HATA Path Loss Model Optimization Using Particle Swarm Algorithm

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Abstract

Fallacious path loss predictions before the placing of base station (BS) cause under evaluation of circulation areas which gives rise to unabating call drops & cross talks. The escalating demands of meeting overhaul needs of applications by users makes the consequence worst, which significantly influences competence of the cellular wireless system.Propagation model is a keystone of coverage planning. To slash cost, proper planning is needed in coverage of network in order to upgrade the quality of service. Now, K factor is taken into account in order to improve or enhance propagation model based on particles swarm optimization (PSO). The root mean square error(RMSE) between confirmed or verified measurements data & data we obtain from prediction model is used to test and validate the technique used. The values of the RMSE acquired by enhancedmodel and those attained by the standard Hata model are also juxtaposed.We reckoned that the model developed using PSO is better than the HATA model and is errorless.

Keywords: Particles swarm optimization algorithm (PSO), Radio propagation, mob. network, PS Optimization

1 Introduction

Cellular mobile communication networks are predominant networks across the world and such network is becoming a very cardinal part of our daily life.There are many propagation path loss models put forward in previous works to foresee coverage. These models are not ample for accurate analysis of the path loss on other topography, the suitability of such models contradicts with dissimilar environment.

To design such system, we bear in mind quality of service (QoS), transmitted frequency(ftr), coverage area, transmitted and received power (Ptx, Prx)and cost of system.Such model desirable to have an element in order enhance a cellular network. With the escalating demand of speedy data services, a prominence is to be made on the expanse of the radio network. Such kind of models are much essential in order to avoid unforeseen problems, essentially after installing and establishing such systems. A general model needs to be enhanced as well as tuned appropriately in order to obtain authentic model .The values for parameters such as htx, down- tilt angle, ftx and Ptx from PSO like models in the design stage would corroborate with the foremost performances and will save our time and cost in system deployment.

Hata model is optimized and enhanced with the use PSO. The Hata model is selected for optimization because it has the least RMSE contrast to the measurement. The result exhibits that the PSO algorithm is performing well.The nominated propagation model optimization approach particles swarm optimization (PSO) algorithm based, it permits to optimize more than 2 parameters in contrast to linear regression mostly which is restricted to the optimization of only 2 specifications. PSO not only gives one solution but a viable solution set,and finest of all solutions is selected. Furthermore, the solution has more diverseness compared to that of another method termed as linear regression method. Basically we have fixed the heights for the transmitter and receiver(tx and rx) antennas and varied the distance between them.This is done in order to

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check whether the results obtained are well suited or not. The resulting path loss with the maximum swarms density is taken as the final resulting path loss.

2 Hata Path Loss Model

The Ldb = debilitation of RF waves due to free space dispersion, scattering, diffraction & is obtained by ratio between the Ptx and Prx. The Hata model is called a radio propagation model (for estimating the path loss in cellular transmissions), well founded for microwave freq. which ranges from 150 to 1500 MHz whose empirical formulation is built on the enumeration from the Okumura Model.
The parameters which are used in the paper are shown below:

fc → operating freq.(MHz)
d → distance between tx and rx (Km)
hm →rx antenna height (m)
hb →tx antenna height (m)

The Hata model is an empiric model dependent on substantialmeasurements.

$$PL = A + B\ log10(d) - E + C \quad (1)$$

Here

$$A = 46.3 + 33.9\ log10\ (fc) - 13.82 log10(hb) \quad (2)$$

and the path loss factor B is given as:

$$B = 44.9 - 6.55 log10(hb) \quad (3)$$

In larger cities, the correction factor for frequency andreceiving antenna height is defined as-
The below represents the correction factor for freq. and h_{rx} or h_m.

$$E = \begin{cases} 3.2[\log_{10}(11.75h_m)]^2 - 4.97 & fc \geq 400MHz \\ 8.29[\log_{10}(1.54h_m)]^2 - 1.1 & fc \leq 200MHz \end{cases} \quad (4)$$

The correction factor C = 0 dB for suburban cities and mediumareas whereas for other type of cities = 3 dB.
Considering fixed antenna heights for both transmitter and receivers path loss is evaluated for suburban,urban and open area. Plotted and tabulated in figure 1 and table 1 respectively.

