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Research paper

Simulation of AI based PSO algorithm in WSN

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Abstract

In the evolving technologies, the Wireless Sensor Network (WSN) has perceived tremendous influences in the past two decades for rectifying the problems of energy immorality to certify the rate of energy consumption of nodes in dynamic deployment and the average computation time. It has been analyzed that, the Particle Swarm Optimization (PSO) algorithm is deliberated as one of the best suited algorithms for Dynamic Deployment of nodes in WSN. It is also examined that, the PSO algorithm doesn't have dynamic support in sustaining the rate of energy consumption limit and moderate computation time. Hence, this work presents a novel idea where the rate of energy consumption in dynamic deployment of nodes and average computation time of information is reduced by applying the Artificial Intelligence (AI) technique to the existing PSO algorithm. This paper also discusses the complete algorithm and its architecture based on AI.

Keywords:*Wireless Sensor Network; Computation Time; Particle Swarm Optimization; Energy Consumption; Artificial Intelligence*.

1. Introduction

Wireless Sensor Network (WSN) is a network, which is self-organized by the huge number of tiny sensor nodes (also called as Motes) and is deployed in the selected area. These sensor nodes carry out the transmission of data among themselves within the deployed range. The data transmission is carried out in such a way that, it is sensed, observed and recognized for an application of real world environment. This network consists of a large number of nodes that communicate and sense the locality either with an external base station (BS) or among themselves. The main features of these nodes are tiny in size, lower cost, lesser computation power, easier short distance communication and multitasking (data sensing, processing and data routing).

In a selected hostile area, these nodes are deployed that seems to be difficult for recharging of nodes. However, many research techniques and works are performed for the purpose of preserving the rate of energy consumption in the nodes and hence the recognized scalability as the main need for the applications of WSN [2]. By carrying out this work, results in prolong of the network life. This extended life of network, reliable data transmission, rate of energy consumption, data computation time are the key requirements of the applications of WSN. Due to the different problems or constraints of sensor nodes, the WSN has many issues in terms of area coverage, lifetime of network and data segregation and scheduling [2].

The Figure 1.1 describes the architecture of WSN consisting of Base Station, and other external communication entities along with the sensor nodes. This large number of nodes are deployed and mounted on the basis of type of applications of WSN. The BS (Static or Dynamic) is placed very close (or within the area of deployment of nodes) to the node deployment. The BS acts as a transmission media between the area of node deployment and external server. The nodes in WSN, consume an inconsistent amount of energy for data transmission and the energy required in the form of battery power differs with respect to the multihop transmission and location of source and destination nodes. In this approach, the BS is stable whereas the remaining nodes are dynamically deployed in the region of application.

Based on K-Nearest Neighbor (KNN) algorithm-a basic and well-known algorithm in Machine Learning (ML), the clusters are formed and a head of all clusters is formed and is called as Cluster Head (CH). The nodes forming the clusters transmit the data to the CH and from there to the BS and further to the External Server and end-users, with the minimum path cost. The minimum path cost of the transmission from source to the destination node is calculated by applying Euclidean-Distance algorithm.

a) Data Transmission and Cluster Formation In WSN

In this work, the sensor nodes, acting as source nodes are dynamically deployed in the selected area to sense and process the data. The destination node that is BS node is static in nature. The nodes are forming the clusters based on KNN algorithm and among these clusters one node is treated as CH. The Figure 1.2 explains the clusters and CH formation in the network [6] and also the data transmission from node to the BS through CH.

b) Motivation to the Work

The main motivation to this work is to enhance the performance of network by minimizing the rate of energy consumption using PSO algorithm with an approach of AI. The average energy of each node and rate of computation time for data transmission are also enhanced. For exploiting the life of WSN network, the average energy of every node of network plays a vital role. Hence the only nodes those are reachable to the static BS with the minimal path cost [1] based on Euclidean distance, are considered for data transmission. Hence in general, this work mainly focuses on, the rate of energy consumption of network, an average energy of each node and the rate of computation time (data transmission time) are implemented based on PSO, KNN and Euclidean Distance algorithms.

