

Neural Networks for Self-Organizing the Down-Tilt Angles of Cellular Base Station Antennas

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Abstract— This paper introduces a new innovative intelligent way for determining the most appropriate antenna down tilt using Neural Network (NN). To judge on the outcome, the paper used the patterns of a planner array antenna and made a comparison between manually tilted patterns and the artificially tilted patterns after injecting the NN behind the antenna. In conclusion, the paper shows that using NN to manage antennas tilt on self-organizing bases is working, the results of the NN tilted antenna patterns were highly aligned with the antenna tilts without NN.

Keywords-Nural Networks,

I. INTRODUCTION

Cellular radio networks' optimization relays heavily on performing extensive drive testes, computer simulations, collecting statistics and network reports. Accordingly, optimization professionals tend to manually tune the network parameters as well as applying some other physical modifications on the base stations' antennas, such as setting antennas' gain, azimuth directions, or down tilt angels [1]. In most cases, carefully optimizing the down tilt angels produces enhanced signal strength levels at the targeted areas, thus reducing the interference levels from other covering cells. However, excessive down tilt angle may lead to dramatic coverage shortages, specifically at the edges of the main loop direction [2]. Most noticeable is that the outcome of this methodology is not efficient when applied at real time due to: continuously dynamic networks, and complex propagation conditions.

To better optimize the antenna down tilt angles this paper uses the linear NN on the back-processing plan of the base station's antenna system. As a new innovative self down tilting antenna system, the linear NN will be able to optimize the antenna tilt resulting on better managing the real time behavior of the base station. The neural network is going to be trained to intelligently choose the most appropriate down tilt angle producing the most suitable vertical beam pattern gain for the used antenna.

II. SYSTEM DESIGN

This paper introduced a new innovative technique granting the antenna systems of the cellular base stations to behave as self-organizing antennas; while maneuvering and

controlling the down tilt angles. Instead of the classical and manual down tilt optimization technique, a direct linear NN was trained to estimate the tilt angle of the vertical radiation pattern of the antenna system. To achieve that a Matlab code was developed, which includes two parts:

Part-1: formulating the desired down tilt patterns: A [40X3] matrix representing the gain values of the vertical radiation patterns (the desired output) corresponding to the tilt angles (0°, 6°, and 12°). they are used as the required input to train the neural network shown in figure (1).

Down Tilt angles			
Vertical pattern angles	T= 0°		
	1.0000	0.8213	0.0807
	0.3068	0.9475	1.1437
	.	.	.
	.	.	.
	.	.	.
	.	.	.
	.	.	.
	0.8213	1.0000	0.9143
	0.3068	0.2695	0.7203
	72°	76°	76°

Figure 1: Down Tilt values used to train the NN

Gain values in the desired matrix were taken from the array pattern for rectangular Planar Array equation:

$$G(\cos \beta) = \frac{(\sin((Nkd \cos(\beta+i))/2))^2}{\sin((kd \cos(\beta+i))/2)} \quad (1)$$

Where:

G(cos β) : Radiation pattern.
N: number of the array elements, which is set as 9.
 $k = \frac{2\pi}{\lambda}$
d: distance between array elements.
i: antenna down tilt

Part-2: Training the NN: these tilt vectors will be fed and an input to train the NN system as shown in figure (2). The desired tilt vectors will be multiplied

by a suitably adapted weighted matrix chosen by the trained neural network itself and then will be added to the bias. Weight and bias values will be adjusted until the response (the actual output) of the network is matched to the target (the desired output) or until getting the minimum error, which is the difference between the actual output and the target. This process is called training (learning), where the NN has the ability to learn from its environment and it can improve its performance through learning.

