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Review on Micro strip Antennas Design by Optimization and Machine learning

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ABSTRACT-

With the advent of time, the ways of the communication have been drastically changed from handwritten letters to emails. Today, we are using modern wireless technology to send or receive the messages or signals, and the backbone of this technology is Antenna. Without proper designing of antenna, the wireless communication system is of no use. In the changing technology era, a compact size, low cost and multifunctional antenna is great in demand. An antenna may be a metallic device which is used to transmit and receive the signals. Microstrip patch antennas have emerged and found use in mobile phones, defense instruments, and wireless wearable devices, among others. Compared to conventional antennas, the Microstrip patch antenna offers greater advantages and superior performance. Microstrip patch antennas have displaced nearly all traditional antennas in practically all wireless applications due to their reduced weight, foldability, ease of fabrication, multiple frequency functioning, and compact size. The study provides an overview of various Microstrip antennas with various feeding mechanisms and their applications over standard antennas. Additionally, machine learning is an excellent tool for designing and optimizing of such kind of antennas.

Keywords: *Antenna Design, Microstrip Patch Antenna Machine Learning*

I. INTRODUCTION

The evolution of antenna can be credited to Mr. James Clark Maxwell who invented the Maxwell equations in 1873, which are considered as the foundation of antenna theory [1]. An antenna is a metallic device for transmitting or receiving radio waves." [2]. Antenna is like ear or eye of the electronic circuitry. J. C. Bose worked on millimeter waves (60GHz), and invented new antenna in the year 1897, and named as Horn Antenna [3]. The revaluation of antenna came into the existence in World War-II when Radar was used to hit the airplanes of enemies. The continued research was carried out by distinguished researchers to invent the different types of antennas for wireless communication such as Wi-MAX, Point-to-Point high speed communication, WLAN, Wi-Fi, Satellite Communication, Bluetooth, GPS, Mobile/ Microwave/ Infrared Communication, MANET/VANET, UWB, GPRS etc. [4,5]. The different wireless applications require distinct antenna, whereas, a multipurpose antenna is always a prime requirement of the market. Due to less weight, small size, ease of fabrication, low profile, multiband/wideband characteristics, Microstrip Patch Antenna (MPA) and Fractal Antennas are gaining huge popularity due to their significant advantages, including low weight, small volume, compliance with electronic components, ease of installation on hard surfaces, low cost, extremely low profile, mechanical robustness, and low fabrication cost. Microstrip antennas [6-8] are intended to operate either in circular or dual polarization in single, dual, and multi-band applications. Such antennas are found in a variety of portable communication devices. They have proven popular among antenna designers and are utilized in a large range of applications in wireless systems, including military and commercial. As a result, its architecture and optimization are required to maximize the system's performance. Machine learning has yielded extremely promising findings in the realm of antenna design and forecast of antenna behavior. Machine learning is a very well tool for designing and optimizing antennas in today's world. Microstrip antenna design is a common genre of antenna design that utilizes machine learning [9,10]. Machine learning is preferred for solving complex math equations involving a large number of variables and a huge amount of information. Today's methods for designing antennas necessitate a lot of expertise, as the design phase frequently necessitates a trade-off among antenna parameters such as good bandwidth and small size.

1.1 Microstrip Patch Antenna

An antenna is a transducer for transmission and reception of electromagnetic waves from a transceiver employed in any wireless communication system. This is the basic and the most essential component of any wireless communication system. There are many performance parameters such as antenna gain, aperture, effective length, bandwidth, polarization, etc. There are several types of antennas that include wire, reflector, microstrip patch, etc. [11-13]. Microstrip patch antenna primarily consist of conducting path having either non-planar or planar geometry [14,15]. The conducting path known as patch and ground plane exist on either side of dielectric substrate, as depicted in Fig. 1. Microstrip antennas, in general, can be categorized as Microstrip travelling antenna, printed dipole antenna and microstrip patch antenna. The first two types can have circular, rectangular, triangular, or elliptical shape only whereas there is no constraint on any specific geometrical shape for design of microstrip patch antenna.

