

Representing a Model for Improving Connectivity and Power Dissipation in Wireless Networks Using Mobile Sensors

Nasrin Elyasi^{✉1}, Omid Pourgalehdari²

1) Department of Computer Engineering, Kerman Branch, Islamic Azad University, Kerman, Iran

2) Department of Computer Science, Rafsanjan Branch, Islamic Azad University, Rafsanjan, Iran

elyasi67@gmail.com; galedari@gmail.com

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Abstract

Wireless sensor networks are often located in areas where access to them is difficult or dangerous. Today, in wireless sensor networks, cluster-based routing protocols by dividing sensor nodes into distinct clusters and selecting local head-clusters to combine and send information of each cluster to the base station and balanced energy consumption by network nodes, get the best performance in terms of increasing longevity and preservation network coverage as compared to other routine methods. Their main purpose is to control the danger area and transfer data to a sink. Therefore, connecting to sensor networks and coverage rate of controlled area is one of the most important concerns to achieve these goals. In this paper, to cluster wireless sensor networks, a method using the Imperialist competitive evolutionary algorithm is proposed that divides wireless sensor nodes into balanced clusters, in addition to, several mobile robots has been used for improving power dissipation of network, to assist in the transmission of sensor networks and improve network connectivity and coverage rate of the controlled area. In this research, the sensor network is based on an islets-based topology that has been used robots to detect and enhance connectivity and cover cavities that are largely around the sensors. The simulation results show that our new model can greatly improve the network coverage connectivity criteria. The simulation results show its successful performance in increasing longevity of the wireless sensor network.

Keywords: Wireless Sensor Networks, Robots, Imperialist Competitive Algorithm, Connectivity, Network Coverage

1. Introduction

Wireless Sensor Network (WSN), is a distributed system consists of Base Stations (BS) and large number of mobile Sensor Nodes (SN) that integrate micro sensing, computing and wireless communication capabilities, which are capable of detecting various events related to its surrounding environment such as speed, temperature, pressure, difference in displacement, light, etc. [1] Although localization of sensor networks has been the focus of numerous studies, most existing literature concentrates on the simple scenario where all the sensor and the anchor nodes are stationary. However, in some practical scenarios, such as underwater sensor networks, track movements of small objects, and Vehicular Ad Hoc Networks (VANets), all the sensor and the anchor nodes are non-stationary. Few recent works have addressed the mobile

anchor assisted localization problem; we refer the reader to see [2] and the references therein. More recently, [3] studied the problem of maximum likelihood (ML) localization for the case where mobile sensor nodes exploit their movement knowledge in the localization process. The described scheme in [3] is non-cooperative [4] in the sense that each sensor can communicate with mobile anchor nodes exclusively, i.e., no cooperation among sensor is allowed. With the non-cooperative approach, however, the sensors cannot localize themselves if they cannot directly connect to a sufficient number of anchor nodes, which might be difficult due to the limited communication range and/or lack of accessible anchor nodes. For example, in a 2-dimensional case, each sensor needs to connect to at least 3 anchor nodes. Otherwise, the sensor cannot localize itself. In order to address this issue, the cooperative localization [5] was also studied, in which each sensor node can communicate with any node within its communication range. To the best of our knowledge, however, the cooperative scheme has never been studied for completely mobile WSNs. This paper proposes multi-hop inter-clustering protocol that selects most optimal Cluster Head (CH) with maximum residual energy at each round of CH selection mechanism along with preventing compromised node to become CH, which leads to better performance than LEACH.

we intent to propose a new model to help resettling the sensor network using several mobile robots, whose main purpose is to improve the connection and coverage of the sensor network used accidentally. Based on this, sensors initially form a cluster pattern to set up multiple nodes that are responsible for collecting additional information and communicating with robots. The goal is to reduce the power consumption of some nodes. In this research, we intend to improve the determination of the cluster centers by the imperialist competitive algorithm and the use of robots in detecting the sensor network topology and charging and displacement of the sensors, trying to increase the network coverage and reduce the network power consumption.

Rest of the paper is organized as follows. In section 2 Cluster-based method is discussed. In section 3 we present the construction of the Using robots in cluster-based method. In section 4 proposed method is discussed. In section 4 we present Evaluation of the proposed model. We conclude our paper in section 6.

2. Cluster-Based Method

One of the most important problems in computer networks, including wireless sensor networks, the organization nodes into the network. In view of the fact that wireless sensor networks are used for monitoring strategic environments, the accuracy of the information gathered is crucial. Information accuracy highly depends on the capability of nodes to do their tasks until the end; as a result, energy consumption plays an important role is selection of cluster head is the key issue in the clustering algorithm, which is also a multiple criteria in decision making procedure [6].

In hierarchical routing protocols whole network is divided into multiple clusters. One node in each cluster play leading rule. Cluster-head is the only node that can communicate to Base station in clustering routing protocols. This significantly reduces the routing overhead of normal nodes because normal nodes have to transmit to cluster-head only. Description of some hierarchical routing protocols is discuss in next subsections [6]

A common method of decreasing overall energy consumption is through hierarchical communication routing methods known as clustering. Clustering protocols are

characterized by dividing the network into subsections or 'clusters' of fixed or varying numbers of nodes. Data is transmitted from the sensor nodes within a cluster to the base station through a selected cluster-head (CH). Cluster-head responsibilities are usually divided equally among sensor nodes, selecting a new cluster-head after each successful data packet transmission, which is referred to as a round[1].a pioneering hierarchical cluster protocol known as the Low-Energy Adaptive Clustering Hierarchy(LEACH) is introduced. Since the development of the LEACH protocol, numerous advances have been made, further improving upon its performance, with a large focus on cluster-head selection algorithms [6] the majority of related WSN research has been focused on stationary sensor nodes.However, in some applications the sensor nodes will not be stationary. In this case, common protocols such as LEACH, see a significant breakdown in performance.