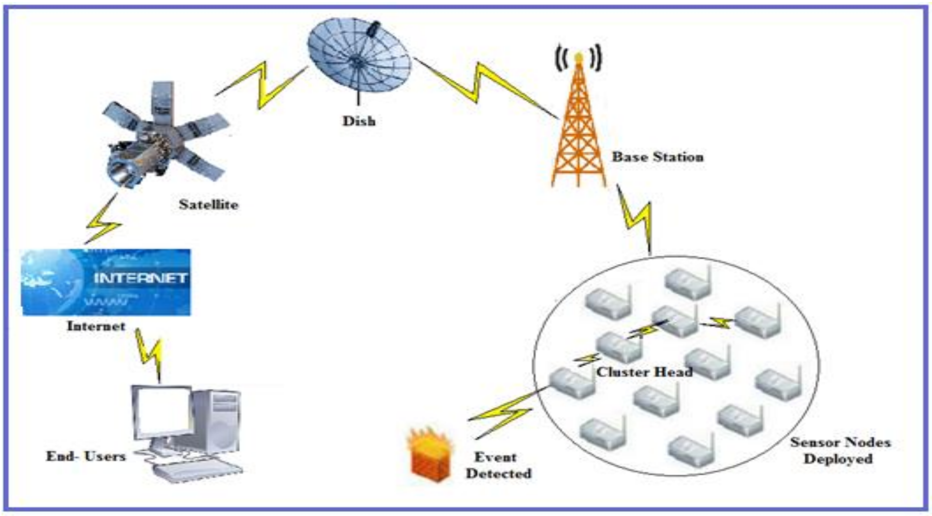

Fig. 1.1: Architecture of WSN.

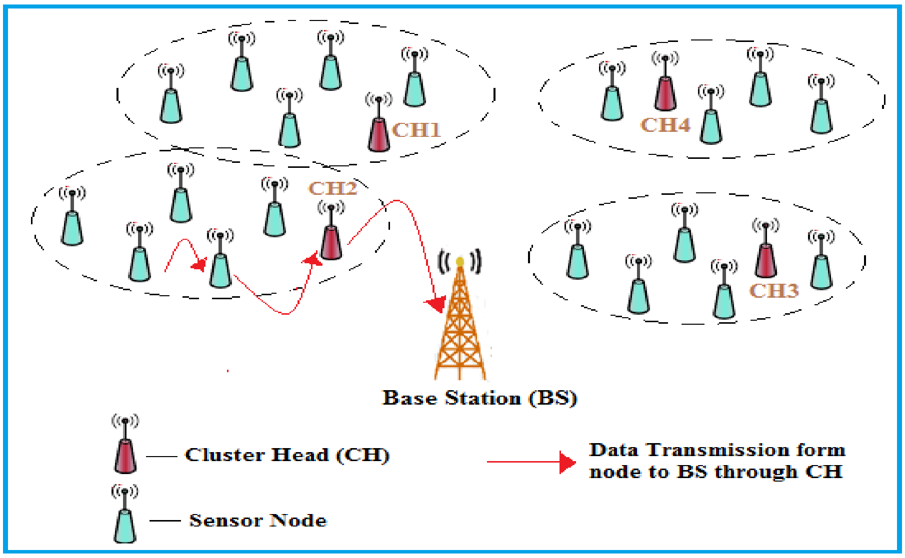

Fig. 1.2: Clusters and CH Formation in WSN.

This work is continuation of our previous implementation of ABC algorithm, a dynamic deployment algorithm with an approach of AI [1]. In this paper the rate of energy consumption was evaluated with an application of AI using, Bellman-Ford Shortest Path Algorithm.

The rest of the paper is structured as follows; Section 2 briefs about the analysis and contribution of existing PSO algorithm, Section 3 analysis AI and ML, Section 4 explains the Implementation, Section 5 discusses the Results and Section 6 concludes along with the future enhancements.

