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TUNNEL BASED ARTIFICIAL NEURAL NETWORK TO CALCULATE THE RADIATION PATTERN OF COMMERCIALLY AVAILABLE CELLULAR PHONE ANTENNA

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Indexing terms: Tunneling, ANN, Radiation Pattern and Cellular Telephone

Abstract: This paper investigates the suitability of the application of artificial neural network to calculate the radiation patterns of commercial cellular phone antennas(whip antennas) in users' realistic conditions. It is found that the tunnel based artificial neural network provides results in good agreement, both in shape and gain of the radiation patterns. The tunneling provides accurate results with considerable reduction in computational time.

Introduction: The wireless industry has grown rapidly in the last few years. This rapid expansion has pushed the research towards the necessity of finding suitable methods and techniques capable of accurate design and testing of mobile devices. Finite Difference Time Domain (FDTD) method, in recent years has been accepted as most widely used method for testing antennas for cellular phones [1-4]. In this paper, we focus our attention on the calculation of far-field radiation pattern of commercial cell-phone antennas(whip antennas) using tunnel based artificial neural network. The antenna considered here, is a base loaded whip antenna, constituted by a helical part at its base and an upper monopole. The experimental data obtained from the measurements at University of Utah, USA were used to train artificial neural network. The cell phone had been activated for the experimental measurements using test mode. The EIRP (gain-power product) was considered as the actual radiated power of the cell-phone was not known. The cell-phone antennas were measured both in pull up (i.e antennas was stretched up) and push down conditions to maintain the realistic users' condition.

Development of Artificial Neural Network Model: The artificial neural network discussed in this paper, is having taxonomy of feed forward supervised backpropagation network. But in this type of network model, the learning time is high as it takes most of its time to come out of virtual valley. Thus, to come out of the false minima is a major problem for non-linear learning. In this paper, tunneling technique has been used to over come this problem. The concept of tunneling technique is based upon violation of Lipschitz condition at equilibrium position, which is governed by the fact that any particle placed at small perturbation from the point of equilibrium will move away from the current point to another within a finite amount of time[5]. The tunneling is implemented by solving the differential equation

$$dw/dt=\rho(w-w^*)^{1/3} \qquad \text{(i)}$$

Where, 'ρ' represents strength of learning and 'w^*' represents the last local minimum for 'w'. The differential equation is solved for some time till it attains the next minima position. To start with the training cycle, some perturbation is added to the weights. Then, the sum of squared error 'E' is calculated. If the error is greater then the last minima than it tunneled according to above equation. If the 'E' error is less than the last local minima then the weights are updated according to the relation,

$$\Delta w(t)=-\eta\nabla E(t)+\alpha\Delta w(t-1) \qquad \text{(ii)}$$

Where, 'η' is learning factor and 'α' is momentum factor. Finally, the training is halted either in the tunneling phase or backpropagation phase, if it attains the required error tolerance.

ISBN: 4-88552-207-2 C3055©IEICE

A network structure of 4x45x1 as shown in Fig.1 is taken for training. Frequency of operation, length of the antenna, and angle are taken as the inputs to the network. The fourth input is for pull up or push down condition. For pull up condition '1' is input and for push down condition '0' is the input. EIRP is taken as output of the artificial neural network. In addition, the other parameters of the network are

Momentum factor=0.205	Time step=$5X10^{-5}$
Noise factor =0.0004	Learning constant =0.02
Perturbation=0.0000005	Strength of learning =0.02

The experimental measurement data of whip antenna for length l= 6cm, 6.5cm, and 7cm at 800mHz and that of length l=7cm at 2700mHz both at pull up and push down conditions are mixed up as single data set to train the network. Total 960 nos. of data are used to train the proposed artificial neural network. The total training time is 650 seconds. The trained artificial network is tested for the whip antenna of l=7.5cm operating at 800mHz and that of l=4cm at 2700mHz. The testing are done for both the conditions i.e pull up and push down. The measured data of University of Utah, USA for these antennas are compared with the test results obtained through tunnel based artificial neural network.

