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Deployment Approach in WSNS Using Metaheuristic Algorithm: A Survey

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Abstract. *Deploying wireless sensor networks (WSN) is one of the areas with the most significant research since the methods employed can have a big impact on the system's overall performance and the amount of energy the sensors in it consume. Thus, an effective deployment problem solution should not only "enhance its performance" but also save the energy needed to extend the lifetime of WSN. Finding an optimal solution for most deployment problems with limited computational resources is challenging, particularly for NP-hard optimization problems. By searching for a nearly optimal solution with constrained computational resources in a reasonable amount of time, metaheuristics present an alternative to exhaustive search and deterministic algorithms in solving these optimization problems. This paper classifies the deployment techniques of sensor networks and the metaheuristic algorithms.*

Keywords: *Wireless sensor network, deployment, metaheuristic algorithm, connectivity, coverage*

1. INTRODUCTION

Wireless sensor networks consist of many small, inexpensive, multifunctional sensor nodes communicating wirelessly over a short range [1]. In wireless sensor networks (WSNs), sensors can sense, collect, and transmit data together [2], as shown in Fig. 1. WSNs are primarily based on several characteristics that must be optimized in order to maintain the quality of services, including energy consumption, latency, energy efficiency, network coverage, load balancing, and many others. Although much work has been done to extend the sensor's lifespan, many sensors are placed in hard-to-reach areas, making it impossible to maximize the sensor's lifetime by adding more or an external energy supply [3]. One of the many challenges in WSNs is node deployment. Deploying nodes involves locating sensor nodes that cover most of the target area and ensuring the base (sink) node is connected. The most crucial problem with putting WSNs into practice is that they must achieve design requirements for energy consumption, coverage, and connectivity. Coverage is a significant problem in WSN that is impacted by the sensor node's sensing range [4]. Information accuracy depends on the quality of coverage within the sensing range, and the target area is considered fully covered if each point in it is in the range of sensing at

least one sensor node. Every node can sense objects or events within its sensing range and communicate this information. To ensure node connectivity, each node can sense objects and events within its sensing range and share this information with its neighbors within its communication range. However, the node's communication range (RC), which guarantees that each sensor node is connected to the sink directly or via a multihop multihop multihop multihop multi-multihop path, impacts connectivity [5]. The network is connected if a single path connects each sensor to the base (sink) node. WSN quality will suffer from coverage without complete connectivity since data will only be guaranteed to reach the sink with connectivity.
Furthermore, there will be coverage holes and exposed points in the target area when there is no coverage. This paper proposes the classification of deployment methods for sensors in WSNs, and the survey is as follows: In Section II, prior studies related to this work are presented. Further, Section III describes the WSN deployment, and Section IV describes the different metaheuristic algorithms for deployment sensor networks. Finally, Section V will provide evaluation metrics for deployment algorithms in wireless sensor networks. Section VI describes the conclusion.

2. Literature review

Several articles have claimed the deployment approaches of sensors in WSN. Rahul Priyadarshi's [6] survey classified the coverage and focused on the challenges of deployment of WSNs, research issues, and sensing models in WSNs. In addition, we listed detailed analyses of different wireless sensor networks, simulators, and performance metrics. The main target of the article was to divide different coverage schemes into four parts: grid-based techniques, computational geometry-based techniques, metaheuristic-based techniques, and force-based techniques. In addition, the study will focus on various simulators used in WSN.

Singh et al. provided an overview of optimization techniques for optimal coverage in wireless sensor networks (WSNs) that draw inspiration from nature [7]. They compared the effectiveness of two nature-inspired algorithms for obtaining the best coverage in wireless sensor networks. They talked about the taxonomy of optimization algorithms in conjunction with the problem domains in WSNs. They combined Lion Optimization (LO) with the Binary Ant Colony Algorithm and the Improved Genetic Algorithm (IGA-BACA). The simulation results verify that LO provides superior network coverage and that its convergence rate surpasses IGA-BACA's. In addition, they noticed that in contrast to IGA BACA, the ideal coverage in LO is reached at a lower number of generations. Researchers will find this review helpful in investigating applications within and outside this field.