LEACH-Mobile is introduced as a variation of the LEACH protocol in which considerations are made to better accommodate sensor node movement. One key assumption with LEACH is that any node has the capability to transmit its data directly to the base station.

In many applications the sensor nodes will not have this capability. LEACH-Mobile is mainly focused on improving network performance, when this assumption is not valid. In this case a large amount of data is lost when nodes move out of range of their cluster-heads. LEACH-Mobile's primary focus is on restructuring node clusters once sensor nodes move out of range during LEACH's steady-state phase.

LEACH-Centralized (LEACH-C) [7] is similar to the LEACH Protocol as far as formatting clusters at the beginning of each round is designed to improve the performance of LEACH. However, instead of nodes randomly self-selecting as a CH, the sink in LEACH-C performs a centralized algorithm. The sink collects location data from the nodes, and then broadcasts its decision of which nodes are to act as CHs back to the nodes. The overall performance of LEACH-C is better than LEACH by dispersing the cluster heads throughout the network. However, LEACH-C is sensitive to the sink location. Once the energy cost of communicating with the sink becomes higher than the energy cost for cluster formation, LEACH-C no longer provides good performance. Sinks may be located far from the network in most WSN applications. So, the dependence on the sink location is a major disadvantage of LEACH-C.

LEACH-CCH (LEACH – Centered Cluster-head), which is a modified LEACH protocol, directed at improving network lifetime when sensor nodes are mobile. LEACH forms the basis for LEACH-CCH. LEACH's operation is broken up into rounds, which consist of a set-up phase, in which clusters are formed and a steady state phase in which data transmission to the base station occurs. At the beginning of the set-up phase, each node determines whether or not to become a cluster-head. This decision is probabilistic and based on the number of rounds since the last time the node was a cluster-head, as well as a predetermined percentage of nodes that should become cluster-heads. Once cluster-heads have been self-nominated, they broadcast an advertisement message to all nodes within the network. Non-clusterhead nodes decide which cluster to join based on the received signal strength of the message. Once this decision is made the non-cluster-head nodes transmit messages to the cluster-head of their choice informing of their decision to join the cluster [8]. Hatamian et al. have proposed a method which performs routing in WSNs using greedy approach, which is able to choose optimum rout based on energy level and distance [9]. Further,omidvar et al. have a proposed an approach for improving energy consumption and to compare

with some of existing algorithms (e.g., *LEACH*, *LEACH-C*, *O-LEACH*, *LEACH-B*, *M-LEACH*, *V-LEACH* AND *W-LEACH*), however proposed approach could defeated these algorithms in term of energy consumption [10]. Sohrabi and khoramian are proposed an efficient protocol for data aggregation hinging around clustering which uses maximum remaining energy and the least distance for choosing the cluster-head to cut the consumption of energy [11]. Pourgalehdari and Salari are reviewed the data aggregation protocols in wireless sensor networks based on the existing research to classify algorithms based on weaknesses and their strength [12].

3. Using Robots in Cluster-Based Method

Mobile robots relying on resettling use sensors cluster scheme to detect connectivity and coverage cavities, installing additional sensors and transferring them again, while the minimum number of packets is exchanged at the peak of the area. We assume that the robots are mobile and initially carry a constant number of sensors to use them if it was necessary. Each robot in the area can deploy its carrier sensors and retrieve additional sensors from the area to the point where it reaches the maximum load. We also consider that the total number of available sensors (those that were initially expanded in addition to the sensors that robots hold) is sufficient to cover the desired (target) area. In a method that uses several robots, there is a network deployment issue, on the one hand, optimizing the number of robots and coordinating the displacement and communication.

3.1 Robot Displacement Pattern in Clustering Method

In this method, N moving robot is considered, which $N \geq 2$, to determine the coordinates between neighbor (adjacent) robots. The sink node position is unnecessary in our proposed model and is not already known. In this method, it is assumed that all robots have a specific received R -range. The network is divided into areas with R widths, and each region is specified for a robot, the robot can eventually run repeatedly if the number of zones exceeds the number of robots. Each robot operates in an area that is dedicated to it and can work with neighboring robots.

As shown in Fig. 1, the robots are initially aligned on the first horizontal edge of the region. Each robot must travel in his area to move to the opposite edge of the area until perform the coverage stage (the arrows indicate the direction of the robots in Fig. 2). When they enter the opposite edge, the robot moves as far apart as d distance in the horizontal direction (on the X -axis) to reach the edge of the other area. After accessing the edge of the new area and communicating with neighboring robots, it must move along the new area in the opposite direction. The same steps are repeated by all robots until all areas are covered.

