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Research Article

Machine Learning Based High Gain Wireless Antenna Design Operating at 5.2GHz Frequency

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Abstract

When it comes to 3G, 4G and the latest technology, 5G, the relevance of wireless communication is increasing day by day in a digitized and developing world. The increasing use of wireless communication highlights the need for wireless communication devices. The need for a premium version arises when the previous elements do not meet the requirements. Wi-Fi networks are one of the most common types of wireless communication. The most important component of the data flow in this system is the antenna. Several studies have been conducted in order to meet the requirements and make appropriate transfers. The planned antenna frequency is 5.2GHz. 5.2 GHz is the newest technology. With the integration of machine learning, predictive systems have been activated. There is planning to develop wideband antenna designs to facilitate wireless communications in this wide frequency range. The main goal of this article is to build a single antenna that can operate across multiple frequency ranges, rather than multiple antennas operating at big range frequencies. About 0.33 is reserved for prediction. Analysis was performed using 500 iterations of 3 parameters. This antenna design uses an FR-4 substrate with a dielectric coefficient of 4.3. Copper is used as a material for ground and patch components. 5.2GHz operating frequency, return loss 31.24dB, bandwidth range 4.9-5.38, gain 3.57dB.

Keywords: Antenna Design, WLAN, Wireless, Machine Learning, Microstrip

1. Introduction

Microwave components specialized to this technical sector have been introduced as improved alternative designs to conventional microwave components with the development of sophisticated communication systems for the Wireless Local Area Network (WLAN) [1-4]. Wi-Fi was created to provide high-speed wireless internet [5]. It was designed to enable wireless connectivity in small public spaces such as the home, workplace, and cafeteria. There have been attempts to expand the region and make it useable across a city. For even a few kilometers of coverage, however, hundreds of radio stations are required. As a result, the price of the process increases exponentially [6]. Machine learning research is divided into five categories. Different forms of learning include supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning, and intensive learning [7]. The learning mechanism of the machine learning algorithm is divided into three parts. The three are the selection process, the error function, and the optimization procedure. There were seven different forms of regression utilized. Their projected and typical states were computed. Mean Absolute Error, Mean Squared Error, Root Mean Squared Error, and R Square Value are the computations [8-9].

Linear regression is used to find the optimal linear connection or hyperplane for a set of points. The Support Vector Machine is a supervised learning method for solving classification problems. Based on the feature and aim, the decision tree classification approach creates a model in the form of a tree structure with decision nodes and leaf nodes. The decision tree algorithm is produced by splitting the data set into smaller or even smaller pieces. The random forest method is another supervised classification technique. It can help with both regression and classification problems. KNN is one of the algorithms used in Supervised Learning for classification and regression. It is considered the most fundamental machine learning algorithm. Unlike other Supervised Learning algorithms, it does not require training. There appears to be a variety of machine learning approaches to pick from these days. The neural network is one of them. The Naive Bayes classifier is a probabilistic pattern recognition approach that may be used with a statement that appears to be fairly restricting at first glance.

Zhang et al. studied frequency values of 2.4, 5.2, and 60 GHz [10]. The gains are 1.9 dBi for 2.4 GHz, 2.4 dBi for 5.2 GHz, and 16 dBi for 60 GHz, respectively. Wang et al investigated frequency values of 2.4, 5.2, 5.8, and 60 GHz [11]. Its gains are 0 dBi for 2.4 GHz, 2.5 dBi for 5.2 GHz, 2.5 dBi for 5.8 GHz, and 6 dBi for 60 GHz, respectively. Sun et al. worked on frequency values of 2.4, 5.2, and 5.8 GHz [12]. The gains are 1.66 dBi for 2.4 GHz, 4.75 dBi for 5.2 GHz, and 5.1 dBi for 5.8 GHz, respectively. Deng et al. experimented on frequency values of 2.4, 3 and 3.5 GHz [13]. By the way, the gains for 2.4 GHz are 1 dBi, 2 dBi for 3 GHz, and 2.5 dBi for

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3.5 GHz. Ding et al. experimented on resonant frequencies of 2.4, 5.2, and 60 GHz [14]. Even by way, its 2.4 GHz gains are 3.97 dBi, 4.07 dBi for 5.2 GHz, and 12.29 dBi for 60 GHz.

The paper has been structured as follows. In section 2, a discussion will be made about the design of the designed antenna, its dimensions, feeding methods, and the preferers application for simulation. In section 3, simulation results of the design antenna are presents. In section 4, the general summary of the study and conclusion have been explained.

2. Material and Method

2.1 Design of Antenna

The Wi-Fi antenna's overall design is shown in Figure 1. Figure 1 depicts the size of the antenna.