Khaoula Zaimen et al. [8] provided the background to study and understand the WSN deployment problem and focused on the solving methods and the optimization model based on Artificial intelligence (AI). In addition, the recent works on deployment in WSNs and their limitations and advantages are covered in the paper. Moreover, simulation experiments were carried out on wireless sensor network deployment problems, ant colony optimization, flower pollination, particle swarm optimization, and genetic algorithms to compare the algorithms' performance. Finally, this paper highlights and discusses many research issues and open challenges that should be explored next time.

Walid Osamy et al. [9] analyze the research on deployment, localization, and coverage difficulties in wireless sensor networks concerning AI methods for wireless sensor network enhancement. They offered an analysis of a recent study that used various AI methods to achieve particular WSN goals between 2010 and 2021. This would lead the researcher to comprehend current AI methodologies applied to various WSN difficulties. After that, they offer a general evaluation and comparison of various AI techniques in WSNs. This will reference the research community in determining the most adapted methods and the advantages of using different AI techniques to solve the localization, deployment, and coverage issues associated with WSNs. In the end, the open research challenges and new approaches are concluded for future research.

In [10], Sadeghi Ghahroudi et al. offer state-of-the-art deployment techniques for comprehensive coverage in mobile wireless sensor networks. In response, they first go over how the difficulties in node deployment affect network performance from different angles. The deployment techniques for mobile sensor networks are divided into two primary groups: geometrical and force-based deployment algorithms. The most recent developments are presented after discussing each category's drawbacks and benefits. Lastly, they present a qualitative analysis of all the algorithms documented in the literature and explore future research.

Amutha et al. [11], this paper provides a state-of-the-art method for classifying WSNs based on various factors such as sensor types, sensing models, deployment techniques, energy efficiency, and coverage. Pavithra et al., in [12] primarily addressed two issues that affect the data transmission to the sink node (base station): the deployment of sensor nodes, which enhances the environment's coverage area, and the routing protocol, which chooses which nodes to keep on a specific network route. Lastly, they talked about the design difficulties that arise when wireless sensor networks are designated. Table 1 describes these studies.

3. Wireless Sensor Network Deployment

Deployment has had a severe effect on all the WSN's performance metrics. The deployment is optimal when all the targeted areas are covered, and communication between network nodes is good with minimal nodes [25]. Thus, finding an optimal solution is often a good topic in the research on deployment problems. Static or dynamic are two types of deployment; deterministic and random deployment are types of static deployment, depending on the application required and the environment [26]. Deterministic deployment is used when the nodes' coordinates are known before distribution. The positions of the sensor nodes are set to minimize energy consumption, network cost, coverage, and the lifetime of the sensors. However, many applications suffer from deployment costs or hostile environments. For that, these applications use random deployment. Randomly, nodes are dispersing in the targeted area [27]. The random deployment approach is simple but has several issues, including disconnectivity due to failures or obstacles [28]. Figure 2 demonstrates the deployment techniques. The WSN will perform better if sensor nodes are deployed deterministically instead of randomly [29]. Dynamic deployment is employed When using mobile WSNs to monitor an event or maximize the network's connectivity, coverage, and lifetime issues. The object of dynamic deployment, also called self-deployment, is to cover all points of interest by randomly deploying nodes and then moving them around to increase coverage.

