Estimation of coverage and energy in bio inspired wireless sensors using Harris hawk algorithm

Hakeem Abdul Wasay, Kavipriya Periyasamy
Department of Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India

Article Info

Article history:

Received Aug 31, 2022
Revised Feb 4, 2023
Accepted Feb 12, 2023

Keywords:

Bio-inspired
Coverage
Energy
Harris hawk
Sensor

ABSTRACT

Wireless sensor networks have various sensors which are wide spread and also equipped with supplies. For the deployment sensor nodes are used for capturing the information, the region of interest is selected and the nodes are deployed. Lower sensing power degrades the DC supply reducing the life of wireless sensor networks, this can also be due to improper sensor deployment. Based on the above various wireless sensor network algorithms are available to compute and implement the required optimal figures. Harris hawk is among the one such algorithm used in wireless sensors. It works on the principle of the bird Harris hawk which catches the prey from a very high altitude, resemblance to this and many other features it is implemented in wireless sensors. Various wireless sensor characteristics can be found, figured and tabulated which are essential in this domain. The characteristics like coverage, connectivity, location, energy, and can be estimated. In the work the coverage and energy fitness is estimated using Harris hawk algorithm and its results are being illustrated.

Corresponding Author:

Hakeem Abdul Wasay
Department of Electronics and Communication Engineering
Sathyabama Institute of Science and Technology
Chennai, India
Email: wasayh63@gmail.com

1. INTRODUCTION

Exchange of information is a necessity in communication as fast progress in microelectronics is in boom meeting the requirements. This development has led to the drastic involvement of wireless sensor networks. The exchange of information between channels via electromagnetic waves with the help of sensor nodal deployment. This type of connections is wireless capable of travelling long distances with greater potential [1]. The sensors in wireless networks are capable of capturing the information around and passing it to the central station from where it is distributed to the network. The sensors deployed are very small in size which require very low hardware such as supply, processor, actuator, and memory. The coverage and energy parameter are not easily estimated in wireless sensor networks using bio inspired techniques. Harris hawk algorithm [2] is used for finding the optimum location of sensors so as to achieve maximum coverage and energy with awareness to the proper sensor deployment in the optimum area of interest.

2. RELATED WORK

Many wireless sensor networks are also available for optimization like whale algorithm, and particle swarm optimization (PSO) algorithm. Several parameters which are essential for sensor network optimization can be estimated using these algorithms [3]-[7]. These algorithms have been used since a period for the development of wireless sensor networks, Harris hawk is also expected to produce realistic results as other algorithms are capable of doing, but implementation of it in bio inspired algorithms makes it a suitable and new approached mathematical and statistical model for obtaining various parameters [8], [9] which include coverage, energy, and connectivity [10]. The existing used algorithms [11]-[15], some as mentioned above are the basement to the implementation of Harris hawk algorithm and estimation of various essential parameters [16]-[19] using Harris hawk algorithm.

3. METHOD

This algorithm is a metheuristic algorithm [20], [21] which works on swarm intelligence approach [22]-[24]. Harris hawk algorithm copies the hunting nature of the bird Harris hawk. These Harris hawk birds hunt in group with good coordination amongst them for their prey. Harris hawk birds are very intelligent and a socialist type in nature. These predator birds has evolved two types of phases in Harris hawk i.e. the exploration and exploitation phases.

Harris hawk's perching behaviour in exploration phase is mathematically given as (1).

$$x(t+1) = x_{random}(t) - ra_1|x_{random}(t) - 2ra_2x(t)| \quad (1)$$

And the its perching behaviour in exploitation phase is mathematically given as (2),

$$x(t+1) = x_{prey}(t) - x_m(t) - ra_3\left(lb + ra_4(ub - lb)\right) \quad (2)$$

where,
$x(t+1)$ is hawk's position vector in coming iteration
$x_{prey}(t)$ is prey's position
$x(t)$ is hawk's present position
$ra_1\ to\ ra_4$ are random numbers in [0,1]
lb is the lower bound
ub is the upper bound
$x_{random}(t)$ is a hawk which is randomly chosen from the present vector.

The estimation of energy is mathematically calculated as (3),

$$E = 2E_0\left(1 - \frac{t}{T}\right) \quad (3)$$

where:
T is the iteration number
E_0 is the initial energy

With consideration to the above equation,

$$if -1 \le E_0 \le 0\ then\ the\ solution\ is\ weak$$

$$if\ 0 \le E_0 \le 1\ them\ the\ solution\ is\ strong$$

the above equations helps in obtaining the coverage and energy.