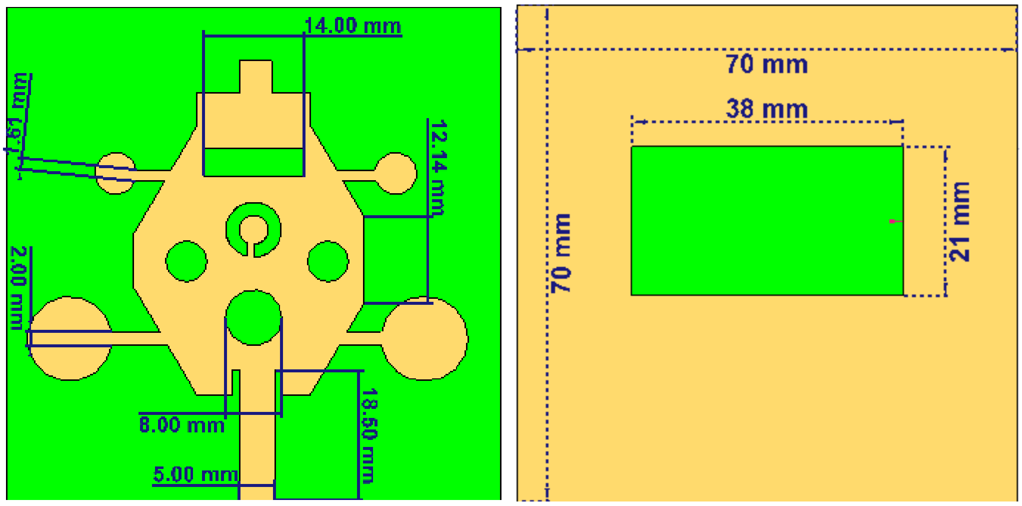


Figure 1*: Proposed Antenna Design*

There are three main components to consider while creating a microstrip antenna. Ground – Substrate – Patch When building an antenna, the ground layer, also known as the conducting layer, is created first. The antenna's ground material is copper, which has a thickness of 0.035mm. Electrical conductivity is required for this layer. The second layer is the substrate layer. The material FR4 is used for this layer. It is 1.6 mm thick and has a dielectric value of 4.3. FR4 material is used in most antenna designs. The second layer is the patch layer. The patch layer is where the antenna emits its radiation. This part has to be conductive. Copper was chosen since it was thought to be acceptable substrate for antenna because of it has low price and much effective. It measures 0.035mm thick.

3. Findings

Table 1 shows the various regression types, as well as their mean square errors and R2 values. Table 2 displays the outcomes of machine learning using Python. The optimal value has been determined to be random forest regression. The rectangular slot on the front is taken as the P1 variable. The rectangular slot on the back is taken as the P2 variable. The P3 variant is the circular slot on the front above the feed. The optimum values for P1 is 0, P2 is 1, and P3 is 1 are those that produce the most accurate antenna return loss value. It is also possible to forecast values outside of the database. Machine learning algorithms take information from a database and use them to produce predictions. The set is trained using 0.33 of the databases.

Polynomial linear regression, random forest regression, SVR and KNN, which are regression types in machine learning, are discussed. The Mean Square Error is calculated by dividing the sum of squares of the variances between each real value and the estimated value associated to that value by the sample size. Although perception has no intrinsic power, comparing many studied models can assist in the selection of the best model. It will always be a positive number. It shows that estimators perform better when the value is close to zero. The mean squared error (MSE) or mean squared deviation (MSD) of an estimator (of a process for estimating an unobserved variable) in statistics measures the average of the squared errors that is, the average squared difference between the estimated values and the actual value.

Table 1: *Regressions and MSE-R^2 Values*

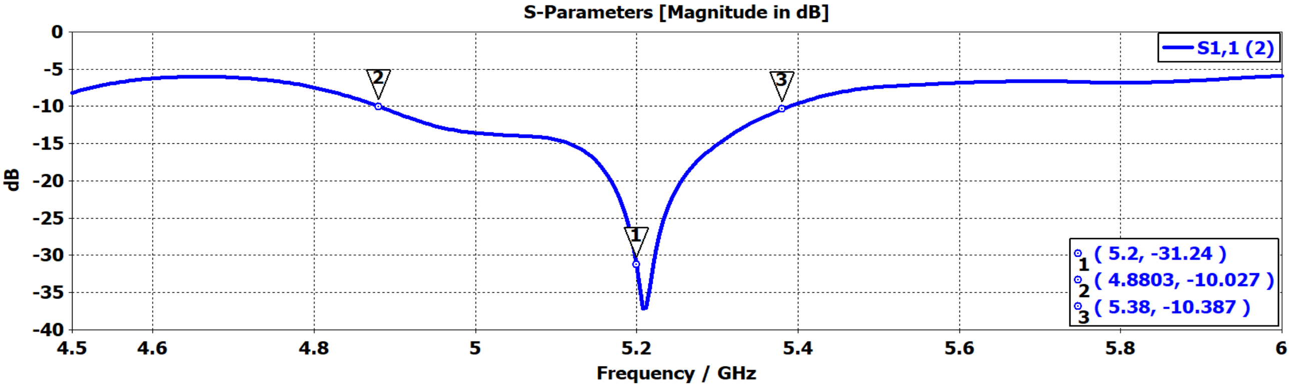
	Mean Square Error	R^2
POLYNOMIAL LINEAR REGRESSION	42.48890	0.47897
RANDOM FOREST REGRESSION	0.002552	0.99968
DECISION TREE REGRESSION	0.003157	0.99996
SVR	48.85987	0.40085
KNN	18.48277	0.77335