3.1. Deployment techniques

The sensor nodes should be deployed to efficiently sense and send data to the destination node, and monitoring the necessary targets is one way to formulate the deployment problem. There are two ways to distribute or deploy the nodes in the field of interest: random deployment and deterministic deployment

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[30]. Grid deployment is another term for deterministic deployment. Deterministic deployment involves predetermining the coordinates of nodes inside the field of interest before the nodes disperse. The placement of sensor nodes is chosen to maximize target monitoring, minimize network expenses, utilize energy efficiently, and extend the lifespan of the sensor network. However, some applications do not support deterministic approaches; this could be because of a hostile environment or the high deployment costs. In this instance, when the nodes are dispersed randomly and aimlessly throughout the field of interest (FoI) without predetermined positions, use the random deployment. The deterministically deployed sensor node will perform better in the WSN than the randomly deployed sensor node [31]. This presents a difficult challenge to optimizing the network's performance while considering the application's many characteristics. In Table 2 below, the various metaheuristic techniques for the deployment of sensors in WSNs are described.

4. The metaheuristic algorithms

Metaheuristic algorithms are optimization techniques that solve complex problems beyond conventional methods' scope. These algorithms scan a vast search space to locate a problem's global optimum. Natural phenomena such as genetics, swarm behavior, and evolution inspire them. Popular metaheuristic algorithms include simulated annealing, tabu search, ant colony optimization, particle swarm optimization, and genetic algorithms. Metaheuristics are algorithmic structures that, when modified to fit the specific problem at hand, can solve various optimization problems [32]. Several metaphor-based metaheuristic algorithms, including those based on biology, physics, chemistry, and other fields, have been proposed recently [33]. In many domains, metaheuristic algorithms have proven to be an effective tool for resolving challenging optimization issues, and their significance in creating different technologies and applications is only expected to grow. Metaheuristic algorithms have been applied to solve several WSN-related problems, such as sensor deployment. The following paragraphs will concentrate on two popular categories of metaheuristics for sensor deployment problems: swarm intelligence optimization algorithms and evolutionary algorithms.

4.1 Evolutionary algorithms

A subfield of bioinspired algorithms known as "evolutionary intelligence" [34] is predicated on population and biological heredity, or the passing down of features from parents to offspring. The population concept allows individuals to search for the best solution simultaneously in multiple directions. A single person is the encoder of a solution to a particular optimization problem. The people from iteration (Itr) are called parents, and those from iteration Itr C1 are called children. Parents use evolutionary reproduction operators to share the search information with their children. Every person has a score that indicates how well they solve a specific issue. High fitness will replace their parents in the following population and work together to create new members with improved performances.

The evaluation algorithm's(EA) search power is due to its ability to share search data among solutions and simultaneously search multiple directions, enabling rapid solution discovery.[35]The most well-known evolutionary algorithms and the corresponding WSN deployment strategies are genetic algorithms(GA), non-dominated sorting genetic algorithms, multiobjective evolutionary algorithms based on decomposition, and cuckoo search algorithms. Genetic algorithms are one of the EAs widely used in different domains. The pseudocode of it is demonstrated in algorithm 1.

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Algorithm 1 Pseudo code of GA

Initialize population
Compute fitness for each chromosome
While the termination condition is not stated, do
    Selection of parents to generate offspring
    Recombine parents (crossover)
    Mutate children
    Compute fitness for new individuals and update the population
End while

4.1 Swarm Intelligence Optimization Algorithms

Swarm intelligence (SI), a branch of artificial intelligence, has been extensively used to address nonlinear issues in various real-world contexts [36]. The behavior of agents collectively forms the basis of SI. Every agent is a potential solution to the issue, and it can change its behavior independently. Furthermore, labor division and self-organization are two fundamental components of a SI system [37]. While labor division refers to the swarm's agents carrying out multiple tasks at once, self-organization is the capacity of a swarm to develop through iterations through the interaction of its components without the need for outside assistance. SI and EA systems share phases like population initialization, stop condition definition, and fitness function evaluation [38]. However, every SI algorithm uses a different approach to monitor its agents' movements. The PSO pseudocode is illustrated in algorithm 2. Figure 3 demonstrates the general framework of an SI system [42]

Algorithm 2 Peseudo code of PSO Algorithm

Initialize particles
Compute fitness for each particle
While the termination condition is not satisfied, do
    For each particle particle$_i$ in the swarm, do
      Compute fitness (particle$_i$)
      Update personal best fitness (particle$_i$)
      Update personal best position (particle$_i$)
    End for
    Update global best solution
    For each particle in the swarm, do
      Update velocity (particle$_i$)
      Updatepostion (particle$_i$)
      Update personal best position (particle$_i$)
    End for
End while

5. **Evolution metrics**

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Before creating and deploying a sensor network, several parameters, or performance metrics, must be carefully considered. Coverage, RSSI, reliability, latency, connectivity, scalability, accuracy, and power consumption are a few of them. A discussion of the metrics is in the following section.