3.1. Flow chart of Harris hawk algorithm

The initialization of the algorithm is started with detection and tracking of the sensor data i.e. prey, their initial positions and coming positions are also iterated. The fitness values [25]-[28] are obtained via estimation. When the coverage is obtained, their values are plotted and tabulated. After the obtainment of coverage fitness, energy fitness [29], [30] is obtained and their values are plotted and tabulated. This can be seen in Figure 1. The coverage and energy fitness parameters are obtained by selecting the required inputs, selection of the appropriate phase when required and finally obtaining the required result as shown in Figure 2 using appropriate looping function sets.

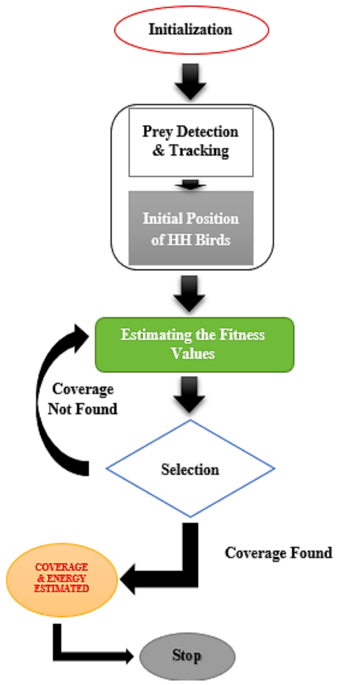

Figure 1. Implementation of Harris hawk algorithm

Figure 2. Flow for coverage and energy estimation using Harris hawk algorithm

4. RESULTS AND DISCUSSION

Engaging in routine physical activity as a method for maintaining and enhancing one's current level of health is an important goal for many people. A tabular version of these findings can be found in Table 1, and the plotted representations of the values obtained for the five different sets of looping functions can be seen in Figures 3-12. Calculating coverage and energy fitness requires using a loop that iterates through the same collection of functions five times. It has been noticed that once the fitness of the coverage has been computed, it is possible to determine the value of the work that has been invested.

Table 1. Coverage and energy fitness values for five function sets

Parameter	HHO	Value
Function set 1	Coverage	-3.8564
	Energy	-3.8605
Function set 2	Coverage	-3.8529
	Energy	-3.8529
Function set 3	Coverage	-3.8603
	Energy	-3.8529
Function set 4	Coverage	-3.8574
	Energy	-3.8574
Function set 5	Coverage	-2.8431
	Energy	-3.8628