P1	0
P2	1
P3	1
POLYNOMIAL LINEAR REGRESSION	-29.486
DECISION TREE REGRESSION	-31.239
RANDOM FOREST REGRESSION	-31.123
SVR	-3.4319
KNN	-21.640

Table 2: *Machine Learning the Best Results*

When Table 1 was examined, it was observed that mean square error and r square values were for 5 different regressions. These regressions were observed as polynomial linear regression, random forest regression, decision tree regression, SVR and KNN. When Table 2 was examined, it was observed that the parameter values were for 5 different regressions. These regressions were observed as polynomial linear regression, random forest regression, decision tree regression, SVR and KNN.

Machine learning algorithms act as computers' minds, promoting learning and improve. More data means more processes are active, which causes the computer to learn and enhance its output. If the forecast does not turn out as expected, the algorithm is retrained until the desired outcome is achieved. This allows the machine learning system to self-train and provide the best possible response, which will increase in accuracy over time. The antenna's S parameter value is shown in Figure 3a. In the range of 4.89-5.38, a 31.24 dB return loss has been determined. Figure 3b depicts the radiation pattern of the proposed antenna with a gain of 0.798 dBi. Table 3 lists some of the machine learning-assisted antenna designs found in the literature, organized by antenna type, algorithm, and result section.



(a)

(b)

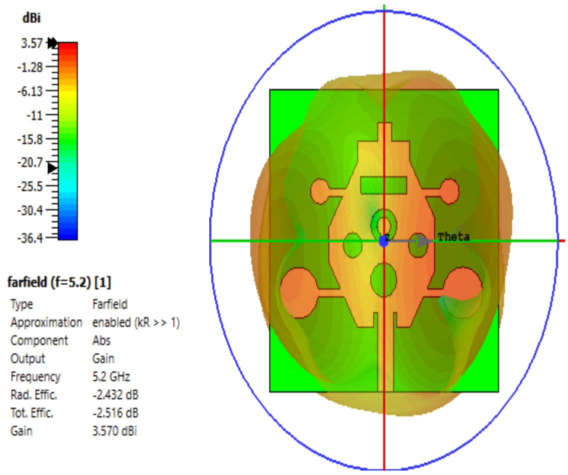


Figure 2: *a- S Parameter b- radiation pattern of proposed antenna*

Table 3: *Literature Review for machine learning assisted antenna designs*

REF NO	ANTENNA TYPE	ALGORITHM	COMPARED	RESULT
15	Reflectarrays	SVM	MoM&ANN	Design process is sped up while keeping high accuracy levels.
16	Rectangular Antenna	SVM	ANN	With a quicker convergence rate, the calculation efficiency improves.
17	E-Shaped Antenna	Linear	Conventional Simulations	The best outcomes discovered without the use of any simulations.
18	Microstrip Antenna	Gaussian ML	Differential Evolution	The speed of the design and optimization procedure by more than four times compared with differential evolution

4. Results

As a conclusion, this 5.2 GHz antenna is one cut above the rest of its industry competitive advantage in terms of both beauty and efficiency. It is more suitable than its rivals due to its effective working in the range of 4.8903-5.38 and low cost. The return loss is 31.24 dB, whereas the gain value is 3.57 dBi. Because this product is already pricey, a lower-cost antenna is constructed with a smaller surface area rather than a greater gain with this type of antenna. The antenna's s parameter graph is obtained after 448 iterations of three parameters. It has been observed that the antenna gives the most accurate results into 500 iterations for the parameter p1=0 p2=1 p3=1 when the antenna is inserted into machine learning. The best value, Decision Tree Regression, has been seen when it is inserted into machine learning. R^2 value is 0.99996. Mean Square Error value is 0.0031570. If the value of the s parameter, which is checked after making an estimation, is -31.2396. This was the closest predictive regression.

Declaration of Interest

I declare that there is no conflict of interest.

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