



A New Hybridised (DE-PSO) Approach Using Data Fusion for Lifetime Improvement in WSN

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Abstract— *The design of an energy-efficient wireless sensor network protocol is one of the major issues in wireless sensor networks (WSN). In this paper, the approach for the routing is modified to make a better utilization of the computing environment using data fusion and provide network a better life time and better energy efficiency. Hybrid algorithm using Differential Evolution and Particle Swarm Algorithm is used for wireless sensor networks to improve the network lifetime and to reduce network's overall energy consumption. In order to improve the global optimization property of the Differential Evolution, the PSO is combined as additional mutation operator. Simulation shows that the solution which is proposed helps in finding the optimal cluster heads and has better network lifetime as compared to the traditional clustering algorithms. The simulation results come in favour of what it is designed for to increase in network's life time and data efficiency and reliability of the network data increases.*

Keywords— *energy efficient; WSN; Minimization transmission energy; Differential Evolution; Particle Swarm Algorithm; optimal number of cluster heads; network lifetime*

I. INTRODUCTION

The widely used sensor network used in monitoring systems and various environment and movement monitoring applications are the Wireless sensor networks (WSNs). These network which are collaboratively built by the sensor nodes of very small size (of the size of the coin) using their separate protocols for the communication and transmission of data contains few hundreds of sensors to thousands of sensors. Patient monitoring, animal monitoring, environment monitoring, movement monitoring are few of the applications of these networks. Along with the applicability, flexibility ease of collecting data they also comes up with some of challenges and constraints. Various research and intensive study is being carried out to overcome the shortcoming which may be in form of the constraints or performance degradation. These networks primitively designed to submit the collected data to the base station. Data communication becomes the main focus carried around the field of WSN. Reduction in energy involved in transmission of information is focus area of various researchers, reduction in energy while maintaining the effectiveness of the sensor node is a big step forward for the network efficiency.

In the past few years Differential Evolution and Particle Swarm Algorithm have emerged as a powerful Optimization Tools. Life time measured in terms of the number of rounds treated as life time, maximization of life time (main purpose) which is directly related to efficiency can be achieved by the routing schedules to reduce the network overhead from the duplicated data arising from different nodes, and in addition it can be done by reduction in data by data aggregation. Different approaches are utilized to work on different requirements. Two matrices remain at the central point of the network design and the efficiency i.e. reduction in transmission energy need and increase in network lifetime. Although these terms may appear similar but are having different meaning and are attained by different approaches. E.g. maximizing network lifetime doesn't guarantee in efficient utilization of energy in transmitting data, this may come in compromising with the coverage of the network. Number of nodes actively participating in communication process describes the first metrics while second is based on the residual energy present in network nodes participating in communication process. The encouragement behind this paper is that, in case if the sensor nodes are inappropriately assigned to the cluster heads during cluster formation then there is an overload at the cluster heads which further leads to earlier death of the CHs [16,17]. This makes an increase in the latency and reduction in the performance of the network. In this paper, we make use of Differential Evolution for local search along with Particle Swarm Optimization for global optimal solutions. Here, the proposed hybridized DE and PSO algorithm aim at maximizing the network lifetime of the WSN by optimal search of the cluster heads. The rest of the paper is arranged in the following manner. Section II. gives a brief regarding the related work done for increasing the network lifetime. In Section III., there is a detailed system model regarding the Wireless sensor network. Section IV. details the proposed DE and PSO algorithm. In Section V., simulation results are discussed and Section VI., conclusion of the paper is defined.