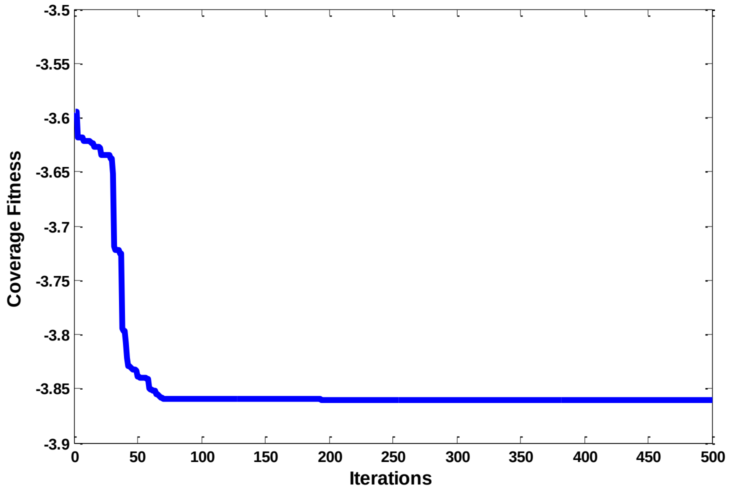

Figure 3. Coverage fitness of function set 1

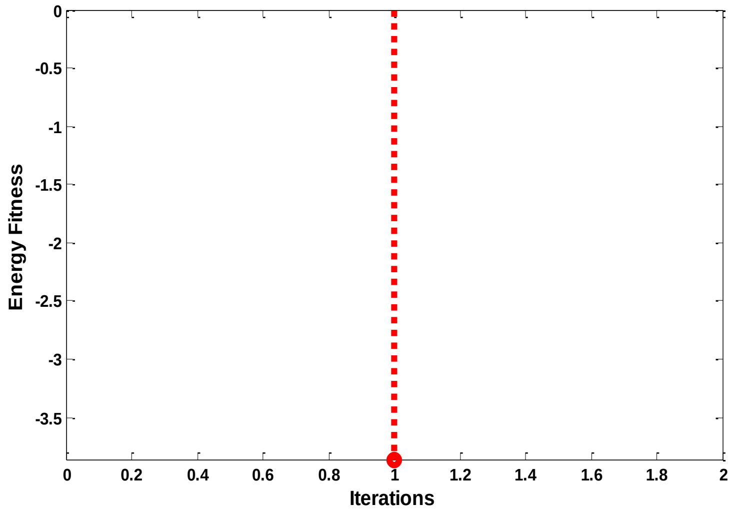

Figure 4. Energy fitness of function set 1

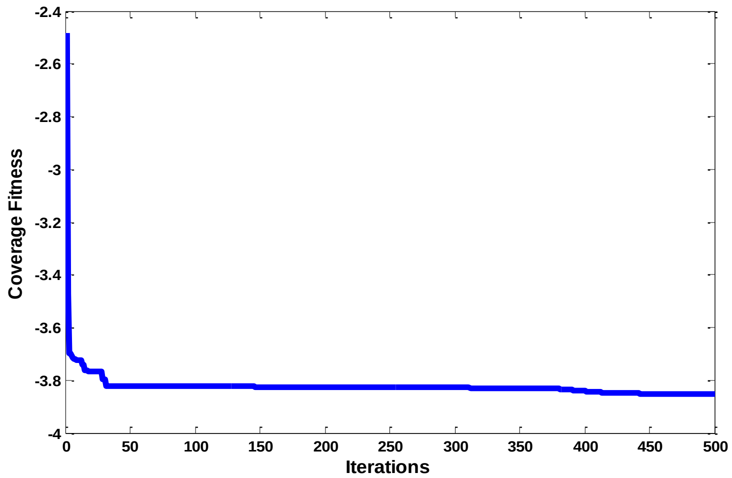

Figure 5. Coverage fitness of function set 2

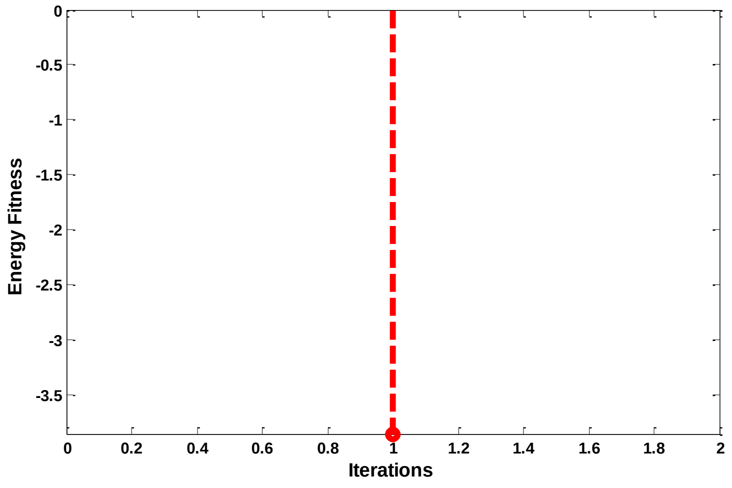

Figure 6. Energy fitness of function set 2

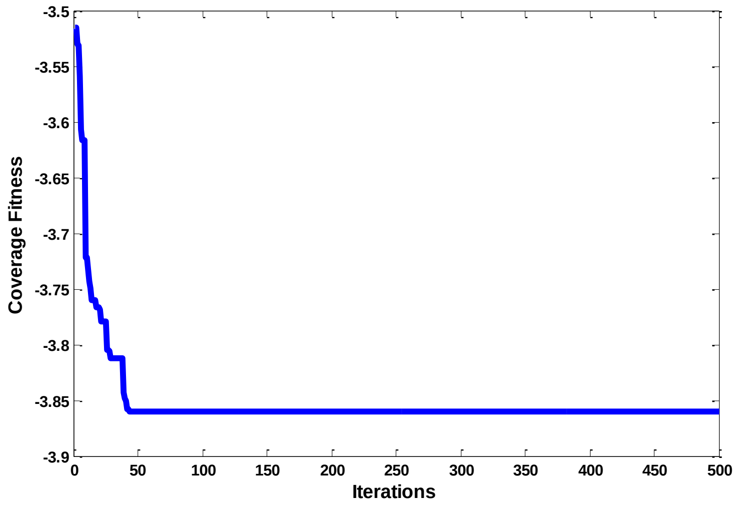

Figure 7. Coverage fitness of function set 3

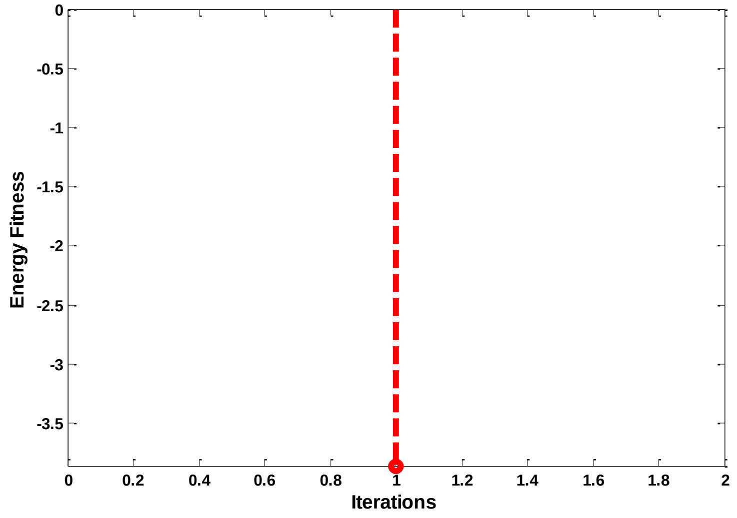

Figure 8. Energy fitness of function set 3

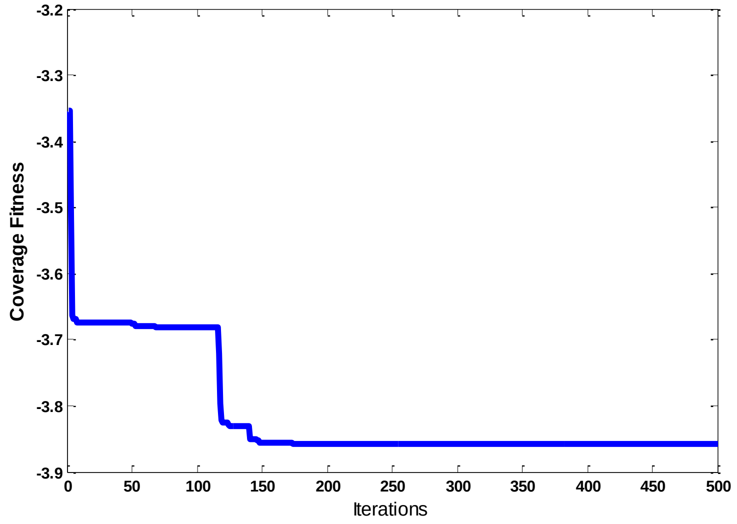

Figure 9. Coverage fitness of function set 4

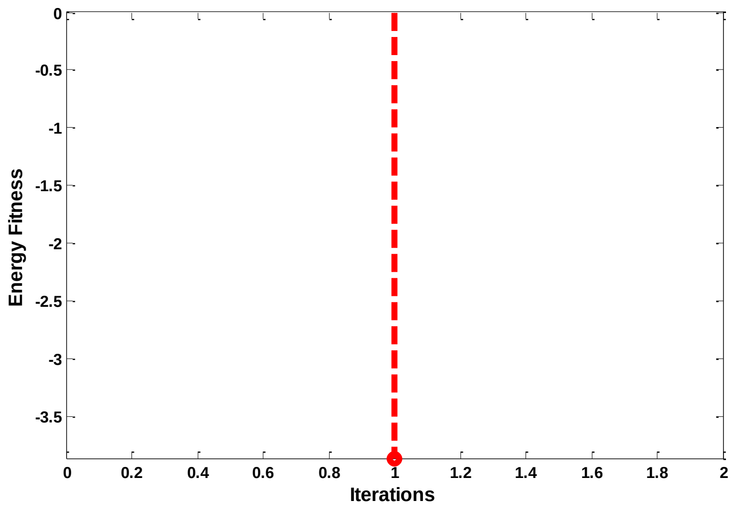

Figure 10. Energy fitness of function set 4

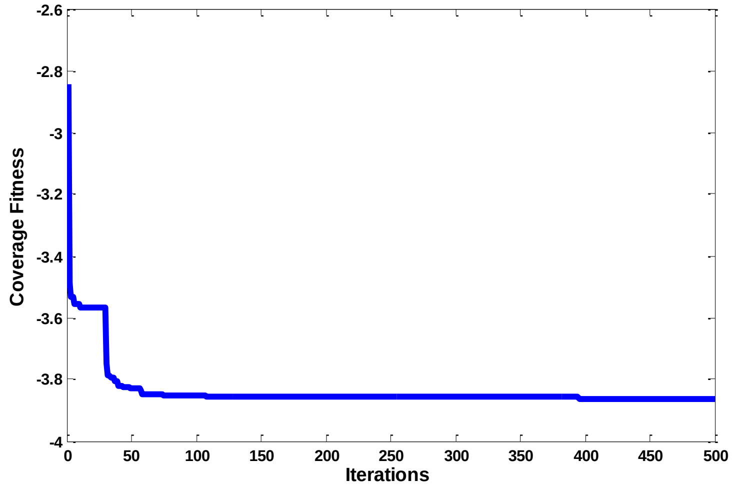

Figure 11. Coverage fitness of function set 5

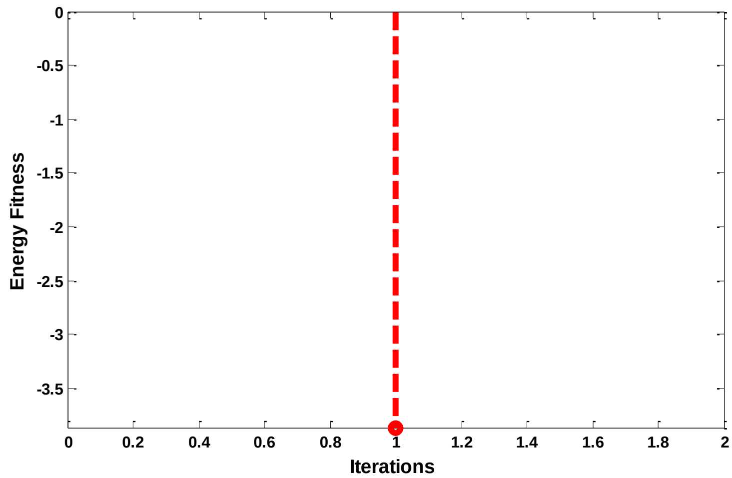