Results and Discussion: Fig. 2 shows the comparison of results of the whip antenna (l=7.5cm) at 800mHz and Fig.3 shows the comparison of ANN result with experimental measurements at 2700mHz for whip antenna (l=4cm). These results are presented for pull up condition i.e when the antennas are stretched fully. The comparisons in the push down conditions for these antennas are depicted in Fig.4 and Fig.5 respectively. The error obtained for pull up condition is 0.213 at 800mHz and 0.395 at 2700mHz. In push down condition the error is 0.321 at 800mHz and 0.248 at 2700mHz. As seen from the figures, the results obtained using tunnel based artificial neural network are in good agreement with experimental measurements both in gain and shape. 480 No.s of data are taken for testing at 800mHz and at 2700mHz frequency in both pull up and push down condition. The total testing time is few seconds. The network is trained with a cluster set of data and is tested for unknown length i.e the length whose data are not used for training. The agreement with experimental results shows the generalization capability of the presented technique.

Conclusion: The good agreement between the ANN results and experimental measurements confirms that tunnel based ANN is a valuable technique to calculate the radiation pattern of cell-phone antenna. The reduction in computational time while providing accurate results is an important finding of this paper. The blind testing on the unknown length by the network and the good agreements in results shows the generalization capability of the proposed technique. The presented technique can be extended to predict the far-field radiation pattern of cell-phone antenna in the presence of human head.

Acknowledgement: Dr. Shyam S. Pattnaik is thankful to Prof. Om P. Gandhi for assigning the measurement work during his visit to University of Utah under BOYSCAST Fellowship. Thanks are due to MHRD, Govt. of India for sponsoring the project.

REFERECES:

1. O. P. Gandhi, G. Lazzi, and C. M. Furse, "Ëlectromagnetic Absorption in the Human Head and Neck for Mobile Telephones at 835 and 1900 MHz," IEEE Transactions on Microwave Theory and Techniques, Oct. 1996.
2. G. Lazzi, and O. P. Gandhi, "Realistic Tilted and Truncated Anatomically Based Models of the Human Head for Dosimetry of Mobile Telephones," IEEE Transactions on Electromagnetic Compatibility, (……….)
3. P. J. Dimbylow, and S. Mann, "SAR Calculations in an Anatomically Based Realistic Model of the Head for Mobile Transceivers at 900 MHz and 1.8 GHz", Physics in Medicine and Biology, Vol. 39, pp.1537-1553, 1994.
4. M.A. Jensen, and Y. Rahmat-Samii, "ËM Interaction of Handset Antennas and a Human in Personal Communications," Proceedings of the IEEE, Vol. 83, pp. 7-17, 1995
5. Pinaki Roy Choudhry, Y. P. Singh and R. A Chansarkar, "Dynamic Tunneling Technique for Efficient of Multilayer Perceptrons," IEEE Transaction on Neural Networks, vol.10, No.1, Jan. 1999.