3 Optimization Process

L_{db} (path loss), also known as path attenuation or debilitation, is the reduction in power density &is considerable component in inspection of telecommunication system. Using the following equation the path loss in dB is studied from the measured

Each of the particle in position (**x**), velocity (**v**) (x.v vectors) has

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$$Ldb = P_t + G_t + G_r - P_r - L_t - L_r \quad (5)$$

Here, P_t is called the power transmitted,
P_r = power received,
G_t,G_r is called gain of transmitter & receiving antenna,
L_t,L_r = transmitter & receiver feeder losses.

$$PL = 54.27 + 33.9\ log10(fc) - 13.82\ log10\ (hb) - 3.2[log10(11.755hm)]^2 + [44.9 - 6.55log(hb)]log(d) \quad (6)$$

F1 and F2are as follows:

$$F1 = 54.27 + 33.9\ log10(fc) - 13.82\ log10\ (hb) - 3.2[log10(11.755hm)]^2 \quad (7)$$

and

$$F2 = [44.9 - 6.55log(hb)] \quad (8)$$

Now, the COST-231 Hata model can be given as :

$$PL \rightarrow F1 + F2log10(d) \quad (9)$$

By using x´andy´coefficients in (9),we obtain

$$PL = x'F1 + y'F2log10(d) \quad (10)$$

A. Particle Swarm Optimization (PSO)

A PSO algorithm gives a solution by finding max or min on a set of solutions, which is known as search space. The algorithm is construct by the procedure given below:

- Element coding (swarm),
- The causation of the position of the starting swarm particles,
- Evaluation of each particle’s fitness,and its velocity and as well as position,

Each of the particle in position (x), velocity (v) (x.v vectors) has its own finest best vector and its fitness value. The Particle Swarm Optimization algorithm is put in two of the phases, one be an initialization phase and second is an iteration phase.

In an initialization phase, an inceptive velocity and position vectors of each and every particle are randomly assigned w.r.t N- dimensonal search space.

Each or single particle is moving towards the best solution by altering velocity in an iteration aspect and position.This is defined by the below equation:

$$v^{n+1}_{id}=C\{\omega v^{n} +c_1 r^{n}_{1d} (x^{n}_{gbestid}-x^{n}_{id})+ c_2 r^{n}_{2d} (x^{n}_{gbestid}-x^{n}_{id})\} \quad (11)$$

-X_{id}^{n+1} ,X^{n} =Pos^{n} of dthcoord. in positive vector of I, n's order shows iterations,

-$X^{n}_{pbestid}$ = personal best position of dth coordinate of ithparticle (in nth iteration) ,

-X^{n}_{gbestd} =Global best position of dth coordinate (at nthiteration),

-I=1…..N^{p}, N^{p}be swarm size,

-d=1…N^{d}, N^{d}be space dimension ,

-$C,C1,C2, \omega, \otimes$ are convergence factor,cognitive and social parameters, inertia weight, and unity time step respectively,

-r^{n}_{1d} & r^{n}_{2d} : 0 and 1 random distributions

The prime solution of particle →personal or local best (Xpbest).

The finest obtainable solution amongst all particles→ the global best (Xgbest).

Each and every particle represent a vector with the parameters which are optimized with arbitrary or random velocities.

4 Method

This modeling is based upon enhanced propagation model using optimization algorithm (PSO). In a specific frequency everypropagation model can become optimal drew on Kfactor propagation mode.