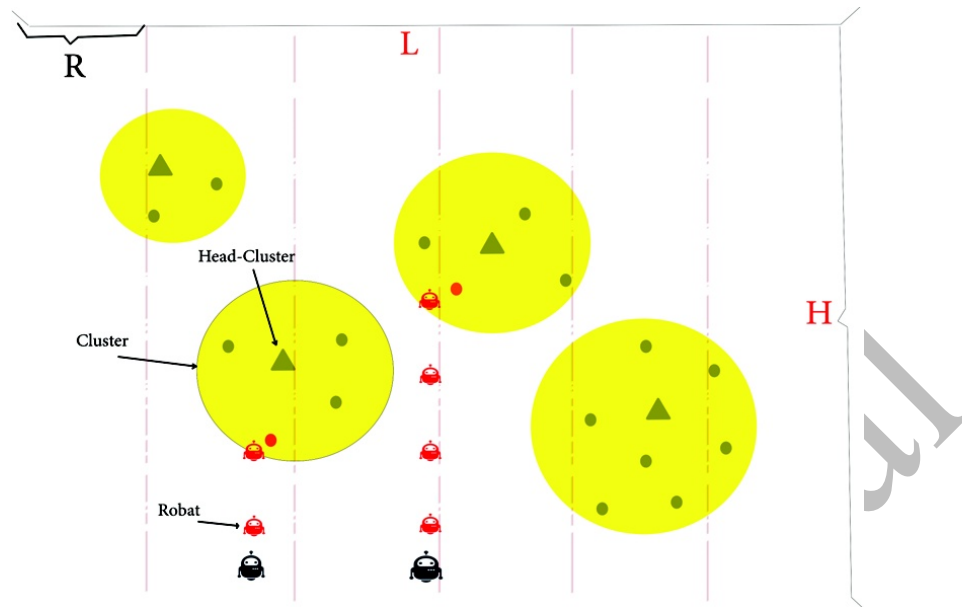


Figure (1) Mobile robots

Horizontal movement of d to reach each of the areas depends on the width of the target area and the number of robots. Every time a robot reaches the horizontal edge of the area, it must shift horizontally to the following distance:

$$D=N*R$$

N is the total number of robots and R is the area width.

In each stage of the displacement, and considering that L is the width of the surface, if L is a multiple of d , then each repetitive robot is changed to complete the crossing of the region. Otherwise, in the last repetition, only the subset of the robots must be changed to reach the remaining areas. In some cases, a pass through the target area is not enough to correct all coverage cavities and connect all areas, so robots can repeat the same constant sample.

The two main tasks are dedicated specifically to robots, which we call the following:

- Discover topology (geographical location)
- Collect additional sensors and replace them

4. Proposed Method

In this algorithm, we have a population of sensors, and each sensor has a series of features and in our optimal issues, we seek the optimal value of these features. Our goal in implementation the imperialist competitive algorithm is to achieve the best clustering, in which the coordinates and characteristics of these clusters are the best possible position, and in order to achieve this goal we need to rank the sensors, and select a series of indicators for these sensors. The sensor can provide features such as high energy, geographic location,.... In our sensor network, we choose the networks that are optimally suited for these features.

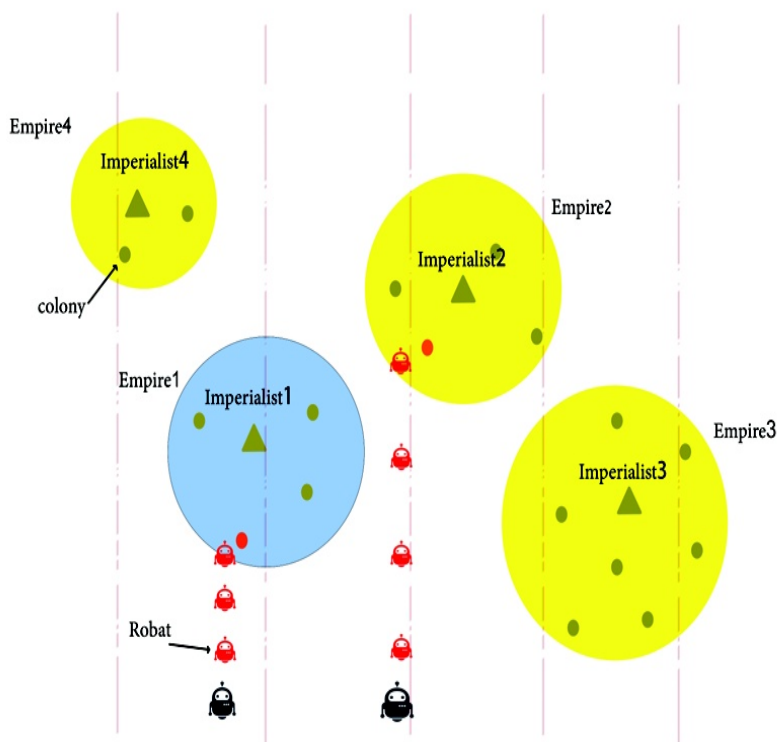


Figure 2. A view of the empire formation in the proposed algorithm

Our method in the proposed algorithm is to allocate sensors to head-clusters or imperialists so that the head-cluster position is such that the sensors do not have problem to send data and the head-cluster is also has sufficient energy to send data to the base station.

4.1 Describes the steps of the proposed algorithm

1. Distribute the sensors randomly in the network and provide a list of their features.
2. The sensors are arranged in the order of the remaining energy, and through these sensors, the sensors that have the most energy, we select as imperialists and create the first clusters.
3. We assign other sensors (low energy sensors) as colonies to colonizers or imperialists (high energy sensors).
4. We move the sensor toward the head-cluster (matching policy) to consume lower energy to transmit the data.
5. If there is a sensor in a cluster that has more energy than the cluster head, we will change the sensor and cluster positions together.
6. We compute the remaining energy of a cluster (taking into account the energy of the cluster head and other sensors).
7. Select one or more sensors from clusters that their remaining energy is about to be ended and transfer it to a cluster that has the most remaining energy.
8. Using robots in a clustering-based method (switching or charging sensors whose energy is about to end).

