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Improved Manta-ray Foraging Optimization for Cluster Head Selection in Sensor Networks

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Abstract

A wireless sensor network (WSN) is consist of more number of sensor nodes that lack energy, storage, and computational capability. One of the primary functions of the sensor nodes is data gathering and transmission to the base station (BS). As a result, network longevity becomes the primary criterion for effective design of data collection systems in WSN. Clustering is one of the process which helps to identify the cluster head (CH), but the perfect solution for identifying the CH is still challenging. The selection of energy-efficient cluster head (CH) technique is proposed in this study employing improved manta ray foraging optimization (IMRFO). An improved manta ray foraging method based on Latin hypercube sampling and group learning is presented to address the drawbacks of the manta ray foraging optimization (MRFO) algorithm, such as sluggish speed of convergence and difficulty escaping from the local optimal solution. To begin, the Latin hypercube sampling (LHS) method is used to populate the population. Second, to avoid early convergence, the Levy flying strategy is implemented during the exploratory stage of cyclone foraging. The adaptive t-distribution technique is added prior to the somersault foraging stage to update the population in order to maximize variety and avoid slipping into the local optimal solution. The suggested technique is put to the test by performing several simulations

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with the base station in various places. The comparison of results with existing methods like GA-Leach, PSO-Leach, SSA-Leach and kmGOA-Leach is made using the matlab simulation and proposed model i.e. IMRFO-LEACH having better performance in terms of all the parameters evaluated.

Keywords

Wireless sensor network, LEACH, cluster head, energy consumption, MRFO.

1. Introduction

A distributed network of sensors known as a wireless sensor network (WSN) examines the external conditions to gather the data and transmit the same data to a neighboring centralized base station (BS) [1]. In [2], the author states three main components which defines a complete structure of WSN i.e. Sensor nodes (SN), Base-Station (BS), and end-users. An analog-to-digital converter (ADC), one or more sensors, a CPU, memory, a transceiver module, and a power source (often a battery) are all components of an electronic sensor node. These nodes are small and reasonably priced. In [3] author stated that information gathering and transmission from the environment are now the responsibility of WSNs. Furthermore, only a small number of neighboring neighbors can engage locally with wireless sensor nodes. to restrict the power factor during transmission [4]. WSNs have filled in prominence as an outcome of their flexibility in critical thinking across different application regions, and they can possibly work on our lives in various ways. Due to the fast progression of sensor innovation, tiny and clever sensors have been created, permitting WSNs to be utilized in a large number of utilizations, for example, in [5] author discussed about military applications, in [6] region checking and transportation, in [7] clinical/wellbeing applications, and in [8] numerous others like ecological applications. In general, the author in [9] suggested that each sensor's information is routed to nearby base station for analyzing. BS is one of the main tools for transferring of data between the users of the network and WSN.

The techniques of clustering are utilized for simple node level organization, adaptability improvement, energy utilization decrease, information collection, strength, and balancing of loads [10]. Clustering coordinates sensor nodes into virtual groupings called clusters, every one of which serves a different capability. The clustering is depicted as the method involved with coordinating nodes into clusters in view of preset models and choosing the most effective node from each cluster to act as a CH [11]. The CH gathers information from all sensor hubs, totals it, and afterward sends it straightforwardly to the BS or through a mediator CH. Rather than giving information from all sensor nodes in a cluster, the CH sends collected information to lessen the quantity of parcels sent across the organization and consequently the

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energy consumed. To make the information available for the end clients, the information from cluster head needs to be analyzed at the base station.

1.1 Problem Statement

In WSN, the LEACH protocol (LP) is that it permits picking a CH with lower energy, which diminishes lifetime of network and consequently diminishes the execution scenario of the network. Thus, different changes to the LP have been suggested to work on its presentation. To expand the exhibition of WSN, a new clustering model i.e., improved manta ray foraging optimization (IMRFO) is suggested in this work. The suggested IMRFO grouping methodology is used to handle the CHs determination issue as a streamlining issue using an original wellness capability that considers intra-cluster distance, sink distance, CH equilibrium, and leftover energy. The proposed model presentation is assessed and contrasted with that of a few grouping strategies portrayed in the writing.

1.2 Contribution of work

In the suggested algorithm, the methodology surpassed certain well-known published techniques is terms of parameters like usage of energy, lifespan of network and the packets received from one end to other. This paper's primary contributions are as follows: (a) According to the definition, the selection of CHs challenge is the problem need to be optimized that makes use of a new fitness function based on a number of network traits that have a big influence on the performance of the network. (b) Introducing the IMRFO algorithm to the WSN community as a trustworthy and effective optimization approach. (c) Documenting the usage of the IMRFO method to evaluate the issue in selecting of optimized CHs and achieve optimal upgradation of WSN in terms of consumption of energy, lifetime of network, and packet delivery ratio. (d) Detailed computations and evaluations of the suggested method for designing WSN under various scenarios are presented.

1.3 Organization of work

The organization of the work in paper is divided into different sections. In section 1 already discussed about the introduction of work, and problem statement. In section 2, related literature is discussed. The description of MRFO and the IMRFO are given in Section 3. The suggested methodology with Leach combined with optimization technique is discussed in the following section 4. Evaluation of results are been discussed in Section 5. Finally, the overall conclusion of work is discussed.