Figure 12. Energy fitness of function set 5

5. CONCLUSION

Implementation of Harris hawk algorithm is done and their coverage and energy fitness is estimated. From the observed results it is observed that coverage fitness and energy fitness are directly proportional to each other. It is also observed that energy fitness is dependent on coverage fitness but it is not vice versa, as it is necessary to obtain coverage to obtain energy and the coverage is a set a values whereas the energy is a value obtained as observed from this paper work.

REFERENCES

[1] R. Abbassi, A. Abbassi, A. A. Heidari, and S. Mirjalili, "An efficient salp swarm-inspired algorithm for parameters identification of photovoltaic cell models," *Energy Conversion and Management*, vol. 179, pp. 362–372, Jan. 2019, doi: 10.1016/j.enconman.2018.10.069.

[2] A. A. Heidari, S. Mirjalili, H. Faris, I. Aljarah, M. Mafarja, and H. Chen, "Harris hawks optimization: algorithm and applications," *Future Generation Computer Systems*, vol. 97, pp. 849–872, Aug. 2019, doi: 10.1016/j.future.2019.02.028.

[3] H. Faris *et al.*, "An intelligent system for spam detection and identification of the most relevant features based on evolutionary random weight networks," *Information Fusion*, vol. 48, pp. 67–83, Aug. 2019, doi: 10.1016/j.inffus.2018.08.002.

[4] D. R. V. A. S. Kumar, N. Domala, A. Karthik, and B. Veena, "CMOS phase detector and phase-frequency detector power and delay estimation using nano dimensional MOS transistors," in *Proceedings of the 5th International Conference on Electronics, Communication and Aerospace Technology, ICECA 2021*, Dec. 2021, pp. 331–334, doi: 10.1109/ICECA52323.2021.9675950.

