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MATLAB Graphical User Interface (GUI) for Wireless Metropolitan Area Network Optimum Performance

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ABSTRACT

Wireless network optimal performance is what communication engineers strive for. Empirical models are used to predict wireless link quality factors such as path loss and the received power in any given transmission environment with irregular terrain. This research work embraces Okumura-Hata model and is used to predict broadcast signal strength for Akure city, Ondo State, Nigeria. Measurement results of signal strength in UHF band taken in the three routes of Akure were compared with the predicted results using the empirical model (Okumura-Hata). A Matlab GUI based on the modified Okumura-Hata model was developed for simulation of results and prediction purposes.

Keywords: *Empirical model, Matlab GUI, Wireless network and UHF band.*

1. INTRODUCTION

Tanenbaum, (2003) [1] reported that Wireless networks link point to point and point to multi-point stations/nodes through transmission of an electromagnetic wave which is received at the other end of the receiving station. All wireless communication is based on this principle. Nowadays, wireless technologies are implemented in different forms as in mobile computing using personal digital assistants (PDA), wireless local area networks (WLAN), metropolitan area networks (MAN), cellular phones, etc., without being connected to the terrestrial communication infrastructure. The radio channel comprises of the propagation medium, the transmitting and receiving antennas. Radio transmission takes place from a transmitter to a receiver through propagation paths. These are referred to as propagation mechanisms arising out of the different interactions with the interfering objects along the path as said by Fleury and Leuthold (1996) [2]. The use of free space communication results in susceptibility to weather effects and transmission paths will also need to be clear in order to maintain a line of sight for point to point communication to exist over different terrains. According to Ranvier (2004) [3], in the design and planning of wireless networks, empirical models, deterministic models and semi-deterministic models are used for predicting their performance.

Several models that approximate the diffraction loss for two or more obstacles have been developed. The Epstein–Peterson method [4]: The attenuation due to each obstacle was calculated separately to obtain an overall result as a sum of partial results. The method produces large errors when two obstacles are closely spaced together. A correction given by Millington [5] may be incorporated to improve the predictions. The Japanese method [19]: In concept, this method is similar to the Epstein–Peterson method. It has been shown in [6] that the produced results are equivalent to the Epstein–Peterson method incorporating the Millington correction given in [5]. In general, the method underestimates the path loss. The Deygout method [7]: A recursive method that calculates the overall loss as the sum of individual losses for all obstacles in order of decreasing Fresnel–Kirchhoff diffraction parameter [9]. In general, the method shows good agreement with the Millington's rigorous method [8]. If there are multiple obstacles and/or the obstructions are closely spaced, the method has been shown to overestimate the path loss [10].

Okumura-Hata Model for Urban Environments

Famoriji (2013) [11] stated that the Hata model for urban areas, also known as the Okumura-Hata model for being a modified version of the Okumura model, is the most widely used radio frequency propagation model for predicting the behavior of cellular transmissions in built up areas. This model incorporates the graphical information from Okumura model and develops it further to realize the effects of diffraction, reflection and scattering in suburban areas and open areas, Hata model predicts the total path loss along a link of terrestrial microwave or other type of cellular communications.

This model is suited for both point-to-point and broadcast transmissions and it is based on extensive empirical measurements taken. The Okumura-Hata model for urban area as stated in Famoriji and Olasoji is given below:

$$PL = 69.55 + 26.16logf - 13.82logh_B - a(h_m) + [44.9 - 6.55logh_B]logd \quad (1)$$

For large city with the wave frequency of transmission, $f \geq 400MHz$

$$a(h_M) = 3.2[\log(11.75h_M)]^2 - 4.97 \quad (2)$$

For specifications, Okumura-Hata has the following range: Carrier frequency: 150MHz $\leq$ f $\leq$ 1500MHz, Base station height: 30m $\leq h_B \leq$ 200m, mobile station height: 1m $\leq h_M \leq$ 10m, distance between mobile station: 1Km $\leq$ d $\leq$ 20Km as stated in Famoriji and Olasoji (2013) [11].

2. RESEEARCH METHODOLOGY

Block diagram (Figure 1) shows the procedure followed in carrying out the research work.