II. RELATED WORK

In [1], a scheme is evolved named as ReDAST, for reliability of data. The data so received go through the process of data acquisition and the simulation is presented in the presence of faulty nodes whose behaviour is unpredictable,

sometimes when the nature of the network and conditions around these nodes is favourable they behave normally but in case some of the circumstances or the situation of the network is against the favouring nature these nodes stop responding, the respond of these nodes effect the size of the network and so the routing in the network. The size decreases with unavailability of these nodes and then this reduced size increases with the respond of these nodes. The behaviour and the area coverage at a time is totally dependent on the nodes present in the network so the big difference arises in the routing requirements and the coverage with the increase and decrease in number of nodes in the network. To prevent the loss arising due to transfaulty nature of the nodes the dual mode of the nodes is used in the network. Data fusion technique is used to process the data to get the information from the redundant information.

In [2], concern is shown towards the data fusion base attack which comes in the form of Denial – of – Service (DoS). Resilient Control System popularly known as RCS is defined in terms of Joint Directors of Laboratories framework for data fusion. A decision hierarchy is built at different levels. To drive the derivation condition along with the existence, interdependency consideration due to observance between different levels of JDL is done. The model so built is finding its application in Load Frequency Control (LFC) for the power system, which work as a measure to verify effectiveness.

In [3], the review of the various data fusion methods adopted along with the various other techniques and schemes is presented. The data aggregation is explored to much higher level as compared to the data fusion as a result is not able to get its share of attention of the research according to its importance in the field of data pre-processing by removing the duplicate values while preserving the data effectiveness for the data interpolation. The outcomes arising due to extensive exploration of each and every technique studied is represented as the comparison for these techniques.

In [15], model presented as a result of extensive research provides the correct sequence for the performing different activities. Popularly known as OODA, the first comes Observe, then the second which provides the execution of Orientation task(orient in short), then comes the Decide (decision making about the supported and unsupported values – the value generated from the actual collection of data and generated by error) , at last comes the act – the information gathering from the nodes , this step is performed in case of sensor nodes by the base station which may be situated in the middle spot or any other spot randomly- in accordance with the application.

III. NETWORK MODEL

The energy dissipation model is a free space model which comprises of the transmitter and receiver with a distance between them, d . The transmission segment comprises of transmit electronics and transmission amplifier and the receiving segment comprises of receive electronics part so that the data can be transmitted in terms of bits. Assume a set of sensors is deployed on a rectangular field [18]. The energy consumed by the sensor nodes to transmit (ET) and receive (ER) the information (n) over the distance (d) is given in Eqs. as described below:-

The energy consumption for the transmission of message is given by:

$$ET = \begin{cases} n \times E_{elec} + (n \times E_{fs} \times d^2), & d < d_{avg} \\ n \times E_{elec} + (n \times E_{amp} \times d^4), & d \geq d_{avg} \end{cases}$$

Where $d_{avg} = \sqrt{\frac{E_{fs}}{E_{amp}}}$, where E_{elec} is the energy dissipated to send one bit of data to run the transmitter or the receiver circuit, E_{fs} and E_{amp} depend on the transmitter amplifier model which has been used under multipath consideration and d denotes the distance connecting between the sender node and the receiver node.

The energy consumption for receiving the message is given by:

$$ER = n \times E_{elec}$$

The Following properties regarding the system is anticipated-

- All sensor nodes are homogeneous in nature.
- When the energy among the nodes is debilitated and over then only the nodes are considered to die.
- Here, we are considering only a single base station outside the application area.
- All the nodes have information regarding their location and once they are deployed in the field, the nodes are stationary.
- The nodes are self-organizing and there is no need to observe after the deployment is done.

IV. PROPOSED HYBRIDISED DIFFERENTIAL EVOLUTION AND PARTICLE SWARM OPTIMIZATION(DE-PSO) ALGORITHM

A. Overview DE-PSO

In this paper we have proposed a clear hybridized version of Differential Evolution and Particle Swarm Optimization, called DE-PSO. DE-PSO starts with the usual Differential Evolution and incorporated Particle Swarm Optimization to reach to the optimal solution. The algorithm has been designed so that the strengths of both the algorithms can be preserved. Results have proved that the proposed DE-PSO is quite competent for solving the considered test functions as well as real life problems. Differential evolution is basically a meta-heuristic evolutionary algorithm [19]. Also, DE is a simple, easily compliant algorithm for optimization of multimodal search spaces. Both GA and DE are evolutionary approaches. There exist some changes from GA though. In GA crossover is applied first which is followed by mutation which is the other way in the case of DE.

