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Research Article

Investigation of an Efficient RF-MEMS Switch for Reconfigurable Antenna Using Hybrid Algorithm with Artificial Neural Network

Qazi Fasihuddin Zahuruddin and Mulpuri Sri Rukmini

Department of Electronics and Communication Engineering, Vignan's Foundation for Science, Technology and Research, Vadlamudi, Guntur, Andhra Pradesh, India

Abstract

Background and Objective: As MEMS (Micro Electro Mechanical System) technology continuously growing, MEMS for reconfigurable antenna design and optimization is becoming an interesting and important research issue. Many RF-MEMS reconfigurable antenna design focused on changing operating frequency while sustaining their radiation characteristics. However, to enhance the performance of the antenna it was proposed to change the radiation characteristics and keeping the operating frequency constant. Thus for achieving this, the main objective of this investigation study was to design efficient RF-MEMS switch for reconfigurable antenna using hybrid optimization algorithm with Artificial Neural Network. **Materials and Methods:** In this proposed research method, for optimization of RF-MEMS switch, parameters like beam length, beam width, switch thickness, torsion arm thickness, holes and gaps are considered and to get optimized parameters, gravitational search optimization algorithm is intended with artificial neural network which has been implemented on the working platform of MATLAB. **Results:** The simulated result indicates that the hybrid algorithm enhanced the global search ability and gives the reasonably good accuracy and reduction in mean square error and Bit error rate. **Conclusion:** Finally after comparing our proposed technique with existing techniques, concluding that we are getting efficient RF-MEMS switch for reconfigurable antenna and performance of the system is increasing.

Key words: RF-MEMS, reconfigurable antenna, artificial neural network, hybrid gravitational search optimization algorithm, mean square error (MSE), bit error rate (BER)

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Corresponding Author: Qazi Fasihuddin Zahuruddin, Department of Electronics and Communication Engineering, Vignan's Foundation for Science, Technology and Research, Vadlamudi, Guntur, Andhra Pradesh, India Tel: 09890108930

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Now a day's researchers are focusing on polarization reconfigurable antenna for developing the advancement in wireless communication systems, because the antenna has ability to avoid the fading losses which causes due to multipath in WLANS[1]. The another type of antenna design based on uni-planar disc-shaped UWB monopole. During the design process there was several challenges like pin diodes was difficult to bias and MEMS is biased by using λ/4 micro strip lines and stubs[2]. For improving the performance of the UWB System many types of planar micro strip and slot antenna with single and multiple band notch performances was designed[3]. The reconfigurable antenna has four types, (a) Radiation pattern, (b) Frequency, (c) Polarization and (d) Combination of a,b,c. It is important to design an antenna to work in different polarization like linear polarization and circular polarization, as the PIN Diode don't have changeable capacity hence RF-MEMS switch is used[4-6]. RF-MEMS switch monolithic to the patch used operation frequency from 4-7 GHZ and more emphasis on a MEMS reconfigured pixilated micro strip patch antenna[7]. In recent years graphene can be used for the construction of reflect array elements and making powerful beam forming platforms[8]. Anagnostou *et al.*[9] proposed the frequency reconfigurable slot-patch antenna with frequency bands from 1.7-3.5 GHz it was. The reconfigurable materials, where dynamic control was enabled by micro electro mechanical systems (MEMS) technology has been given by Debogovic and carrier[10,11]. First, they showed reconfigurable composite right-/left-handed transmission lines (CRLHTLs) having state of the art phase velocity variation and loss, thereby enabling efficient reconfigurable phase shifters and leaky-wave antennas (LWA).

For the application of cognitive radio system a novel frequency reconfigurable E-shaped patch design was proposed by Zhu *et al.*[12] in which methodology to design reconfigurable antennas with radio frequency micro electro mechanical system (RF-MEMS) switches using particle swarm optimization, a nature-inspired optimization technique was used. For optimizing frequency reconfigurable pixel antennas have been given by Aghdam[13]. A polarization-reconfigurable antenna composed of two independent, co-located and orthogonal ("crossed") narrow micro strip patch antennas with a novel pressure- driven fluidic loading network was proposed by Costantine *et al.*[14], in which circuit models for the antenna with each reconfiguration mechanism were developed.