2. Analysis of PSO algorithm

Particle Swarm Optimization algorithm is a computational, global and bioinspired stochastic search algorithm and is proposed by J. Kennedy and R. Eberhart [3-6]. PSO algorithm supports both the static and dynamic node deployment applications [6]. This algorithm represents the behavior of flock of birds or Fish School [4]. This algorithm consists of candidate solutions named as Particles. The movement of these particles is guided and is also influenced by the finest known spots in the search space and is kept on updating for best positions based on the parameter considered in an application of WSN.

The particles of PSO algorithm explore an n-dimensional hyperspace in the global solution search [6]. Here n-represents the number of ideal parameters that are to be determined. Let i be one of the particles that occupies a X_{id} position in the area of deployment. Here d- represents the dimension of particle's position. Similarly the velocity of this particle is represented as V_{id}. According to the hypothesis [10-14] of PSO algorithm, it is observed that, $1 \leq i \leq s$, and $1 \leq d \leq n$ where s-represents the swarm of candidate solutions (particles). In PSO, the position at which the i-particle has minimal cost related to the parameter is considered as $Pbest_{id}$ and similarly $Gbest_{id}$ is represented for the maximal cost.

In every iteration-k, the position-X and velocity-V are calculated using the following equations (1) and (2).

$$V_{id}(k+1) = \omega * (k) + \varphi_1 * r_1(k) * (Pbest_{id} - X_{id}) + \varphi_2 * r_2(k) * (Gbest_{id} - X_{id}) \quad (1)$$

$$X_{id}(k+1) = X_{id}(k) + V_{id}(k+1) \quad (2)$$

In the equations 1 and 2, φ_1 and φ_2 are constants, $r_1(k)$ and $r_2(k)$ are random numbers those are distributed in the range of [0,1].

The Flow diagram in Figure 2.1 gives an idea of transitions in PSO algorithm [15-17]. The main contribution of PSO algorithm in this work is,

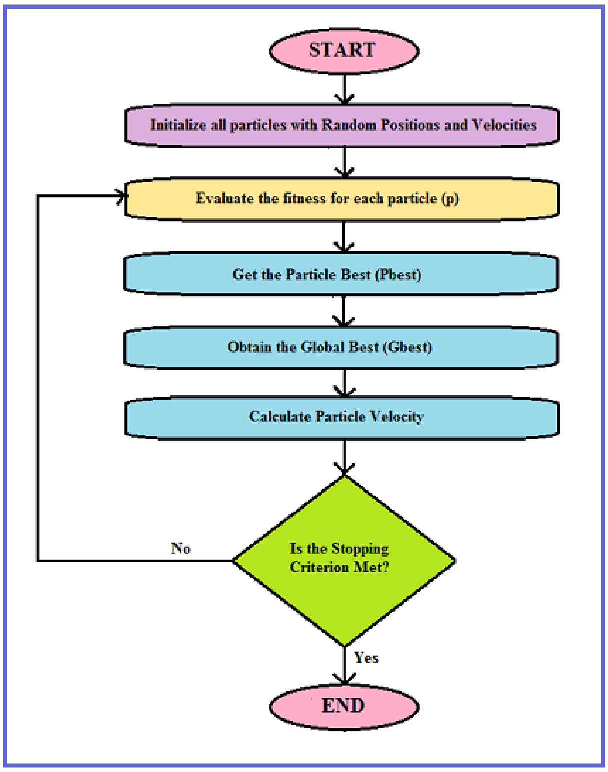

Fig. 2.1: Flowchart of PSO Algorithm.

3. Analysis of artificial intelligence and machine learning

Artificial Intelligence is the domain that deals about the simulation of Intelligence to the computers or any machines. AI enables any system more accurate in analyzing the problem and forecasting the results. Machine Learning (ML) is a methodology of data analysis and is a branch of AI. ML plays a vital role in adopting the algorithms which can collect an input data and computes an output using the statistical analysis which predicts the output within adequate results. K-Nearest Neighbor (KNN) algorithm [9] is one of the simplest and most standard and widespread algorithms in Machine Learning. Even with its simplicity feature, KNN algorithm gives more competitive results.

a) Analysis of KNN Algorithm:

KNN algorithm is a non-parametric learning algorithm. This algorithm is also called as a Lazy algorithm as it does not make use of any training data points for Generalization. In KNN, there is no training phase is used explicitly. This is widely applied for regression and classification problems. KNN algorithm basically works on three features, like;

i) Ease to understand output
ii) Time of Calculation
iii) Power of prediction

In this work, that considers the KNN algorithm, the value K represents the number of nodes with same distance to destination node and average energy [7] of node. This K-value is found by using a Euclidean Distance algorithm [9] and this algorithm is discussed in brief in the following section. Again this algorithm is studied under two classifications as;

a) 1-Nearest Neighbor classifier and
b) Weighted Nearest Neighbor classifier

Here, the Weighted Nearest Neighbor classifier approach has been adopted as two parameters like same distance and same average energy of node, are considered to find the value of K.

Advantages of KNN algorithm: The following are the main advantages of KNN algorithm.

a) KNN algorithm is very simple for implementation.
b) This algorithm is a versatile.
c) There is no need to undergo assumptions, tune or adjust various parameters or build any model.
d) It is not only applied for regression and classification problems but also applied for Search problems.
e) Analysis of Euclidean Distance Algorithm

Euclidean Distance or Metric is applied to find the distance between any pair of points in any dimensional space. The Figure 3.1 explains to find the distance between the points p and q in Two-Dimensional Space.

In one-dimensional space, the Euclidean distance between the pair of point p and q is found using an equation (3) as below;

$$d(p,q) = \sqrt{(q-p)^2} = |q-p| \quad (3)$$

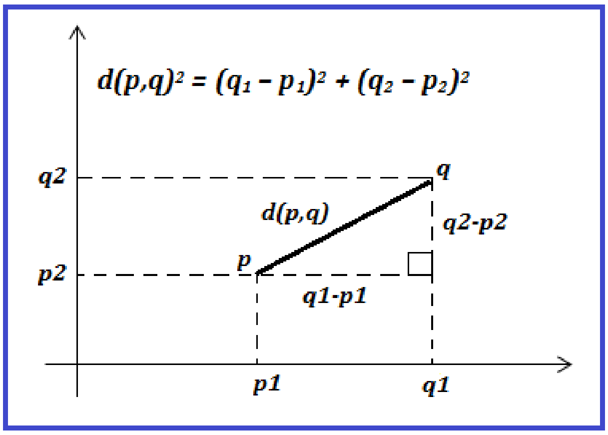

Fig. 3.1: Euclidean Distance between Point P and Q.

In two-dimensional space, the Euclidean distance between the pair of point p and q is found using an equation (4) as below;

$$d(p,q) = \sqrt{(q_1-p_1)^2 + (q_2-p_2)^2} \quad (4)$$

4. Implementation

The simulation of this work is carried out using the MATLAB version R2013a and is mainly focused on minimizing the rate of energy consumption during data transmission, maximizing the average energy of each node and minimizing the data computation time. Based on this work, the Figure 4.1 gives a clear idea of Node Deployment and Data transition. In figure 4.1 the selected area for deployment of 200 sensor nodes is 100X100 square meters and 300 Iterations are carried-out. In figure 4.1 (a), the nodes are dynamically deployed and the destination node called as Base station is a static node. In figure 4.1 (b), the clusters are performed along with the cluster head.

The process of cluster and cluster head formation is based on KNN and Euclidean algorithms. The nodes with the same distance from them to the static BS and with nearly same average energy form the clusters and CH. The data transition takes place as in figure 4.1 (c), this data is transferred to the static BS through CH.

