

# A Soft Computing Techniques Analysis for Planar Microstrip Antenna for Wireless Communications

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**ABSTRACT**- The use of neural-network computational modules for radio frequency and microwave modelling and design has lately gained popularity as an uncommon but useful technique for this type of modelling and design. It is possible to train neural networks to study the behaviour of active and passive mechanisms and circuits. In this study, technologists will learn about what neural networks are and how they can be used to model microstrip patch antennas. An artificial neural network is used in this work to investigate in depth several designs and analysis methodologies for microstrip patch antennas. Various network structures are also discussed in this study for wireless communications. Microstrip antenna design has been presented and the use of ANN in microstrip antenna design are also shown in this article.

**Keywords:** IANN, Microstrip, Antenna, Wireless Communication.

## ARTICLE INFORMATION

**Author(s):** K.D. Jyothi, P. Bala Srinivas and S. Kumar;

**Received:** 20/05/2022; **Accepted:** 20/07/2022; **Published:** 10/08/2022;

**e-ISSN:** 2347-470X;

**Paper Id:** IJEER100310;

**Citation:** 10.37391/IJEER.100310

**Webpage-link:**

<https://ijeer.forexjournal.co.in/archive/volume-10/ijeer-100310.html>



This article belongs to the Special Issue on **Recent Advancements in the Electrical & Electronics Engineering**

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## 1. INTRODUCTION

Now a days, due to the increasing demand for faster communication, scientists and researchers have been attempting to improve existing devices and develop new ones. Recent advancements in communication and radar technology have accelerated antenna growth. An antenna allows data to be broadcast from one area to another. Newer technologies have modified the role, size, and design of antennas. Antennas have evolved rapidly over time, yet testing and implementation remain constant. The performance of a single antenna element may vary depending on the system and environment. An antenna is required to suit the needs of today's and tomorrow's wireless communication systems [1-3]. Researchers have a big challenge in developing small antennas for improved wireless and mobile communications. Smaller communication equipment requires smaller data transmission antennas [4-7].

Patch antennas can be analysed numerically or analytically. Methods based on mathematical or analytical notions of electrical or magnetic current distribution in the patch. It is classified into four types: MOM, SDT, and FEM (FEM). Magnetic current distribution modelling includes transmission line, cavity, and multi-port network models (MNM). Numerical approaches can solve the problem, but they are tedious and time intensive, and the outcome can change if the geometry changes. The analytical models can also be used for a few patches'

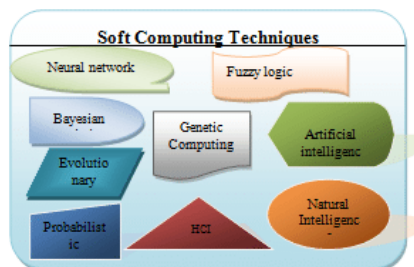
antenna forms. Artificial Neural Networks (ANN) are a novel type of soft computing based on learning (ANNs). Soft computing was coined by Zadeh in 1992. Soft computing differs from hard computing in that it does not require complex arithmetic. Soft computing includes ANNs, fuzzy logic, machine learning, and evolutionary computation (PSO-particle swarm optimization) [5-7]. Neural Networks are thought of as a model that mimics the human brain's functions. An example of a soft computing technique that takes its methodology from biological processes is the neural network. With the use of this comparison, artificial neural networks (ANNs) were able to learn and adapt like a human brain through training and testing. It was motivated by biological systems to handle non-linear challenges in scientific and antenna engineering sectors. Fault tolerance, high speed processing, parallel processing, non-linear mapping, and approximation are some of the capabilities of ANNs. Microstrip antenna properties, such as radiation pattern, bandwidth, and gain, can benefit from these soft computing advantages as well. An ANN model for a microstrip line is developed, and it is shown to be faster than the usual method. To determine the resonance frequency of thick circular microstrip antennas, an RBF network neural model was developed [8-10]. The network is trained using a variety of learning algorithms in accordance with the learning approach. Delta-bar-delta extended techniques were used by the neural model to get the best results from the MLP. employing radial basis function networks to improve laser diode line width. The clustering methods are learned using an extended delta-bar-delta algorithm. The concept of fractal geometries, which is employed in nature to model complex structures like coastlines and clouds, can be applied to the downsizing of antennas. An artificial neural network can be used to estimate the rectangular microstrip patch antenna's input impedance (ANN). A coaxially fed rectangular microstrip antenna based on ANNs was presented by the same author for use in calculating radiation resistance [11-18].