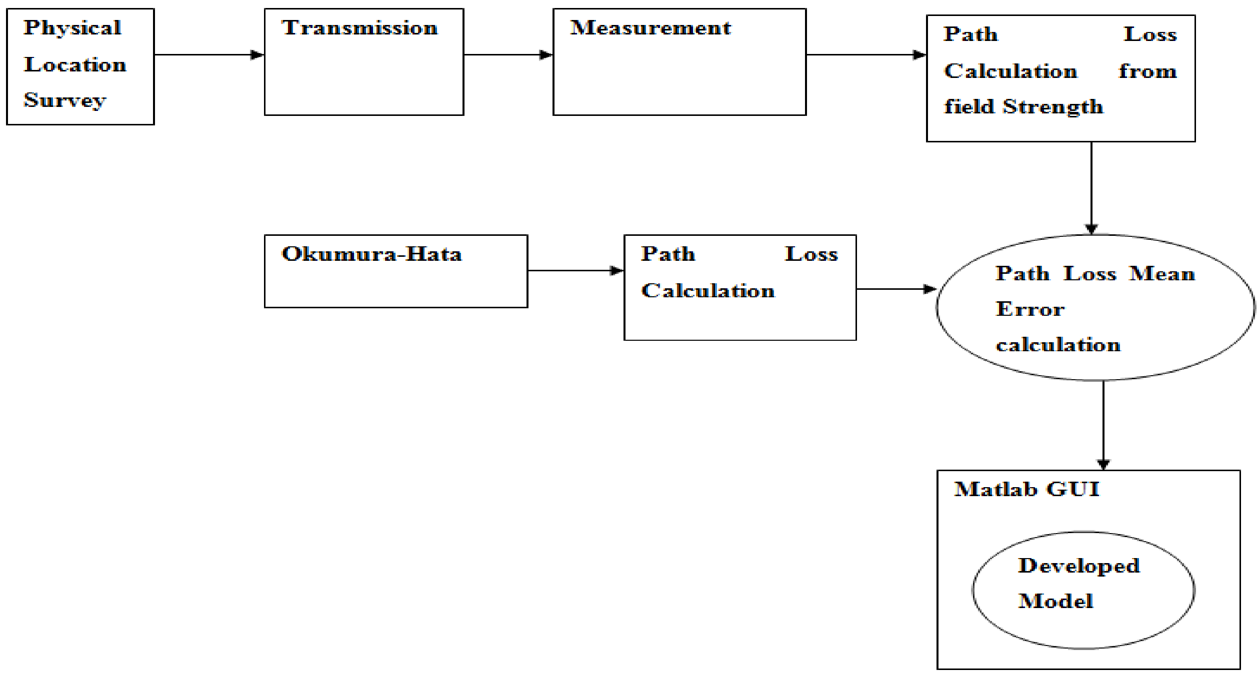

Figure 1: Block diagram showing the research procedure

2.1 Physical Location Survey

Physical location survey was first conducted to select sites. During the site survey, obstacles such as trees, hills and structures capable of causing obstruction of radio signal along the line of sight were taken into account. Investigation was carried out along three different routes (i.e. locations away from the transmitting station of Ondo State Radiovision Corporation OSRC). These include Route A, Route B and Route C representing OSRC/Ilara/Igbara Oke highway (Akure South), OSRC/Iju/Ado highway (Akure North) and OSRC/ Oyemekun/ Alagbaka highway respectively.

2.2 Measurement

Akure city, in Ondo State of Nigeria, was used as the study area. It is situated in the tropics at Lat 7.25^{0}N, Long 5.2^{0}E, altitude 420m above sea level; an agricultural trade centre with light industries and is minimally influenced by industrial pollutants or aerosols Olasoji and Kolawole (2011) [12]. A series of measurements of television broadcast signal strength were carried out in the UHF band (470 - 862 MHz) by the use of Yagi array antenna coupled through a 50-ohm feeder to the UNAOHM model EP742A field strength meter in various observation points between the transmitting antenna at OSRC and the receiving antenna in the respective location were mapped using the GPS (Global Position Satelite) receiver. The position of the transmitting antenna or base station was marked as a “home” waypoint on the mark position page of the GERMIN GPS Map 76 receiver and stored in the memory. A trip of 20km with the aid of a slowly moving vehicle away from the base station through Route A was taken at an incremental rate of approximately 1km line of sight. This procedure was also used to determine straight line distance between the receiving antenna in the other routes and the transmitting antenna that was permanently fixed at OSRC, Akure.

