ISSN 2395-695X (Print)
ISSN 2395-695X (Online)

International Journal of Advanced Research in Biology Engineering Science and Technology (IJARBEST)

Vol. 2, Special Issue 10, March 2016

DESIGN AND PREDICTION OF MICROSTRIP PATCH ANTENNA BY ARTIFICIAL LEARNING METHODS

Mr. P. NAGARAJAN, IInd ME (Communication System),
Mrs. C. SUJATHA, ME (Ph.D) Associate Professor/ECE
SSM Institute of Engineering and Technology, Dindigul, Tamilnadu, India
pheonix.ngr@gmail.com

ABSTRACT

The design of rectangular and circular Microstrip Patch Antenna using artificial learning methods is proposed. This project used Feed Forward Back Propagation Algorithm (FFBPN), Resilient Back-propagation (RPROP), Levenberg -Marquardt (LM) and Radial Basis functions (RBF) are used to obtain the resonant frequency of both antennas. The model of ANN algorithm was developed and implemented in MATLAB, which determine the parameters contains dielectric constant, substrate thickness, width, length and radius of the patch are given to obtain optimized resonant frequency of both rectangular and circular antennas. Performance analysis is done to find the optimized function. Then based on the resonant frequency of optimized function, rectangular and circular antennas are designed using HFSS. Using the antenna design the bandwidth, return loss, radiation pattern is found. Based on the return loss value best antenna is found for various applications.

1. Introduction

Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource.

The aim of the thesis is to design a rectangular and circular Microstrip Patch Antenna and study the effect of antenna dimensions Length (L), and substrate parameters relative Dielectric constant (εr), substrate thickness (t) on the Radiation parameters of Bandwidth, Beam-width and return loss. To finding the resonant frequency of the antennas using MATLAB and the design of an antennas using HFSS.

A microstrip antenna consists of conducting patch on a ground plane separated bydielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on micro strip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns.

Various parameters of the microstrip antenna and its design considerations were discussed in the subsequent chapters. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch. An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing an antenna for your application as follows:

- Antenna radiation patterns
- Power Gain
- Directivity
- Polarization

2. Related Work

There has been a significant amount of work measuring the potential and benefits of IB-DAS. In [8], extensive signal propagation measurements have been conducted to serve as a basis for assessing IB-DAS capacity. For high-speed downlink packet access (HSDPA), measurements of IB-DAS performance are presented in [6] to provide guidelines for system deployment, showing that IB DAS can provide better capacity and coverage in comparison to the use of pico-cells.

The study in [6] reveals that sufficient coverage, which is strongly related to antenna output power, is the key factor in planning IB-DAS with HSDPA. Measurement-based coverage and capacity analysis for IB-DAS with universal mobile telecommunication system (UMTS) is provided. In [4], the authors focus on the energy efficiency aspect of an IB-DAS architecture. The simulation results demonstrate that IB-DAS has superior energy efficiency over an all-wireless system combining macro-cells and femto-cells.

Performance engineering of IB-DAS has been studied in several papers. In [1], the authors study spectral efficiency in respect to the number of antennas, subject to interference between antenna elements at different floors. For a similar setting, joint signal processing with interference cancellation is investigated in [2]. A mathematical channel model for indoor propagation of high building is proposed in [10]. The model as well as system simulations have been used to analytically and numerically characterize the achievable rate of IB-DAS. For a given IB-DAS topology, algorithms for transmission scheduling and resource coordination among the antennas are presented in [7]. For a comprehensive treatment of system specification and common engineering practices of deploying IB-DAS, we refer to the textbook by Tolstrup [5].

For mathematical optimization of IB-DAS deployment, an integer programming formulation for determining the cabling and equipment is presented in [9], with the primary objective of reducing cable cost. Due to the nature of integer programming, the approach admits solutions for relatively small scenarios only. In [3], the authors formulate the optimization

ISSN 2395-695X (Print)
ISSN 2395-695X (Online)

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Vol. 2, Special Issue 10, March 2016

problem of optimally locating the antennas and setting their output powers (which form part of the input to the problem we study) for coverage and interference avoidance. A simulated annealing algorithm is proposed and evaluated by comparing the results to that of uniform power.

3. Artificial Neural Networks

An artificial neural network (ANN), usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation [9]. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data.