This paper provides a soft computing techniques-based analysis for microstrip antenna for wireless applications. This paper

comprises of four different subsections apart from introduction. In *Section II*, detailed analysis of methodology for soft computing has been provided. In *Section III*, ANN model analysis has been provided. In *Section IV*, results analysis has been given and conclusion of the paper is mentioned in *Section V*.

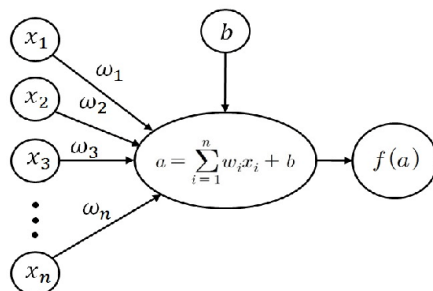
## 2. METHODOLOGY FOR SOFT COMPUTING

When it comes to computer engineering, soft computing technique refers to a field that is defined by the use of inexact, imprecise, and approximate solutions to computationally difficult issues in areas such as science, medicine, management, and the humanities, among others. Approximate reasoning and randomised or functional search are two main categories of soft computing that can be divided into subcategories. As illustrated in *Figure 1*, approximate thinking can be represented by Fuzzy logic and probabilistic models, whereas randomised search can be represented by neural networks and evolutionary algorithms [10-17].



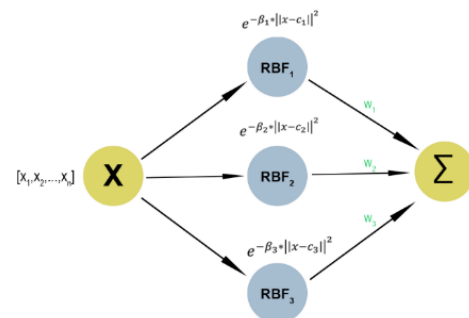
**Figure 1:** Types of Soft Computing

ANN is based on the human brain's functioning principle and is used in artificial intelligence. Feed forward and feed backward ANNs are two types of ANNs. For the correction of relative faults between the input and output, feed backward neural networks use feedback to connect the output to the input rather than feed forward neural networks. By doing so, a closed path is created within the system, enhancing transmission quality. The artificial neural network technique of using multilayer perceptron (MLP) and radial basis function (RBF) neural networks is used to formulate the work in this thesis. *Figure 2* depicts the fundamental structure of an artificial neural network, which includes a weighted sum of input and a threshold or bias. The activation function is applied to the sum of the individual components. The activation function can be sigmoid, signum, or piecewise linear, among other forms. The inputs, weights, biases, and non-linear functions of each neuron are distinct [6-11].

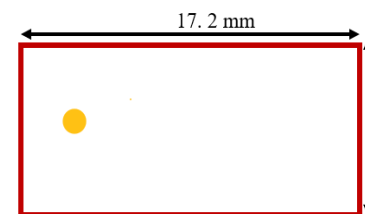


**Figure 2:** Basic concept of ANN

One hidden layer, depicted in *Figure 3*, separates the input and output of the Radial Basis Function (RBF) supervised neural network. As opposed to other neural models, it has a simpler structure and lower complexity. RBF uses the backpropagation approach for training and has a significantly easier training process than MLP. For example, an RBFN has an input, a middle, and an output layer that all work together. The pattern classes are represented by the output layer, whereas the input vector space is represented by the output layer. So only the middle layer and the weights between the middle and output layers determine the design. When the middle layer is determined, between input and middle layer, there are no weights that can change. To find the middle layer, classic methods either randomly select Clustering methods such as K-means and Self Organizing Feature Maps (SOFM) or samples taken from the training patterns (SOFM). For the middle layer, we suggest an approach that is both faster than existing clustering methods and more accurate than random selection [5-14].