5.1 Power consumption

Each WSN node requires energy for data collection, processing, and communication. The heterogeneous properties of the sensor node and the energy capacity determine how much energy is used. Our target is to minimize the consumption of power for each sensor node. Several algorithms for strategies primarily aim to lower the power usage per node. Scheduling algorithms preserve coverage and connectivity during the sensor node's sleep phase and prolong the network's lifespan. Finding the best path between the sensor nodes is another method to reduce power usage.

5.2 Accuracy and Latency

Accuracy and latency are related to one another. Latency, which measures the overall delay of the delivered message, is the amount of time needed to send a message from the source node to the destination node. Accuracy is the successful transmission of the message to its intended location in the allocated amount of time; reducing delay ensures network accuracy, a critical WSN performance parameter. [39]

5.3 Scalability and Reliability

Scalability in network architecture refers to a network's capacity to grow by adding nodes while preserving efficiency [40]. Reliability serves as a gauge for data delivery. These two metrics are critical for the WSN to operate more effectively. A WSN needs to have accurate and reliable information for the sink.

5.4 Signal strength

The link quality is reflected in the signal strength. The distance between two nodes during communication is used to determine node reachability. The received signal strength indicator, or RSSI, is represented mathematically in Eq. 1.[41]

$$RSSI = -10 * c * \log10\,(d) + s \qquad (1)$$

where d is the measured distance from the sensor in meters, cis is the path-loss exponent or propagation constant of a wireless signal, and s is the signal strength in reception mode (Dbm) (decibel milliwatts).

5.5 Coverage and connectivity

Coverage is a primary parameter that ensures the network's service quality. Another impact factor that provides maximum coverage is connectivity.

6. CONCLUSIONS

In this survey, we review previous research on using metaheuristic algorithms to address deployment sensor problems, starting with problem formulation and moving on to traditional deployment algorithms and metaheuristic algorithms. There is certainly potential for improvement in the performance of metaheuristic-based algorithms for the deployment sensor problem, as they still use basic metaheuristics or only modify the search operator. Put another way, the adjustments made by the current research using metaheuristics for the deployment of sensors in wireless networks are only a portion of the improvement techniques; as a result, it is reasonable to anticipate several possible metaheuristic modification techniques that will help improve the metaheuristics' performance.

The so-called effective and efficient methods for metaheuristics on various optimization deployment problems should improve the deployment problem metaheuristics' performance. This suggests that the metaheuristic-based deployment algorithm may achieve better results than the present techniques with some effective metaheuristic modifications.

