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# Novel Artificial Neural Network Path Loss Propagation Models for Wireless Communications

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**Abstract**

Different propagation models proposed for different scenarios but a unique model did not exist, which will be suitable for all types of environments. Artificial Neural Network model is developed by training it to the entire expected domain. It calculates the path loss. An extra input is used, named 'type of environment' to model the network. This approach is new and gave accurate results in comparison to the established models. The paper also presented the approach of handling big task using N array ANN. The results were encouraging.

**Index terms:** Artificial Neural Network, COST231, Davidson, Eukumara model, Hata Model, ITU 529.

## 1. INTRODUCTION

The present age is the age of wireless. The behavior of electromagnetic waves is not uniform in the medium. One has to take the help of Radio propagation [1-2] models to determine the path loss. It is usually an empirical mathematical formulation for the behavior of propagation for different conditions. These formulations in general contain function of distance, frequency and some medium characteristics. The empirical models utilizes large amount of date collected from specific environment domain for its development. In wireless communication systems, many individual links encounter different paths, obstructions, atmospheric conditions and other phenomenon. A single model is incapable to formulate the exact loss for all wireless

systems. Therefore, leads to development of different models for different types of radio links. Depending on the application, the models [3-4] are classified.

Application of ANN in engineering community is two decade old. ANN has the potential to generalize a function to any degree of accuracy.

## 2. ANN AND PROPAGATION MODELS

Artificial neural network (ANN) has some distinguished characteristics, including the ability to learn from data, to generalize patterns in data and to model nonlinear relationships. Different branches of engineering have applied successfully this technique for design and analysis [3] in their problem domain. This prompted to develop a single ANN model for path loss prediction for different environments of wireless propagation. Different researchers propose various models; here I take practical models like ITU 529, Davidson, and COST 231 for analysis. In the table 1 the specifications like frequency of operation, range, and mobile antenna height are given.

**Table: 1** Some Practical Propagation Models

| Model | Distance (km) | Frequency (MHz) | Base Antenna Height(m) | Mobile antenna Height (m) |
|---|---|---|---|---|
| ITU 529 | ≤ 100 | 150 to 1500 | 30 to 200 | 1 to 10 |
| Davidson | ≤ 300 | 30 to 1500 | 20 to 2500 | 1 to 10 |
| COST 231 | ≤ 100 | 1500 to 2000 | 30 to 200 | 1 to 10 |

## 3. IMPLEMENTATION ASPECTS OF NOVEL - ANN

### 3.1 Novel ANN Concept:

Problem solving capability of ANN depends on its architecture. These networks in theory can perform any complex nonlinear mapping. The neural network architecture used in most of the cases for the modeling is a multilayered feedforward neural network [5-6] trained in the supervised mode using a backpropagation algorithm.

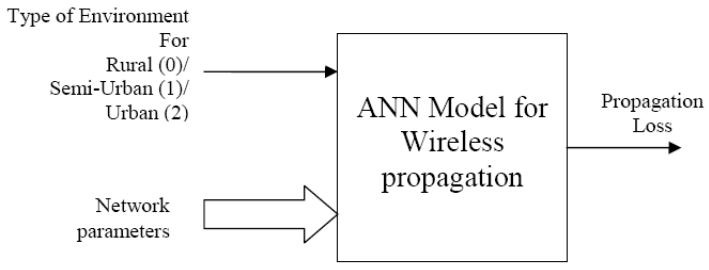


**Figure 1:** Novel ANN concept

For robustness of wireless propagation models, the concept of novel ANN is used. Different empirical formulas exist for different environments like rural, semi-urban, and urban. There is no unique formula exists for path loss determination, which is suitable for all environments. In this paper, an extra input namely the 'type of environment' is presented as input to the ANN model as shown in the figure 1. The Neural Network after training works as a novel model suitable to any environment. The network developed takes four inputs [frequency, antenna height, distance, type of environment] and gives the path loss in dB as output.

The number of neurons in the hidden and output layers is ten and one respectively. The network designed gives the path loss for different conditions of the environment depending on the value of a parameter termed as type of environment.