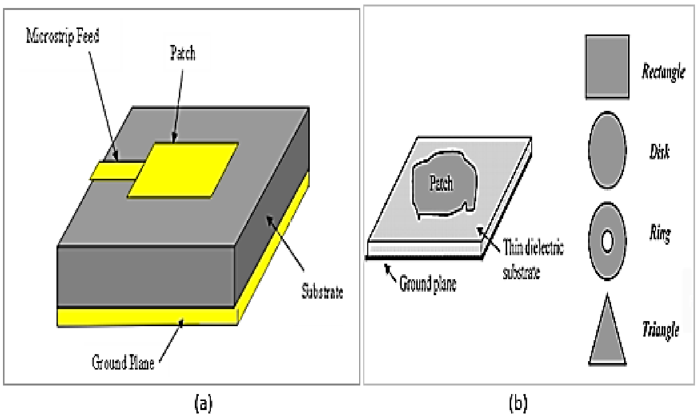

Fig1: (a) Basic Structure of Microstrip Patch Antenna [16]; (b) fundamental configuration of the MPA [17].

1.2 Working of Patch Antenna

A microstrip or patch antenna operates in a way that when current though a feed line reaches the strip of the antenna, then electromagnetic waves are generated. The waves from the patch start getting radiated from the

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width side. But as the thickness of the strip is extremely small thus the waves that are produced within the substrate get reflected by the edge of the strip. The continuous structure of the strip along the length does not permit the emission of radiation. Furthermore, on experiencing a sudden discontinuity in the structure of the patch, radiations are again emitted from the second width side of the patch. As this discontinuous structure favors reflections, thus the patch antenna radiates only a small fraction of supplied incident energy. This makes the antenna inefficient, that rather displaying the characteristics of a good radiator, it somewhat acts as a cavity. The low radiating ability of microstrip antenna allows it to cover the only small distances of wave transmissions like local offices, stores or any indoor locations. As such inefficient transmission is not supportable at a centralized location in an extremely large area. Generally, hemispherical coverage is provided by a patch antenna at an angle of **30^o to 180^o** at width from the mount.

Radiation Pattern Characteristics

- The patch of the antenna must be a very thin conductive region**,** $t<<\lambda_0$ (: λ_0 free space wavelength).
- The ground plane must have comparatively very large dimensions than the patch.

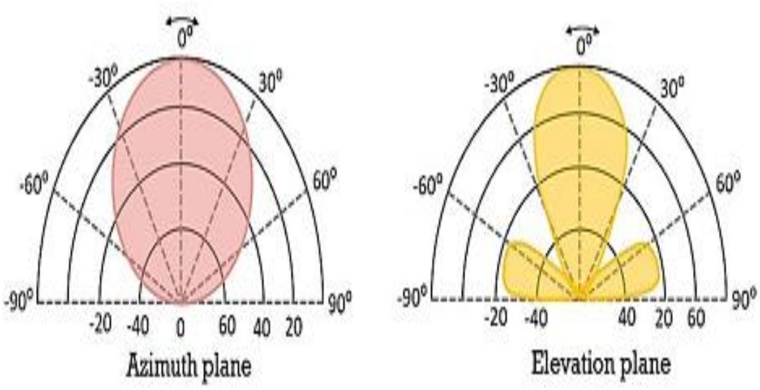

Fig 2: Radiation patterns of Microstrip Patch Antenna [16]

- Photo-etching is done to fabricate the radiating element and feed lines on the substrate.
- A thick dielectric substrate with dielectric constant within the range of 2.2 to 12 provides good antenna performance.
- Arrays of microstrip elements in the antenna configuration provide greater directivity.
- Microstrip antennas provide high beamwidth.
- A very high-quality factor **is** offered by a patch antenna. A large Q results in a narrow bandwidth and low efficiency. However, this can be compensated by increasing the thickness of the substrate. However, the increase in thickness beyond a certain limit will cause an unwanted loss of power [16].

1.3 Feeds of Microstrip Patch Antenna

a. Microstrip Line Feed: A narrow width conducting strip is directly connected at one edge of the patch. This enables to etch the microstrip line feed on the substrate itself that results into planar type of structure [18].

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b. Proximity-coupling Feed: The feed line is placed in between two dielectric substrates. The upper dielectric substrate also supports the radiating [19]. This helps in reducing spurious radiations significantly and thereby providing extremely high bandwidth.

c. Aperture-coupling Feed: An aperture is used in the ground plane for providing the coupling between the microstrip patch and the feed line. It implies that the ground plane separates aperture coupling feed and the radiating patch [20].

d. Co-axial Feed: This technique is very common. The inner conductor of the coaxial cable is welded to the radiating