[5] D. R. V. A. S. Kumar, A. Taranum, and M. S. Goud, "Technique for migration to IPV6 for a secure SCADA architecture," *International Journal of Emerging Technology and Advanced Engineering*, vol. 4, no. 4, pp. 128–133, 2014.

[6] G. Wu, W. Pedrycz, P. N. Suganthan, and R. Mallipeddi, "A variable reduction strategy for evolutionary algorithms handling equality constraints," *Applied Soft Computing Journal*, vol. 37, pp. 774–786, Dec. 2015, doi: 10.1016/j.asoc.2015.09.007.

[7] G. R. Padmini, O. Rajesh, K. Raghu, N. M. Sree, C. Apurva, and K. Saikumar, "Design and analysis of 8-bit ripple carry adder using nine transistor full adder," in *2021 7th International Conference on Advanced Computing and Communication Systems, ICACCS 2021*, Mar. 2021, pp. 1982–1987, doi: 10.1109/ICACCS51430.2021.9441928.

[8] A. Karthik and J. L. MazherIqbal, "Efficient speech enhancement using recurrent convolution encoder and decoder," *Wireless Personal Communications*, vol. 119, no. 3, pp. 1959–1973, Aug. 2021, doi: 10.1007/s11277-021-08313-6.

[9] S. Kirkpatrick, C. D. Gelatt, and M. P. Vecchi, "Optimization by simulated annealing," *Science*, vol. 220, no. 4598, pp. 671–680, May 1983, doi: 10.1126/science.220.4598.671.

[10] J. H. Holland, "Genetic algorithms," *Scientific American*, vol. 267, no. 1, pp. 66–72, Jul. 1992, doi: 10.1038/scientificamerican0792-66.

[11] J. Luo, H. Chen, Q. Zhang, Y. Xu, H. Huang, and X. Zhao, "An improved grasshopper optimization algorithm with application to financial stress prediction," *Applied Mathematical Modelling*, vol. 64, pp. 654–668, Dec. 2018, doi: 10.1016/j.apm.2018.07.044.

[12] M. Wang *et al.*, "Toward an optimal kernel extreme learning machine using a chaotic moth-flame optimization strategy with applications in medical diagnoses," *Neurocomputing*, vol. 267, pp. 69–84, Dec. 2017, doi: 10.1016/j.neucom.2017.04.060.

[13] L. Shen *et al.*, "Evolving support vector machines using fruit fly optimization for medical data classification," *Knowledge-Based Systems*, vol. 96, pp. 61–75, Mar. 2016, doi: 10.1016/j.knosys.2016.01.002.

[14] Q. Zhang, H. Chen, J. Luo, Y. Xu, C. Wu, and C. Li, "Chaos enhanced bacterial foraging optimization for global optimization," *IEEE Access*, vol. 6, pp. 64905–64919, 2018, doi: 10.1109/ACCESS.2018.2876996.

[15] A. A. Heidari, R. A. Abbaspour, and A. R. Jordehi, "An efficient chaotic water cycle algorithm for optimization tasks," *Neural Computing & Applications*, vol. 28, no. 1, pp. 1–29, 2015.

[16] D. Yousri, T. S. Babu, and A. Fathy, "Recent methodology based Harris hawks optimizer for designing load frequency control incorporated in multi-interconnected renewable energy plants," *Sustainable Energy, Grids and Networks*, vol. 22, Jun. 2020, doi: 10.1016/j.segan.2020.100352.

[17] J. Yu, C. H. Kim, and S. B. Rhee, "The comparison of lately proposed Harris hawks optimization and jaya optimization in solving directional overcurrent relays coordination problem," *Complexity*, vol. 2020, pp. 1–22, Jan. 2020, doi: 10.1155/2020/3807653.

[18] E. Rodríguez-Esparza *et al.*, "An efficient Harris hawks-inspired image segmentation method," *Expert Systems with Applications*, vol. 155, p. 113428, Oct. 2020, doi: 10.1016/j.eswa.2020.113428.

[19] M. H. Qais, H. M. Hasanien, and S. Alghuwainem, "Parameters extraction of three-diode photovoltaic model using computation and Harris hawks optimization," *Energy*, vol. 195, Mar. 2020, doi: 10.1016/j.energy.2020.117040.