### 3.2 Generalized Concept:

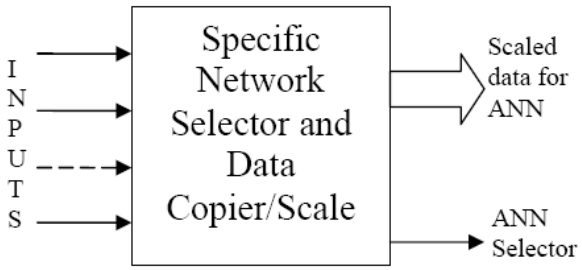


**Figure: 2** Generalized concept

In figure 2, the general method is illustrated that can be applied in the similar situation i.e. if there is M, different formulas correspond to different situations, and they are accurate in their respective environment. The models take same type of input variables, and all gives the same type of output variable. By this technique, development of a compact model is possible using the concept of novel neural network. Realization using neuro-processors is also possible.

Alternatively, one can have 'M' ANN models and find a suitable logic to trigger the corresponding ANN. It is like a switched Artificial Neural Network. In figure 3, the logic gives output '1' to the required / correct ANN model and rest of the outputs are '0'. The summer will get output only from the correct ANN model, and the contributions from other models will be zero.

The ANN uses sigmoid transfer function and linear transfer function for the hidden and output neuron respectively. Resilient backpropagation algorithm is used for training with delta_inc = 1.12 and delta_dec = 0.79.

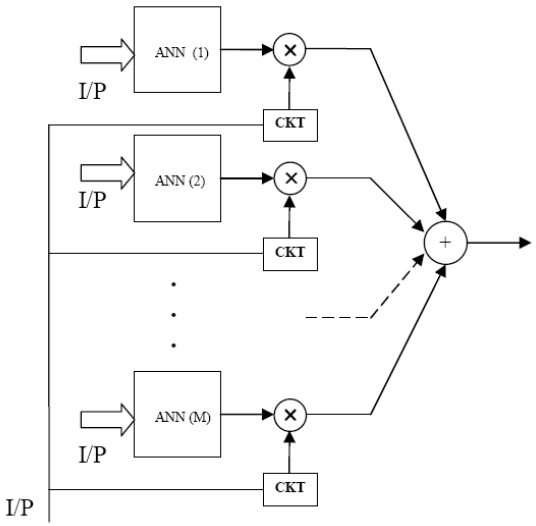


**Figure: 3** Multiple ANN models (M -ANN)

## 4. RESULTS AND DISCUSSION

Table 1 shows the range of practical models and their valid range of operation.

Table 2: Comparison of different propagation models with the proposed Novel ANN model

| **Parameter ( f(MHz), d(Km), bA(m), Mah(m))** | **ITU 529 (dB)** | **Cost 231 (dB)** | **M-ANN (dB)** | **Novel ANN (dB)** |
|---|---|---|---|---|
| f =200; d = 50; bA=50; Mah=20; Env = open | 142.11 | 136.67 | 142.01 | 142.09 |
| f =200; d = 50; bA=50; Mah=20; Env = Suburban | 159.36 | 153.92 | 159.46 | 159.39 |
| f =200; d = 50; bA=50; Mah=20; Env = Urban | 166.22 | 160.78 | 166.31 | 166.24 |
| f =1800; d = 50; bA=50; Mah=20; Env = Urban | 195.37 | 197.32 | 197.21 | 197.30 |

Data is generated for open, suburban, urban (small/medium), urban (Larger) in the suitable range using these models and the network is trained and tested, and the results are encouraging. Here, two types of approaches are considered. The first and second approaches are based on figure 1 and figure 3 respectively. The second approach gives better results than the former approach.

## 5. CONCLUSION

This paper presented a Novel ANN model for prediction of path loss for different environments of the propagation medium. The results were in good agreement with the established empirical models. The ANN model presented took care of the different empirical models for accuracy. The ANN model can further be improved by incorporating different other factors. There is scope for further research.

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