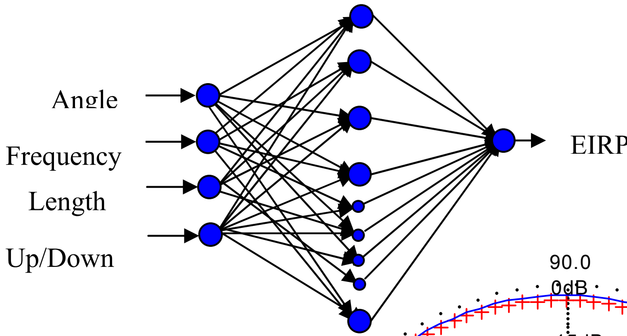

Fig-1 Network Architecture

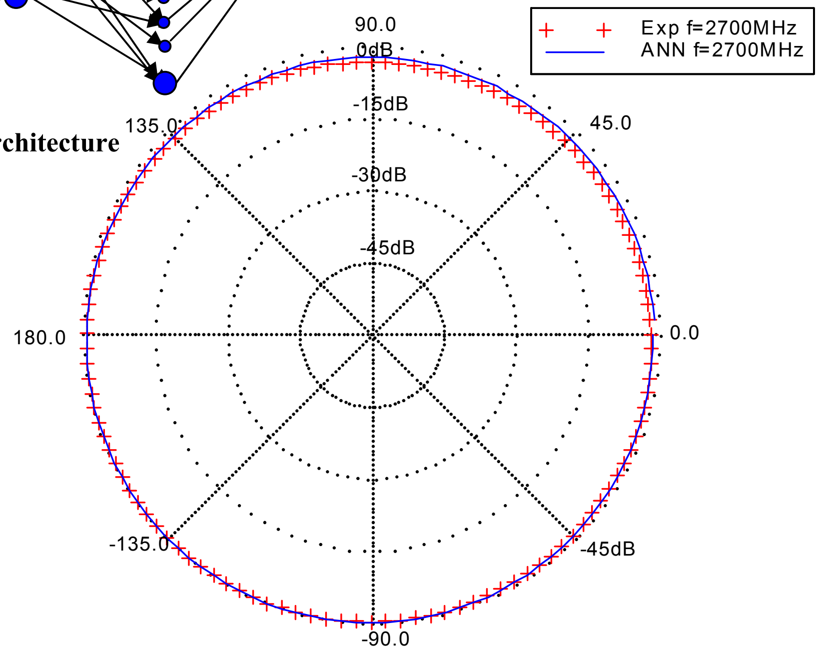

Fig-2 Comparisons between Radiation pattern of Experimental and ANN results at 2700MHz when the antenna is in pull up condition

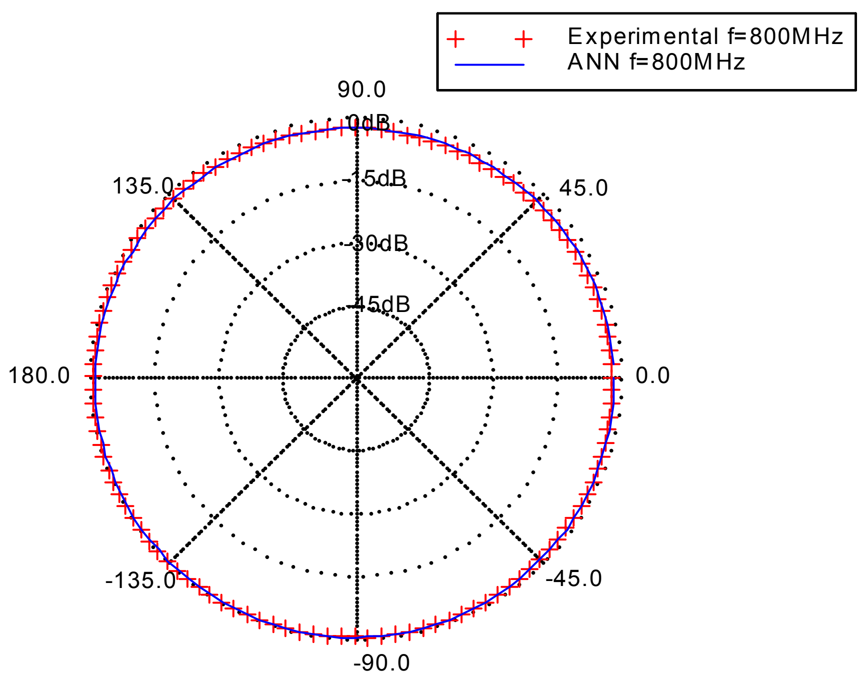

Fig-3 Comparison between Radiation pattern of Experimental and ANN results at 800MHz when the antenna is in pull up condition