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Impact Factor:10.2
Subject Engineering

2. Related Work

In this section the examination of some of the clustering methods which include nature inspired models of clustering and some of the heuristic clustering approaches. Firstly, the approaches based on heuristic clustering approaches have been developed and are discussed by various authors. In [11], author identified a lower energy based adaptive clustering hierarchy (LEACH) to enhance the energy efficiency in WSN. An improved variant of leach which helps in establishing a quasi-optimal number of CHs is proposed by author in [12] and is termed as LEACH-B (balanced).

The suggested LEACH-B is similar to that of LEACH, where both methods use random integers and evaluated the threshold range. The advance in LEACH-B is it involves a new selection stage by ranking all the nodes based on the residual power. Depending on the rank the CHs are selected. This process takes longer time for selecting the CH.

In [13] author suggested a new model for selecting the CH in quick time i.e., energy LEACH (E-LEACH). The key element utilized for selecting the CH is residual energy (RE) of the node. So that the nodes with higher RE are selected as CH. In this method the receivers need to be in on state to receive the data which degrades the performance of sensors network and energy consumption is high. M-LEACH is an identical technique to LEACH [14], except that instead of mobilizing the data straight to the BS, it transmits data to the next-hop CH node. It does not, however, undergo a formation phase of cluster. In multi-hop data transfer across CHs, it overlooks critical parameters like as energy and node degree. In [15] author suggested PEGASIS algorithm which is one of the heuristic methods created to improve LEACH. In this technique, sensors are arranged in a chain, with one of them randomly selected to serve as the chain's leader. Another drawback is that a node's leftover energy is not considered during the CH selection procedure. In [16] author suggested a distance-based clustering and is termed as least distance clustering (LDC).

The EPEGASIS algorithm [17] is offered in four approaches to handle the problem of hot spots. To go forward and conserve transmission energy, the optimal communication distance must be determined. Many different clustering algorithms have been created that are based on natural approaches. LEACH-C was introduced by the author in [18]. It should be mentioned that LEACH has a large number of CHs because each node can choose one on their own. By enabling the BS to obtain node details like location and the energy available during the CH selection step, LEACH-C improves the LEACH protocol. The authors of [19] suggested an improved LEACH protocol (FLLEACH), which uses fuzzy logic (FL) to determine how many CHs should be chosen for the WSN. The flaws with FL-LEACH are the fuzzification and defuzzification methods' accuracy and complication. Evolutionary algorithms are suggested for dealing

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March 2023
Impact Factor: 10.2
Subject Engineering

with optimization problems in a vast search space due to their flexibility, higher quality responses, speedy resolving, and capacity to escape local optima.

In [20] the author suggested particle swarm optimization (PSO) for solving the issue of cluster head selection. In [21] the author suggested grey wolf optimization (GWO). Various other approaches like genetic algorithm (GA) in [23], butterfly optimization in [22] are utilized by the authors. Further author in [24] suggested differential evolution (DE) algorithm for achieving the best cluster head. To improve the selection procedure levy flight concept is introduced by the author in [25]. In this global search is introduced by combining levy cuckoo with PSO so that the performance of the network will be enhanced by balancing the dissipation of energy. In [26] author suggested clustering process using whale optimization algorithm (WOA-C).

For energy-aware CHs selection, the selection and application of a fitness function are made easier by the WOA-C methodology. It considers the node's leftover energy as well as the overall energy of the nodes nearby. However, while choosing a CH, this method ignores load balance, intra-cluster distance, and sink distance. A mix of HSA and PSO algorithms is used in the selection of CH with energy-efficiency [27].

3. Manta Ray Foraging Optimization (MRFO)

The concept of manta ray is divided into three stages of foraging. In each foraging stage the behavior of manta-ray is evaluated.

3.1. Foraging based on chain

In this option initially the manta rays will identify the spot of plankton and swims in the direction of moving plankton. This method identifies better place where the concentration of plankton is higher. The optimum answer may not be known, but according to MRFO, the best plankton has so far been shown to have a high concentration that manta rays want to contact and feed on.. Manta rays align themselves in a foraging chain from head to tail. Everyone but the first person moves toward the meal and the person in front of it. That is, throughout each iteration, each person receives information on both the solution that is currently in front of them and the best solution so far. The following is a representation of this chain foraging mathematical model [28].

$$x_i^d(t+1) = \begin{cases} x_i^d(t) + r.\left(x_{best}^d(t) - x_i^d(t)\right) + \alpha\left(x_{best}^d(t) - x_i^d(t)\right), & i = 1, \\ x_i^d(t) + r.\left(x_{i=1}^d(t) - x_i^d(t)\right) + \alpha\left(x_{best}^d(t) - x_i^d(t)\right), & i = 2, \dots, N \end{cases} \quad (1)$$

$$\alpha = 2.r.\sqrt{|\log(r)|}$$

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

Here, the position for i^{th} individual is $x_i^d(t)$ in the d^{th} dimension at time *t*, weight coefficient is termed as α, and *r* is a random vector in [0, 1]. $x_{best}^d(t)$ is the place showing higher-concentration planktons. The current position of the i^{th} individual is updated by the position $x_{i-1}(t)$ of the current $(i-1)th$ individual and the position $x_{best}(t)$ of the food.

