A Review of a Single Neuron Weight Optimization Model for Adaptive Beam Forming

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***Abstract*—In this paper, we review our recent, reported work on using artificial intelligence based software technique to control electronic sensor or wireless communication equipment in narrow and diverging paths such as in underground tunnels and at traffic junctions. In order to make the systems fast as well as needing minimal computational calculations and memory – thus to extend the battery life and minimize cost – we used the single layer Perceptron to successfully accomplish the formation of beams which may be changed according to the nature of the junctions and diverging paths the mobile or stationary system is to handle. Moreover, the beams that survey the scenario around (e.g. in case of guiding a driverless vehicle) or communicating along tunnels (e.g. underground mines) need to be kept narrow and focused to avoid reflections from buildings or rough surfaced walls which will tend to significantly degrade the reliability and accuracy of the sensor or communicator. These requirements were successfully achieved by the artificial intelligence system we developed and tested on software, awaiting prototype development in the near future.**

***Index Terms*— Beam Forming; Neural Network; Single Layer Perceptron; Smart Antenna.**

I. Introduction

In telecommunication, the applications of Adaptive Array Antenna have become popular due to its consistency in faster beam steering techniques that cannot be obtained by using a mechanical system or the switched beam array. Adaptive Array Antenna has the ability to detect and track other communication units and to generate narrow beams in a direction to align itself towards desired users. It can simultaneously minimize unwanted interferences or shadowing to achieve an optimized weight thus make it more flexible, smart and reliable. Here, a smart antenna called a Smart Beam Forming Antenna is proposed by combining an Adaptive Array Antenna and Artificial Neural Network (ANN) System. A Single Neuron Model is used to achieve weight optimization. A fast Neural Network Adaption is used for beam steering in order to align the adaptive beam towards the desired users while reducing or nulling interference from unwanted signals. The crucial part of designing a smart antenna is the ability of the antenna in handling intricate situations such as moving traffic patterns by providing flexible electrical tilt, beam width and azimuth control. Smart Antennas have been used at base stations (BS) as it provides a solution that is more versatile, cheaper, with low memory usage and fast beam steering technique. In parallel, the growth of fast cell site expansion, expanding the quantity of cell sectors and data transfer capacity (bandwidth), and better air interface abilities will be basic to move into introducing artificial intelligence (Perceptron) smart antennas to the best possible 5G frameworks.

A. Artificial Neural Network (ANN)

An ANN is a numerical structure which comprises interconnected artificial neurons, in a highly reduced scale works like the brain. An ANN can gain "experience" from information either in a managed or unsupervised way. In Figure 1 is shown how the ANN tries to copy the human brain that gets signals from sensors like the eye, ear and touch. These signals are then processed by the brain. In ANN the sensors might be real-time image sensors (camera), sound sensors (microphone) or capacitive touch sensors which are the inputs to the ANN. On account of smart antennas, the inputs are normally transmitted signals from transmitting antennas. In ANN the input signals are processed mathematically, such as by multiplying each input signal by a number (namely a weight, w_i) and phase shifting the signal (where complex weights are used, b_i). Subsequently, the weighted input signals are summed up and placed at the input of a transfer function (or activation function) block that will yield the final output signals. For the human brain, the final output signals might be activating signs to the muscles, for instance, to move the human body for physical activity. In smart antennas, the final output signals might be to redirect the beam towards the desired users. An ANN is structured (Figure 2) with a substantial number of highly interconnected processing elements called Artificial Neurons, which are organized in layers. The Weights (w_i) and biases (b_i) are known as Adjustable Scalar Parameters of the neuron. The parameters can be adjusted to meet the desired behavior as part of the network training process. The transfer function is expressed in one of the following forms: hard-limit (or step), the linear and the sigmoid (or logistic) function where the final output signals are mathematically expressed as

$$Y = F(S) = F\left[\sum_{K=1}^{N} X_K W_K + b\right] \quad (1)$$