**Figure 3:** Input, hidden and output layers of radial basis function

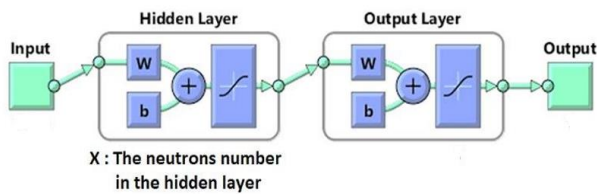


**Figure 4:** Rectangular Microstrip antenna

It has recently been shown that nonlinear neural optimization networks can be employed in the design of microstrip antennas. An approach for estimating the feed position of a rectangular microstrip patch antenna using an ANN model based on a feed forward network and a back propagation algorithm is provided in this study.

## 3. TRAINING DATA AND GENERATION

Using the data received from the mathematical formulation and PCAAD software, the network is trained to recognise patterns. The entire project has been broken down into two sections. When a fixed frequency is used, the patch size (patch length and patch width) is changed and a neural network is trained to recognise the feed position in the first phase. A trained neural network is used in the second step, as seen in *Figure 5*. The resonant frequency and, consequently, patch sizes are altered in the third phase [5-12].



**Figure 5:** ANN model for analysis

The resonant frequency for the designed microstrip antenna is 5.5 GHz and substrate dielectric constant is 4.4. The height of substrate is 1.6 mm. The length of rectangular patch is calculated [3]:

$$L = \frac{c}{2f_o\sqrt{\epsilon_r}} \quad (1)$$

Where,  $c$  is speed light,  $f_o$  is the resonant frequency. And effective permittivity is given by [8]

$$\epsilon_r = \frac{(\epsilon_r + 1)}{2} + \frac{\epsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}} \quad (2)$$

The change in length

$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3)(\frac{w}{h} + 0.264)}{(\epsilon_{eff} - 0.25)(\frac{w}{h} + 0.8)} \quad (3)$$

The effective length is given by

$$L_{eff} = \frac{c}{2f_o\sqrt{\epsilon_r}} - 2\Delta L \quad (4)$$

The lengths of patches for various widths were estimated using the equations (1-4) as a starting point. Then, using the PCAAD

**Table 1:** Shows the results of designed antenna

S. N.	Length in mm	Width in mm	Trained network feed position in mm	PCAAD software feed position in mm	Error (%)
1	22.6	14.6	12.548	12.546	0.015939
2	22.4	15.1	10.945	10.948	0.027412
3	22.3	15.8	8.931	8.993	0.062114
4	22.1	16.2	7.5253	7.5258	0.006644

## 5. CONCLUSION

The neural model provided in this paper produces results that are almost correct while requiring little in the way of computational effort. A significant advantage of neural computation is that, with adequate training, a neural network totally avoids the need to repeat complex iterative processes for each new design that is provided to it. This is a significant advantage. This straightforward approach is extremely useful in engineering applications. The neural models employed in this work can be further developed to incorporate additional characteristics such as the form of the patch, the choice of dielectric constant, the thickness of the patch, and so on.

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programme, edge impedances (input impedance at the edge of the patch) were calculated for each of the lengths and widths that were tested. The distance  $x$  between the feed position and the radiating edge of the patch was calculated using the following formula [3-5]:

$$y(r) = y_o \cos 2 \left( \frac{3.14r}{L} \right) \quad (5)$$

$L$  is the patch's length divided by the impedance at the patch's radiating edge, denoted by  $y(r)$ . To generate the training data  $r$ , we varied the width  $w$  from 5 mm to 45 mm and the frequency ranges from 3.5 to 6.9 GHz. The length of the patch was estimated using equations (1-4) for varied frequencies and widths. PCAAD and equation were used to collect training data on feed position by equation (5).

## 4. RESULTS AND DISCUSSION

It was necessary to train an artificial neural network (ANN) based on the back propagation approach and the feed forward network. The input vector consists of two rows, each of which contains the values for width and length. The feed point of the target vector is represented by a single row. The network parameters are as follows: the number of hidden layers is one, with 500 neurons in each of the hidden layers and a single neuron in each of the output layers. In order to compare results, the network was used to calculate feed position for arbitrary width and length values after training, and the result was compared with the value calculated via PCAAD as shown in Table 1.

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