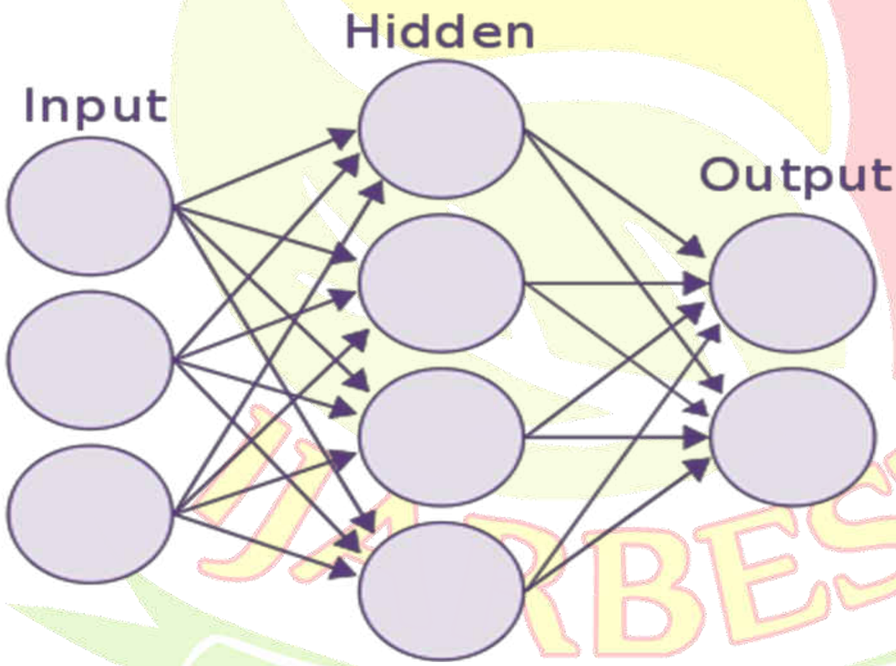

Figure : 3.1. Architecture of Neural Networks

3.1. Background Concepts

The original inspiration for the term Artificial Neural Network came from examination of central nervous systems and their neurons, axons, dendrites, and synapses, which constitute the processing elements of biological neural networks investigated by neuroscience. In an artificial neural network, simple artificial nodes, variously called "neurons", "neurodes", "processing elements" (PEs) or "units", are connected together to form a network of nodes mimicking the biological neural networks - hence the term "artificial neural network".

Because neuroscience is still full of unanswered questions, and since there are many levels of abstraction and therefore many ways to take inspiration from the brain, there is no single formal definition of what an artificial neural network is. Generally, it involves a network of simple processing elements that exhibit complex global behavior determined by connections

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between processing elements and element parameters. While an artificial neural network does not have to be adaptive per se, its practical use comes with algorithms designed to alter the strength of the connections in the network to produce a desired signal flow.

These networks are also similar to the biological neural networks in the sense that functions are performed collectively and in parallel by the units, rather than there being a clear delineation of subtasks to which various units are assigned. Currently, the term Artificial Neural Network (ANN) tends to refer mostly to neural network models employed in statistics, cognitive psychology and artificial intelligence. Neural network models designed with emulation of the central nervous system (CNS) in mind are a subject of theoretical neuroscience and computational neuroscience.

In modern software implementations of artificial neural networks, the approach inspired by biology has been largely abandoned for a more practical approach based on statistics and signal processing. In some of these systems, neural networks or parts of neural networks are used as components in larger systems that combine both adaptive and non-adaptive elements. While the more general approach of such adaptive systems is more suitable for real-world problem solving, it has far less to do with the traditional artificial intelligence connectionist models. What they do have in common, however, is the principle of non-linear, distributed, parallel and local processing and adaptation.

3.2. Types of Artificial Neural Networks

Artificial neural network types vary from those with only one or two layers of single direction logic, to complicated multi–input many directional feedback loop and layers. On the whole, these systems use algorithms in their programming to determine control and organization of their functions. Some may be as simple, one neuron layer with an input and an output, and others can mimic complex systems such as d ANN, which can mimic chromosomal DNA through sizes at cellular level, into artificial organisms and simulate reproduction, mutation and population sizes.

Most systems use "weights" to change the parameters of the throughput and the varying connections to the neurons. Artificial neural networks can be autonomous and learn by input from outside "teachers" or even self-teaching from written in rules.

4. Prediction Of Microstrip Patch Antenna By Artificial Learning Methods

In this section, Design of rectangular and circular microstrip patch antenna using HFSS. First we obtained the resonant optimized frequencies of both antennas using MATLAB.