9. We remove clusters with low remaining energy and a small number of sensors.
10. If the network energy is at the optimal level according to the chosen time, stop or go to the 4. The Flowchart for proposed algorithm is given in Figure 3.

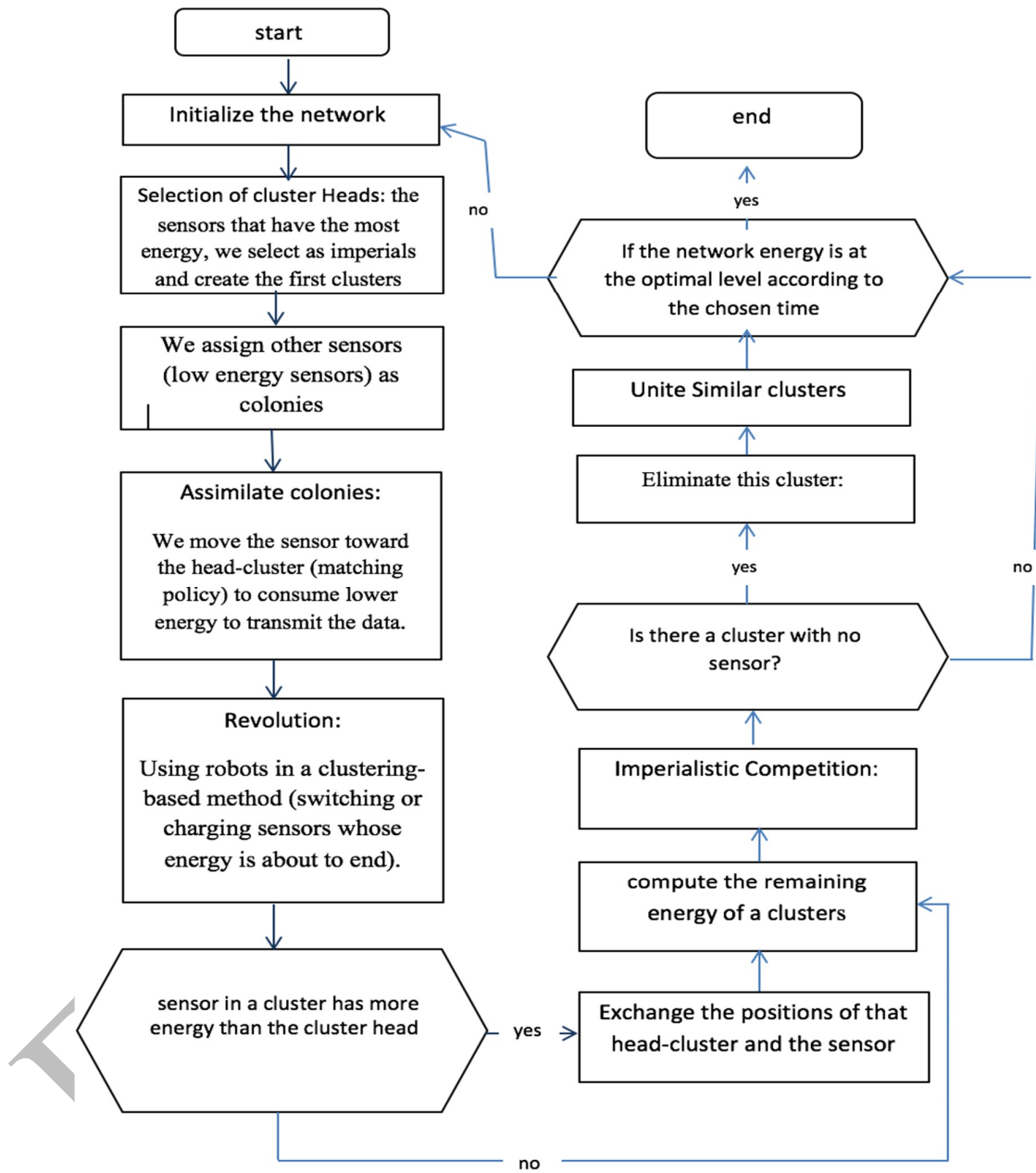


Figure 3. Proposed algorithm

5. Evaluation of the Proposed Model

Simulation was carried out in MATLAB environment. In the initial simulation, the performance evaluation of the suggested method for the target areas was performed and then the robots were moved through the target area and all areas were examined only once. In this section, we first evaluate the amount of connections and the rate of topology coverage. This is while the number of robots and topology is changing. Set the number of robots for the optimal number of required robots and then evaluate the ratio of coverage and connections. On the other hand, we change the topology of the primary network based on the coverage average and connections. To evaluate the proposed method, the parameters of the network coverage rate and the number of active sensors remained at simulation time have been considered. The simulation parameters are similar to Table (1). The number of sensors in the environment are equal to 100, the primary energy of the sensors, is considered to reduce the simulation time to 0.01 Jules, and the size of the data sent by the sensors is 4000 bits. The following table summarizes the various simulated parameters we use. In the initial topology, 100 sensors that are randomly located on the islet are used. In these experiments, the sensor area is considered to be $100 * 100 \text{ m}^2$.