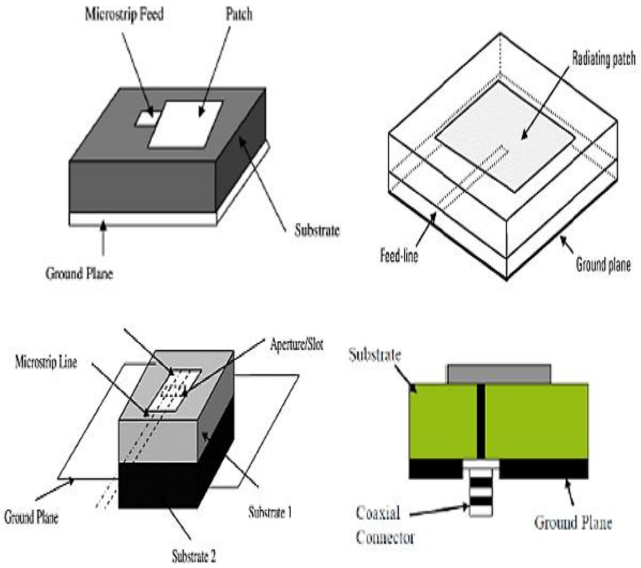

Fig 3: Microstrip Feeds: (a) Line feed (upper left); (b)proximity-coupling (upper right); (c) Aperture-coupling feed (lower left); and (d) Co-axial Feed (lower rt) [21]

element of the antenna after penetrating it through the dielectric substrate on the opposite end of the substrate. Whereas the outer conductor of the coaxial cable is directly connected with the ground plane. This technique has an advantage of placing the feed at convenient place on any point on the patch so as to achieve impedance matching of coaxial cable with that of antenna input port.

II. DESIGNING OF MICROSTIP PATCH ANTENNA

2.1 Designing

Let the conducting patch be a rectangular one which exists on one side of the dielectric substrate. Let `$L$' represents length and `W' represents width of a rectangular conducting patch. The microstrip substrate has dielectric constant, denoted by εr and thickness, h. The following steps are proposed to be used while designing and developing a microstrip patch antenna.

Step 1. Calculation of the width (W) of the microstrip patch

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}} \qquad (1)$$

Where c denotes the velocity of electromagnetic waves, $\varepsilon_r$represents the dielectric constant, f_0 represents the centre frequency.

Step 2. Effective dielectric constant, ε_{eff}

$$\varepsilon_{eff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left[\frac{1}{\sqrt{1+12\frac{h}{w}}}\right] \quad (2)$$

Step 3. Effective length, L_{eff}

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \quad (3)$$

Step 4. Extension length, ΔL

$$\Delta L = 0.412h \frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)} \quad (4)$$

Step 5. Actual length of the microstrip patch

$$L = L_{eff} - 2\Delta L \quad (5)$$

A modified microstrip-fed monopole antenna which has planar structure and different frequency band notch function for ultra-wideband (UWB) application is proposed here. In this design, two slots were inserted on either side of the feed line which exists on the ground plane. It enables to enhance the bandwidth of microstrip patch antenna. During the development phase of microstrip patch antenna, the patch had been cut into H-shape. By introducing DGS, the inductance and capacitance get changed which simultaneously increases the antenna bandwidth. In this antenna FR4 substrate is used with thickness of 1mm and with dielectric constant of 4.4. The patch length which is just opposite to the feed line restores with Murkowski geometry. In the 1st iteration various parameters like return loss, gain and radiation pattern was calculated and the centre part of the line gets removed (Fig. 4a). The same process was repeated in the 2nd iteration and the shape became as shown in Fig4 (b) [22]

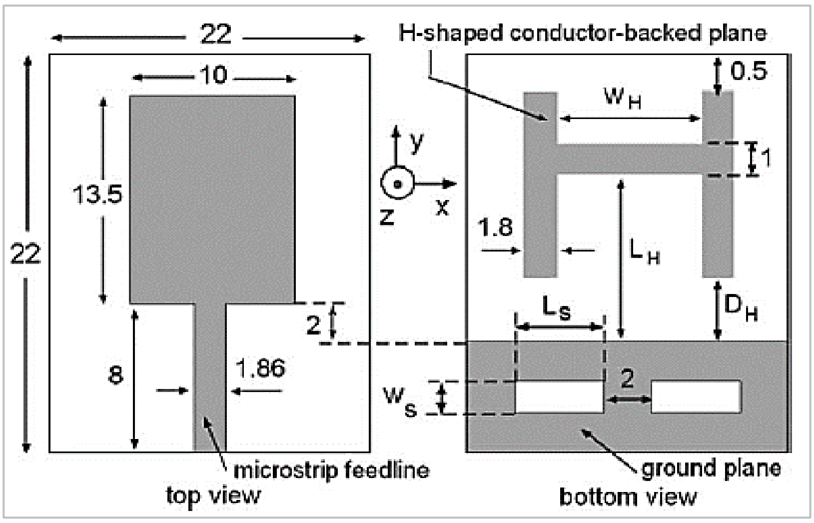

Fig 4(a): Geometry of Planar Monopole Antenna [23]