3.2. Foraging based on Cyclone

Manta rays establish a lengthy drilling chain and move in a pattern with spiral way in search of food when they spot planktons in deep ocean. Every manta ray swims near to the one in front of it while spiraling towards the feast. People in 2D space follow the person in front of them in addition to moving in a spiral path in the direction of the food. The spiral motion of manta rays in 2D space can be described by the mathematical equation below. [28]:

$$\begin{cases} X_i(t+1) = X_{best} + r.\left(X_{i-1}(t) - X_i(t)\right) + e^{bw}\cos(2\pi\omega).\left(X_{best} - X_i(t)\right), \\ Y_i(t+1) = Y_{best} + r.\left(Y_{i-1}(t) - Y_i(t)\right) + e^{bw}\cos(2\pi\omega).\left(Y_{best} - Y_i(t)\right) \end{cases} \quad (2)$$

where w is a randomly generated value between 0 and 1. The following modification to this motion will simulate n-D space [40]:

$$x_i^d(t+1) = \begin{cases} x_{best}^d(t) + r.\left(x_{best}^d(t) - x_i^d(t)\right) + \beta.\left(x_{best}^d(t) - x_i^d(t)\right), i = 1, \\ x_{best}^d(t) + r.\left(x_{i-1}^d(t) - x_i^d(t)\right) + \beta.\left(x_{best}^d(t) - x_i^d(t)\right), i = 2, \ldots\ldots, N, \end{cases}$$

$$\beta = 2e^{r_1 T - t + \frac{1}{T}}.\sin(2\pi r_1) \quad (3)$$

where the weighting coefficient is β, T is the maximum number of iterations possible, and $r_1$is a random integer in the range [0, 1]. So far, the best strategy discovered is foraging based on cyclone, which has a higher utilization of the ROI. This characteristic is also used to improve the exploring process. By giving each person a fresh, random place in the search universe, people are encouraged to look for a new job that is far from the best one that already exists. This method is largely for exploration, allowing the MRFO to undertake a comprehensive search. This mechanism's mathematical equation is as follows [28]:

$$x_{rand}^d = Lb^d = r.\left(UB^d - LB^D\right)$$

$$\begin{cases} x_{rand}^d(t) + r.\left(x_{rand}^d(t) - x_i^d\right) + \beta.\left(x_{rand}^d(t)x_i^d(t)\right), \quad i = 1, \\ x_i^d(t) + r.\left(x_{i=1}^d(t) - x_i^d(t)\right) + \alpha\left(x_{rand}^d(t)x_i^d(t)\right), \quad i = 2, \ldots, N \end{cases} \quad (4)$$

where LB^D is said to be the lower dimension limit and UB^D is said to be the upper dimension limit respectively, and x_{rant}^d is a randomly generated position throughout the search space.

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March 2023
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Subject Engineering

3.3 Improved Manata-ray Foraging Optimization (IMRFO)

The initial population in the basic MRFO is produced at random. This method creates an initial population that is frequently irregularly distributed or even overlaps individuals, which somewhat reduces the optimization efficacy of the process. McKay et al. [29] introduced the Latin hypercube sampling (LHS) approach, which offers the following benefits above the standard method of random sampling.

(1) LHS sample points can accomplish full space coverage and are equally dispersed in the search space;

(2) LHS is more resilient and stable. As a result, we use the LHS approach to start the population for increasing the variety of the initial population and improve performance.

Assuming N starting individuals are formed in d-dimensional space, the following steps are taken to initialize the population using the LHS method:

Step 1: Determine the size of population 'N' and dimension 'd'.

Step2: Calculate the interval for individual x as $[l_b, u_b]$, where l_b is the lower limit and u_b is the upper limit of variable 'x' respectively.

Step 3: Subdivide the interval of 'x' variable into tiny interval 'N' equally.

Step 4: At random, choose a point in each dimension's subinterval.

Step 5: To generate the initial population, integrate the points that were gathered from every dimension.

The MRFO is enhanced by the following when Levy flight technique is incorporated into the location update calculation of the cyclone forage exploration stage:

$$x_i^d(t+1) = \begin{cases} x_{rand}^d + Levy(\lambda) \otimes \left[r.\left(x_{rand}^d - x_i^d(t)\right) + \beta.\left(x_{rand}^d - x_i^d(t)\right)\right], i = 1, \\ x_{rand}^d + Levy(\lambda) \otimes \left[r.\left(x_{i-1}^d - x_i^d(t)\right) + \beta.\left(x_{rand}^d - x_i^d(t)\right)\right], i = 2, \dots, N \end{cases} \quad (5)$$

Where, $Levy(\lambda) = \frac{u}{|v|^{-\lambda}}$, here u and v are taken from normal distribution, i.e.,

$u \sim N(0, \sigma_u^2)$ & $v \sim N(0, \sigma_v^2)$

The terms σ_u and σ_v are given as,

$$\sigma_u = \left\{\frac{\Gamma(1+\lambda)\sin(\pi\lambda/2)}{\Gamma(1+\lambda/2)\lambda 2^{\lambda-1/2}}\right\}^{1/\lambda}, \sigma_v = 1$$

3.4. Foraging based on Somersault

This behavior is said to be focused on the location of the food. Each individual is hanging in a different location while swimming around the pivot. They constantly upgrade their locations in accordance with the greatest spot they have thus far discovered. The theoretical formalism for this tactic is displayed below [30].