In Genetic Algorithm, mutation is used so as to support diversity of population and hence applied occasionally. On the other hand Differential Evolution uses mutation operation in every generation to produce a better offspring. In GA

there is a binary representation while DE can make use of set of real numbers [20,21]. PSO can be referred as a computational technique that optimizes an issue by using a series of iterations attempting to enhance a candidate solution regarding given quality measure or application. PSO generally optimizes an issue based on candidate population in the search-space in conformity with the mathematical formulae over velocity and position of the particle. With each iteration, the velocity of the particle faces an updation of each particle using the current velocity of the particle and the previous local_best and global_best position [22,23]. Based on it, new_velocity, new_position of the particle can be estimated. The same procedure is repeated for each iteration. The two equations for the working of PSO are that of velocity vector and position vector which are expressed as below:

$$vid = \varphi vid + c1r1(pid - xid) + c2r2(pgd - xid) \quad (1)$$

$$xid = xid + vid \quad (2)$$

The first part of equation (1) is the representation of the inertia of the velocity which is previous, the second part tells us about the personal thinking (traits) of the particle and the third part is the representation of the cooperation among particles and is therefore named as the social component. c1, c2 are the acceleration constants and φ is the inertia weight which φ are predefined by the user and rand1, rand2 are the uniformly generated random numbers.

B. DE-PSO Algorithm for Proposed Solution

The proposed DE-PSO as mentioned is basically a hybridized version of Differential Evolution and Particle Swarm Optimization. DE-PSO starts like the regular DE algorithm up to the point when there is a generation of trail vector. If the condition is satisfied by the trail vector given, then it is incorporated in the population otherwise the algorithm enters the PSO phase and helps in generation of a new candidate solution. The method is repeated iteratively until the optimum value is reached. The addition of PSO phase creates a commotion in the population, which therefore helps in the maintenance of the diversity of the population and producing a feasible optimal solution.

The pseudo code of the Hybrid DE and PSO (DE-PSO)

Algorithm is:

Initialization of the population

For i = 1 to N (Size of the population) do

Select rand1, rand2, rand3 $\square \square$ N randomly

// rand1, rand2, rand3 are selected such that rand1 \neq rand2 \neq rand3 //

For j = 1 to D (dimension) do

Select jrand \square D

If (rand () < CrossoverRate or j = jrand)

// rand () denotes a identically distributed random

Number between 0 and 1 //

Candidate_{ji,g+1} \square \square X_{rand1,g} \square DW \times (X_{rand2,g} - X_{rand3,g})

End if

If (f(Candidate_{ji,g+1}) \square \square f(X_{ji,g}) \square) then

\square X_{ji,g+1} = Candidate_{ji,g+1}

Else

PSO activated

Find a new particle using equations (1) and (2).

(Let this particle be NK_{ji})

If (f(NK_{ji}) \square \square f(X_{ji,g}) \square) then

X_{ji,g+1} = NK_{ji}

Else X_{ji,g+1} = X_{ji,g}

End if

End if

End for

End for.

Fitness Function- The sustainability of an individual highly depends upon the fitness value. There is a fitness function based upon which fitness value of every individual is calculated. In our study, Fitness function comprises of the following three parameters-

- Remaining Energy(E)
- Distance from Cluster Heads to Base Station(BSD)
- Total Intra-Cluster Communication Distance(IC)

After Scaling the fitness function, we have the fitness function as:

$$\text{Fitness} = E + \frac{IC}{N} + \frac{BSD}{N}$$

Where n=total number of nodes in the network. Fitness Function signifies that there is more attention on decreasing total distance from base station to cluster heads.