The rationale behind all above study was to identify the research gap and getting motivation to do research work in the area of optimization RF-MEMS switch parameters for reconfigurable antenna. Hence main objective of proposed work are:

- To simulate and analysis of hybrid GSO algorithm with ANN suited for RF-MEMS switch
- To identify and select the design parameters with optimal dimensions which are used for the efficient RF-MEMS switch for reconfigurable antenna
- To get accuracy of proposed algorithm more than other existing algorithm
- To get reduction in bit error rate (BER) and mean square error (MSE) of proposed algorithm than other existing algorithm

MATERIALS AND METHODS

In this proposed research methodology for optimizing the design parameters of RF-MEMS switch for reconfigurable antenna, Hybrid Gravitational Search optimization Algorithm with artificial neural network is proposed, which was depicted in Fig. 1. It consists of following main parts: 1: An artificial neural network and 2: Hybrid gravitational search optimization algorithm. The simulation of this technique is done in the working platform of MATLAB and the performance of the system is evaluated. For implementing and getting the results it takes around two years from March, 2016 to March, 2018.

In the Fig. 1, an artificial neural network (ANN) consists the input layer, output layer and one hidden layer which consists of neurons . This ANN is used to get the training data which used for optimization with hybrid algorithm.

For optimization of RF-MEMS switch parameters that are selecting the parameters as shown in Table 1.

Another important part of this methodology was hybrid gravitational search optimization algorithm (HGSO), in this proposed algorithm, agents are considered as objects (numbers) and their performance is measured by their masses. All these objects attract each other by the gravity force and this force causes a global movement of all objects towards the objects with heavier masses. Hence, masses cooperate using a direct form of communication, through gravitational force. The heavy masses which correspond to good solutions move more slowly than lighter ones. Each object (number) has four specifications: position, inertial mass, active gravitational mass and passive gravitational mass. The position of the mass corresponds to a solution of the problem and its gravitational and inertial masses are determined using a fitness function. Which was given in the following mathematical Eq. 1 and 2:

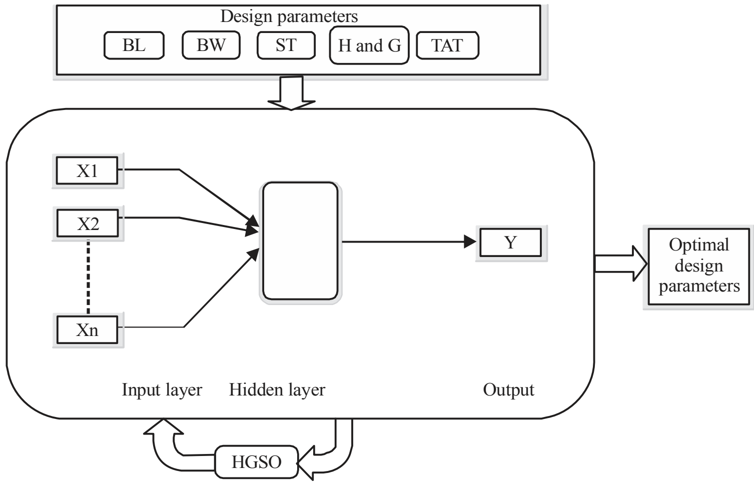

Fig. 1: Proposed architecture of ANN with hybrid algorithm

BL: Beam length, H and G: Holes and gaps, BW: Band width, TAT: Torsion arm thickness and ST: Switch thickness

Table 1: Switch parameters

Parameters	Proposed range values for parameter (μm)	Expected value for parameter (μm)
Beam length	100-500	336
Beam width	100-300	192
length of torsion arm	10-100	55
Thickness of switch (t)	0.1-5	0.8
Holes	0.1-2.0 and 24 holes	1.0 and 24 holes
Gap	1-5	2.5

$$m_r(t) = \frac{Fit_r(t) - Worst(t)}{Best(t) - Worst(t)} \quad (1)$$

$$M_r(t) = \frac{m_r(t)}{\sum_{s=1}^{n} m_s(t)} \quad (2)$$

where, fit_r (t) represent the fitness value of the agent r at time t and worst (t) are defined as follows:

$$Best(t) = \min_{j\varepsilon\{1.....N\}} fit_s(t) \quad (3)$$

$$Worst(t) = \min_{j\varepsilon\{1.....N\}} fit_s(t) \quad (4)$$

For maximum problem above two equations can be changed below respectively:

$$Best(t) = \min_{j\varepsilon\{1.....N\}} fit_s(t) \quad (5)$$

$$Worst(t) = \min_{j\varepsilon\{1.....N\}} fit_s(t) \quad (6)$$

By controlling exploration and exploitation the performance of HGSO is enhanced depends on the H best objects that will attract the others. H Best is a function of time, with the initial value H_0 at the beginning and decreasing with time. Hence at the beginning, all objects apply the force and as time passes, H best is decreased linearly and at the end there will be just one object applying force to the others. Which is given by following modified Eq.:

$$F_r^b(T) = \sum_{s\varepsilon Hbest, s\neq r}^{N} rand_s F_{rs}^b(T) \quad (7)$$

where, H best is the set of first H agents with the best fitness value and biggest mass.

RESULTS

The simulation results of the proposed hybrid algorithm with ANN is shown in Fig. 2-4 in which green line is indicating the proposed technique with neural network and blue line is indicating the existing technique without neural network. The main key findings from these figures are Accuracy, Mean square error and Bit error rate, respectively.

Figure 2 was indicating the accuracy of proposed technique at three different iteration 50, 75 and 100 shown on x-axis and got accuracy values as 83, 93 and 94.8, respectively on Y-axis and the accuracy values of existing technique without neural network are 81, 88 and 91, respectively. Figure 3 was indicating the mean

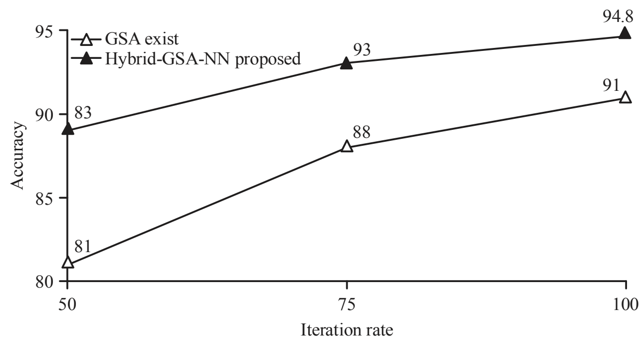

Fig. 2: Simulation result of accuracy of proposed and existing technique

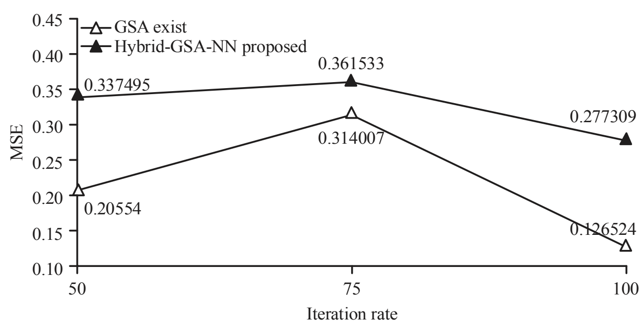

Fig. 3: Simulation result of mean square error of proposed and existing technique

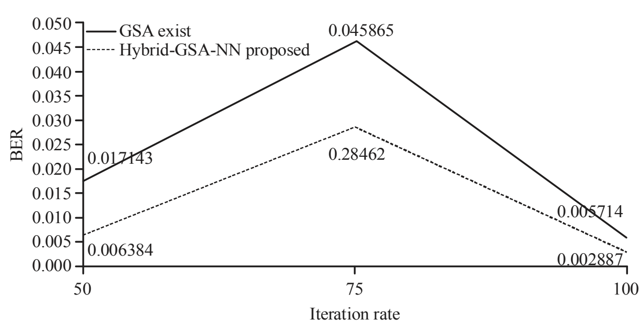

Fig. 4: Simulation result of bit error rate of proposed and existing technique

square error of proposed technique at three different iteration and got MSE values as 0.20554, 0.314007 and 0.126524 and the MSE values of existing technique without neural network are 0.337495, 0.361533 and 0.277309. Figure 4 was indicating the bit error rate of proposed technique at three different iteration and got BER values as 0.006384, 0.28462 and 0.002887 and the BER values of existing technique without neural network were 0.017143, 0.045865 and 0.005714.