$$x_i^d(t+1) = x_i^d + S.\left(r_2.x_{best}^d - r_3.x_i^d\right) \quad i = 1, \dots, N \quad (6)$$

S = 2 is factor used for somersault, this is used to set the range of manta rays, whereas r_2 is one of the rand value and $r3$ is also a rand value and having a range from 0 to 1 range. Each participant can travel to any location inside a new search domain by selecting their somersault range. Then, as shown in equation, they are moved to the location that is determined to be the best fit between their current position and their symmetrical position (6). The disturbance of the existing position decreases as the distance between each person's location and the ideal position increases. Everyone eventually finds the optimal option in the search space. As a result, as the number of repetitions grows, the diversity of hollow foraging reduces. The area which is dense around x_{best}^{d} can be highly valuable, whilst the rare ones can greatly aid in exploring. MRFO, like other metaheuristic optimizers, starts by creating a random population in the problems field. At the end of each cycle, each individual changes their location in relation to the leading individual and the reference position. To conduct an exploratory and exploitative search, the t/D ratio is decreased from 1/T to 1.

4. Proposed Work

Initially the CH identification problem is been created and to overcome the problem an optimization technique is designed for the suggested model. The LEACH-IMRFO is then used to solve the optimization issue by locating the fitness function's minimal value. Here we indicate that the selection of CHs issue is written in the form of a minimization problem. The CH algorithm in the suggested formulation is dependent on some of the parameters, one is the separation between the cluster heads in the network and the sensor nodes, other is the separation from the cluster head to base-station, the factor of balancing and finally the energy utilized the nodes. During CH selection, the BS will be informed on the location and remaining energy of each sensor node to ascertain whether it satisfies the energy need. Formation of cluster comes next.

4.1. Leach Protocol

It is a self-organizing protocol where the clusters are been adjusted and number of rounds are introduced. LEACH assumes that the BS is stable, far from the sensors, and exists a uniformity in all the sensor nodes and having a finite source of energy. Sensors may continuously monitor their surroundings, connect with one another, and relay data to the BS. LEACH works by selecting CHs based on a specified likelihood. The drawback of LEACH is that it allows for the selection of a CH with lower-energy, which helps in reducing the longevity of network and which implies the performance of network. The suggested method is utilized to improve the performance of LP with numerous modifications.

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Volume 1 Issue1
March 2023
Impact Factor:10.2
Subject Engineering

4.2 Assumption for Implementation of work

Based on the assumptions made for functioning of network the sensors nodes which are not CH will combine with the nearby CH for formation of cluster chain.

- All sensors are assumed to be placed over the detecting range, and are positioned randomly to stay immobile.
- In the field of sensing, the sensor nodes available has the option of being designated as a CH of sensor node.
- All the sensor nodes considered in the network are uniform in nature which have equal energy and same mode of communication.
- The delivery of data is performed by all the sensor nodes to their respective BSs or head nodes which is said to be the cluster head.
- Imbalance in count of sensor nodes and CHs, where nodes are more in number than CH.
- Depending on the transmission distance, the sensor nodes use variable amounts of power for transmission of data.
- The nodes are set to be in viable range of communication and at the same time wireless communication link is made available.
- The location of BS depends on the range of sensing zone, the stationary base-station can be placed within or outer range of sensing zone.

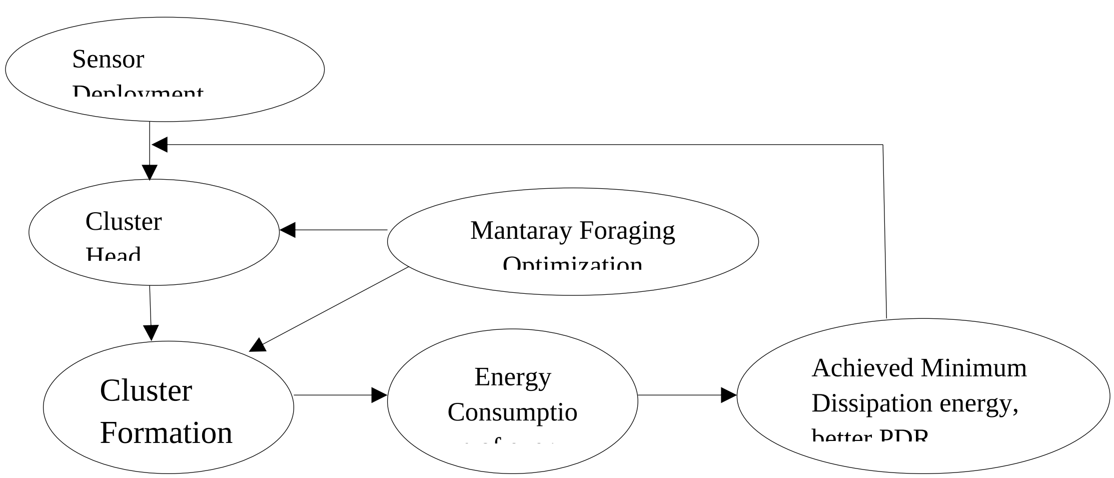

Figure1. Proposed System Model

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

4.3 Algorithm: I-MRFO Clustering

Input: The sensor nodes with particular set which are considered i.e., $S = \{s_1, s_2, s_3, \ldots \ldots, s_A\}$

Output: Optimized and best positions of cluster heads $CH = \{CH_1, s_2, s_3, \ldots \ldots, s_A\}$

