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Research Article

Machine Learning Predictive Wi-Fi Antenna Design for Wireless Communication Technologies

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Abstract

The use of the Internet has become indispensable with the developing technolog. Antennas are the most important stage to access the Internet. Recently, development studies have increased considerably for antennas, which are the first step of wireless communication technology. In this study, a Wi-Fi antenna design with 2.4 GHz operating frequency that can be used in wireless communication technology has been realized. The designed antenna has dimensions of (Length) 90- (Width) 70 mm. It is very small size is very advantageous in terms of use. Microstrip antenna has been chosen to meet the necessary needs. While designing the antenna, CST Microwave Studio program has been used and numerical calculations have been made. After the antenna design has been made, machine learning support has been provided. The most appropriate return loss estimation has been made according to the selected algorithms. The most effective lengths of the antenna have been determined and parametric analysis has been performed. The results of the selected algorithms have been observed. Based on these results, the algorithm that made the closest prediction has been determined. As a result of this study, an antenna design with a return loss value of 21 dB and a bandwidth value operating between 2.37 GHz - 2.42 GHz frequencies have been carried out. The designed antenna is acceptable according to IEEE 802.11 standards. Decision Tree gave the best prediction result according to machine learning algorithms.

Keywords: Antenna Design; Machine Learning; Microstrip Patch, Wi-Fi.

1. Introduction

Recently, the use of the internet and wireless communication technologies have increased tremendously, so the need for antennas to be used in this technology has increased so much [1]. One of the most important examples of wireless communication technology is WLAN (wireless local area network) systems [2]. It includes Wi-Fi antennas with 2.4 GHz operating frequency within WLAN systems. Antennas are one of the microwave components that are always open to improvement and innovation. Recently, studies on microstrip antennas have increased considerably [3]. Improvement and development studies on microstrip antennas have become quite common. High performance antennas are needed in this area. In his study, Palandöken deals with the new antenna design method based on artificial materials. The substrate or radiating part of the antenna as a solution for better antenna designs is described, from basic electrical limitations to proposed design solutions [4]. At the beginning of antenna improvement studies, dimensional changes in designs come first. Designing a small size antenna will make it cost effective and compact [5]. Ghouz et al achieved a moderate gain (6.0 dBi) at 38 × 36 mm2, a satisfactory efficiency (81%). The proposed antenna is of simple designs and compact dimensions and can be used for many wireless applications including Wi-Fi, LTE and WiMax [6]. It has been done in studies that the usage area of the antenna is valid for many frequencies. Patel et al. designed a multiband antenna operating at frequencies of 2.47–2.54GHz, 4.14–4.23GHz, 5.43–5.78GHz and 6.71–7.42GHz [7]. Another development work is to change the antenna geometry and create slots on the antenna [8]. Raad H. Thaher and Zainab S. Jamil did parametric studies on the antenna and drilled slots in certain areas. The antenna they designed works in 2.4/5.8 GHz bands for Wi-Fi/WiMAX applications. The results of return loss are 32.77 dB at 2.4 GHz at 7.4% bandwidth and 25.955 dB at 5.8 GHz with 8.17% bandwidth [9]. In order to provide machine learning support after the antenna design has been made, Misilmani et al. conducted a study covering the main aspects of machine learning, including the basic concept, differentiation with artificial intelligence and deep learning, learning algorithms, broad applications in various technologies, with a focus on its use in antenna design [10]. Antennas have a certain frequency range to operate. IEEE 802.11 standards have been taken into account while determining the frequency ranges. IEEE 802.11 standards are the general name of the developed wireless networks [11]. 802.11 standards represent protocols created over WLAN within the local network. This standard has been also taken into account

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in this study. In the designed antenna, it is aimed to design the most suitable microstrip antenna in terms of return loss and antenna gain. After the design has been carried out, the results of the machine learning algorithms have been observed.

The paper is structured as follows. In Section 2, a discussion will be made about the design of the designed antenna, its dimensions, and the preferred application for simulation. In Section 3, simulation results of the designed antenna are presented. In the last section, section 4, the general summary of the study is explained.

