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An energy efficient sensor movement approach using multi-parameter reverse glowworm swarm optimization algorithm in mobile wireless sensor network

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ABSTRACT

In mobile wireless sensor network, coverage and energy conservation are two prime issues. Sensor movement is required to achieve high coverage. But sensor movement is one of the main factors of energy consumption in mobile wireless sensor network. Therefore, coverage and energy conservation are correlated issues and quite difficult to achieve at the same time. In this paper, these conflicting issues are considered, using one of the latest Bio-inspired algorithms, known as Glowworm Swarm Optimization algorithm. Considering the limited energy of sensors, this paper presents an Energy Efficient Multi-Parameter Reverse Glowworm Swarm Optimization (EEMRGSO) algorithm, to move the sensors in an energy efficient manner. Our proposed algorithm reduces redundant coverage area by moving the sensors from densely deployed areas to some predefined grid points. In this proposed algorithm, energy consumption is reduced by decreasing the number of moving sensors as well as the total distance traversed. Simulation results show that, our proposed EEMRGSO algorithm reduces total energy consumption utmost 60% compared to the existing approach based on Glowworm Swarm Optimization algorithm. At the same time, our proposed algorithm reduces the number of overlapped sensors significantly and achieves an effective coverage of 80–89% approximately.

1. Introduction

In the past few years, wireless sensor network (WSN) is applied in diverse application areas including business, transportation, health-care, environmental monitoring and industrial automation. A large number of sensors are deployed in the area to be monitored. Mobile sensors are more efficient to cover the region than static sensors. Since mobile sensors are deployed arbitrarily at the time of initialization, energy efficiency is one of the main concerns in this scenario. The movement of sensors towards each other should be in an energy efficient manner. From past few years swarm intelligence has been used in diverse fields [1–16] including WSN intended for coverage optimization, network lifetime optimization, energy efficient routing and efficient deployment of sensor nodes.

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Table 1
Properties of GSO applicable to mobile sensor network.

Properties of GSO	Properties of mobile sensor network
In GSO luciferin is associated with glowworms. Emitted light intensity of a glowworm is proportional to the luciferin value.	Each sensor has battery power within it which determines the ability of receiving and transmitting data.
A glowworm identifies another glowworm as a neighbor, when it is located within its neighborhood range.	In WSN a sensor identifies another sensor as a neighbor, when it is located within its neighborhood range.
Local information used.	Information within the sensing region is used.
Useful for applications where the neighborhood size is defined by the limited sensing range of the mobile agents.	The neighborhood size is defined by the limited sensor range of the mobile sensors.
Luciferin information is used to select target neighbor.	Sensor nodes residual battery power is used to select target neighbor sensor.
GSO is very useful for dynamic topology.	Network topology of mobile WSN is dynamic

Glowworm Swarm Optimization (GSO) algorithm is one of the most recent Bio-inspired heuristics for optimization problems. In this paper, based on reverse GSO approach, an energy efficient algorithm, EEMRGSO is proposed for the movement of mobile sensors, where every sensor node is considered as an individual glowworm. Due to random sensor deployment, two nodes can have the same coverage area. It results in the redundancy of network coverage, which is wastage of the precious sensor resources. Therefore, efficient sensor movement is needed for effective coverage. In this view, mobile WSN is better than static WSN for network coverage. However, the movement of sensor nodes consumes a considerable amount of energy for which the sensor network exhausts early. In our proposed EEMRGSO algorithm, an energy efficient sensor movement approach is proposed to optimize the energy consumption by reducing the number of sensor movements as well as the total distance traversed. Our proposed algorithm also reduces the number of sensors overlapped to minimize the redundancy of coverage area.

2. Motivation of our work

Several optimization algorithms exist for mobile WSN [1–16]. Though particle swarm optimization (PSO) is very useful optimization algorithm for dynamic topology [7–8,10], in PSO the dynamic neighborhood is achieved by evaluating the first k neighbors. Such a neighborhood topology is limited to computational models only and is not applicable in a realistic scenario, which is required in our proposed approach. Table 1 shows the features for which GSO algorithm is chosen as a suitable optimization algorithm for our proposed mobile WSN. GSO algorithm is based on the behavior of glowworms. Glowworms have luminescent quality called luciferin with them for which we can see cold light [1]. According to the nature of glowworms, they always move towards their neighbors having brighter luciferin than its own. But in our approach, a sensor node is attracted towards its neighbor which has lowest battery power to maximize the coverage, which is reverse of the characteristics of the glowworm. One more difference with GSO algorithm is, in our approach it is considered that each sensor will have some memory element in it.

In WSN higher the coverage rate, higher is the quality of service. Usually mobile sensors are more efficient to cover a region under observation. But in mobile sensor network a significant amount of energy consumption happens due to movement of the sensors which reduces the network lifetime. In mobile WSN, energy consumption mainly depends on the number of sensor movement and the traversed distance. Another issue of WSN is redundant coverage area. After random sensor deployment, two nodes can have the same coverage area. This results in the redundancy of network coverage. It may lead to wastage of the precious sensor resources. So motivation of our work is to

(i) Reduce energy consumption due to sensor movement by decreasing the number of moving sensor nodes.
(ii) Reduce energy consumption by minimizing the distance of moving sensor from the target sensor as much as possible.
(iii) Reduce the number of overlapped sensors, therefore minimizing the redundancy of the coverage area.

3. Authors contribution

According to the basic GSO algorithm [1,4] every glowworm calculates a probabilistic value to select its neighboring glowworm which has a higher intensity of luciferin than its own. The glowworm decides to move towards the selected glowworm on the basis of this probability value. For each glowworm *i*, the probability of movement towards a neighbor *k* is as follows,

$$p_{ik}(t) = \frac{f_k(t) - f_i(t)}{\sum_{j\in G_i(t)} f_j(t) - f_i(t)} \tag{1}$$

where $f_i(t)$ represents the luciferin level associated with glowworm i at time t· $G_i(t)$ is the set of neighbors of glowworm i at time t and is denoted as, $G_i(t) = \{k : d_{ik}(t) < {r_d}^i(t); f_i(t) < f_k(t)\}$ and $k \in G_i(t)$. Euclidian distance between glowworms i and k is represented as $d_{ik}(t)$ at time t and ${r_d}^i(t)$ signifies the variable neighborhood range associated with glowworm i at time t.