Step1. Initialize individual $P_i, \forall i, j, 1 \leq i \leq N_p, 1 \leq j \leq D = m$, number of CHs

$X_{ij}(0) = x_{i,j}(0), y_{i,j}(0)$ \\[position of nodes which are deploted]

Step2. For

$i = 1\ to\ N_p\ do$

Calulate fitness of each individal i.e. P_i using equation 1

The best among the individuals is $x_{best} = P_i$

end for

Step3. While

Crtieria of stop is unsatisfactory do

For

$i = 1 : N_p$ do

If $rand < 0.5$ Then \\[cyclone faraging]

If ${}^{t}/_{T_{max}} < rand$ Then

Updation of the position of P_i using equation 2

else

updation of the position of P_i using equation 5

end if

Computing the individuals fitness $f(x_i(t+1))$ if $f\big(x_i(t+1)\big) < f(x_{best})$

THEN the best individual $x_{best} = x_i(t+1)$

\\Someresalut Foraging

Updating the position of P_i using equation 6

Computing the fitness of each individual $f(x_i(t+1))$ if $f\big(x_i(t+1)\big) < f(x_{best})$

THEN the best individual $x_{best} = x_i(t+1)$

Calculate $dis(X_{i,j}(t+1) = s_k)$

$X_{i,j}(t+1) \rightarrow \{s_k \big| \min\ (dis(X_{i,j}(t+1), s_k) \forall i, 1 \leq k \leq N_p\}$

end for

Step4: end while

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

Step5. Identify best solution and Return x_{best}

Step6. The nodes which are near to the x_{best} selected as CHs

Step7. Stop

Individuals constitute a group of CHs in the IMRFO technique during execution, and each set of CHs represents 10percent of the network's active sensor nodes. A set of active sensors are been considered by the IMRFO algorithm and is given as $S_A = \{s_1, s_2, s_3, \dots \dots, s_A\}, A \leq N$, as inputs and the optimal set of CHs as outputs. The problem of selecting CH is solved using the IMRFO algorithm.

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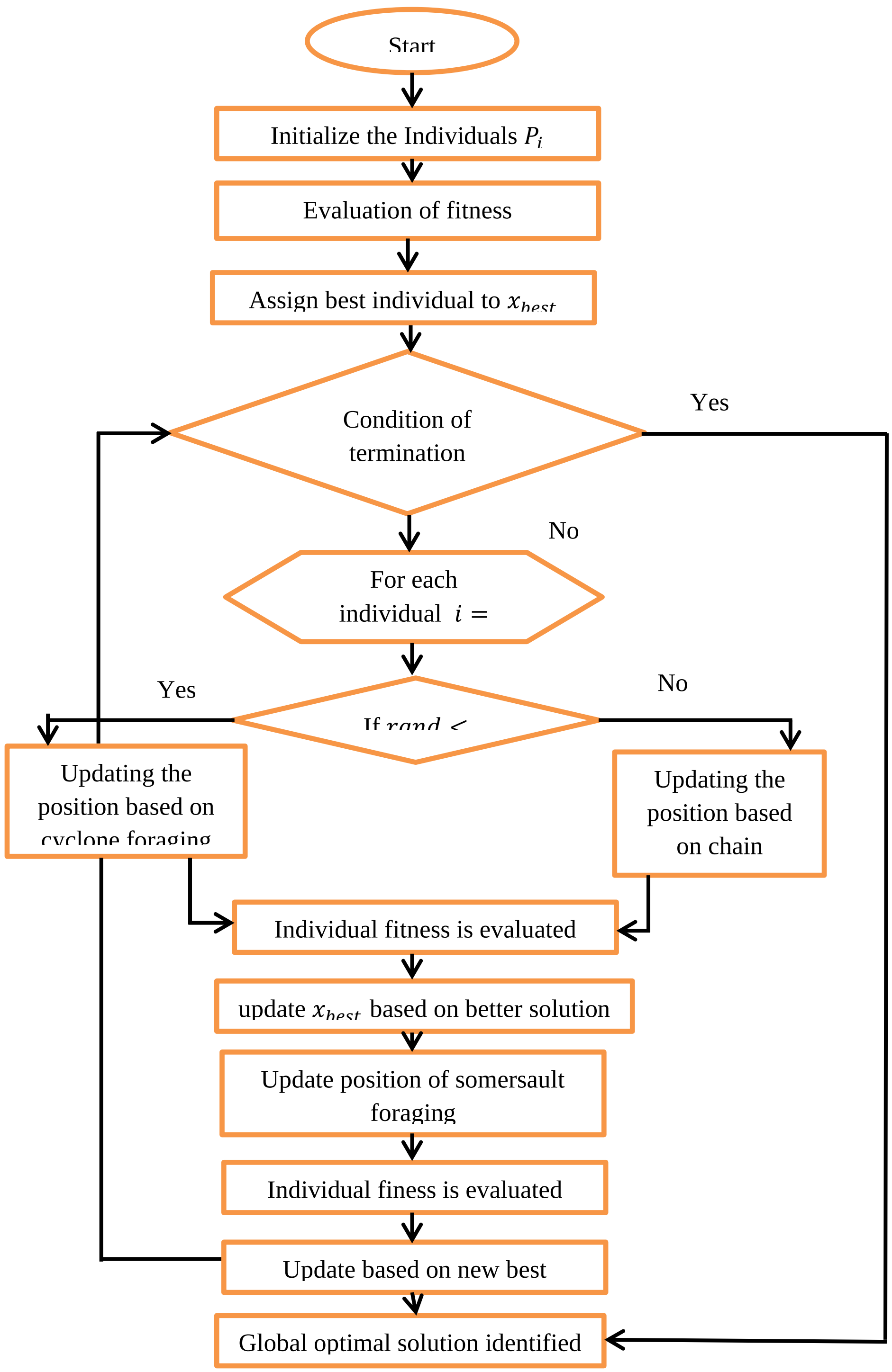