2. Material and Methods

2.1 Designing the Proposed Antenna

While designing the antenna, micro strip antenna has been preferred due to its geometry, lightness, low production cost and compactness [12]. Microstrip antenna has 3 important layers. These are Ground - Patch – Substrate. The ground part of the designed antenna is made of copper and its thickness is 0.035 mm. This layer is conductive. The substrate layer is the second layer. FR4 material has been chosen for this layer. Its dielectric coefficient is 4.3 and its thickness is 1.6 mm. This material is generally preferred in antenna designs. The dimensions of the substrate-Patch layer (Length) are set as 90 mm- (Width) 70 mm. The last layer where the radiation takes place is the patch part [13]. In this part, it should be conductive like ground. Copperis used in the patch part of the designed antenna and its thickness is taken as 0.035 mm. While the data have beentaken for machine learning, the parameters that have been modified on the Patch are determined from this section. While determining the parameters, values have been taken from various parts of the antenna, but the 3 selected parameters are the ones that have the most impact on the antenna. Therefore, machine learning has been done over these 3 parameter changes.

2.2 Antenna Feed

There are many feeding methods to be used when designing the proposed antenna [14]. According to thedesign, the most suitable feeding method has been selected as microstrip feeding. A more suitable value has beenobserved in this feeding method compared to the others. The input impedance between the antenna and the supplyline should be normalized. The normalized input impedance result is 50 ohms [15]. This value is the internationally accepted value [16]. Important for proper integration of antenna and feed line.

2.3 Simulation of Proposed Antenna

CST microwave studio program has been used in antenna design. The antenna designed as a result of the simulation is shown in Figure 1. The parameters entered during antenna simulation are shown on the figure. It is shown on the antenna in the port where the feed line is used.

2.4. Machine Learning Algorithms in Proposed Antenna

In order to design the antenna based on machine learning, 3 different parameters have been selected over the antenna. These 3 selected parameters are the most effective parameters for the antenna. The first parameter (P1) had the most influence over the feed line width. The second parameter has been on the slit width at the ground of the antenna (P2). The third parameter has been taken over the width of the patch part of the antenna (P3). Parametric analysis has been performed with 125 parameters of 5x5x5 and the return loss values have been recorded.

3. Results

The results of the simulations of the antenna designed in the CST microwave studio program are examined. The return loss, gain and radiation pattern graph required for the antenna are given below. Machine learning regression results are shown.

The return loss value of the designed antenna has been observed according to the CST simulation program. S parameter result is shown in Figure 2. The return loss of the designed antenna is 21 dB. The operating frequency range is 2.37 GHz - 2.42 GHz. This operating frequency range and return loss value are in acceptable standards.

The gain of the proposed designed antenna has been obtained as 0.627 dBi as seen in Figure 3.