This project used Feed Forward Back Propagation Algorithm (FFBPN), Resilient Back-propagation (RPROP), Levenberg-Marquardt (LM) and Radial Basis functions (RBF) of ANN to obtain the resonant frequency of rectangular microstrip patch antenna. The model of ANN algorithm was developed and implemented in MATLAB which determine the parameters containing dielectric constant, substrate thickness, width, length and radius of patch for obtain resonant frequency of antenna and results obtained from these models are compared with standard formula. The results obtained through these algorithms shows very good agreement with the experimental results available in literature. The performance of network is tested with 160 samples of different width and length and the performance is measured with this training samples and the optimized result is implemented in HFSS. The performance has compared rectangular and circular antennas and will find the return loss, bandwidth, radiation pattern of rectangular and circular microstrip patch antennas and predict which antenna is best suitable for various applications.

The various neural network algorithms are used for finding the optimized result for antennas in literature survey of this project but in this project used to Levenberg-marqurate, radial basis function and resilient back propagation. The various algorithms are used to compare the performance of the antennas and finding the mean square error for these algorithms using MATLAB. First will find out which algorithm is gives the best performance for finding resonant frequency of an antennas. This project proves radial basis function is best suitable for analyzing performance of an antennas. Then design of rectangular and circular microstrip antenna for given resonant frequency values using HFSS. In the antenna designing methodology FR4substrate are used and coaxial feeding is used. This software is best suitable for antenna designing and evaluates the antenna parameters like return loss, bandwidth and radiation pattern of both antennas. The parameters are compared and select which antenna is best suitable for various applications.

5. Experimental Analysis

Neural network offers the advantage of superior computational ability due to high degree of interconnectivity for solving complex problems and this advantages being used in this project for obtaining resonant frequency of both rectangular and circular antennas. The ANN model is trained with 160 samples of width, length, substrate thickness and dielectric constants. The training performance network algorithm is checked when target value obtained from in Matlab is provided. The performance is obtained from testing samples which is similar in type but different values which is not included during training of samples and the performance is measured with this training samples.

The model of neural network developed in MATLAB and response of the microstrip antenna performance validation of rectangular patch antenna, training of RMPA in 769 epochs and is performance of different neural networks algorithms, giving the best approximation to the target values. The performance graph is displayed of training and testing for circular patch antenna respectively and is performance of different neural networks algorithms, giving the best approximation to the target values. The comparison results of 5 testing samples supplied to the network after training between different ANN. The values obtained from these networks are very close to target values. The difference between the outputs of artificial neural network against target is measured in terms of Performance which is very close to set goal to be achieved in testing for better performance of the network. The results obtained from testing samples in developed ANN model are useful for obtaining resonant frequency of rectangular and circular microstrip patch antenna efficiently.

The software used to model and simulate the microstrip patch antenna is HFSS. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Return loss, and Fields. An antenna design is 3D model. It consists of patch elements on one side of a

ISSN 2395-695X (Print)
ISSN 2395-695X (Online)

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Vol. 2, Special Issue 10, March 2016

dielectric substrate and a planar ground on the other side. It was assigned with air box boundary and virtual radiation to create far field radiation pattern and assigned with a excitation of lumped port. The material used for substrate is FR4 having dielectric constant 4.4 &loss tangent of 0.02. The antenna uses coaxial feeding technique. The position of feed point is obtained by using trail & error based method.

The 3D output for a rectangular and circular microstrip patch antennas. 3D radiation pattern of antenna also indicates total gain of antenna. The total obtained gain of antenna when using FR4 as a substrate material is 5.92 dB. A circular patch antenna gain. The simulation of above design is being done using HFSS software. The substrate used here is FR4 having dielectric constant 4.4. The above given dimensions are used to simulate the structure. The operating frequency of this design is 2.34 GHz and the obtained return loss.

6. Conclusion and Future Work

The rectangular and circular microstrip patch antenna was designed using artificial learning methods. The results obtained from different models shows that, the performance error of RBF algorithm is very accurate and efficient when compared with performance error of other ANN algorithms. The resonant frequency were found using the MATLAB for given length, width and radius of the patch antennas. Based on the obtained resonant frequency the antennas were designed using HFSS. The radiation pattern, bandwidth and return loss were found on both antennas. The performance parameter was achieved both rectangular and circular antennas, so this conclude that the return loss of rectangular patch is -27db, so rectangular patch antenna is best suitable for various applications.

In future work to design rectangular dual band frequency antenna for various shapes like S-shape, E-shape and compare this antennas performance for the purpose of reducing return loss and frequency losses and find which shape is best suitable for reducing losses.

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