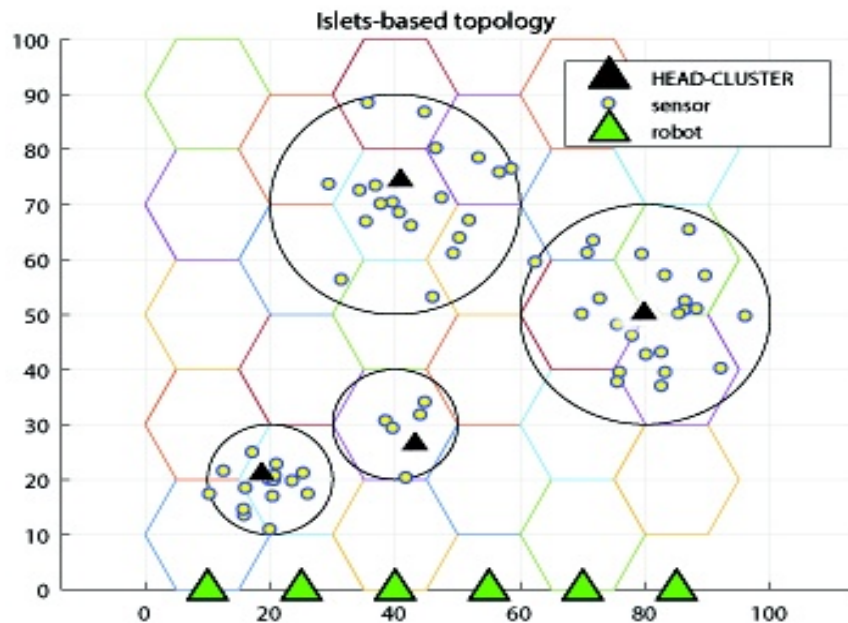


Figure 4. A view of the empire formation in the proposed algorithm

5.1 Connections Level

The level of connections (CR) is determined by the number of islets that are connected to the main regions after the robot's performance. We examine two related islets as a simple example of them. This number is related to the difference between the initial number of the islet and the final number of the islet. Therefore, we define and determine the amount of connections (CR) as follows:

$CR = (\text{Final Number of Islets} - \text{Initial Number of Islet}) / \text{Initial Number of Islets}$

As discussed, simulations have shown that increasing the number of robots caused improvement and advancement in the level of connections and communications. However, using at least two robots, we assign communication values in 10 cases of the initial topology (geographic position) of the islets.

Table 1. Network simulation parameters

Network Dimensions (L*H)	100*100 m2
Height of each hexagonal side	10 m
Amount of environment sensors (N)	100
Communication radius (Rc)	41.23 m
Sensing radius (Rs)	20 m
Capacity of each robot	5 sensors
Robot Communications Range ®	20 m
Robot sensor threshold (Threshold)	5
Primary energy threshold	0.01
The size of sent packets	4000
EFS=amount of energy loss per transfer	$10 * 0.000000000001$
EMP=amount of lost energy for each cluster	$0.0013 * 0.000000000000 \setminus$

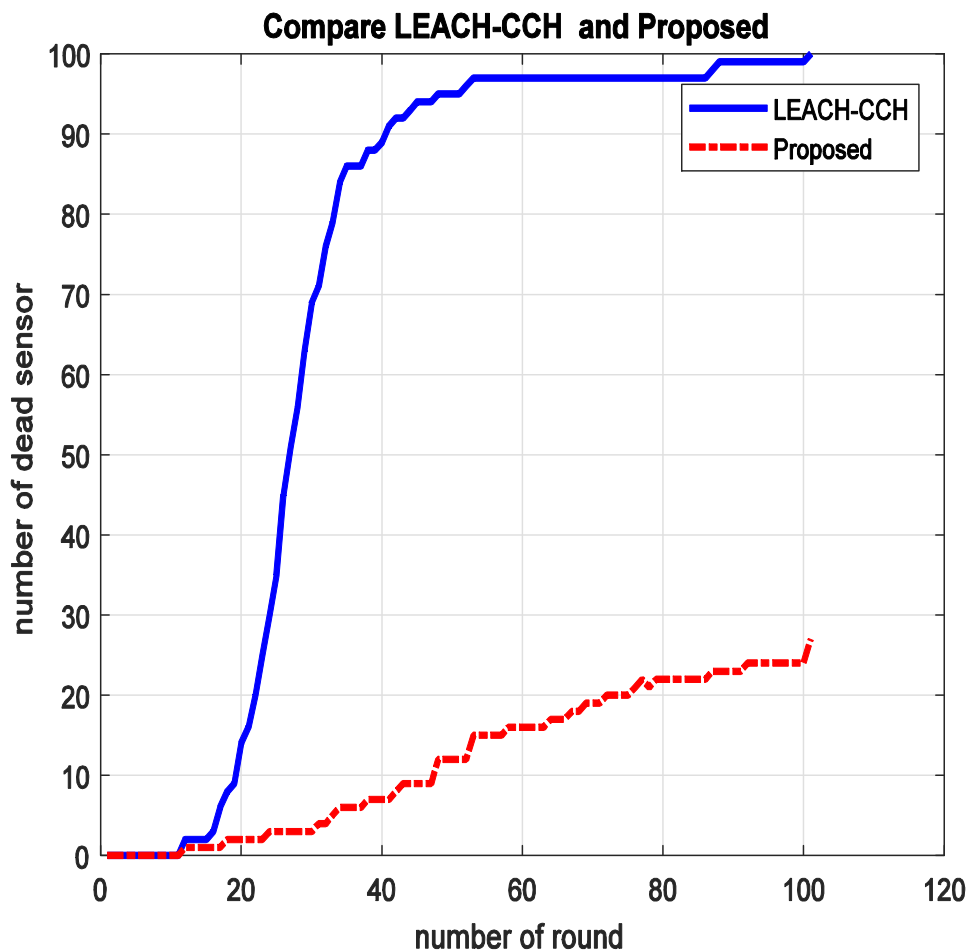


Figure 5. The number of lost sensors

Figure (5) shows the number of lost sensors during simulation with the LEACH-CCH algorithm and the proposed ICA-Robot algorithm.