Figure2.Flowchart of proposed model

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

The node which is not a CH make requests to the CH to join the cluster when the CHs are chosen. Then, based on the shortest distance, non-CH nodes can join a cluster with the closest CH and the distance is termed as Euclidean distance. Figure2 depicts the suggested model's flowchart.

5. Results and Discussion

5.1 Analysis of simulation

The suggested IMRFO procedure is carried out in MATLAB. The procedure is put through its paces in three separate situations. We establish three alternative situations in which the BS's location is altered to examine the impact of this variable. Current simulation results take into account all three of these possible BS locations. The BS is positioned in the exact middle of the area of interest in case 1, at the very edge of the area of interest in case 2, and outside the area of interest altogether in case 3. Ten percent of the simulated WSN's nodes are designated as CHs. This paper compares the effectiveness of the proposed algorithm for designing WSN to that of a number of established optimization methods, including PSO, LEACH, GOA, and SSA. The simulation environment used to compare the IMRFO against other routing protocols is summarized in Table 1.

Table1. Parameters used for simulation

Parameter	**Value**
Field Size	100 x100 m^2
Nodes count	500 to 100
Locality of BS	(50-200), (50-50), (100-100)
CHs count	50-10
Node energy at inception	0.5 joule
E_{elec}	50 nJ per bit
Energy expenditure of data aggregation	5 nJ per bit
Dimension of each Packet	6000 bits
Dimension of each Message	300 bits
d_0	75mm

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Amounts of representatives	30
Iterations count	50 to 100

5.2 Evaluation Metrics

The research measures the effectiveness of the executed strategy in terms of a variety of metrics, including network throughput, dropped packets, energy use, data delivery rate, residual energy, and amount of live nodes.

5.2.1. Assessment of Packet delivery ratio

The PDR using different methods is been simulated and the results are shown below table2, table3, and table4. Here, the consideration of different positions of base-station with N number of nodes. Placement of the BS includes the outfield, the corners, and the middle. The number of nodes considered in our work is 100, 300 and 500. As the observed results of executed model having vast improvement in delivering of packets irrespective to the position of base station and the number of nodes.

Table2. Packet delivery ratio with different BS positions for 100 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	0.144666	0.125832	0.162774	0.117260	0.134848
BS@ Edge (100,100)	0.166028	0.114210	0.173979	0.113900	0.115231
BS@ Middle (50,50)	0.129865	0.116919	0.147139	0.113833	0.124356

Table3. Packet delivery ratio with different BS positions for 300 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	0.516850	0.512207	0.640973	0.511114	0.515682
BS@ Edge (100,100)	0.532421	0.503547	0.604486	0.199272	0.513804

ISSN:2321-3914
Volume 1 Issue1
March 2023
Impact Factor:10.2
Subject Engineering

BS@ Middle (50,50)	0.539743	0.497661	0.645312	0.380142	0.512015

Table4. Packet delivery ratio with different BS positions for 500 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	0.531817	0.512217	0.674250	0.151114	0.514686
BS@ Edge (100,100)	0.532442	0.503539	0.738302	0.199334	0.513796
BS@ Middle (50,50)	0.539748	0.497656	0.734993	0.380111	0.511988

5.2.2. Assessment of network life time

The nodes which are left till the last round and nodes is alive is used to calculate the network lifetime. Plotting the number of dead nodes against the number of rounds will reveal the last node death (LND). Energy efficiency improvements extend network lifetime.

The NLT values are been evaluated by varying the situations of base station and the positions are middle, edge and outward. The number of nodes is varied to test the performance of the proposed work. The results obtained are shown table5, table6 and table7.

Table5. Network Life time with different BS positions for 100 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	6829	5188	7483	1109	6042
BS@ Edge (100,100)	8611	6155	9065	1685	7853
BS@ Middle (50,50)	9999	7911	11247	1665	9364

Table6. Network Life time with different BS positions for 300 nodes

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	7565	5662	8497	1334	6639
BS@ Edge (100,100)	9960	6859	10752	1944	8955
BS@ Middle (50,50)	12925	9009	14266	1879	11052

Table7. Network Life time with different BS positions for 500 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	8316	6167	9981	1472	7301
BS@ Edge (100,100)	11280	7473	12751	2122	10030
BS@ Middle (50,50)	12676	10070	16263	2023	12676

5.2.3. Assessment of throughput

The quantity of valuable data that the BS is receiving can be estimated by looking at the network's throughput. Every round, the network's throughput is recorded and charted. Consequently, a crucial consideration for any routing strategy is network throughput.The performance is done using different terms by discriminating the total number of nodes, discriminating cluster heads. The evaluated parameters are shown in figure3, figure4 and figure5. The experimental results conducted by considering base station at corner, centre and outfield positions and are tabulated in table8, table9 and table10. Various routing protocols have been compared by varying the conditions. Leach, PSO-Leach, GWO- Leach, SSA-Leach is compared with the IMRFO-Leach.

