expressed as the function of distance.

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

Where n path loss exponent d_0 is reference distance and d is transmitter-receiver separation distance [2] .N depends upon the propagation environment, for free space n=2.the value of n must be larger when obstruction is present in the propagation environment. Here, paper proposes an path loss model for suburban city of India (Dehradun, Uttarakhand) in 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:

$PL_{dB} = A + B\ log\ d - C$ ………… (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}=$46.3 + 33.9\log_{10}\ f_c - 13.82\log_{10}(h_t) - \mathrm{a}(h_r) + [44.9 - 6.55\log_{10}h_t]\log_{10}\ d + C$
...……. (3)
C= 0 db, for suburban areas and medium cities
$\mathrm{a(h_r)} = (1.11\log_{10} f_c - 0.7)h_r - (1.5\log_{10}f_c - 0.8)$, 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:-
$PL_{dB} = A_{fs} +\ A_{bm} - G_b - \mathrm{G_r}$ ..... (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 5.1.2 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. 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.

$\mathrm{E(n)} = \sum_{\mathrm{i=1}}^{\mathrm{k}}\{\mathrm{L_p(d_i)} - \acute{\mathrm{L}}_{\mathrm{p}}(\mathrm{d_i})\}^2$ ………… (5)
$L_p(d_i)$ = measured path loss at distance di
$\acute{\mathrm{L}}_p(di)$ = Estimated path loss using equation (1)
The value of n is calculated by equating equation to zero,

$dE(n)/dn = 0$
Hence, value of path loss exponent is evaluated for all three models.

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.

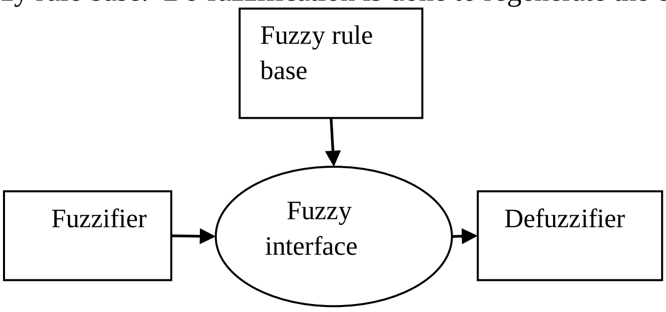

Fig.1 Fuzzy Prediction Model

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.
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.

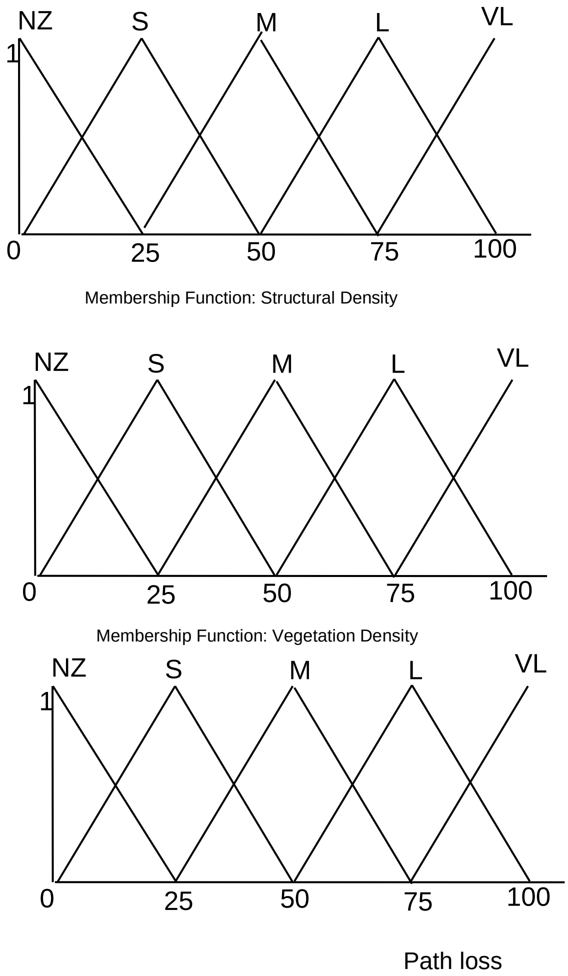

Fig.2 Membership Function of Fuzzy Input and Output

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" .The major parameters which define the characteristics of path loss are transmitter antenna height (h_t) , receiver antenna height (h_r),vegetation mass, structural mass. Hence, we have examined the propagation model and by applying fuzzy logic approximation to defined unknown environment using set of known environment. 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.

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