For urban area, okumura hata model is givenby where frequency is greater than 300MHz

$$L\text{dB}=A+(d)-E \quad (12)$$

where

$A= 69.55 + 26.16\log f_c-13.82 \log h_b$

and

$B= 44.9-13.82 \log h_b$

$E= 3.2\log 11.75 h_m^2-4.97$, for $h_m = 1.5m$

$E= 9.19*10^{-4}$

$E=0.000919$ (here E can be treated as 0)

Equation 12 can be written as-

Adding values of A and B from above then we get

$$L_{dB} = 69.55+26.16\log f_c - 13.82\log h_b + 44.9-13.82\log h_b (d) \quad (13)$$

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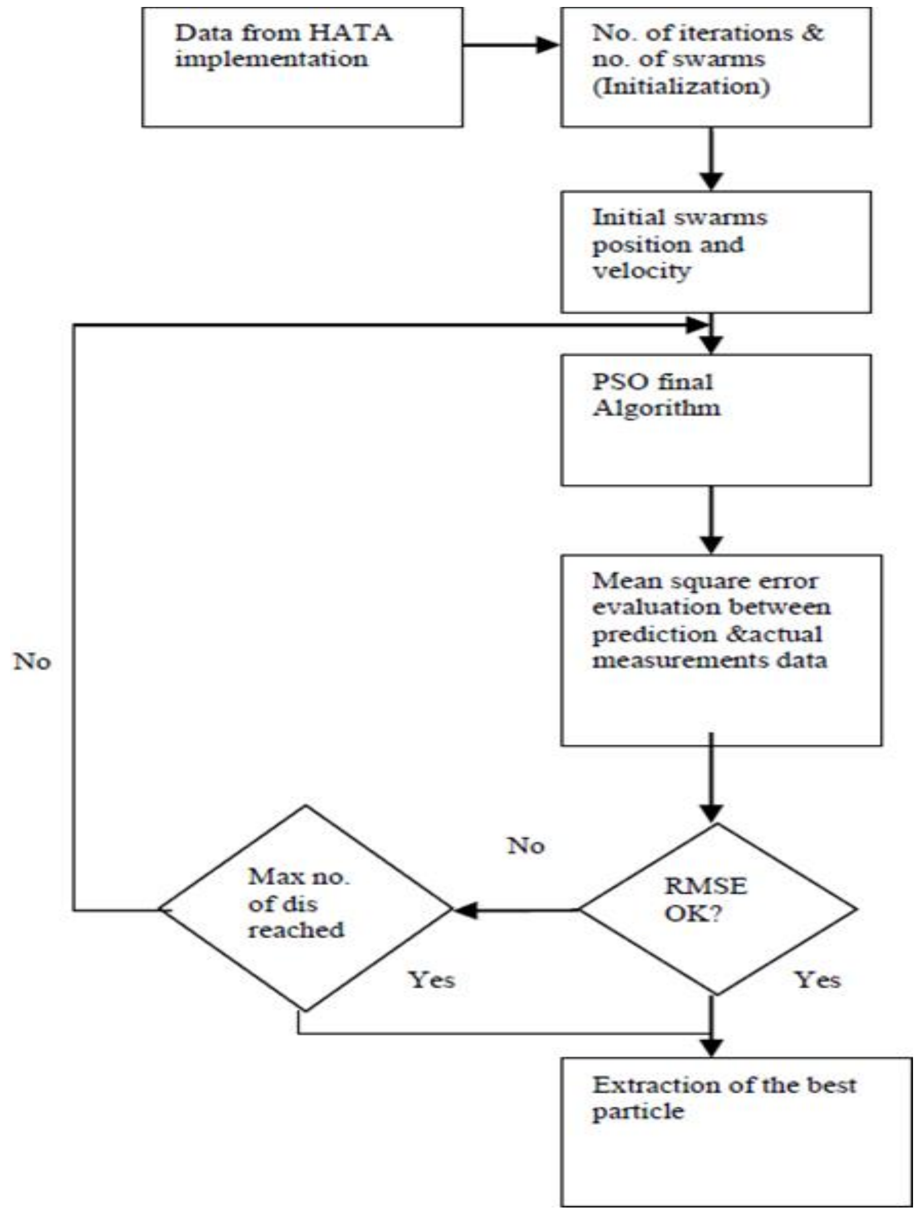
5 Flowchart



6 Result Analysis

In the assignment,the disposition parameters of PSO algorithm considered are : swarm size is 5000, maximumnumber of iterations is 1000,correction factor is 2 and numberof runs per iteration is 1000, results for which are figured in fig.2. Among all the cases assessed in this particular paper, the optimal solution is obtainable using PSO. The firmware has been carried out on PC Core i5 3.8 GHz CPU and with 8GB RAM.

