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Artificial Neural Networks for Intelligent Communication Systems: A Study

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Abstract: - **The paper is a study of the application of Artificial Neural Networks for problem solving and optimizing the performance in different communication systems. Artificial neural networks are being used for spectrum sensing, pattern recognition and many applications in wireless communication. The main objective is to reduce the complex analysis of a communication system. This paper gives the state of the art of research of Artificial Neural Networks making the communication systems adaptive and smart.**

Index Terms- **ANN, Communication systems, Neural Networks.**

I. INTRODUCTION

Machine learning in a communication system has now necessity as the systems have to be made intelligent, dynamic so that they can take necessary decision to adapt to the prevailing environment or conditions of the system. In communication systems ANN can be applied to optimize a few parameters inorder to enhance the QoS of the communication system. Studies form different paper show that ANN has been applied when there is a complex mathematics involved or there is predictions based on some empirical formulations. The neural networks are applied for different problem solving purpose like efficient resource allocation like in handoff, spectrum sensing, Adaptive classification of modulation technique, satellite Image processing, Handoff problem in cellular networks etc. We have tried to discuss the work in these domains in this paper. The paper is as follows. In section II a brief overview of neural networks is given and the section III the application of neural network in different communication systems are discussed. The neural network are biologically inspired soft computing techniques [1][2]. The ANN is trained as per the requirement of the communication system. In this paper we have studied and surveyed how ANN can be applied to Engineering problems of a Communication system.

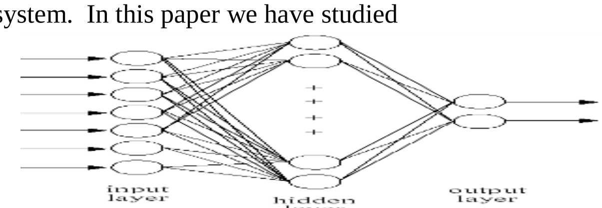

Figure 1: Neural Network Structure

II ARTIFICIAL NEURAL NETWORKS:

Artificial Neural Networks are neuroscience inspired computational tools applied for Engineering problems like pattern recognition, spectrum sensing etc. The concept of ANN was first given by the neurophysiologist W. McCulloch and the logician W. Pits in 1943 for the study of the human brain. The idea of artificial neural network (ANN) was then applied to computational models. The artificial neuron is the unit model of the ANN structure which gets input from all neighboring neuron and gives an output depending on its synaptic weight and activation functions. The ANN is a set of nonlinear functions with adjustable parameters to give a desired output [1][2]. These are trained using input-output data to generate a desired mapping between input stimulus to the targeted output [1][2]. The structure of an ANN consists of neurons arranged in the form of layers, the three layers being the input layer, hidden layer and the output layer. Usually the number of neurons in the input layer and output layer is equal to the number of inputs to the ANN model and the number of outputs respectively. The number of hidden layers and the number of neurons in it can be decided based on the performance the ANN model. Learning can be a supervised learning or it can unsupervised. In supervised learning the weights are adjusted till the difference between the desired output and the output of the network is negligible.

The ANN has been used to make the system learn from the environment and take decision. So it can reduces the complex mathematics that may be involved with an engineering problem. Hence the neural networks are able to learn patterns, features, and attributes of the system. The attributes can be highly nonlinear, complex, and numerous, yet ANNs can be constructed for the purpose, thus reducing the complexity of the solution [3]. For this reason, they have long been used to describe functions, processes, or classes that are otherwise difficult to analytically formulate. Therefore, ANNs can be used not only to classify or recognize received stimuli but to assist in the solution adaptation process as well. This paper gives the state of art of ANN in different Communication systems. In this paper we discuss some of the Communication Engineering aspects solved using the artificial neural networks.

A. Mobile station location identification using ANN:

In [4] an ANN based Mobile station location identification system is designed. The authors propose an algorithm that utilizes time of arrival (TOA) measurements and the angle of arrival (AOA) information to locate MS when three base stations (BSs) are available. When the MS is heard by three BSs, the proposed algorithm utilizes the intersections of three TOA circles (and the AOA line), based on various neural networks, to estimate the MS location in non-line-of-sight (NLOS) environments. The mobile positioning technique plays an important role in providing location-based services in wireless communication networks. With this new feature, it can be applied to several valuable location-based services. Applications of wireless location services include the E-911 wireless emergency services, location-based billing, fleet management and intelligent transportation system (ITS) [5]. The ANN model proposed helps find the location of the mobile station. If the TOA measurements are available then the location of the BS is estimated by the intersection of the circles as given in figure 2

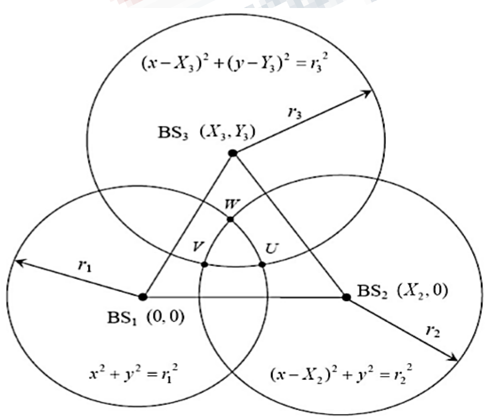

Figure 2. Geometrical layout of three circles [4].