REFERENCES

[1] Srivastava, A. and P. K. Mishra (2021). "A Survey on WSN Issues with its Heuristics and Meta-Heuristics Solutions." Wireless Personal Communications 121(1): 745-814.
[2] Sohrabi, K., et al. (2000). "Protocols for self-organization of a wireless sensor network." IEEE Personal Communications 7(5): 16-27.
[3] Singh, A., et al. (2020). "A Machine Learning Approach to Predict the Average Localization Error With Applications to Wireless Sensor Networks." Ieee Access 8: 208253-208263.
[4] Ghosh, A. and S. K. Das (2008). "Coverage and connectivity issues in wireless sensor networks: A survey." Pervasive and Mobile Computing 4(3): 303-334.
[4] Wang, J., Zhu, Z., Zhang, F., & Liu, Y. (2023). An Improved Salp Swarm Algorithm for Solving Node Coverage Optimization Problem in WSN. Preprints. https://doi.org/10.20944/preprints202304.1025.v1
[5] Zhu, C., et al. (2012). "A survey on coverage and connectivity issues in wireless sensor networks." Journal of Network and Computer Applications 35(2): 619-632.
[5] Bouarourou, S., et al. (2023). "An Efficient Model-Based Clustering via Joint Multiple Sink Placement for WSNs." Future Internet 15(2): 75.
[6] Priyadarshi, R., Gupta, B., & Anurag, A. (2020). Deployment techniques in wireless sensor networks: a survey, classification, challenges, and future research issues. The Journal of Supercomputing, 76, 7333-7373.
[7] Singh, A., et al. (2021). "Nature-inspired algorithms for Wireless Sensor Networks: A comprehensive survey." Computer Science Review 39: 100342.
[8] Zaimen, K., Moalic, L., Abouaissa, A., & Idoumghar, L. (2022). A survey of artificial intelligence-based WSN deployment techniques and related objectives modeling. IEEE Access.
[9] Osamy, W., et al. (2022). "Coverage, deployment and localization challenges in wireless sensor networks based on artificial intelligence techniques: a review." Ieee Access 10: 30232-30257.
[10] Sadeghi Ghahroudi, M., et al. (2023). "Distributed Node Deployment Algorithms in Mobile Wireless Sensor Networks: Survey and Challenges." ACM Transactions on Sensor Networks 19(4): 1-26.
[11] Amutha, J. et al. (2020). "WSN strategies based on sensors, deployment, sensing models, coverage and energy efficiency: Review, approaches and open issues." Wireless Personal Communications 111: 1089-1115.
[12] Pavithra, L. et al. (2021). Wireless Sensor Networks: A Review on Sensor Deployment and Routing Protocols for Different Applications. IOP Conference Series: Materials Science and Engineering, IOP Publishing.
[13] Xu, L.-D., et al. (2023). "Wireless Sensor Deployment Based on Multiobjective Adaptive Fish Migration Optimization." Journal of Sensors **2023**.
[14] Kiani, V. and M. Imanparast (2023). "A Bi-objective Virtual-force Local Search PSO Algorithm for Improving Sensing Deployment in Wireless Sensor Network." Journal of AI and Data Mining **11**(1): 1-12.
[15] Barnawi, A. and A. Bawazir (2023). "Multiobjective Deployment of Wireless Sensor Networks in 3-D Environments using Metaheuristics."