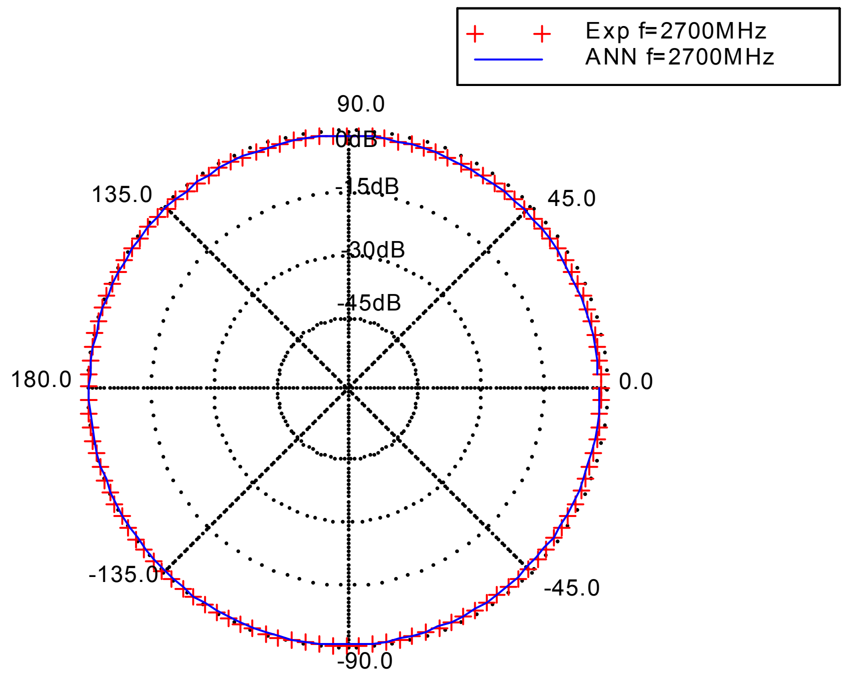

Fig-4 Comparisons between Radiation pattern of Experimental and ANN results at 2700MHz when the antenna is in push down condition

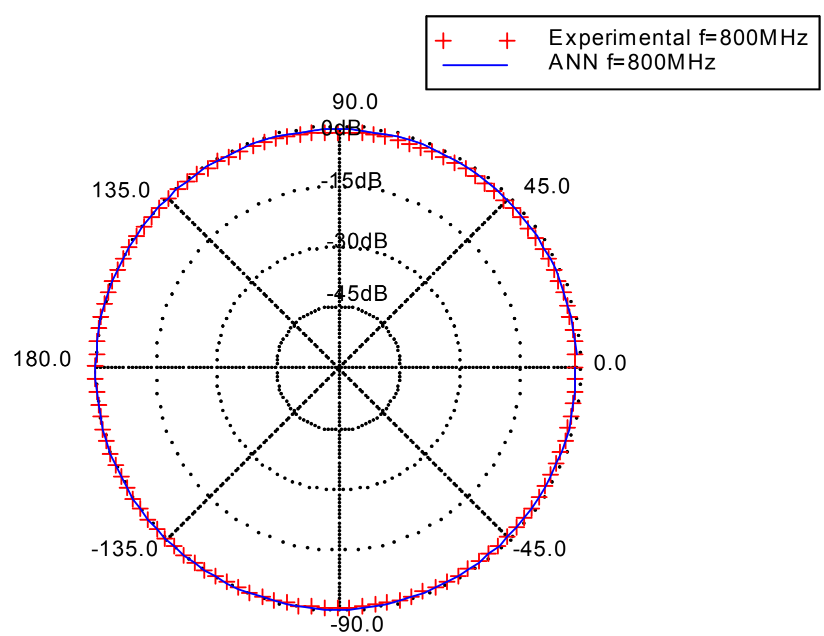

Fig-5 Comparisons between Radiation pattern of Experimental and ANN results at 800MHz when the antenna is in push down condition