The true location of the MS is in the intersection region of the circles denoted by U,V and W. From this the input output parameters for the training of the ANN model are extracted. The input parameters taken are the values of intersection i.e. U, V and W and at the output of the ANN model the position of the MS is predicted. Further the ANN model was enhanced by considering the AOA measurement and the three TOA measurements. The intersection of the three TOA and one AOA information gives the alignment of the MS wrt to the BS. The single AOA measurement helps find the angle between the serving BS and the MS. So the intersection between the three TOA and the AOA are given as input to the ANN and the location of the MS is estimated.

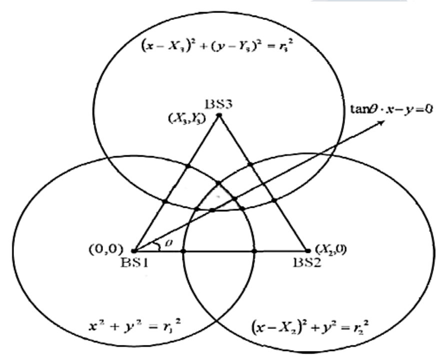

Figure 3. Geometrical layout of three circles and one line for MS location identification [4]

These parameters are given as input to the ANN model and was found by the authors that the proposed algorithm can reduce NLOS errors and obtain a more accurate MS location estimate.

B. ANN Based Call Handoff Management Scheme for Mobile Cellular Network:

In this paper [6], an Artificial Neural Network based handoff algorithm is proposed and ANN is used for fast and accurate handoff decision. A handoff process is basically the changing of the controlling base station when the mobile station moves form cell to other. So inorder to make the call continuous the handoff process is required. The handoff has to be initiated in such a manner that there is no unnecessary handoff or there is no call termination. Handoff is dependent on the velocity characteristics and the pathloss which is further dependent on the distance between the transmitting base station and the mobile station, path loss exponent and the velocity of the MS. So based on these factors the algorithm is developed in this paper. Signal strength from the serving and target base stations and traffic intensities of the serving and target base stations are considered. A three-layered ANN model is chosen in the design. Signal strengths from the serving and target base stations are estimated using least square estimation method incorporating Rayleigh fading. The input parameters to the ANN model are the signal strength of mobile from the serving basestation and the transmitted base station, traffic intensity of the serving and the target base station. Depending on these parameters the ANN model will decide whether a hand off is required. So handoff process are initiated at a proper state of the network.

C. A Hybrid Path Loss Prediction Model based on Artificial Neural Networks:

This paper [7] presents a hybrid, error correction-based, neural network model to predict the path loss for suburban areas at 800 MHz and 2600 MHz, obtained by combining empirical propagation models, ECC-33, Ericsson 9999, Okumura Hata, and 3GPP's TR 36.942, with a feedforward Artificial Neural Network (ANN). The performance of the hybrid model was compared against regular versions of the empirical models and a simple neural network fed with input parameters commonly used in related works. Results were compared with data obtained by measurements performed in the vicinity of the Federal University of Rio Grande do Norte (UFRN), in the city of Natal, Brazil. In the end, the hybrid neural network obtained the lowest RMSE indexes, besides almost equalizing the distribution of simulated and experimental data, indicating greater similarity with measurements.

Prediction data is calculated by models Ericsson 9999, Free Space, ECC-33, and TR 36. 942. The experiment was set in suburban areas, at the frequencies of 800 MHz and 2600 MHz. ECC-33 model was applied in 2600 MHz, while Free Space model was employed in the frequency of 800 MHz; Ericsson and TR 36.942 covered both bands. An error correction-based ANN model, using empirical models, is applied in the prediction of path loss. The ANN is trained to learn the error between measured values and the ones calculated by the propagation models. The difference error is obtained by taking the difference between the pathloss measured and the pathloss predicted.

E=PLmeasured–PLpredicted.

Th output of the ANN is the corrected pathloss. ANN model applied is a feedforward Multilayer Perceptron type with 2 inputs, 1 output and one hidden layer. The input set consist of two vectors with 455 elements each (in the 2600 MHz scenario, while in 800 MHz case, it consists in 450 elements). The transfer functions used for hidden and output layers were the tangent-sigmoid and linear, respectively, while the algorithm chosen to train the network was the Levenberg-Marquardt backpropagation.