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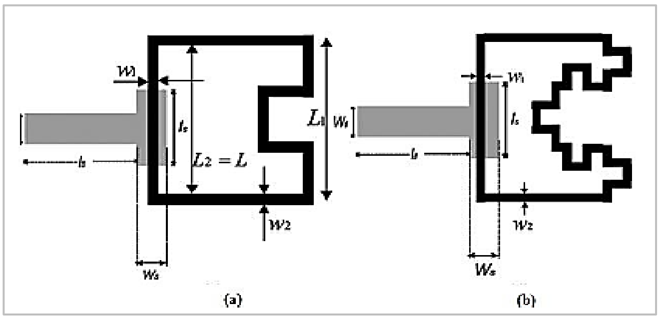

Fig 4(b): Antenna design with 1st and 2nd iteration fractal [23]

This antenna was designed using LED3 software material used is aluminum and the dimension of the ground plane was kept as 20 x 20 cm2. With two iterations, it is observed that the bandwidth increases, as depicted in Fig. 5. It is seen that the 3 dB bandwidth for FR4 category substrate is calculated to be (2.49 - 2.41 =) 0.08 GHz and the return loss was -20.1 dB.

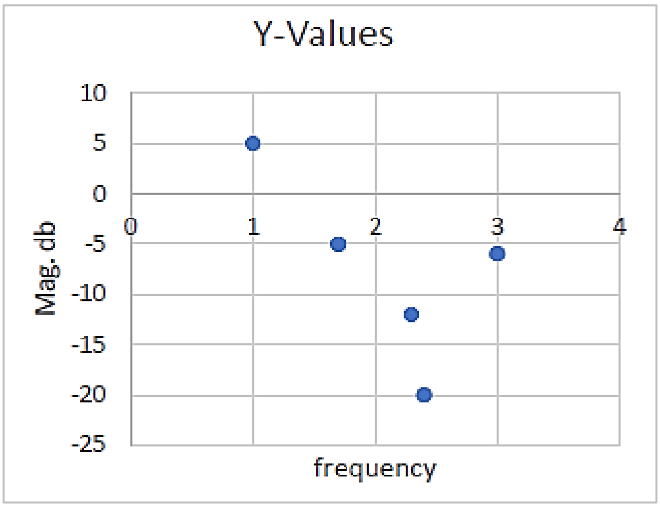

Fig.5: Bandwidth and return loss of H-shaped antenna using FR4 substrate [20,24]

III. MACHINE LEARNING

3.1 Machine Learning and the Antenna

The concept of machine learning dates back to the 1950s; there has been an unexpected interest in ML techniques in recent years. This has been sparked by the abundance of data available in the world's digital era and access to high-performance computation and improved mathematical formulation and grasp of learning approaches. ML innovations, such as generative adversarial networks and deep reinforcement learning, have changed many sectors of study and industry. Although some forms of ML algorithms, particularly deep neural networks, are considered "Black Box" technologies, they could achieve good performance in practice. Artificial neural network (ANN) is one of the most common machine learning techniques that can be used in conjunction with traditional CEM approaches to reduce the energy function. In addition, the stability of ANNs results in achieving solutions to MoM. Based on the current distributed computing developments, neural networks may be utilized to effectively solve large and complicated tasks due to their capabilities from the distributed and parallel processing perspectives. ANNs were also employed with FDTD to speed up EM issues, and they proved to be effective. For instance, a global modeling method for Millimeter-Wave Circuits and Microwave design can be achieved by a considerably quicker global modeling than the usual FDTD approach.

ANN models, in general, have positive properties that aid in the solution of EM tasks. An essential property of ANNs is their ability to approximate the mappings of nonlinear input-output data by maximizing the relationship between input and output data. On the other hand, the adaptability of ANN to the changes in the training environment is another significant property of it. One of the key benefits of machine learning is that it reduces the computation time observed in CEM approaches. This benefit is obvious when optimizing several parameters or when it is needed to build a large model structure. The geometries of microstrip antennas, particularly complicated geometrical antennas, or the new model structures are still challenging to be handled efficiently using the established theories of antennas. This can be shown when given some of these geometries have low accuracy. In real-time, machine learning may be used to model and forecast scattering problems as well as evaluate and improve antennas performance [22,25].