[20] A. Khan, M. Sulaiman, H. Alhakami, and A. Alhindi, "Analysis of oscillatory behavior of heart by using a novel neuroevolutionary approach," *IEEE Access*, vol. 8, pp. 86674–86695, 2020, doi: 10.1109/ACCESS.2020.2992281.

[21] B. P. Sahoo and S. Panda, "Load frequency control of solar photovoltaic/wind/biogas/biodiesel generator based isolated microgrid using harris hawks optimization," in *2020 First International Conference on Power, Control and Computing Technologies (ICPC2T)*, Jan. 2020, pp. 188–193, doi: 10.1109/ICPC2T48082.2020.9071507.

[22] L. Abualigah, "Group search optimizer: a nature-inspired meta-heuristic optimization algorithm with its results, variants, and applications," *Neural Computing and Applications*, vol. 33, no. 7, pp. 2949–2972, Apr. 2021, doi: 10.1007/s00521-020-05107-y.

[23] L. Abualigah, A. Diabat, S. Mirjalili, M. Abd Elaziz, and A. H. Gandomi, "The arithmetic optimization algorithm," *Computer Methods in Applied Mechanics and Engineering*, vol. 376, Apr. 2021, doi: 10.1016/j.cma.2020.113609.

[24] L. Abualigah, "Multi-verse optimizer algorithm: a comprehensive survey of its results, variants, and applications," *Neural Computing and Applications*, vol. 32, no. 16, pp. 12381–12401, Aug. 2020, doi: 10.1007/s00521-020-04839-1.

[25] B. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering," Keele University and University of Durham, EBSE Technical Report, EBSE-2007-01, Jul 2007.

[26] B. Kitchenham, O. Pearl Brereton, D. Budgen, M. Turner, J. Bailey, and S. Linkman, "Systematic literature reviews in software engineering - a systematic literature review," *Information and Software Technology*, vol. 51, no. 1, pp. 7–15, Jan. 2009, doi: 10.1016/j.infsof.2008.09.009.

[27] M. Mafarja *et al.*, "Evolutionary population dynamics and grasshopper optimization approaches for feature selection problems," *Knowledge-Based Systems*, vol. 145, pp. 25–45, Apr. 2018, doi: 10.1016/j.knosys.2017.12.037.

[28] I. Aljarah, M. Mafarja, A. A. Heidari, H. Faris, Y. Zhang, and S. Mirjalili, "Asynchronous accelerating multi-leader salp chains for feature selection," *Applied Soft Computing Journal*, vol. 71, pp. 964–979, Oct. 2018, doi: 10.1016/j.asoc.2018.07.040.

[29] J. G. Digalakis and K. G. Margaritis, "On benchmarking functions for genetic algorithms," *International Journal of Computer Mathematics*, vol. 77, no. 4, pp. 481–506, Jan. 2001, doi: 10.1080/00207160108805080.

[30] S. García, D. Molina, M. Lozano, and F. Herrera, "A study on the use of non-parametric tests for analyzing the evolutionary algorithms' behaviour: a case study on the CEC'2005 special session on real parameter optimization," *Journal of Heuristics*, vol. 15, no. 6, pp. 617–644, 2009, doi: 10.1007/s10732-008-9080-4.

BIOGRAPHIES OF AUTHORS

Hakeem Abdul Wasay is an Engineering educator focusing on teaching through interactive methodologies. His subjects of interests cover digital electronics, wireless communicatons. Currently he is working as an Assistant Professor has a rich teaching experience of 12 years. He has chaired sessions in National Conferences. His latest initiative is the Robotic Hub formed for the students to develop and aptitude for Research and Development. He introduced Technical magazine Techzine in the Department for the students in the year 2012. He can be contacted at email: wasayh63@gmail.com.

Dr. Kavipriya Periyasamy obtained her Bachelor's in Engineering (B.E) in the year 2000 from AVC College of Engineering, Bharathidasan University. She received her Master's degree in Applied Electronics, first class with distinction, from Sathyabama University, Chennai in 2005 and also, she obtained her doctorate in the field of wireless networks and communication in the year of 2015. Her current area of interest is wireless networks, wireless communication, wireless sensor networks and circuit analysis. She joined as a teaching faculty in the year 2001 and presently working as an Associate Professor in Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India. She had published more research articles in reputed Journals and Conference Proceedings. She taught a wide variety of courses for both Under Graduate and Post Graduate levels over a period of eighteen years. She can be contacted at email: kavipriya.ece@sathyabama.ac.in.