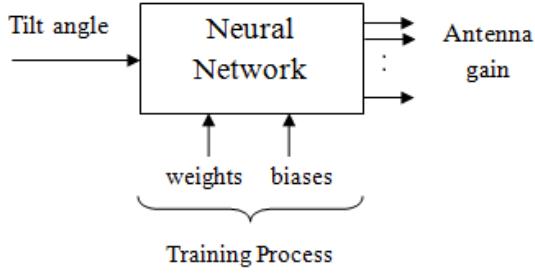


Figure 2: Self-organizing NN system

As shown in figure (3), this process is repeated until the NN network system reaches the steady state, where there are no more significant changes in the weights [3]-[4]. The linear NN's specific settings: number of trainings sessions, error goal, and the maximum learning rate were set as follows: 5000, 10-5, and 0.1 respectively.

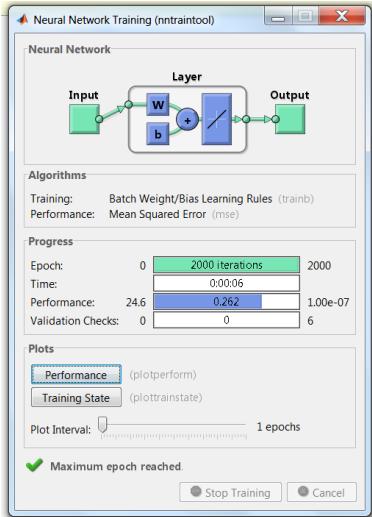


Figure 3: Linear NN training process

III. RESULTS

The simulation results of the trained NN on a sample of three down tilt angles (0° , 6° , and 12°) are presented in figure (4). The linear array vertical radiation patterns where drawn in polar coordinates, given that the number of antenna elements is 9, with a spacing distances equals to $\lambda/2$ between each of them. The results for the three down tilt angles when using the trained NN are almost similar to those without NN. However, the results of the simulations for the 6° down tilt angle when using the NN are slightly reduced in comparison to the tilt without the NN. In such cases, the neural network was trained on certain tilt angles where it estimates the gain values with a small error, given that the NN has the ability to learn and generalize. Generalization means that the network can produce outputs for inputs not included in training. This suggests that more NN training is required.

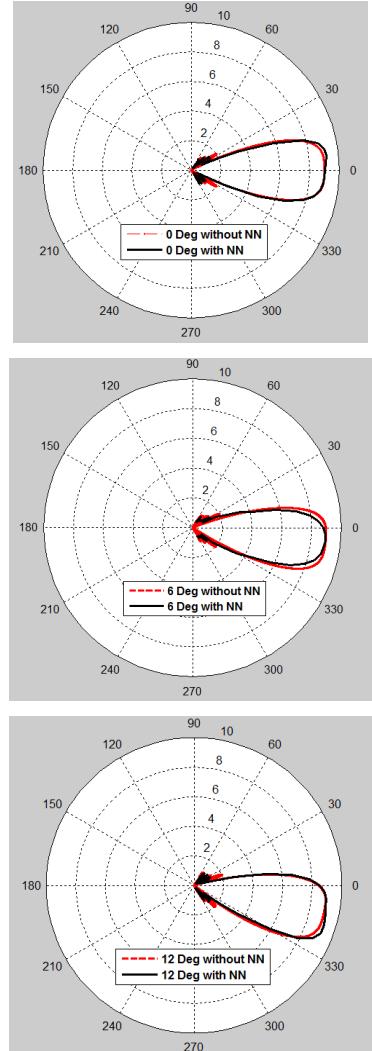


Figure 4: The neural network plot for linear array radiation pattern, in polar coordinates for down tilt angles: 0° , 6° , 12°

IV. CONCLUSION

Determining the suitable antenna down tilt angle is a very critical issue in cellular network, since it affects the system performance, aiming to enhance the signal strengths of serving cells, in addition to reducing the interference levels with the cellular system. This paper introduced a new innovative idea using the NN in estimating the proper antenna gain at certain down tilt angles. The presented results using the NN are almost similar to the antenna system without the NN, but with slight error deviations depending on quality of training and learning the NN on the desired output values. This paper also showed the effectiveness of using the neural

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