3.2 Prediction antenna variables

A large body of literature exists where ML has been used to design and optimize antennas. Most of these works have employed the usage of ANNs to find direct relationships between different antenna parameters, such as between the geometrical properties of the antenna and the antenna characteristics. As the complexity of an antenna's structure increases, the number of geometrical parameters increase, and it becomes hard to derive relationships between these parameters and values for the resonant frequency and other radiation characteristics. The usual approach for optimizing a design is simulating the antenna to finally reach the desired values, a process described as computationally heavy and time demanding. Instead, ML can accelerate the design process by providing a mapping between whatever the desired inputs and outputs may be. In general, the following procedure can be adopted:

- Numeric values corresponding to the desired inputs with their respective outputs are obtained by simulations and are stored in a database.
- Once this dataset is created, it is split into training, cross-validation, and test-sets, where the percentage of each depends on the amount of data samples
- A ML algorithm is chosen to learn from this data. The choice of the algorithm relies on the complexity of the problem, the amount of data at hand, and the mathematical formulation of the algorithm.
- After training and testing the model, it can be used to predict output values for the desired inputs

Although this process demands going into simulations to create a dataset for training, once a model is obtained, predictions can be made for any desired inputs at very high speeds, and within very low error margins compared to simulated results. Several metrics have been in the literature to quantify this error, among which are: The Output Error: obtained by calculating the difference between the output obtained by simulations and the output predicted by the ML model. The unit of this error depends the parameter being predicted and could be in dB, Hz, mm, or any other unit. It is expressed by:

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$$e_i = y_d - y_i \qquad (6)$$

where e_i is the output error, yd is the desired output, and y_i is the output predicted by the ML model. The mean squared error (MSE) expressed by:

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(e_i)^2 \qquad (7)$$

where N is the size of the training samples. The error percentage is obtained by the following:

$$error\% = \left|\frac{y_d - y_i}{y_d}\right| \times 100 \quad (8)$$

3.3 Types of Machine Learning

a. Supervised Learning

In this type of machine learning, the generalization of a model can be achieved on a collection of pairs of labeled input-output to predict unknown input. In supervised learning, there is a separation between datasets used in training and testing. The training set samples are usually linked with targets or labels, but the samples of the test set lack these labels. It is possible to break the tasks of supervised learning into the following sections. 1) Classification: The objective of classification is to classify data using a limited number of categories. Multi-class classification usually includes a set of more than two classes, whereas binary classification is based on a collection of two classes. 2)Regression: The objective of regression is to predict the label of real values for data that has yet to be seen. Some of the regression techniques available are support vector regression (SVR) [26], kernel ridge regression (KRR) [27], linear regression (LR) [28], and least absolute shrinkage and selection operator (LASSO) [29].

The workflow of supervised learning is depicted in Figure 6. This figure starts with pre-processing the raw data by cleaning, dimension reduction, and feature extraction. Then, the pre-processed features are split into training, validation, test sets, along with their target labels. The machine learning algorithm is applied to the training set with the help of a validation set to improve the generalization capability of the trained model. Finally, the resulting model is stored to predict the labels of the new unseen test data.

b. Unsupervised Learning

In this type of machine learning, specific labels for fresh data can be predicted after obtaining an unlabeled dataset. Unsupervised learning, unlike supervised learning, does not distinguish between train and test data. Two applications/tasks of unsupervised learning are presented in the following. 1) Dimensionality reduction: This task involves decreasing the number of dimensions in which data is represented by preserving the original representation's key characteristics. 2) Clustering: This task involves finding the areas or groups within big datasets based on the similarity of their characteristics.

c. Reinforcement Learning

This type of machine learning involves an agent that engages actively with the environment used to learn this agent to attain a target objective. This paradigm, which is used in cognitive sciences, optimization, and control theory, is based on the concept of incentives provided to the agent in quantities proportionate to the agent's successes, which he wants to maximize. Markov decision processes (MDPs), which describe the interactions and their working environment, are a frequently used model in this subject. This model is called Markovian since the reward probabilities and transitions are based on the present state of the model rather than its whole history.