3. RESULTS

Okumura-Hata model (see equation 1) was used to predict the path losses along the three routes. The corresponding path loss for each signal field strength measured were calculated using equations 3, 4 and 5 as obtained from Rappapot (2002) [13]. The specification of Okumura-Hata model about transmitting antenna height is within antenna the range of 30m to 200m. However, the base station height used for the calculations is 325m. All other specifications of this model were met by the conditions of the experiment. Also, the measurements taken along the Northern, Southern and Central routes of Akure city are assumed to be applied to other parts of the city.

$$P_r = \frac{P_t G_t G_r}{PL} \quad (3)$$

$$P_r = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4} \quad (4)$$

$$E\left(\frac{V}{m}\right) = \frac{\sqrt{30 P_t G_t}}{d(LOS)} \quad (5)$$

3.1 Comparison with Measurements

The corresponding error statistics in terms of the mean prediction error was determined for the model. The prediction errors were calculated as the difference between the measurement and prediction. Tables 1 shows path loss mean error for Okumura-Hata model along routes: A, B and C respectively. It was observed that Okumura-Hata model under estimated the path loss.

Table 1: Path Loss mean error of Okumura-Hata models along the Routes

Routes	A	B	C
Path Loss Mean Error (dB)	21.33	19.17	25.40

3.2 The Developed Model

The mean deviation errors (as shown in Table 1) were added to the Okumura-Hata model (see equation 1) to generate a path loss model suitable for prediction along the routes under consideration in Akure city. Therefore the modified Okumura-Hata model developed for the three routes are stated below:

$$\mathrm{PL_A} = 69.55 + 26.16\mathrm{logf} - 13.82\mathrm{logh_B} - \mathrm{a(h_m)} + [44.9 - 6.55\mathrm{logh_B}]\mathrm{logd} + 21.33\mathrm{dB} \quad (6)$$

$$\mathrm{PL_B} = 69.55 + 26.16\mathrm{logf} - 13.82\mathrm{logh_B} - \mathrm{a(h_m)} + [44.9 - 6.55\mathrm{logh_B}]\mathrm{logd} + 19.17\mathrm{dB} \quad (7)$$

$$\mathrm{PL_C} = 69.55 + 26.16\mathrm{logf} - 13.82\mathrm{logh_B} - \mathrm{a(h_m)} + [44.9 - 6.55\mathrm{logh_B}]\mathrm{logd} + 25.4\mathrm{dB} \quad (8)$$

where PL_A, PL_B *and* PL_C representing the path loss prediction along routes A, B, and C respectively and all other terms remain as previously defined. The mean of equations: 6, 7 and 8 gives equation 9 can be generally used for prediction of path loss in Akure city.

$$PL = 69.55 + 26.16logf - 13.82logh_B - a(h_m) + [44.9 - 6.55logh_B]logd + 21.97d \quad (10)$$

3.3 Simulation of Model

The wireless radio frequency (RF) simulator used for the models developed is presented in Figure 1; it shows the parameters used by the same simulator. The GUI takes in height of the transmitter in metre, height of the receiver in metre, frequency of transmission in MHz, gain of transmitter in decibel (dB), gain of the receiver in dB, transmitted power in dB and distance LOS that exist between the transmitter and receiver in kilometer as inputs. It simulates the predicted path loss and corresponding received power in the area considered as outputs. T_x and R_x represent transmitter and receiver, respectively.

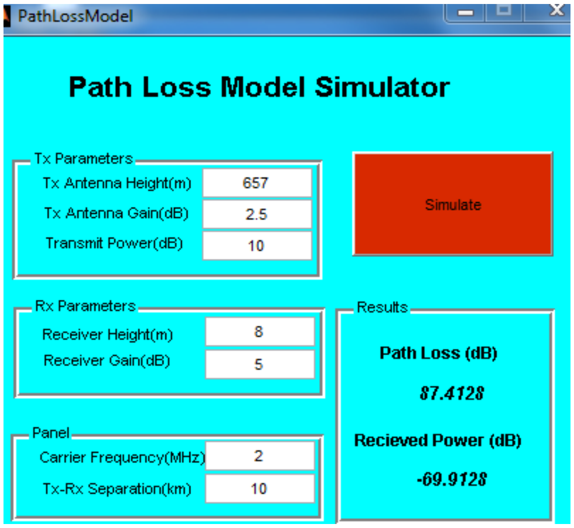

Figure 1: Transmission Parameters of Matlab GUI Simulator

4. CONCLUSION

This research work employed Okumura-Hata model to predict path loss in Akure city (metropolitan area network). The results which were compared with the path loss obtained from broadcast signal field strength measurements. However, a modified Okumura-Hata model developed was incorporated into Matlab GUI for simulation. The Matlab GUI can be deployed by wireless communication engineers for easy network design and planning in cities and for determining network performance.

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