DISCUSSION

With the help of results analysis as indicated that the accuracy of current proposed technique is increasing in each iteration as compared to existing technique i.e., GSA without neural network. Likewise mean square error and bit error rate are reducing at higher iteration as compared to existing technique. Wang and Song[15] proposed GSA without artificial neural network in which he did the research on the solution of function optimization problem based on the gravitation search algorithm (GSA) and stated that the GSA parameter can be used flexibly to improve the algorithm's convergence velocity and improve the accuracy of the solutions with ANN hence in this proposed technique we implemented GSA with ANN which improved the accuracy.

Rajagopalan *et al*.[16] proposed the PSO algorithm for optimization of MEMS reconfigurable but this algorithm has some disadvantages such as easy falling into local minima, slow convergence speed and poor accuracy hence compare to this proposed technique is better.

The artificial neural network it used here consists of feed forward neural network which gave the better solution for global search forecasting optimization compare to back propagation neural network as Sexton *et al*.[17] have recently demonstrated that the solutions obtained by back propagation often perform poorly on even simple problems when forecasting out of sample.

Mohamad *et al*.[18] proposed the Cuckoo search algorithm for optimization but the drawback of this algorithm is it loses a diversity of population very fast i.e., all the solutions became similar to current best solution this is not happening in this proposed technique.

Yuan[19] proposed the genetic algorithm for optimization purpose without neural network achieved better forecasting accuracy but the drawback of this getting better global eoptimum solution which is solved in this proposed technique.

Chaki and Ghosal[20] has proposed Genetic Algorithm with ANN for optimization, it used feedback propagation for neural network which has poor performance and also global search ability is less this drawback is overcome in this proposed technique.

Ghodrati and Lotfi[21] proposed A Hybrid CS/PSO algorithm for global optimization, the drawback of this algorithm is poor global search ability for optimization it is overcome by using proposed technique.

Thus from all above discussion we could justified that the result of proposed system is more efficient and the performance of antenna is improved as compare to other existing techniques.

CONCLUSION

With the performance analysis of result which we have been discussed above we could say that our proposed technique is better than existing one hence it came across conclusion to say that efficiency of performing well in terms of increasing in the accuracy and reduction in the mean square error and bit error rate our proposed technique performs better than existing technique, also global search ability is enhanced and finally getting an efficient RF-MEMS switch suited for reconfigurable antenna. In future, advanced adaptive techniques could be employed to mitigate errors further and can improve the performance.

SIGNIFICANCE STATEMENTS

This study discover the to intend a Hybrid Gravitational Search Algorithm with Neural Network for Optimization of Design Parameters of RF-MEMS Reconfigurable Antenna and identifying the optimal parameters of RE-MEMS switch that can be beneficial for enhancing the performance of reconfigurable antenna. Hence this study will help the researchers to uncover the critical areas of RE-MEMS switch parameters optimization and reconfigurable.