[16] Cao, L., et al. (2023). "An Energy-Saving and Efficient Deployment Strategy for Heterogeneous Wireless Sensor Networks Based on Improved Seagull Optimization Algorithm." Biomimetics **8**(2): 231.
[17] Nematzadeh, S., et al. (2023). "Maximizing coverage and maintaining connectivity in WSN and decentralized IoT: an efficient metaheuristic-based method for environment-aware node deployment." Neural Computing and Applications **35**(1): 611-641.
[18] S. Birtane, A., et al. (2022). Efficient Deployment of Wireless Sensor Nodes with Evolutionary Approaches. 2022 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA).
[19] Jindal, R. (2021). Intelligent Deployment Strategy for Heterogeneous Nodes to Increase the Network Lifetime of Wireless Sensor Networks.
[20] Elfouly, F. H., et al. (2021). "Efficient node deployment of large-scale heterogeneous wireless sensor networks." Applied Sciences **11**(22): 10924.
[21] Karimi-Bidhendi, S., et al. (2020). "Energy-efficient node deployment in heterogeneous two-tier wireless sensor networks with limited communication range." IEEE Transactions on Wireless Communications **20**(1): 40-55.
[22] Du, Y. (2020). "Method for the optimal sensor deployment of WSNs in 3D terrain based on the DPSOVF algorithm." Ieee Access **8**: 140806-140821.
[23] Al-Fuhaidi, B., et al. (2020). "An efficient deployment model for maximizing coverage of heterogeneous wireless sensor network based on the harmony search algorithm." Journal of Sensors **2020**: 1-18.
[24] Hajizadeh, N., et al. (2020). "Node deployment in wireless sensor networks using the new multiobjective Levy flight bee algorithm." IET Wireless Sensor Systems **10**(2): 78-87.
[25] Ramadan, R. A. (2009, March). Agent-based multipath routing in wireless sensor networks. In 2009 IEEE Symposium on Intelligent Agents (pp. 63-69). IEEE.
[26] Available online: https://courses.cs.ut.ee/demos/visual aco/#/visualisation (accessed on 3 November 2021)
[27] Elfouly, F. H., Ramadan, R. A., Khedr, A. Y., Yadav, K., Azar, A. T., & Abdelhamed, M. A. (2021). Efficient node deployment of large-scale heterogeneous wireless sensor networks. Applied Sciences, 11(22), 10924.
[28] Nematzadeh, S., Torkamanian-Afshar, M., Seyyedabbasi, A., & Kiani, F. (2023). Maximizing coverage and maintaining connectivity in WSN and decentralized IoT: an efficient metaheuristic-based method for environment-aware node deployment. Neural Computing and Applications, 35(1), 611-641
[29] Priyadarshi, R. et al. (2020). "Deployment techniques in wireless sensor networks: a survey, classification, challenges, and future research issues." The Journal of Supercomputing 76: 7333-7373.
[30] Liu, L., et al. (2005). Deployment Issues in Wireless Sensor Networks. Mobile Ad-hoc and Sensor Networks, Berlin, Heidelberg, Springer Berlin Heidelberg.
[31] Senouci, M., et al. (2014). "Random deployment of wireless sensor networks: A survey and approach." Int. J. of Ad Hoc and Ubiquitous Computing 15: 133-146.
[32] Abdel-Basset, M., et al. (2018). Chapter 10 – Metaheuristic Algorithms: A Comprehensive Review. Computational Intelligence for Multimedia Big Data on the Cloud with Engineering Applications. A. K. Sangaiah, M. Sheng and Z. Zhang, Academic Press: 185-231.
[33] M. Almufti, S., Ahmad Shaban, A., Arif Ali, Z., Ismael Ali, R., & A. Dela Fuente, J. (2023). Overview of Metaheuristic Algorithms. Polaris Global Journal of Scholarly Research and Trends, 2(2), 10–32.
[34] Al-Mousawi, A. (2020). "Evolutionary intelligence in wireless sensor network: routing, clustering, localization, and coverage." Wireless Networks 26.
[35] Tsai, C.-W., et al. (2015). "Metaheuristics for the deployment problem of WSN: A review." Microprocessors and Microsystems 39(8): 1305-1317.

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

[36] Chakraborty, A. and A. Kar (2017). Swarm Intelligence: A Review of Algorithms: 475-494.
[37] Ab Wahab, M. N., et al. (2015). "A comprehensive review of swarm optimization algorithms." PLoS One 10(5): e0122827.
[38] Brezočnik, L., et al. (2018). "Swarm intelligence algorithms for feature selection: a review." Applied Sciences **8**(9): 1521.
[39] Srivastava, A. and P. K. Mishra (2021). "A Survey on WSN Issues with its Heuristics and Meta-Heuristics Solutions." Wireless Personal Communications 121(1): 745-814.
[40] Deif, D. S. and Y. Gadallah (2017). "An Ant Colony Optimization Approach for the Deployment of Reliable Wireless Sensor Networks." IEEE Access 5: 10744-10756.
[41] Priyadarshi, R. et al. (2020). "Wireless Sensor Networks Deployment: A Result Oriented Analysis." Wireless Personal Communications 113.
[42] Brezočnik, L., et al. (2018). "Swarm intelligence algorithms for feature selection: a review." Applied Sciences 8(9): 1521.