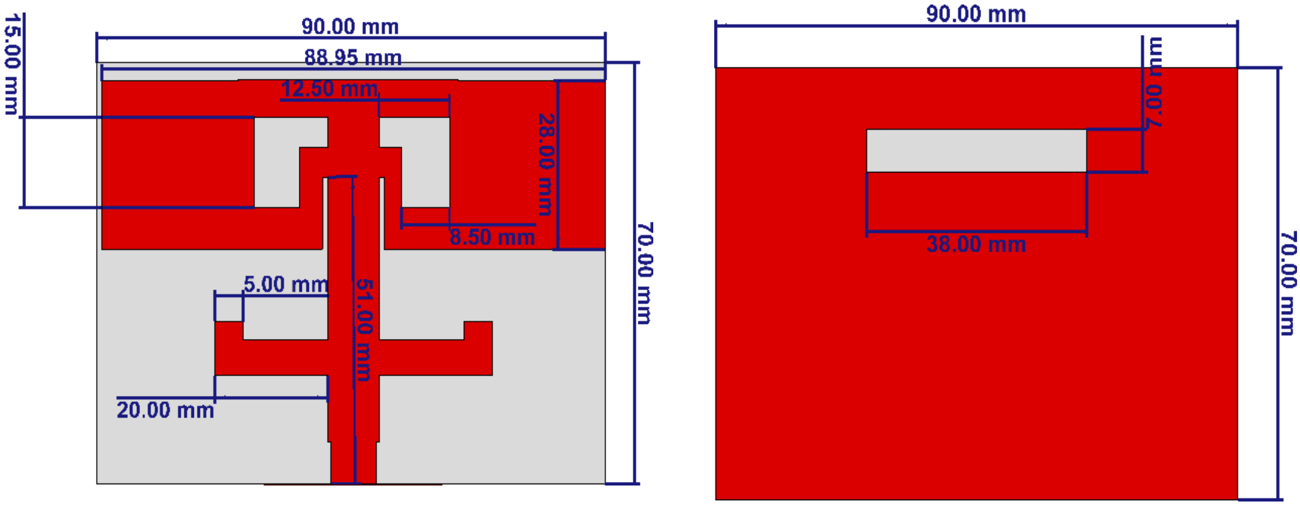

Figure 1. *Proposed Antenna Design Front and Back View*

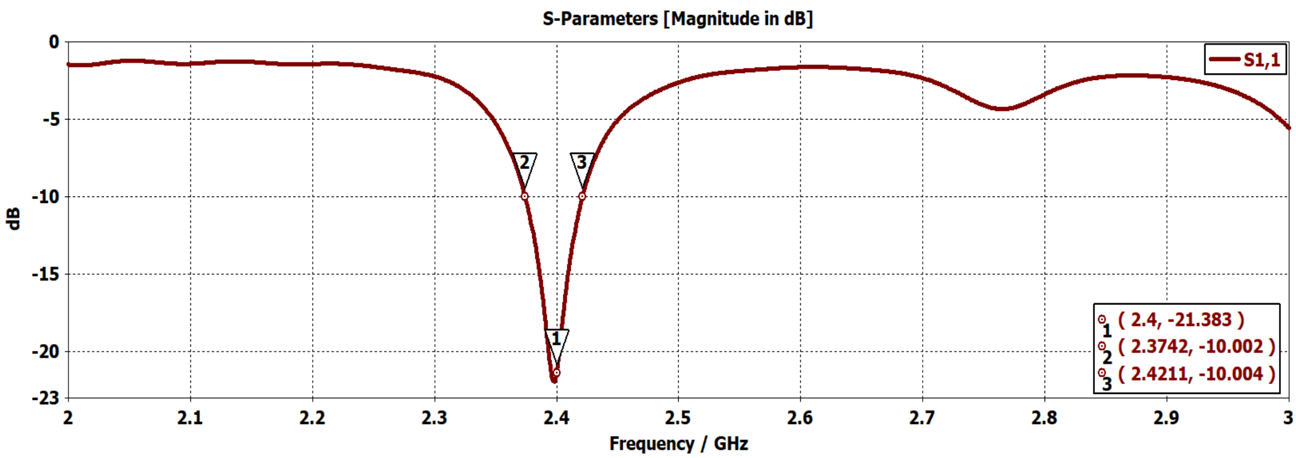

Figure 2. *Return loss result of proposed antenna*

Machine learning code has been written. 4 different algorithms have been selected. The selected algorithms are shown in Table 2. In machine learning, the data has been used for 30% learning and 70% testing. The estimation process has been carried out through the algorithms that completed their learning. According to the results obtained from the antenna designed, the Decision Tree Regression algorithm gave the best result out of the 4 regression models available.

It has been seen that the Decision Tree algorithm gave direct results when any random value has been selected from the data set. Although the machine learning algorithm learned these valuescompletely, when a value has been selected from 70% of the data set, it still made the best guess, considering thatit did not learn any data. When the parameters that are not used in machine learning are entered on the antenna (the values in Table 1), the return loss result value is shown in Figure 4. Accordingly, when the value has been taken from the user and predicted by machine learning, the decision tree algorithm gave the best result. This situation observes in Table 2 that he made the closest estimate here. When asked to predict a value that is not in the data set, any 3 values have been taken from the user and the result has been compared with the correct result. Accordingly, decision tree regression madethe best guess. The values received from the user are shown in table 1, the result and the estimation results are shown in Table 2.