V. SIMULATION RESULTS AND ANALYSIS

The simulation was carried out using Matlab 2012 simulator. Along with DE-PSO, the performance of the network is analysed for GA, LEACH-GA algorithm. The parameters [23,24] taken into consideration for simulating the network are shown in Table I. The network parameters such as the number of dead nodes, number of alive nodes, half node dead, last node dead, energy consumption and throughput are analysed and plotted against the number of rounds. The wireless sensor network comprises of various sensor nodes deployed randomly as shown in Fig.1

Table II Simulation Parameters

PARAMETERS		VALUES
Number of nodes(N)		50
Network area		100×100m ²
Size of population		100
Length of chromosome		N
Differential Weight (F)		0.5
Crossover probability (CR)		0.2
Initial Energy		0.5
Data Packet size		4000 bits
Transmitter	Electronics	50nJ/bit
(E_{elec})		5nJ/bit/report
Data Aggregation (E_{da})		10pJ/bit/m ²
Transmit amplifier (E_{fs})		0.0013pJ/bit/m ²
Transmit amplifier (E_{amp})		

The WSN comprises of several nodes deployed randomly as shown in Fig. 1. These are now grouped into small sectors called clusters. The number of nodes are 50 and the network area is 100×100m².

Following are some simulation metrics which are considered for the analysis of effect of homogeneous nodes on the execution of clustering algorithms.

- Node Death Rate: This demonstrates the total number of nodes which are alive over rounds. A lower node death rate happens because of network load balance. The area of the node death rate is divided among stable region as well as unstable region. All nodes are alive in the stable region while rest of the region is unstable.
- Network Lifetime: It can be defined as the period of time when the network is in a working state. It basically classifies lifetime of network in three parts First Node Death (FND), Half Node Death (HND), and Last Node Death (LND).

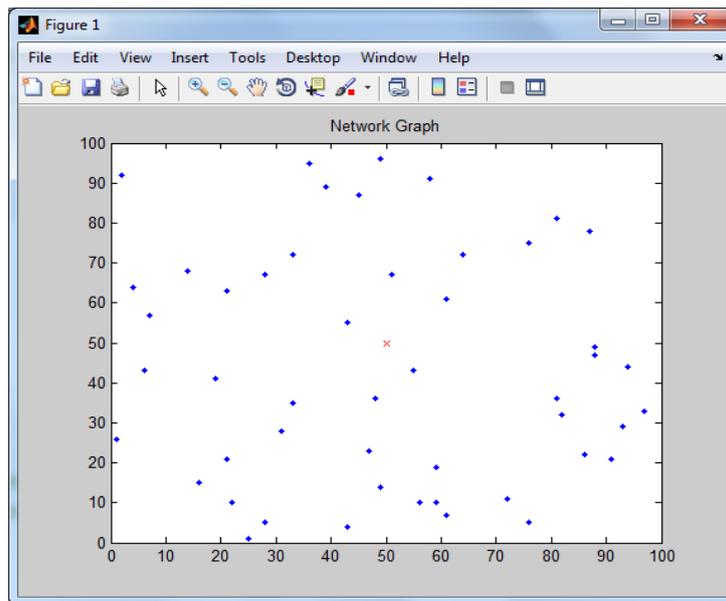


Fig.1 Random Deployment (Network Graph) of Wireless Sensor Network.

Fig 2. Shows the comparison of half node dead. It shows the half number of node dead (50%) graph between GA and DE-PSO for number of nodes in terms of rounds. For 50 number of nodes, the half number of nodes in GA and DE-PSO were dead in 972 and 978 number of rounds respectively. Hence it is clearly shown that the proposed algorithm performs better than the GA(Genetic algorithms).