D. Classification of Primary Radio Signals:

A new technique, Automatic Modulation Classification (AMC) suggested in [8] determines the primary modulation technique in the cognitive radio environment. The objective of the ANN training is to identify the primary signal's modulation technique. So the AMC here tries to distinguish 2ASK, 4ASK, BPSK QPSK and 2FSK from each other. The salient features related to each modulation technique is applied as input to the ANN model like Power spectral density, Standard deviation of the absolute value of the non linear components of the instantaneous phase , Standard deviation of the direct value of the non linear component of the direct instantaneous phase, Standard deviation of the absolute value of the normalized instantaneous amplitude σaa The neural network are trained with these four features of the signal at the input to identify the modulation technique. 2500 training data set with the four inputs and five outputs is used to make the neural network learn to identify and distinguish the modulated signals. The structure of the ANN has seven neurons in the hidden layer and five neurons in the output layer [9].

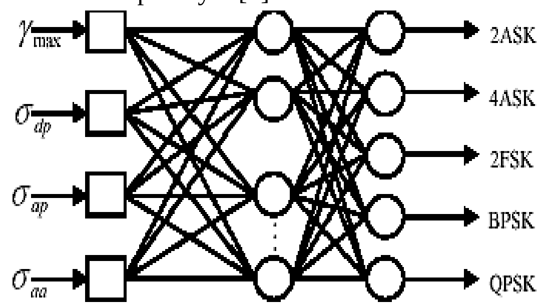

Figure 4 . Multilayer feedforward Network structure [8]

The ANN model accurately identifies the modulation technique [9].

E. Channel capacity Estimation using ANN

The radio spectrum has become a scarce resource because of the evolving technology and the increased demand for spectrum. So cognitive radio (CR) is now the relevant technology under development that enables one to utilize the spectrum more efficiently [10]. The cognitive radio tries to identify which frequency bands are free and which are occupied with a primary user. An artificial neural network (ANN) model that predicts the channel capacity of the received signal is designed. This information is analyzed theoretically which is subsequently verified by a suitable simulation scheme for identifying possible white space in a given band. The channel information here is the channel capacity which is predicted from the SNR of the channel scanned, distance between the transmitting and the receiving system. A QPSK transmission and reception system over an AWGN channel is assumed. The bandwidth of the channel is taken as 5 KHz. This channel state information is analyzed by determining the bandwidth efficiency and mutual information for identifying the spectrum holes. We observe that channel capacity predicted by the ANN model can be considered as a decision making parameter to declare the channel occupancy status as it provides a measure of the bandwidth efficiency, entropy (H) and mutual information (I) over the channel [11]

III. CONCLUSION

In this paper we have discussed how ANN can be applied in the various Communication systems for increasing the Qos of the system. ANN can be applied to make the communication system learn and adapt to the environment. As ANN is being applied in the various optimisation aspects of a communicaion system it makes these systems more adaptive and intelligent. We are currently working on how ANN can be applied for dynamically deciding the modulation technique that can be applied or most suitable for a particular channel characteristics.

REFERENCES

[1] S. Haykin, Neural Networks: A Comprehensive Foundation. Upper Saddle River, NJ: Prentice-Hall, 1999.

[2] Rajasekaran ,Vijayalakshmi Pai, "Neural Network, Fuzzy and GA algorithms:Synthesis and Applications", PHI, 2013

[3] W.H.Tranter. et.al "A Survey of Artificial Intelligence for cognitive radio". IEEE Transactions On Vehicular Technology, Vol. 59, No. 4, May 2010.

[4] Chien-Sheng Chen, "Artificial Neural Network for Location Estimation in Wireless Communication Systems" Sensors 2012, 12, 2798-2817; doi:10.3390/s120302798

[5] Caffery, J.J.; Stuber, G. Overview of radiolocation in CDMA cellular systems. IEEE Commun. Mag. 1998, 36, 38–45.

[6] P. P. Bhattacharya,,A Sarkar, I.Sarkar,S Chatterjee, " An ANN Based Call Handoff Management Scheme for Mobile Cellular Network", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, No. 6, December 2013

[7] B J. Cavalcanti, G A. Cavalcante, L M. de Mendonça G M. Cantanhede, M.M. de Oliveira, A G. D'Assunção, "A Hybrid Path Loss Prediction Model based on Artificial Neural Networks using Empirical Models for LTE And LTE-A at 800 MHz and 2600 MHz", J. Microw. Optoelectron. Electromagn. Appl. vol.16 no.3 São Caetano do Sul Sept. 2017.

[8] J.J Popoola and R.V.Olst, "Application of neural network for sensing primary radio signals in a cognitive radio environment," AFRICON, pp.1-6, Sept. 2011.

[9] E.E.Azzouz and A.K.Nandi, "Automatic modulation recognition of communication signals," Kluwer Acad. Pub., Boston, pp46-47, 1996.

[10] J. Mitola III, "Cognitive Radio: An Integrated Agent Architecture for Software Defined Radio", Ph.D. Dissertation Royal Instt.Tech., Sweden, May 2000.

[11] S. Pattanayak, R Nandi, "Identification of Spectrum Holes using ANN Model for Cognitive Radio Applications",IEEE EUROCON, 2013 Croatia. DOI:10.1109/EUROCON.2013.6624977