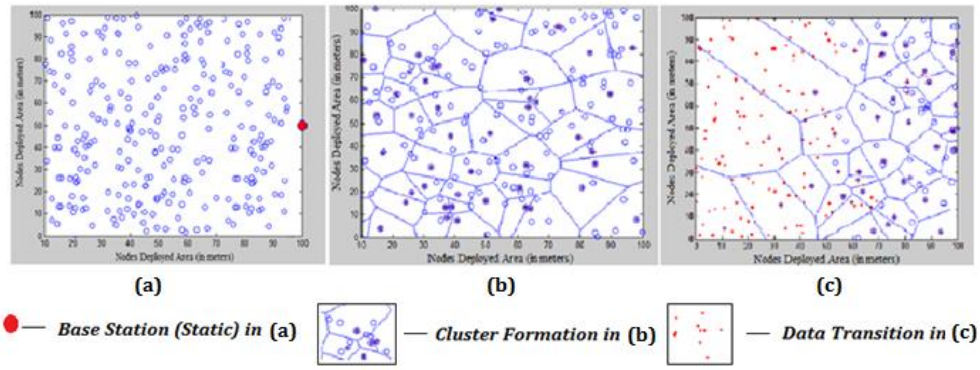

Fig. 4.1: Deployments of Nodes and Data Transition.

5. RESULTS

The table 5.1 briefs about the Number of sensor nodes, network size, that is, size of deployment area, and so on.

Table 5.1: Parameters of Simulation Environment

Parameters	Value
Network Size	100X100 m^2
Number of Sensor Nodes	200
Number of Iterations	300
Best Cost	28.0 J/s
Data Size	5000bits
Mean Cost	89.33 J/s
VarMax	10
VarMin	-10
VarSize	[1,5]

The figure 5.2 (a) gives a computation time of data transition without an AI approach and figure 5.2 (b) gives a computation time of data transition with an approach of AI. In this work, the data transmission happens between the nodes by following the shortest distance between a pair of nodes that is calculated using a Euclidean Distance and KNN algorithm. By observing the graph in figure 5.2 (a), transmission is happening in a normal way without following shortest path between a pair of nodes.

Here the data transition starts at 20th iteration and completes at 50th iteration. Similarly in figure 4.2 (b), the data transition starts at 20thiteration and ends at around 32nd iteration. Hence it is observed that the rate of computation time with an approach of AI is minimum compared to the computation time without an approach of AI.

The figure 5.3 gives the simulation results considering the average energy of each node as one of the parameters. In figure 5.3 (a), without an approach of AI, the average energy of each node reduces to minimum of 0.03 Joules/sec during the 50th iteration. But in (b), with an approach of AI, the average energy of each node average energy is reduced to 0.05 Joules/sec during the same 50th iteration. Hence it is concluded that the average energy of each node is maintained without much loss of energy during data transmission.

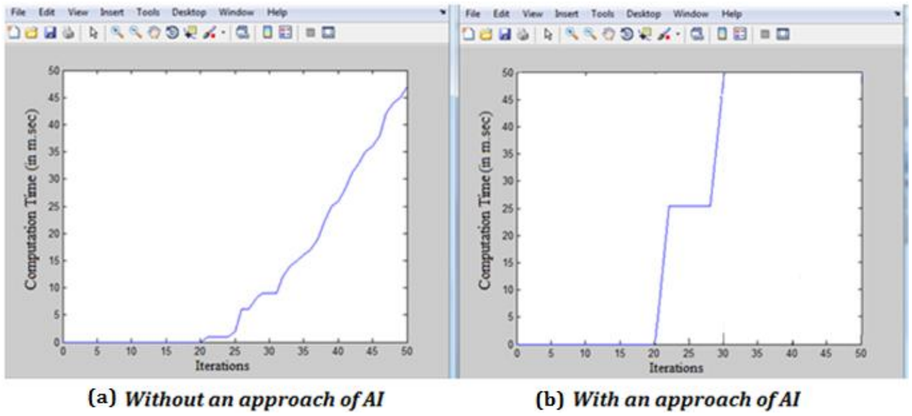

Fig. 5.2: Rate of Computation Time of Data Transition.