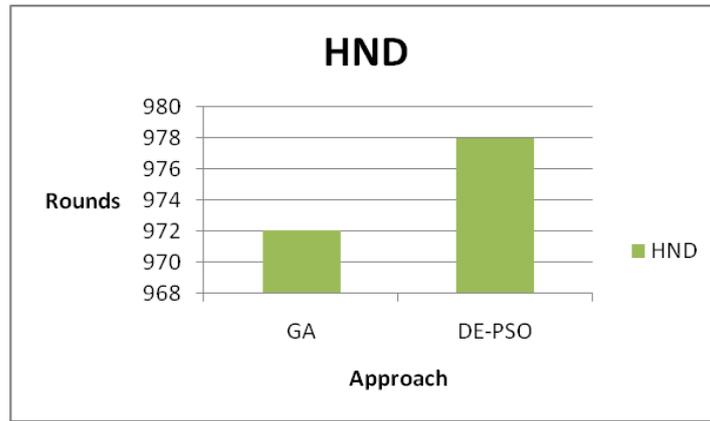


Fig.2. Half node dead (HND) comparison over number of rounds.

Fig 3 shows the Last Node Dead (100%) graph between GA and DE-PSO for 50 number of nodes in terms of rounds. The last node dead for GA was in 1427 and for DE-PSO was in 1543 number of round respectively. Overall from each of these three graphs it is clear that in DE-PSO algorithm nodes survive longer than GA. Thus DE-PSO prolong network lifetime than GA.

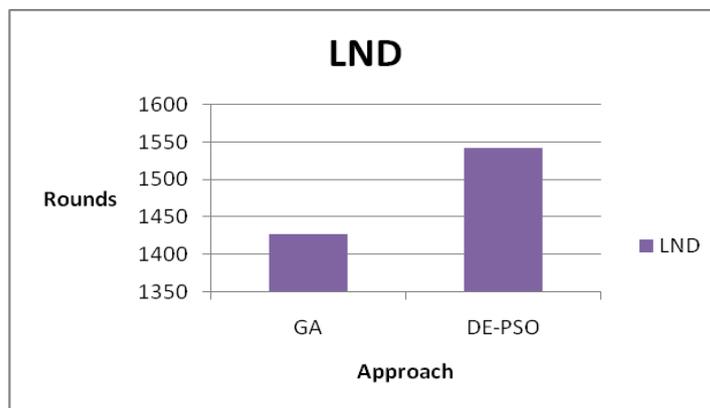


Fig.3. Last Node Dead (LND) comparison over number of rounds

The remaining energy of the network with varying number of rounds is shown in Fig. 4. It depicts the energy remaining after every round. The batteries employed in the WSN are very Minimal in size and cannot be replaced hence, the consumption of energy by residual energy must be as minimal as possible. From the graphs we can conclude that in the proposed DE-PSO algorithm, the remaining energy of the network is more than when compared to GA. The reason behind this is the selection of a suitable fitness function which generates a better candidate. The remaining node energy of all sensors at the end of simulation has been plotted in Fig 4. Energy consumption by the network is calculated by summarizing the network nodes residual energy and getting it plotted against the number of rounds of the network provides the outlook of energy requirement of the network at any stage. Reduction in energy requirement for the network directly communicates the network efficiency.