Finda

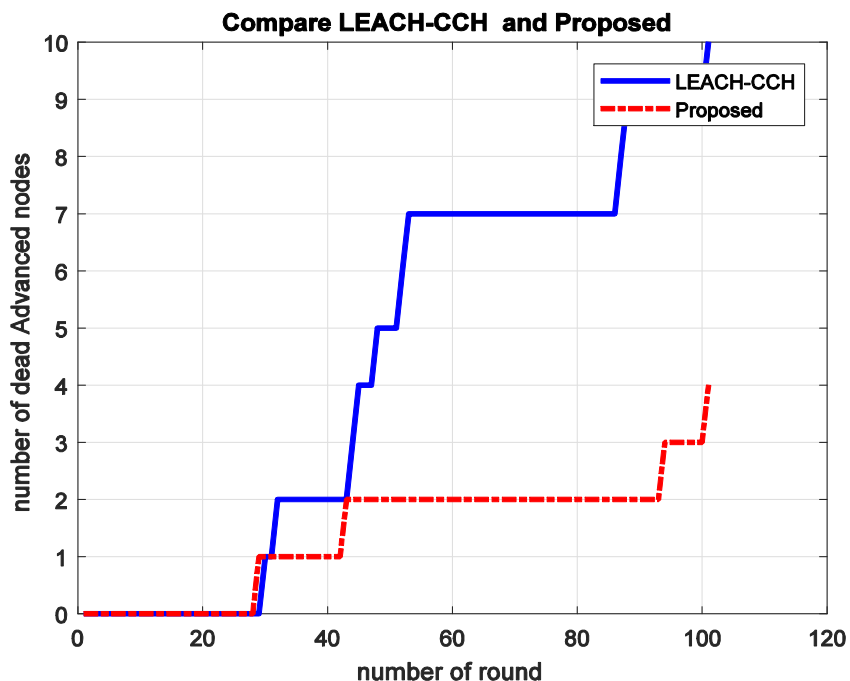


Figure 6. The number of lost advanced nodes

Figure 6. shows the number of lost advanced sensors (cluster head) during simulation with the LEACH-CCH algorithm and the proposed ICA-Robot algorithm.

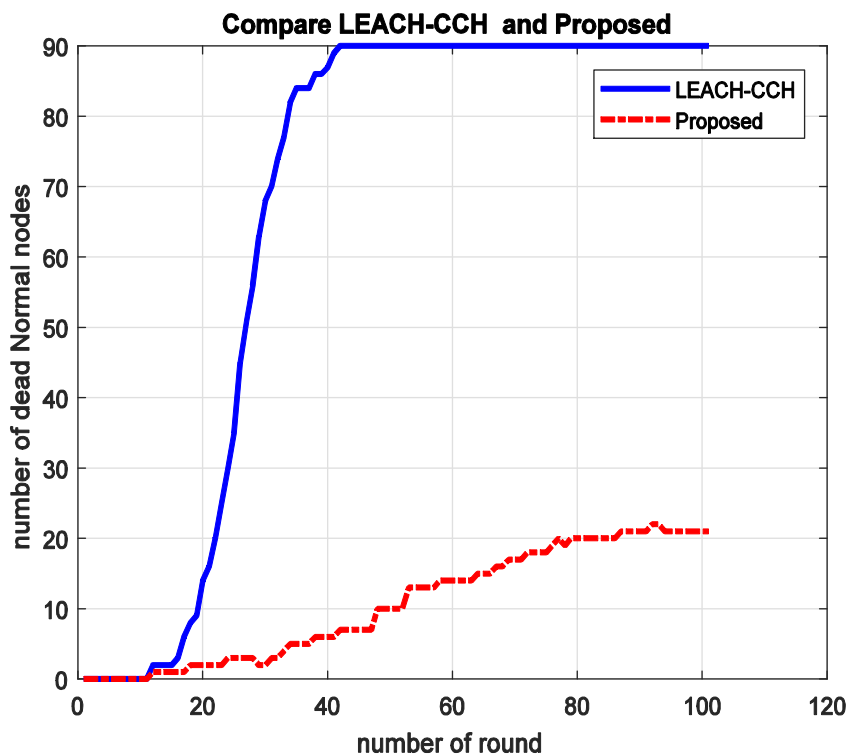


Figure 7. The number of lost normal nodes

Figure 7. shows the number of lost normal sensors during simulation with the LEACH-CCH algorithm and the proposed ICA-Robot algorithm .As can be seen from Fig. 5 to 7, in the proposed algorithm, the number of lost normal sensors in the cluster head is reduced and the network life increases.