ISSN:2321-3914
Volume 1 Issue1
March 2023
Impact Factor:10.2
Subject Engineering

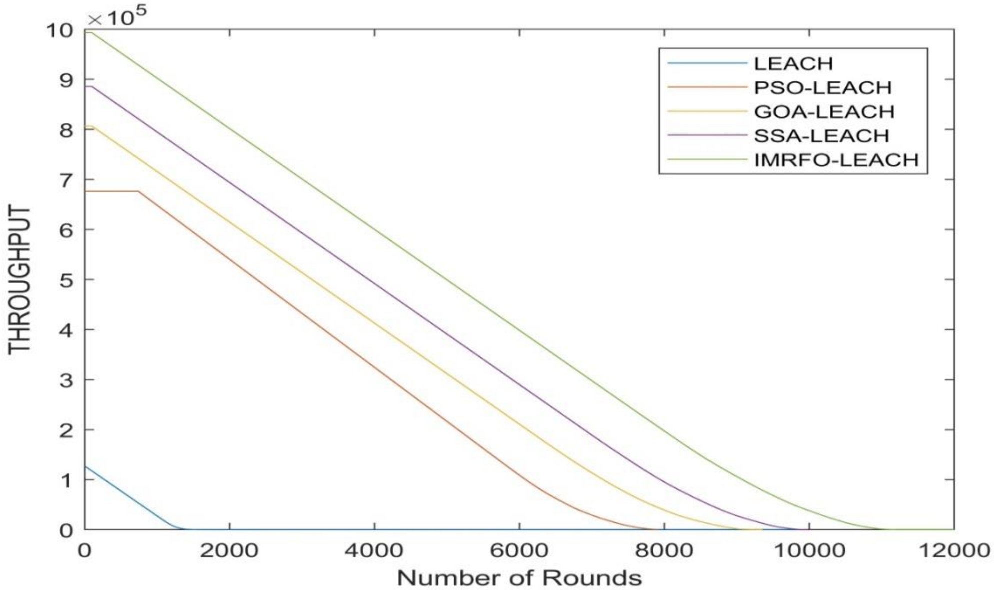

Figure 3. Throughput for BS at center (50,50)

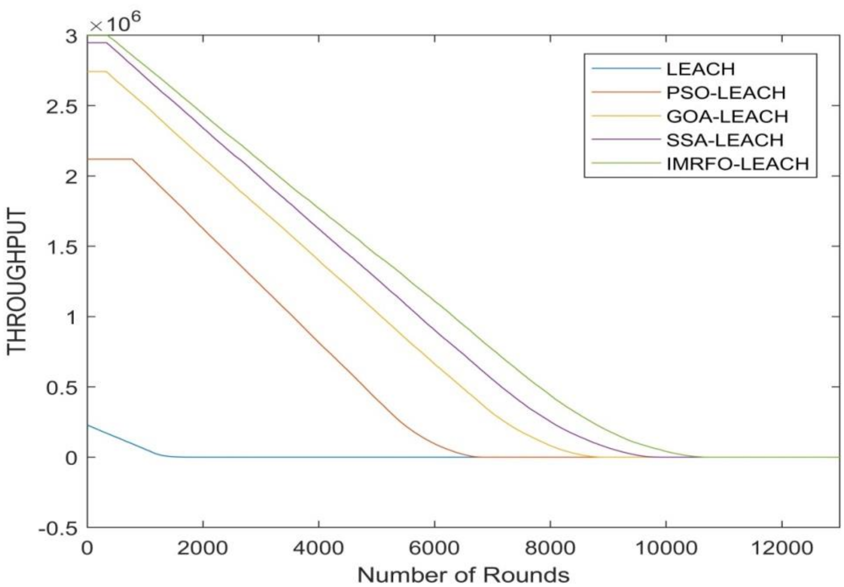

Figure4. Throughput for BS at corner (100,100)

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

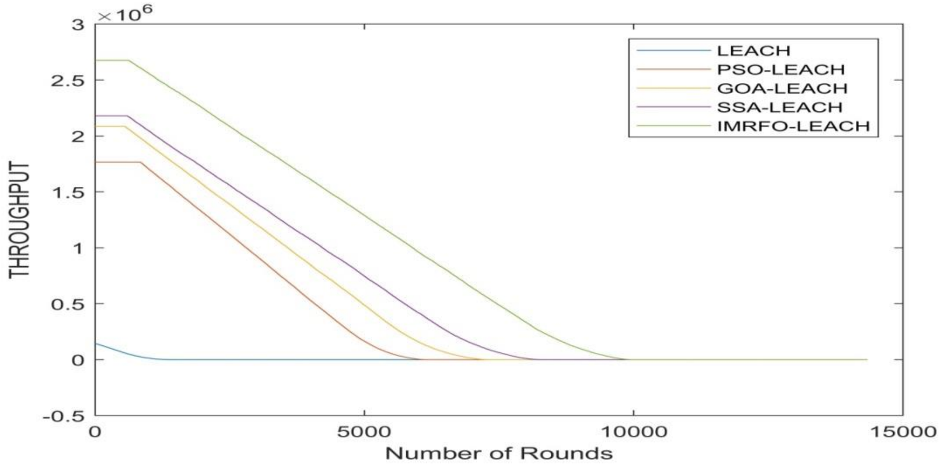

Figure5. Throughput for BS at outfield (50,200)