Figure and tables

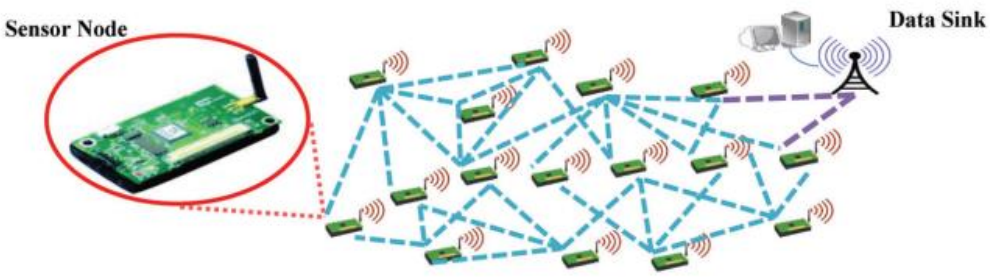

Fig 1: sensor node and a wireless sensor network

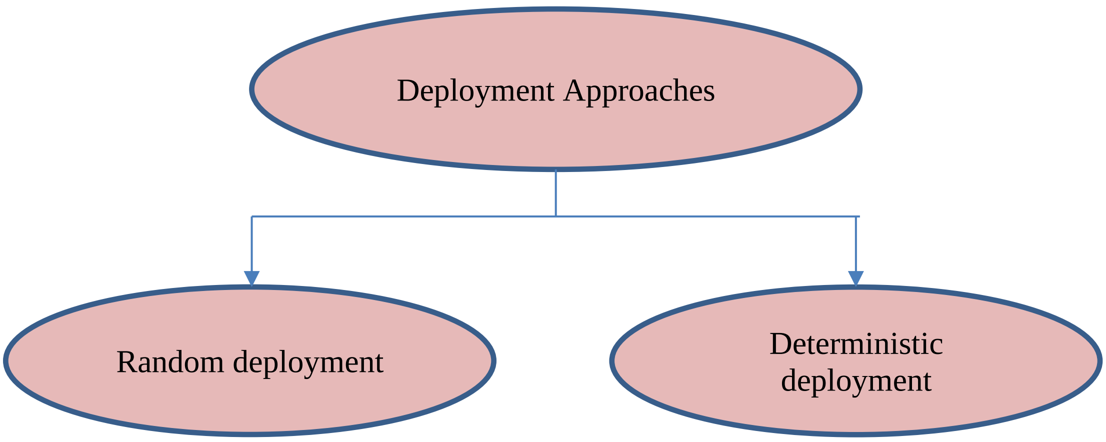

Fig.2. Deployment approaches in WSN

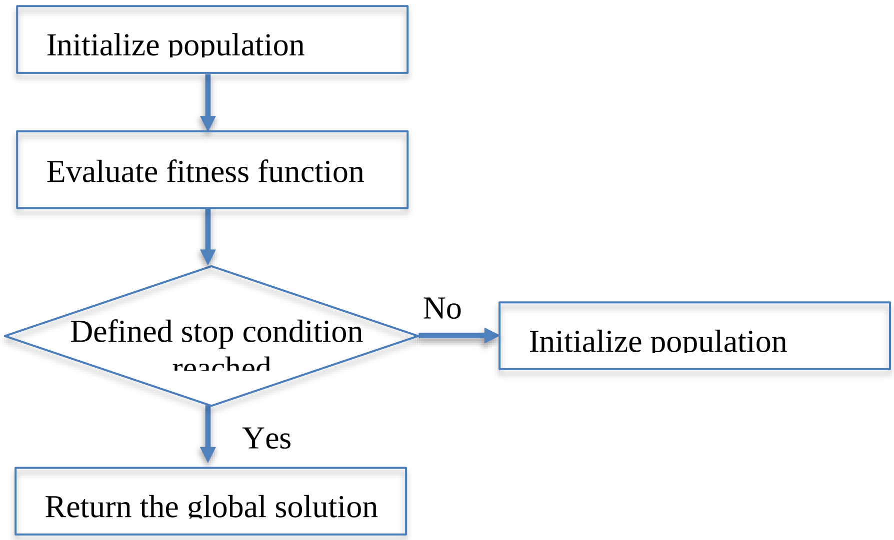

Fig.3. SI framework [43]

Table (1) describes related studies.