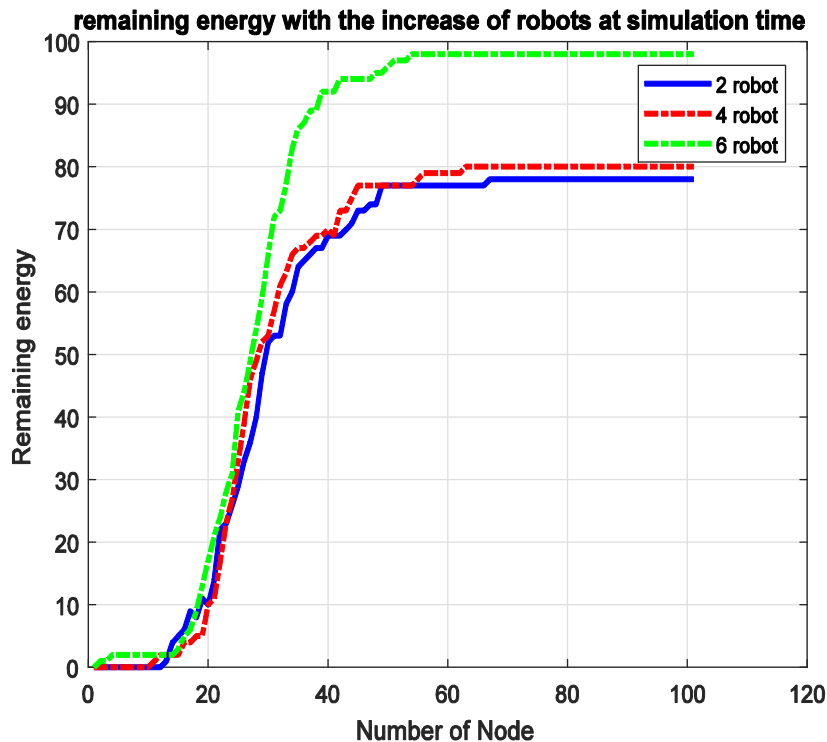


Figure 8. The number of lost sensors

Figure 8 shows the number of lost sensors during simulation. As can be seen from figure, with the increase of robots at simulation time, the number of sensors lost is also reduced.

Final

Number of packets sent to the sink with the increase of robots at simulation time

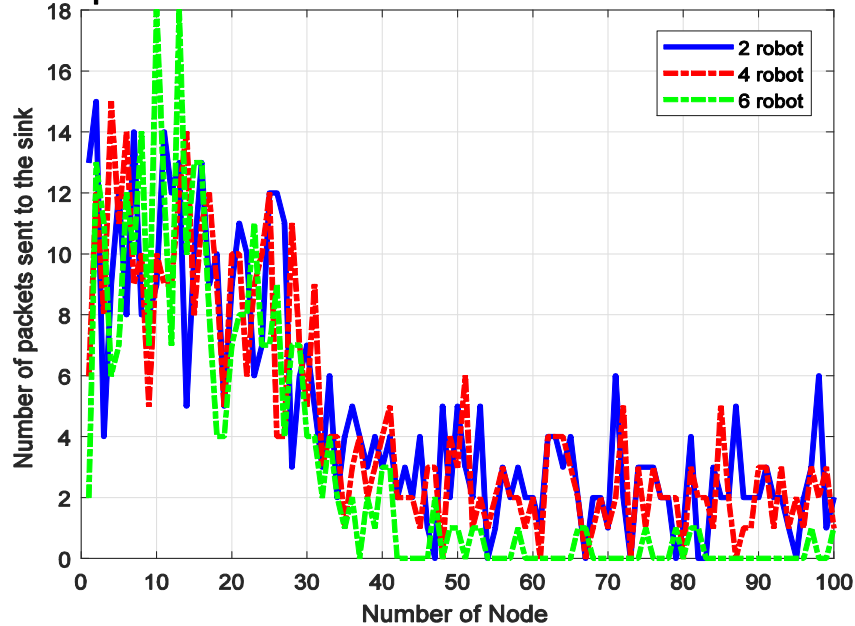


Figure 9. Number of packets sent to the sink

Figure 9 shows the number of packets sent to the sink during the simulation. As can be seen from the figure, the number of packets sent to the sink also increases with increasing robots at simulation time. The connection rate increases while using a topology with a high number of islets. This is due to the fact that the initial topology is associated with a high number of islets, and communications can be provided more quickly by the insertion of some sensors in the islets.