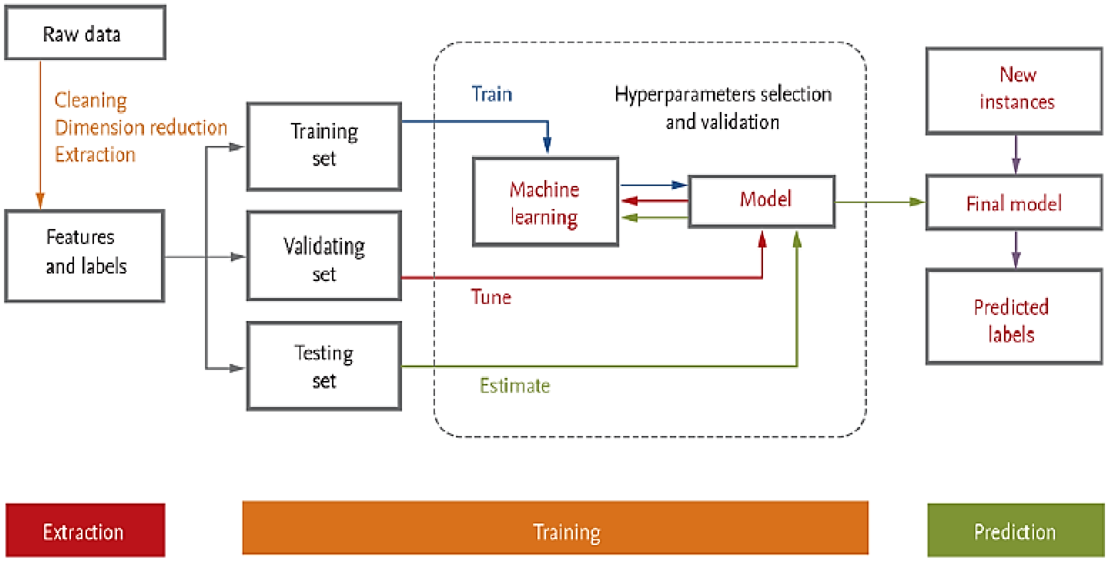

Fig 6: Workflow to develop a supervised machine-learning-based predictive model for antenna design process [30]

3.3.1 Machine Learning in Optimizing Antennas

In the literature, many research efforts employed machine learning models for optimizing the parameters of microstrip antennas. The most commonly used model to perform this optimization is the neural network. However, the antenna structure determines the number of geometrical parameters needed in the optimization process, and as this number increases, it becomes hard for the model to derive a better relationship among these parameters. Table 1.s presents the recent approaches employed for optimizing the parameters of microstrip antennas. As shown in the table, it can be noted that the most common method in parameter optimization is neural networks in the form of MLP or SVR with the help of other approaches. In addition, most of the parameters targeted by parameter optimization are the resonance frequency based on the geometrical information of the microstrip antenna.

3.3.2 Patch based antenna design using Machine learning

a. Rectangular Patch

The simplest form of antenna design using ML is the design of rectangular patch antennas. In References [31,32], multi-layer perceptron (MLP) neural networks have been used for the synthesis and analysis of rectangular microstrip antennas.

b. Circular Patch

Another well-known and simple type of microstrip antennas is the circular patch antenna The design of a circular patch antenna with thin and thick substrates, using ANN, was presented in [33]. The ANN took as input the radius of the patch, the height and permittivity of the substrate, to generate the resonance frequency using MLP and RBF networks. The effectiveness of five learning algorithms in the training of MLPs was investigated, the delta-bar-delta (DBD), the extended delta-bar-delta (EDBD), the quick propagation (QP), the directed random search (DRS), and the GA. After comparing train, test, and total errors of the mentioned algorithms, it was deduced that EBDB attained the best results with a test error of 2 MHz compared with 13, 142 and 271 MHz in error for the DBD, DRS, and GA approaches respectively.

c. Elliptical Patch

ANNs were used in two works for the design of elliptical patch antennas. The design and modeling of an elliptical microstrip patch antenna using ANN was presented in [22] For the purpose of computing the RL and the gain of the antenna, a FFBP neural network was trained in MATLAB ussing the three major axes of the connected ellipses as input parameters. A dataset was obtained from CST simulations. The obtained results were compared to those of the simulated and measured results of a fabricated antenna, and a good agreement was revealed with error values as low as 0.0202 dB for the Gain and 0.2014 dB for the RL.

Table 1: Recent approaches for optimizing the parameters of microstrip antennas

Ref		**Input**	**Output**	**Results**
[24]	SVR + different kernel configurations	Patch’s height and width	Resonant frequency	Error = 3dB
[32]	RBF	Patch’s radius, and substrate’s permittivity and height	Resonant frequency	Error = 2 MHz
[34]	MLP	Substrate’s resonant frequency, thickness, and relative dielectric constant	Radius, effective radius, and directivity of the patch	MSE was 9.7^{-4}, 9.80×10^{-4}, and 7.76×10^{-4} for the respective inputs
[35]	SVR + Gaussian kernel	Patch’s width and length	Voltage standing wave ratio (VSWR), gain, and resonant frequency	NA

