Analysis of MIMO Antenna using Artificial Neural Network

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Abstract: MIMO antennas are more prominent due to its promising capability of improving spectral efficiency, energy efficiency and robustness of any antenna system. In this paper, MIMO antenna is designed using IE3D software and its analysis is done by using Artificial Neural Network approach. The final results calculated from the Artificial Neural Network are in agreement with simulated results from IE3D software.

Keywords: MIMO, ANN, IE3D, Resonant frequency.

Introduction

Multiple-antenna MIMO technology is becoming more popular in wireless communications and has been included into wireless broadband standards like LTE and Wi-Fi. In wireless communications, MIMO means multiple-input and multiple-output and is used by taking combination of multiple transmitters/receivers or antennas at both sides of digital communication systems. MIMO is the technique for sending & receiving more than one data signal simultaneously. An approach to analyze the resonant behaviour of MIMO antennas using ANN model is explained in this paper. The proposed ANN model is designed to calculate the resonant frequency (f_r) of an MIMO antenna with length (L) and width (W) as input variables. The ANN model is a simple model and very easy to use. Resonant frequency (f_r) is very easily calculated from ANN model. The ANN model provides an efficient, time saving method to find resonant frequency for different dimensions of MIMO antenna [1]. In the next section, we have discussed some antenna geometries analysed using ANN models. In Section-III, a brief explanation of proposed MIMO antenna is presented. In Section-IV, we have explained the ANN model for the antenna, further the results are discussed in Section-V. In the end, section-VI presents the conclusion of paper is explained.

Literature Review

The main objective of MIMO antenna is to reduce the correlation between the received signals among the antenna ports and maximize the channel capacity [2].The correlation between the received signals is mainly due to the mutual coupling of the transmitting MIMO antennas [3]. By calculating the mutual coupling we can analyse the electromagnetic field interaction which are existed between antenna elements of MIMO systems [4].ANNs are one of the most intelligent techniques that can be used to solve many engineering and mathematical problems. Recently, ANN models have achieved popularity for analyzing and designing of antennas [5-10]. Singh introduced a method to calculate the resonant frequency of rectangular microstrip patch antenna using Feed Forward Back Propagation Algorithm, Resilient Back-propagation, Levenberg-Marquardt and Radial Basis functions of ANN [5]. Gehani et al. designed an antenna by using ANN with adaptive neuro-fuzzy inference system [6]. The ANN tool was also used by Rai et al. for designing of microstrip antenna [7].
The analysis and the design of X-band reflect array using ANN model was proposed in [8]. ANN was used for dual band frequency estimation of coaxial fed fractal patch antenna proposed by Arora and Dhaliwal [9].Santos et al. explained the use of ANN for analyzing and designing of several shapes of microstrip antennas [10].Crispim et al. (2004) proposed a Microstrip Patch antenna which consists of four multilayer stacked patches and a U slot for enhancing the return loss and mutual coupling. The proposed antenna covers the universal mobile telecommunication system (UMTS) and WLAN applications. It is also applicable for MIMO applications [11]. AR Kaye and DA George (1970) introduced the concept of MIMO which include multichannel transmission systems and crosstalk i.e. interference.

MIMO Antenna Design

The MIMO antenna is designed by using IE3D software. In this design microstrip antenna is used due to its light weight and thin size. The structure of an inverted U-shaped MIMO patch antenna, as shown in Fig 1, is proposed in this paper.

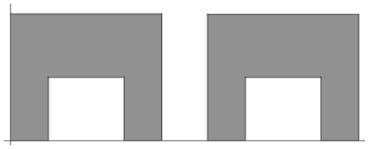

Fig. 1 Proposed MIMO antenna design

The proposed antenna is designed on the RT duroid substrate with thickness 'h' = 3.175 mm and 'ϵ_r' = 2.2. Two identical microstrip patch antenna elements are used and placed on the same substrate. We alter the length and the width of the above shown design 24 times and corresponding resonant frequencies are calculated and then these resonant frequencies are used to develop an ANN model for antenna analysis. The ANN approach is used because it is easy to calculate resonant frequencies from ANN model. MIMO antenna is well suited for wireless (WLAN), Aeronautical radio navigation, WiMAX, satellite communications and wireless communications.

ANN Model for MIMO Antenna

The resonant frequency plays the major role in antenna operation. If we calculate resonant frequency from the IE3D simulator for the MIMO antennas then it takes large time and it becomes intricate when we deal with more complex geometries. For this problem the solution is to use ANN models.

The proposed ANN model has length (L) and the width (W) as inputs and resonant frequency as output. The block diagram of ANN model is shown in Fig. 2. The multilayer perceptron network model having multiple layers of neurons connected in feed forward manner is used.

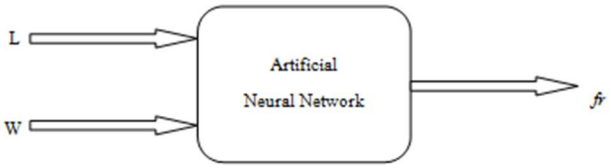

Fig. 2 ANN Model

Results and Discussion

Backpropogation algorithm is used to train the proposed ANN model. The '*traingd*' network function is used for training of ANN. This function updates the weights and biasing values according to gradient descent.

In this network model, there are two input neurons, three hidden layers and an output neuron. With the help of IE3D software tool, data set is created in which resonant frequencies are generated in correspond to the different values of 'L' and 'W'.

Using this data set, the ANN is first trained and then tested for different values of 'L' and 'W' of antenna. The simulation results from IE3D software tool are compared with ANN results as shown in table 1.The ANN results are also compared graphically with simulation results as shown in Fig. 3 which reveals that there is agreeable matching of ANN outputs with the desired simulation results.

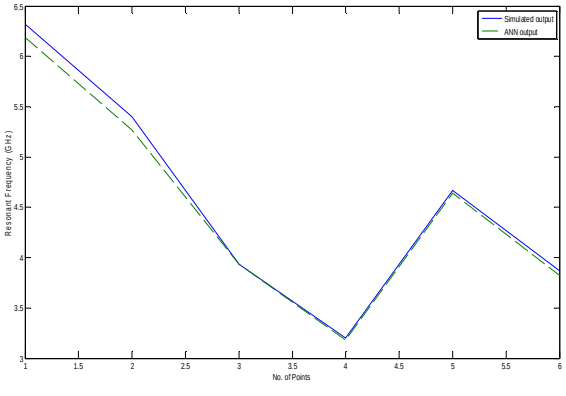

Fig. 3 Performance comparison of Simulated and ANN results

Table 1.Performance analysis of ANN for test data set

S. No.	L (mm)	W (mm)	IE3D Simulated Output (f_r)	ANN Output (f_r)	% Error
1.	20	18	6.316	6.186	2.058
2.	24	22	5.402	5.266	2.517
3.	32	30	3.935	3.934	0.025
4.	40	38	3.201	3.181	0.624
5.	46	44	4.668	4.638	0.642
6.	56	54	3.871	3.819	1.343
				Average % Error =	1.201

Conclusion

An inverted U-shaped MIMO antenna is designed using IE3D software. Then an ANN model is proposed to analyze the resonant behaviour of the designed antenna. The simulated resonant frequency value is compared with ANN output to validate the accuracy of ANN model. The comparison of results have shown that the average % error is 1.201 which means the ANN performance has good agreement with simulated outputs obtained from IE3D software. The proposed ANN model gives a simple and efficient way to calculate resonant frequency of the MIMO antenna for the given values of dimensions.

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