Table8. Throughput with different BS positions for 100 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	544930.24	441624.85	698951.79	72385.00	521316.24
BS@ Edge (100,100)	736795.24	529886.85	849679.79	114078.00	685600.24
BS@ Middle (50,50)	885926.24	676402.85	993414.79	127346.00	806812.24

Table9. Throughput with different BS positions for 300 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	2179748.21	1766498.43	2875798.18	144775.00	2085250.21

ISSN:2321-3914
Volume1 Issue1
March 2023
Impact Factor:10.2
Subject Engineering

BS@ Edge (100,100)	2947205.21	2119508.43	3998710.18	228152.00	2742328.21
BS@ Middle (50,50)	3543667.21	2705616.43	4673646.18	254680.00	3227210.21

Table10. Throughput with different BS positions for 500 nodes

STANDING OF BS-(X,Y)	SSA	PSO	IMRFO	LEACH	GOA
BS@ Outward (50,200)	2179741.04	1766501.43	3375784.07	144764.00	2085225.04
BS@ Edge (100,100)	2947192.04	2119510.43	3998696.07	228163.00	2742339.04
BS@ Middle (50,50)	3543649.04	2705612.43	4973632.07	254673.00	3227202.04

5.2.4. Analysis of alive nodes

The number of alive nodes for various techniques is tabulated in table11. The evaluation of alive nodes is performed for various positions of base station and also varying total number of nodes. All cases the proposed IMRFO-LEACH having good number of alive nodes by which the transmission of data can be improved. The related outputs are shown in figure by considering base station at centre.

Table11. Live Nodes for BS at middle (50,50)

Number of alive nodes	SSA	PSO	IMRFO	LEACH	GOA
200	6980	5492	8434	1043	6279
180	8294	5985	9069	1159	7091
160	8742	6223	9690	1219	7559
140	9320	6597	10568	1241	8003
120	9937	6806	10998	1283	8282
100	10307	7053	11597	1313	8614

ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

80	10787	7431	12109	1330	8901
60	11177	7677	12308	1376	9371
40	11477	7945	12715	1436	9703
20	11673	8159	12863	1468	9791

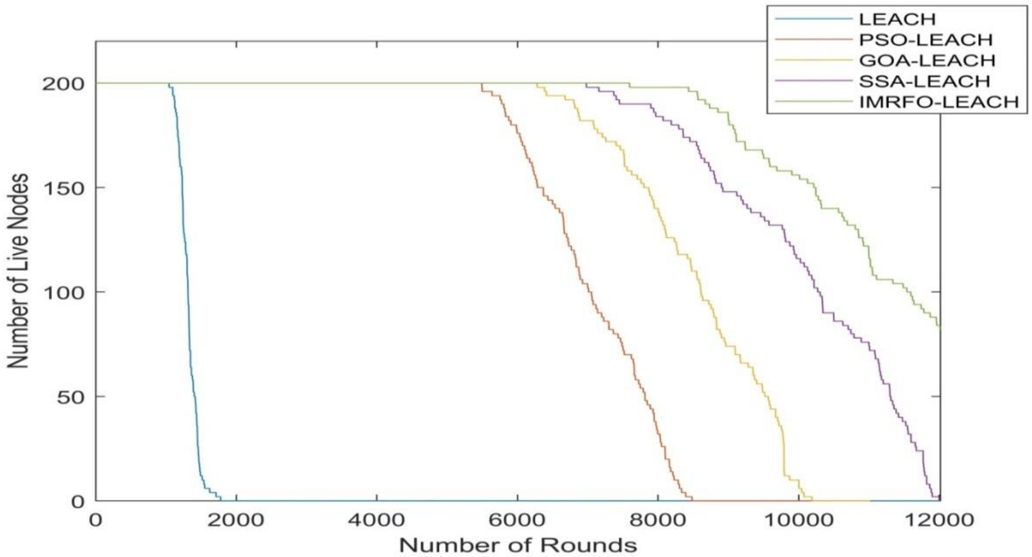

Figure3. Live Nodes for when BS at center (50,50)

6. Conclusion

In the design of wireless sensor networks an IMRFO is been utilized to choose cluster heads (CHs). The problem of CH selection is been improved by utilizing a fitness functions of the optimization technique. The fitness function will consider the important metrics in the network to minimize the selection process. The parameters like distance from nodes to CH, nodes to BS and BS to CH, balancing of CH, energy consumption. Using comprehensive simulation data, the model executed in this paper having good energy efficient CH choice. The proposed model compared with existing model like PSO-LEACH, GOA-LEACH, and SSA-LEACH. The achieved results showed that the executed methodology outperformed all the previous studied models in terms of energy consumption, throughput, networks lifetime, and the packet delivery ratio.

ISSN:2321-3914
Volume 1 Issue1
March 2023
Impact Factor:10.2
Subject Engineering

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ISSN: 2321-3914
Volume 1 Issue1
March 2023
Impact Factor: 10.2
Subject Engineering

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Volume 1 Issue1
March 2023
Impact Factor: 10.2
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