[36]	Standard SVR	Height and length of the rectangular patch	Input impedance Rn, bandwidth (BW), and resonant frequency f_r.	Percentages of error are 1.21% for f_r, 2.15% for BW, and 0.2% for R_n

d. Special patch designs

Other types of special patch designs have been also designed in the literature using different ML techniques. In [4], the design of a three-layer annular microstrip ring antenna with pre-specified operational features were facilitated using ANNs, where structural design parameters were computed. A dataset of reflection coefficient vs frequency was used to train an MLP ANN to generate the geometrical properties of the patch as well as the physical properties of the substrate. Upon testing, the root MSE of the model was determined to be 1%. In [38], the design of a two-slot rectangular microstrip patch antenna was facilitated using MLP and RBF, based on an ANN trained with different learning algorithms. The MLP-based networks were trained using five learning algorithms: LM algorithm, scale conjugate gradient backpropagation, Fletcher Powell CG backpropagation, gradient decent with momentum, and adaptive gradient decent. It was determined that the LM algorithm resulted in the least MSE compared to the other MLP-based algorithms, but the RBF-based network resulted in a lower error percentage of 0.09%. In [8], the resonance frequency of rectangular patch antennas printed on isotropic or uniaxially anisotropic substrate, with or without air gap, was modeled using ANN. Spectral dyadic Green's function was used in conjunction with a developed single neural network. To reduce the computational complexities, required time, and amount of data needed to maintain the accuracy of the ANN model, a single matrix was used to present the effective parameters.

IV. RELATED WORK

Durga, R. V., et.al [6] designed a Frequency Reconfigurable antenna with a U-slot with a high gain of 9.2dB and can be reconfigured from 1.61-1.68GHz, the analysis of reconfigurability aspect and the behaviour of lumped components is studied using Machine Learning. Reconfigurable antennas are those which are capable of changing the resonant frequency based on the switching circuits used. These switching circuits use an additional load such as PIN Diodes, MEMS Switches etc., The authors considered PIN Diode since it is easy to design and is economical for our analysis in HFS S. The effect of each lumped component (R, L &C) is individually studied and it is observed that R value has a correlation coefficient of 0.961 with return loss, and correlation coefficient of 0.090 is obtained for frequency. R value is said to have significant effect on reconfigurability aspect of the antenna.

Table.2 Summary of the works analyzed by the researchers

S. No.	Author's Name	Tool/Method Used	Paper Title	Application Domain	Inferences
1.	*Durga, R. V., et.al*	Frequency Reconfigurable	*Design, Implementation and Machine Learning*	Machine Learning	R value is said to have significant effect on

		antenna with a U-slot	*Analysis of Frequency Reconfigurable Microstrip Antenna for Defense Applications.*		reconfigurability aspect of the antenna.
2.	*Panicker, P. H., et.al*	AI techniques	*Applications of AI Techniques like Machine Learning Methods and Deep Learning Models (ANNs) in Emerging Areas: A Review.*	Microstrip Patch Antenna using Machine Learning	Analyze the use of techniques and its applications in the field of microstrip patch antenna.
3.	*Aoad, A. et.al*	Multiband rectangular microstrip antenna using spiral-shaped configurations	*Design and manufacture of a multiband rectangular spiral-shaped microstrip antenna using EM-driven and machine learning*	MPA using Machine Learning	Machine learning models have the best prediction ability with a mean square error (MSE) of 0.03, and 0.05
4.	*Sharma & Pandey*	Regression-based ML approaches	*Efficient modelling of compact microstrip antenna using machine learning.*	Machine Learning	The proposed GPR model is validated by fabricating and characterizing a prototype of a microstrip antenna.
5.	*El-kenawy, et.al*	Advanced meta-heuristic optimization algorithm	*Advance Artificial Intelligence Technique for Designing Double T-Shaped Monopole Antenna.*	GWO, SCA, and MLP	The proposed algorithm offers the superiority and validation stability evaluation of the predicted results to verify the procedures' accuracy.