remaining energy of network with the increase of robots at simulation time

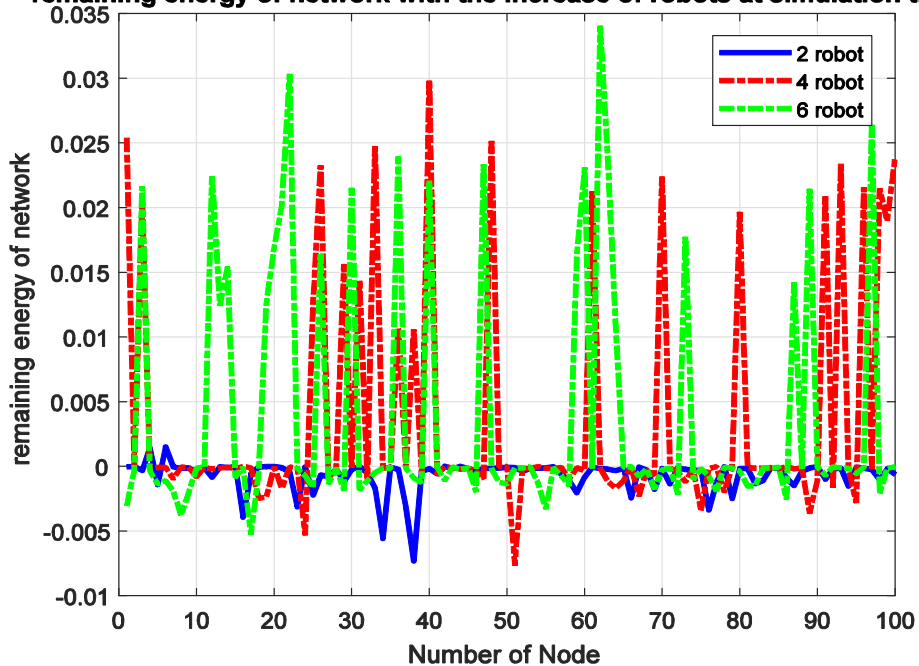


Figure 10. Remaining Energy of Network

Figure 10 shows the remaining energy of the network during simulation, the energy value of each sensor is 0.01 Jules, taking into account that 100 network energy sensors equals to 1 Jules, by increasing the number of robots in the network and replacing the lost sensors with the new sensors, the remaining energy of the network will increase.

6. Result

In this study, a new design for transfer and transport in sensor networks was presented using the imperialist competitive algorithm, which was used for mobile robots to improve coverage and connections in different areas. In this method, by inactivating unnecessary nodes in the network and using robots to discover the topology, collecting additional sensors, and eventually replacing the sensors in the revolutionary stage of imperialist competitive algorithms, network's energy consumption have been greatly saved and longevity of the network have increased, and the robots heal their cavities by replacing the disabled sensor with their sensors and thus improved coverage and connectivity. The proposed method focuses on how to use the approaches through initial and random use to complete coverage and connectivity points. Our solution is based on the scale and specific geographic situation where the sensors are first positioned and set on the islets. We used hexagonal pavements and cluster algorithms with these sections.

The simulated results show that the proposed method performance has been effective both in increasing connections and coverage. The results have proven that using only a small number of robots and the use of the imperialist competitive algorithm, can significantly improve the coverage rate after the simple intersection of robots from the recorded areas. As a result, it can be concluded that changes in the topology of a network can improve the connection status and the change in the topology of a network can reduce the power dissipation in a wireless sensor network. The results of the simulation of the new algorithm showed that our algorithm was able to improve the previous algorithms:

- Increase network longevity
- Improved connection and coverage

Considering the benefits of routing methods, extensive research is under way on the development of these kinds of protocols.

However, there are still major problems such as energy consumption of nodes, power consumption, geographical location of the network, environmental constraints, as well as user requirements and the quality of service, depending on the type of application and topology of networks, as well as radio interactions between different paths between wireless sensor networks that are a lot of available research background for them, and researchers are looking to improve the performance status and reducing power consumption of these types of networks.

Resources

- [1] Snehal P. Dongarea , Prof. R. S. Mangrulkarb,“ Optimal Cluster Head Selection Based Energy Efficient Technique for Defending against Gray Hole and Black Hole Attacks in Wireless Sensor Networks” *Procedia Computer Science* Vol: 78 pp 423 – 430, 2016.
- [2] G. Han, J. Jiang, C. Zhang, T. Q. Duong, M. Guizani, and G. K.Karagiannidis, “A survey on mobile anchor node assisted localization in wireless sensor networks,” *IEEE Commun. Surveys Tutorials*, vol. 18, no. 3, pp. 2220–2243, third quarter 2016.

- [3] S. Salari, S. Shahbazpanahi, and K. Ozdemir, "Mobility-aided wireless sensor network localization via semidefinite programming," *IEEE Trans. Wireless Commun.*, vol. 12, no. 12, pp. 5966–5978, Dec. 2013.
- [4] S. Tomic, M. Beko, and R. Dinis, "RSS-based localization in wireless sensor networks using convex relaxation: Noncooperative and cooperative schemes," *IEEE Trans Veh. Tech.*, vol. 64, no. 5, pp. 2037–2050, May 2015.
- [5] S. Salari, I. Kim, F. Chan "Distributed Cooperative Localization for Mobile Wireless Sensor Networks," *IEEE Wireless Communications Letters*, Vol: pp.2162-2337, Issue: 99 2017.
- [6] S. EL KHEDIRIA, N. NASRI, A. WEI, A. KACHOURID, "A New Approach for Clustering in Wireless Sensors Networks Based on LEACH," *Procedia Computer Science* Vol: 32 pp 1180 – 1185, 2014.
- [7] M. Bani. Yassein, A. Al-zoubi Y. Khamayseh and W. Mardini "Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)," *International Journal of Digital Content Technology and its Applications*. 2009.
- [8] J. Corn and J. W. Bruce "Clustering algorithm for improved network lifetime of mobile wireless sensor networks" *Computing, Networking and Communications (ICNC)*, 2017.
- [9] Sohrabi, M. K., & Khorramian, E. (2015). An Efficient Protocol for Data Aggregation in Wireless Sensor Networks. *Journal of Advances in Computer Research*, 6(4), 53-67.
- [10] Omidvar, R., Parvin, H., Rad, F., Eskandari, A., & Chamkoori, A. (2017). A New Dynamic Clustering Control Method in Wireless Sensor Networks. *Journal of Advances in Computer Research*, 8(3), 19-29.
- [11] Hatamian, M., Barati, H., & Movaghar, A. (2015). A new greedy geographical routing in wireless sensor networks. *Journal of Advances in Computer Research*, 6(1), 9-18.
- [12] O. Pourgalehdari, M. Salari, (2017). A Review on Data Aggregation Protocols in Wireless Networks. *International Journal of Computer Sciences and Engineering*, 5(3), 50-56.

Final Approval