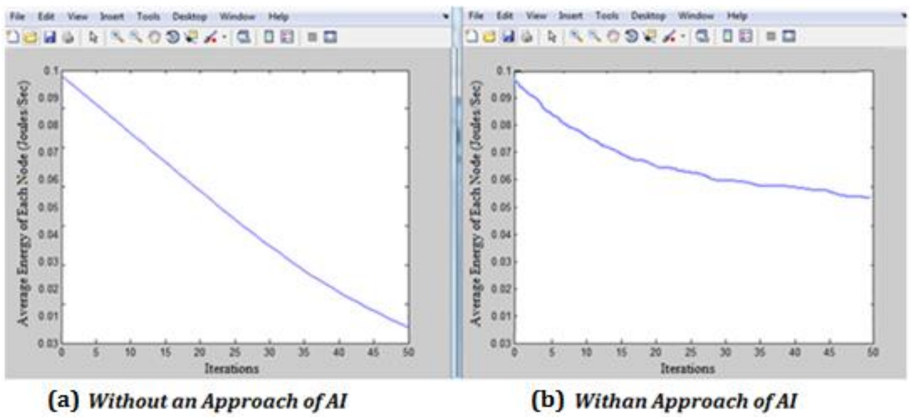

Fig. 5.3: Average Energy of Each Node during Data Transmission.

The figure 5.4 is directly related to the contents in the Table 5.2 and it is observed that, the performance of PSO algorithm with an approach of AI, that is by adopting KNN and Euclidean Distance algorithms, the rate of energy consumption are less compared to the general PSO algorithm.

Table 5.2: Rate of Energy Consumption after Every 50 Iterations

Iterations	Rate of Energy Consumption without an approach of AI	Rate of Energy Consumption with an approach of AI
1	0.45688	0.57794
50	0.34413	0.03125
100	0.33553	0.02565
150	0.33553	0.02379
200	0.31859	0.02095
250	0.31482	0.01893
300	0.31482	0.01778

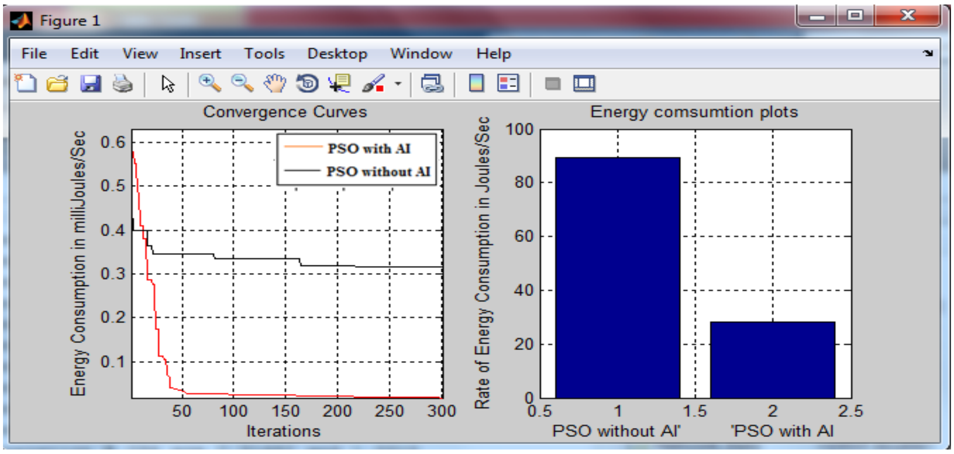

Fig. 5.4: Rate of Energy Consumption Using PSO Algorithm with and Without an Approach of AI.

6. Conclusion and future enhancement

The performance of network in WSN is enhanced by numerous PSO-based cluster and cluster head formation and selection scheme algorithms. This is accompanied in terms of maximizing the throughput by minimizing rate of energy consumption, average energy of each node and reducing the time of computation of data. This PSO algorithm is designed with an approach of KNN applied to form the clusters and cluster heads based on shortest path between pair of nodes again which is found by the using Euclidean Distance Algorithm. The simulation results conclude that, the parameters of WSN satisfy the needs for the better throughput and performance of WSN in the selected area of deployment for the particular application by reducing the rate of energy consumption. This work also concludes that the computation rate of data is higher in PSO algorithm with an approach of AI than without an approach of AI.

The future scope includes an implementation of this PSO algorithm to enhance the performance of WSN by considering the other parameters like Average distance between every pair of nodes, standard deviation and magnitude of attractive force between the nodes.

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