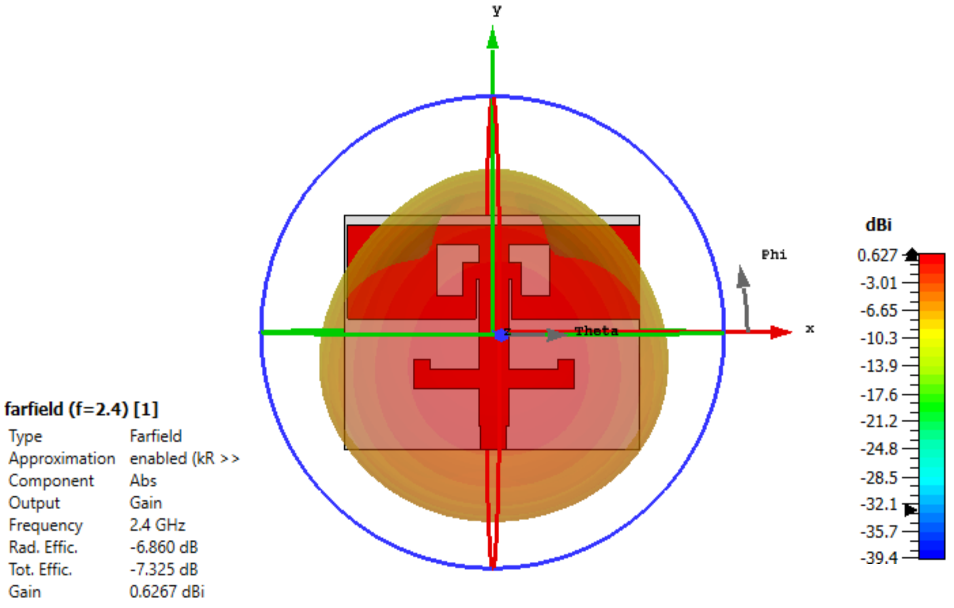

***Figure 3**: Radiation Pattern Result of Proposed Antenna*

Table 1. *Proposed Antenna Selected Parameters Values*

SELECTED PARAMETERS	SELECTED PARAMETERS VALUES
P1	2.5
P2	1.5
P3	4

Table 2. *Proposed Antenna Machine Learning Results*

Machine Learning Algorithms	Prediction of Return Loss Value
Polynomial Linear Regression	-10.142 dB
Random Forest Regression	-17.009 dB
SVR	-7.5001 dB
Decision Tree	-15.6028 dB

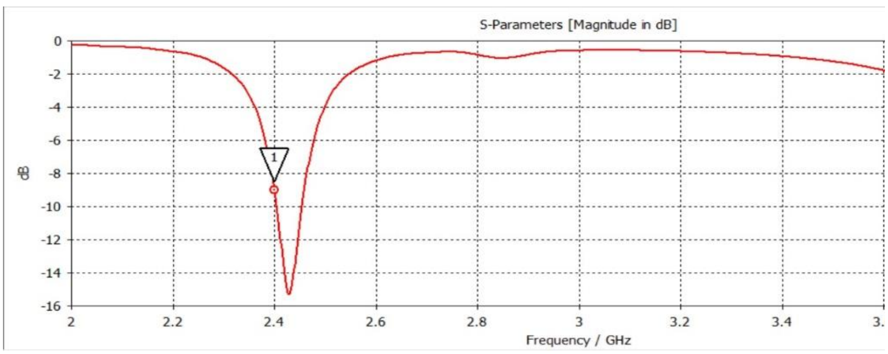

***Figure 4**. S Parameter Result*

Declaration of Interest

I declare that there is no conflict of interest.

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