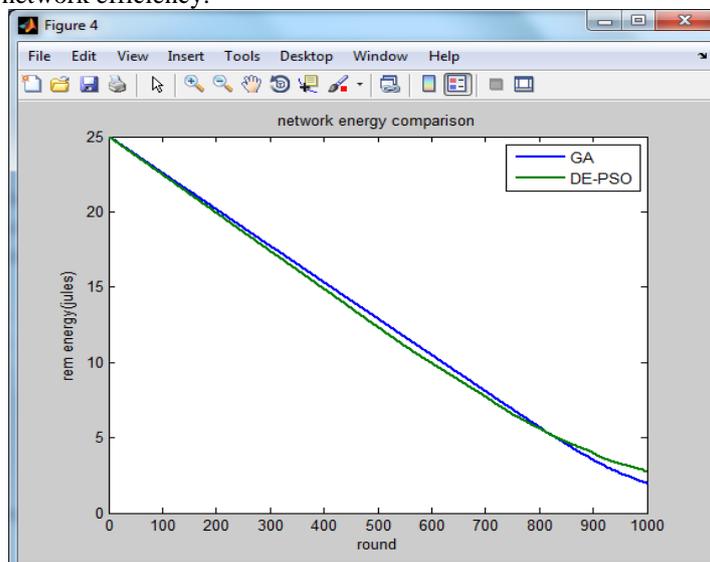


Fig.4 Remaining energy by the network/number of rounds

Figure 5 shows comparison of node death rate of LEACH-GA and proposed DE-PSO. Death rate of node is divided into two segments: stable region and unstable region. All the nodes are alive in the stable region and therefore unstable region have a few number of alive nodes. In LEACH there is a random selection of cluster head so there is a probability that a node with less remaining energy could get selected for cluster head which therefore has a capability to die early and the network gets unbalanced. GA does not have a capability to consider communication of intra-cluster distance and also does not optimize number of cluster heads in each round. Proposed DE-PSO has a capability to optimize number and optimize the selection of cluster heads, therefore has a better load balance of network compared to previous algorithms.

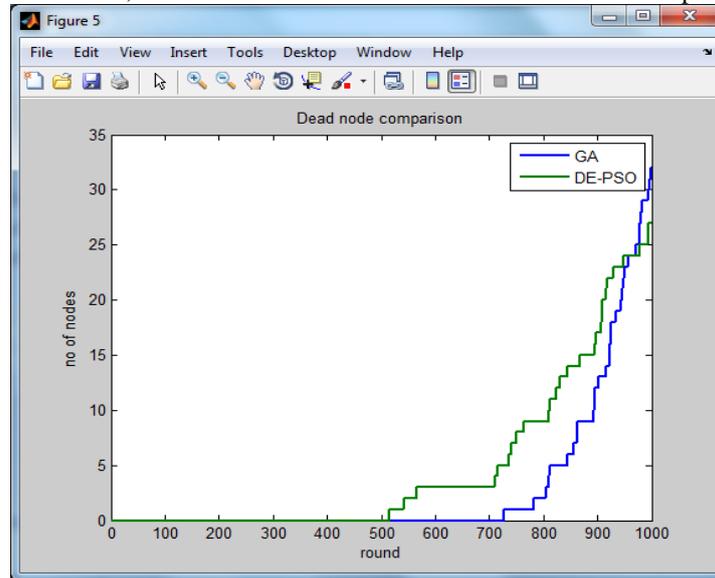


Fig.5 Dead Node Comparison

VI. CONCLUSIONS

In this paper, a hybridized Differential Evolution and Particle Swarm Optimization (DE-PSO) is proposed, which is a hybrid of Differential Evolution and Particle Swarm Optimization. It has been designed to improve the network lifetime by prolonging the death of the cluster heads and performance is increased by decreasing the number of dead nodes. DE-PSO includes a fitness function taking into account the residual energy and distance between the cluster head and the nodes. Among many methods, the experimental results have proved that the network lifetime with DE-PSO algorithm has been improved as compared to GA algorithm. Simulation and the experimentation results are plotted and the summarization of these results ensures to have efficient and reliable network for the data reliability and energy efficiency. The data fusion task separates the irrelevant data from being on the base station. Sensing data so collected, processed, filtered and forwarded to the base station contains the supported values. The proposed algorithm has shown an enhancement over the experimented protocol and taken as the base for the work undertaken. The difference between the existing procedures and proposed algorithm include proposed algorithm keep track of the energy consumption and the coverage in the network and the selection is done to have the best results for the given scenario. As the network time increases the coverage and the transmissions provided by the network are among the cases which cover the maximum space and area and provide the all direction network optimization.

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