Panicker, P. H., et.al [7] analyze the use of these techniques and its applications in the field of microstrip patch antenna. In key areas, such as communication networks, microstrip antennas, signal and image processing (like speech and character recognition), Internet of things and embedded systems etc., there have been major breakthroughs aided and made possible through the use of artificial intelligence techniques such as machine learning and deep learning models (primarily including ANN). Purnamasari & Zulkifli [9] review and compare the implementation of genetic algorithms in the microstrip antenna design process to improve antenna gain. However, most of the implementations of this method generally requires computer resources with high computing and storage space and takes a lot of time to run the simulation. Therefore, machine learning methods are used to optimize the antenna design to reduce the iteration process and increase antenna gain. Genetic algorithm is one of the efficient optimization methods and has been widely used in the electromagnetic field. Kurniawati, N., et.al [10] focused on rectangular patch microstrip antenna with resonant frequency ranged from 1-8 GHz. The dataset used to make the prediction is obtained from simulation with antenna width ranged from 19-63 mm and length 10-54 mm. There are four algorithms employed: DT, RF, SVR, and ANN. Among all algorithms, random forest with estimator 15 gives the best result with Mean Square Error (MSE) value is 3.45. From the obtained result, the researchers can estimate the rectangular patch microstrip antenna dimension based on the desired parameters, which can't be done by the antenna simulation software before. Sharma & Pandey [11] presented an application of regression-based ML approaches to compute resonant frequency at dominant mode TM10, slot dimensions of square patch, and patch dimensions of compact microstrip antenna (SPCMA) in the frequency band of 0.4856–7.8476 GHz. In the design process, a squared patch microstrip antenna with two identical slots at the opposite side of a radiating edge of the antenna is loaded. The resonant frequencies of three thousand eight hundred and twenty-two SPCMAs have simulated with CST microwave studio 2019 by varying slot size, the thickness of the material, patch length, and dielectric materials is in accordance with specification of VHF, ULF, L, S, and C band applications. A comparison of 20 regression-based machine learning algorithms including artificial neural network is presented, and it is observed that the Gaussian Process Regression (GPR) model predicts physical or electrical parameters more accurately. The proposed GPR model is validated by fabricating and characterizing a prototype of a microstrip antenna. The fabricated antenna performance is very close to the designed antenna and predicted by GPR. Saxena, R., et.al [12] propose a novel Evolutionary Computing named Adaptive Genetic Algorithm (AGA) based ANN model is developed for rectangular MPA. Considering at-hand and Next generation Ultrawideband application demands, the emphasis has been made on retaining optimal low-cost design with desired cut-off frequency. The proposed method employs multiple sets of theoretically driven training instances or patch antenna design parameters which have been processed for normalization and sub-sampling to achieve a justifiable and reliable sample size for further design parameter prediction. Aoad, A. et.al [39] presents a multiband rectangular microstrip antenna using spiral-shaped configurations. The antenna has been designed by combining two configurations of microstrip and spiral with consideration of careful selection of the substrate material, the dimension of the rectangular microstrip, the distance between the turned spiral, and the number of turns of the spiral. The efficiency and accuracy have been improved using machine learning algorithms as well. Machine learning has been studied to model the proposed antenna based on the performance requirements, which requires a sufficient training data to improve the accuracy. Three different machine learning models are applied to improve the accuracy and generalization performance and compared to simulation and measurement results. El-kenawy, et.al [40] propose an advanced meta-heuristic optimization algorithm in this work for the optimization problem of antenna architecture design. The algorithm is designed, depending on the hybrid between the Grey Wolf Optimizer (GWO) and the Sine Cosine Algorithm (SCA), to train neural network-based Multilayer Perceptron (MLP). The proposed optimization algorithm is a practical, versatile, and trustworthy platform to recognize the design parameters in an optimal way for an endorsement double T-shaped monopole antenna. The proposed algorithm likewise shows a comparative and statistical analysis by different curves in addition to the

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ANOVA and T-Test. It offers the superiority and validation stability evaluation of the predicted results to verify the procedures' accuracy. He, H., et.al [41] propose an ANN model is proposed to predict the desired performance of a microstrip patch antenna which works at the center frequency at 10.2 GHz with a 1 GHz frequency bandwidth. In this model, a general methodology for the fitting of the calculated responses with rational function approximations was used in the description of S-parameter, gain, and directivity. In this case, the aforementioned performances of the antenna were replaced by the orders, residuals, and poles of the rational functions. A dataset of the correspondence between the geometrical variables of the microstrip patch antenna and the responses were collected in the state-of-the-art EM-CAD (Electromagnetic computer-aided design) software for training the ANN and further test. A validation was employed to confirm the validity and efficiency of this proposed method. Kumar & Yalavarthi [42] presents a comprehensive review on basic optimization algorithms for micro-strip patch antenna design using machine learning. Classification of machine learning based algorithms: deterministic, stochastic and surrogate model assistant is discussed. Further machine learning models training for optimizing output and for prediction of antenna parameters is presented in this paper.

V. CONCLUSION

This research paper shows the machine learning based techniques to optimize the microstrip patch antenna parameters with the performance improvement. This paper is useful to the readers who work on a particular antenna using the Machine Learning Techniques.

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