The optimized Hata model is verify by contrasting or verify it with hata model without implementation of PSO algorithm as in figure 1. The path losses are evaluate and plot for the COST- 231 Hatamodel. The optimization of COST-231 Hata model, availing Particles Swarm Optimization alogorithm is giving exceed optimized values as shown in fig 3 and tabulated in table II.

TABLE I.HATA MODEL ASSESSMENT WITHOUT USING PSO ALGORITHM

Distance (m)	Pathloss (dB)urban	Pathloss (dB) open	Pathloss (dB)suburban
1	25.5027	-5.4680	14.1243
9	59.1158	28.1450	47.7374
25	74.7450	43.7742	63.3665
49	85.0396	54.0689	73.6612
81	92.7288	61.7581	81.3504
121	98.8685	67.8978	87.4901
169	103.9797	73.0089	92.6013
225	108.3580	77.3872	96.9796
289	112.1875	81.2167	100.8091
361	115.5905	84.6198	104.2121
441	118.6527	87.6819	107.2743
529	121.4361	90.4653	110.0576
625	123.9872	93.0164	112.6088
729	126.3419	95.3711	114.9635
841	128.5282	97.5575	117.1498
961	130.5687	99.5980	119.1903

$Fc=1.5*10^9/10^6=1.5*10^3=1500MHz$

Rx height =2m

Tx height=30m

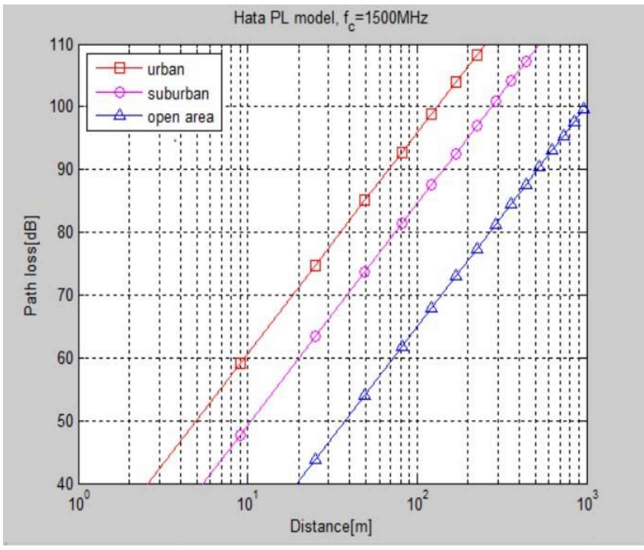


Fig. 1: HataPath Loss Model without using PSO algorithm

FOR OPTIMIZATION:

Renewals = 1000;

Immobility = 1.0; Emendation factor = 2.0;Swarms = 5000;