REFERENCES

1. Yang, Z.X., H.C. Yang, J.S. Hong and Y. Li, 2014. Bandwidth enhancement of a polarization-reconfigurable patch antenna with stair-slots on the ground. IEEE Antennas Wireless Propag. Lett., 13: 579-582.
2. Chawla, P. and R. Khanna, 2012. Optimization algorithm of neural network on RF MEMS switch for wireless and mobile reconfigurable antenna applications. Proceedings of the 2nd IEEE International Conference on Parallel Distributed and Grid Computing, Solan, India, December 6-8, 2012, IEEE., USA., pp: 735-740.
3. Suganthi, S., K. Murugesan and S. Raghavan, 2012. ANN model of RF MEMS lateral SPDT switches for millimeter wave applications. J. Microw. Optoelectron. Electromagn. Applic., 11: 130-143.
4. Chawla, P. and R. Khanna, 2016. A novel approach of design and analysis of fractal antenna using a neurocomputational method for reconfigurable RF MEMS antenna. Turk. J. Electr. Eng. Comput. Sci., 24: 1265-1278.
5. Chawla, P. and R. Khanna, 2012. Design and optimization of RF MEMS switch for reconfigurable antenna using feed-forward back-propagation ANN method. Proceedings of the 2012 Nirma University International Conference on Engineering (NUiCONE), December 6-8, 2012, IEEE., USA., pp: 1-6.
6. Chawla, P. and R. Khanna, 2014. A novel design and optimization approach of RF MEMS switch for reconfigurable antenna using ANN method. Proceedings of the International Conference on Communications, Devices and Intelligent Systems (CODIS), Vol. 2, Kolkata, India, December 28-29, 2014, IEEE., USA., pp: 188-191.
7. Kumar, R. and R. Vijay, 2014. Reconfigurable antennas: A survey. Int. J. Eng. Dev. Res., 2: 3090-3099.
8. Spasos, M.N., 2011. RF-MEMS switches for reconfigurable antennas. Ph.D. Thesis, School of Engineering and Desig, Brunel University, London.
9. Anagnostou, D.E., M.T. Chryssomallis, B.D. Braaten, J.L. Ebel and N. Sepulveda, 2014. Reconfigurable UWB antenna with RF-MEMS for on-demand WLAN rejection. IEEE Trans. Antennas Propag., 62: 602-608.
10. Badamchi, B., J. Nourinia, C. Ghobadi and A.V. Shahmirzadi, 2014. Design of compact reconfigurable ultra-wideband slot antenna with switchable single/dual band notch functions. IET Microw. Antennas Propag., 8: 541-548.
11. Ali, M., N. Bishop, W. Baron, B. Smyers, J. Tuss and D. Zeppettella, 2014. A MEMS reconfigurable pixel microstrip patch antenna for conformal load bearing antenna structures (CLAS) concept. Proceedings of the 2014 IEEE Antennas and Propagation Society International Symposium (APSURSI), Memphis, TN, USA., July 6-11, 2014, IEEE., USA., pp: 1093-1094.
12. Zhu, H.L., S.W. Cheung, X.H. Liu and T.I. Yuk, 2014. Design of polarization reconfigurable antenna using metasurface. IEEE Trans. Antennas Propag., 62: 2891-2898.
13. Aghdam, S.A., 2014. A novel UWB monopole antenna with tunable notched behavior using varactor diode. IEEE Antennas Wireless Propag. Lett., 13: 1243-1246.
14. Costantine, J., Y. Tawk, S.E. Barbin and C.G. Christodoulou, 2015. Reconfigurable antennas: Design and applications. Proc. IEEE., 103: 424-437.
15. Wang, J.S. and J.D. Song, 2016. Function optimization and parameter performance analysis based on gravitation search algorithm. Algorithms, Vol. 9, No. 1. 10.3390/a9010003.
16. Rajagopalan, H., J.M. Kovitz and Y. Rahmat-Samii, 2014. MEMS reconfigurable optimized E-shaped patch antenna design for cognitive radio. IEEE Trans. Antennas Propag., 62: 1056-1064.
17. Sexton, R.S., R.E. Dorsey and J.D. Johnson, 1998. Toward global optimization of neural networks: A comparison of the genetic algorithm and back propagation. Decis. Support Syst., 22: 171-185.

18. Mohamad, A.B., A.M. Zain and N.E.N. Bazin, 2014. Cuckoo search algorithm for optimization problems-A literature review and its applications. Applied Artif. Intell., 28: 419-448.
19. Yuan, F.C., 2012. Parameters optimization using genetic algorithms in support vector regression for sales volume forecasting. Applied Math., 3: 1480-1486.
20. Chaki, S. and S. Ghosal, 2015. A GA-ANN hybrid model for prediction and optimization of CO2 laser-MIG hybrid welding process. Int. J. Automot. Mech. Eng., 11: 2458-2470.
21. Ghodrati, A. and S. Lotfi, 2012. A hybrid CS/PSO algorithm for Global optimization. Proceedings of the Asian Conference on Intelligent Information and Database Systems, March 19-21, 2012, Springer, Berlin, Heidelberg, pp: 89-98.