# Ref	Techniques of Classification	Publishing year
[10]	state-of-the-art deployment techniques are suggested for comprehensive coverage in mobile wireless sensor networks.	2023
[8]	The wireless sensor network deployment problem focuses on solving methods and optimizing models based on AI.	2022
[9]	Deployment, Localization, and Coverage difficulties in WSN relating to AI methods for wireless sensor network enhancement.	2022
[12]	the deployment of sensor nodes, the routing protocol, and the design difficulties arise when wireless sensor networks are designated.	2021
[7]	compared the effectiveness of two nature-inspired algorithms for obtaining the best coverage in WSNs and talked about the taxonomy of optimization algorithms in conjunction with the problem domains in WSNs	2021
[6]	classified the coverage, focused on the challenges of deployment of WSNs, research issues, and sensing models in WSNs.	2020
[11]	a state-of-the-art for classifying wireless sensor networks based on various factors such as sensor types, sensing models, deployment techniques, energy efficiency, and coverage.	2020

Table (2) comparison between metaheuristic algorithms

Year & Ref	Methods	Objectives	Sensor type	Deployment type	Area Type	Results
2023 [13]	Multiobjective adaptive fish migration	enhance the initial sensor deployment, maximize the area's	------	Random deployment	2D	------

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	optimization (MAFMO) algorithm	coverage rate, and reduce the amount of movement of the sensors				
2023 [14]	bi-objective virtual-force local search PSO algorithm **(BVFPSO)**	Increasing the coverage rate and decreasing the moved distance.	binary sensor model	Random deployment	2D	0.1 cover 0.26 moved distance
2023 [15]	Genetic Algorithm (GA) and Binary Particle Swarm Optimization (BPSO).	extending network lifetime, maximizing connectivity, and reducing cost	heterogeneous WSN	Random deployment	3D	------
2023 [16]	Seagull Optimization Algorithm Optimized by *PSO* (*PSO-SOA*)	Network coverage and minimizing energy consumption in the network	heterogeneous WSN	Random deployment	2D	93.9%
2022 [17]	an enhanced version of the GWO algorithm to work adaptively in such problems and named it Mutant-GWO (MuGWO).	reducing the number of nodes by increasing the coverage rate and maintaining the connectivity, provides realizing the fault tolerance without any additional cost using its dynamic topology mechanism	------		2D	99.14%
2022 [18]	Genetic Algorithm	maximize the coverage by making the minimum number of sensors active in WSNs.	------		2D	-----------
2021 [19]	genetic algorithm (GA) and particle swarm optimization (PSO) algorithm using multihop transmission	increasing the lifetime.	Heterogeneous sensors		2D	--------
2021 [20]	Ant-Colony optimization algorithm	find the optimum location of the mobile nodes to optimize field coverage	heterogeneous sensor		----------	---------
2020 [21]	heterogeneous two-tier Lloyd algorithm	find the optimal AP and FC deployment to minimize the total communication power consumption.	Homogeneous sensors, heterogeneous APs, and heterogeneous FCs		2D	--------
2020 [22]	distributed particle swarm optimization	improve the coverage and	RSN and MSN	Random deployment	3D	---------

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	(DPSO) algorithm and a proposed 3D virtual force (VF) algorithm	connectivity in 3D terrain after initial random deployment in WSNs and address the challenges of the PSO algorithm and VF algorithm				
2020 [23]	probabilistic sensing model (PSM) and harmony search algorithm (HSA)	coverage and cost	Heterogenous sensor	Random deployment	2D	100%,50%
2020 [24]	combination of multiobjective bee algorithms and Levy flight (LF) random walk	connectivity and coverage	------	Random deployment	3D	--------