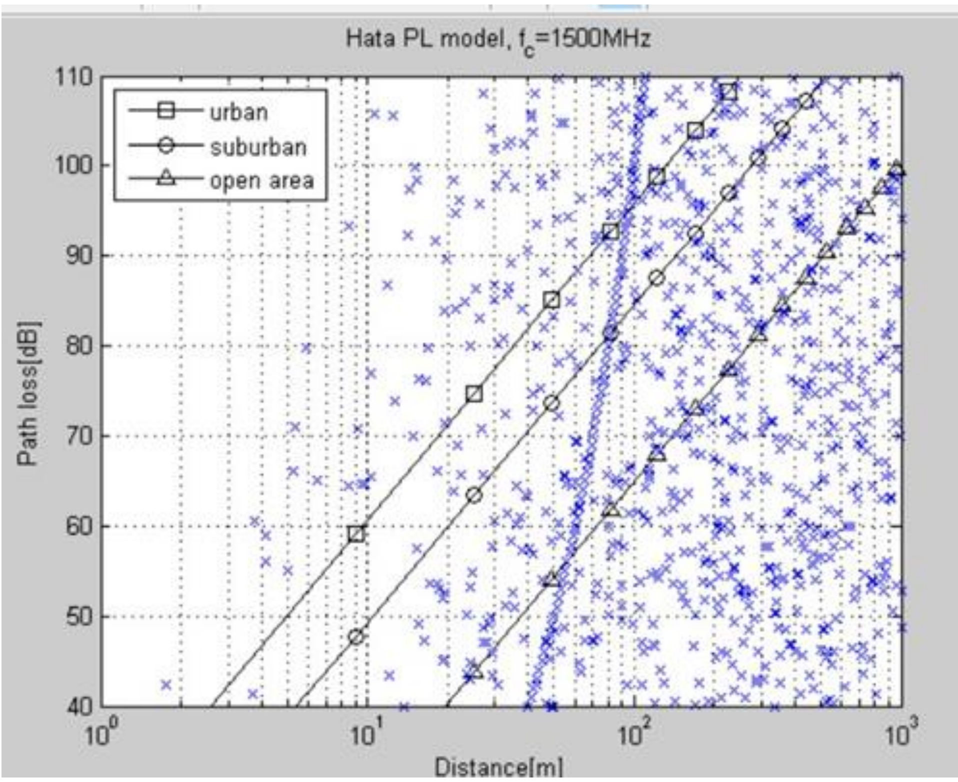


Fig. 2:Hata Path Loss Model using PSO algorithm

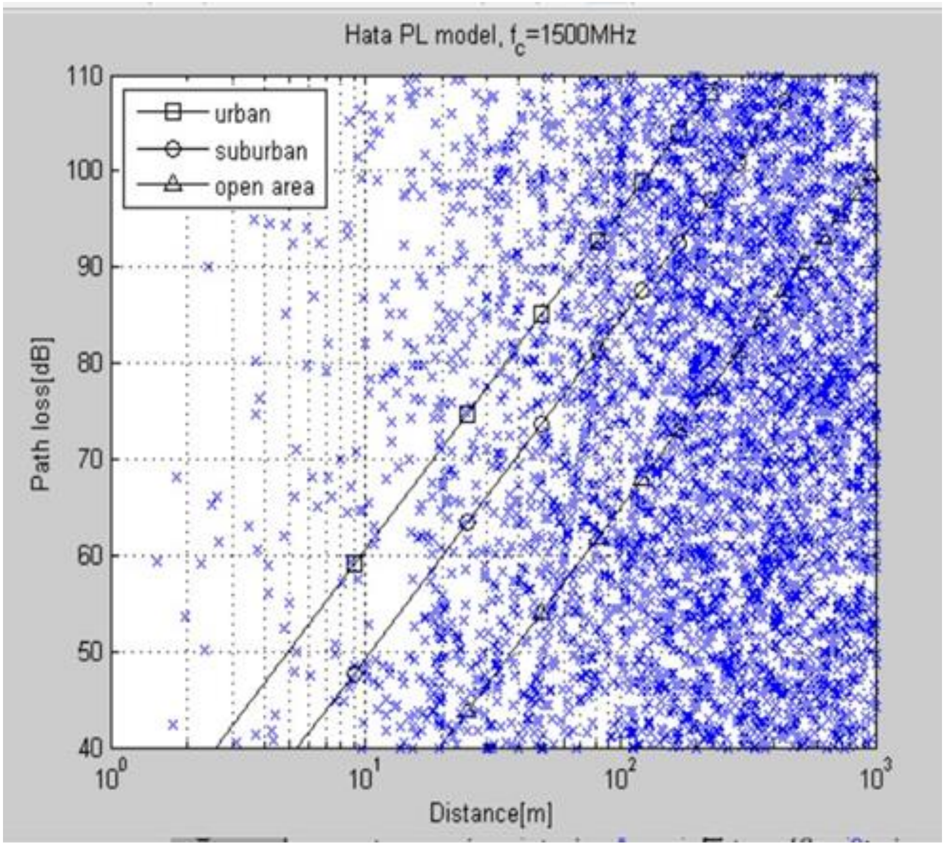


Fig. 3: Hata Path Loss Model using PSO with increased swarm density

TABLE II. ASSESSMENT FOR HATA MODEL USING PSO ALGORITHM

Distance(m)	Pathloss (dB)urban	Pathloss (Db)open	Pathloss(dB) suburban
1	24.5027	-6.4680	13.1240
9	57.168	27.1400	45.7370
25	72.9850	42.7700	62.3660
49	84.0396	52.0680	72.6610
81	91.7289	60.7580	80.3504
121	96.9885	62.8970	86.4900
169	102.9794	70.0080	91.6010
225	107.3090	75.3800	95.9790
289	110.1800	80.2100	99.8000
361	114.59050	82.6100	102.2120
441	116.6520	85.6810	105.2740
529	119.4000	89.4600	108.0500
625	120.9870	92.0100	110.6080
729	124.3009	93.3700	113.9633
841	127.5200	96.5570	115.1499
961	128.5600	97.5988	116.1900

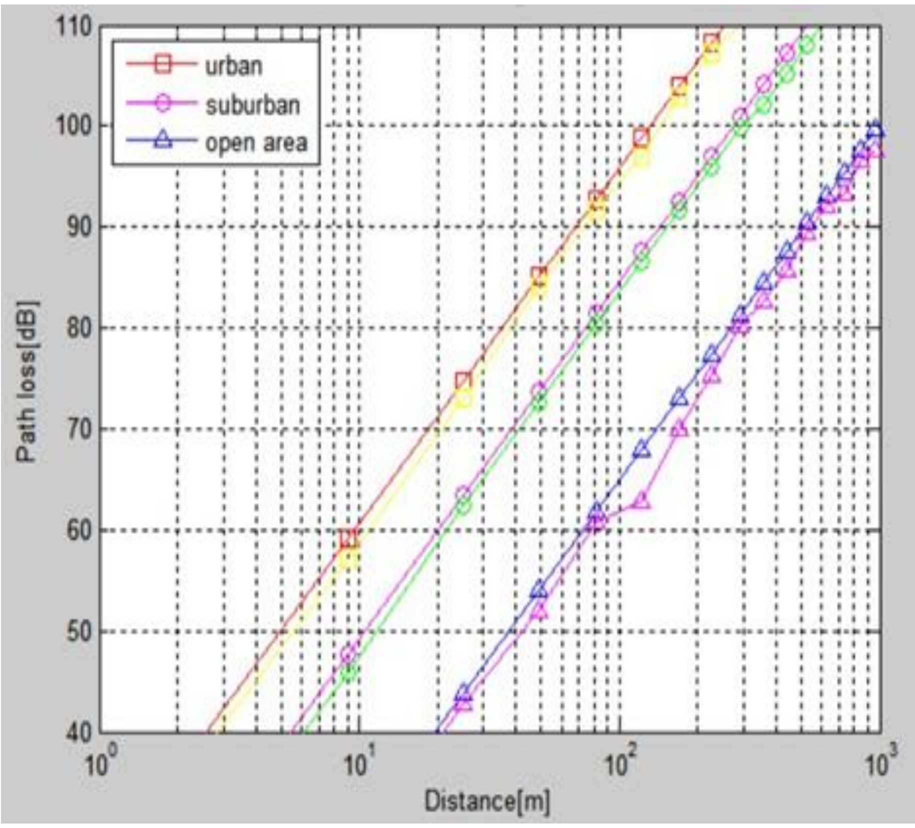


Fig. 4: Hata Path Loss Model using PSO with less swarm density

7 Conclusion

We put forward an optimized and enhanced path loss model. The hata models optimization process is done by PSO. The optimized and enhanced Hata model using PSO was authenticated, corroborated and juxtaposed with other Hata model without using the optimization algorithm **ie shown in fig.4**. The outcome manifested that the PSO algorithm is performing better. Concisely, the optimized Hata model shows improvement in performance in contrast to that of the original Hata model.The method stated here could perfectlybe used to design/gauge propagation models.The PSO algorithm doesn't provide anomalous decoding of the problem mix-up but shows a better performance.

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