A New Hybrid Coverage Optimization Technique based on Evolutionary Algorithms

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***Abstract*—** With time passage, the world becomes more complex that's why the decisions must be optimal one. The optimization can be helpful to obtain best result. In this paper, we have done the optimization of wireless sensor network for best area coverage of nodes. A hybrid technique for coverage optimization is developed which is based upon the evolutionary algorithms. In this paper, the results show that the coverage rate improves as the hybrid algorithm is used to deploy the nodes.

***Keywords*—** *Coverage; optimization techniques; Sensor Nodes; Swarm Optimization Algorithm.*

I. INTRODUCTION

Wireless sensor network is made up of these sensor nodes that can perform functions of sensing, computation and data communication of any condition. This technology can be used in several areas such as military, industrial production, transportation, and health etc. With the development of wireless communications, it is possible to construct cheap, small-sized and low-power sensor nodes. To operate the Wireless sensor networks more efficiently energy efficient deployment, architecture, protocols and algorithms are needed [1]. Coverage, Energy Consumption, Lifetime and efficient Routing are the major issues that causes problem for efficient performance of network. Our main concern is with the area coverage and deployment of nodes to make a network efficient with maximum coverage of area. Many techniques, algorithms and methods were developed and applied to the sensor networks.

We proposed an algorithm based on combined functioning of Particle Swarm Optimization Algorithm and Genetic Algorithm to cover maximum area of network. The main role is of PSO (particle swarm optimization). With time passage, the world becomes more complex that's why the decisions must be optimal one. It is optimization method to obtain best result. Optimization was originated in the 1940s, when the British military faced the problem of allocating limited resources to several activities [2]. There are several optimization methods for solving different optimization problems. The optimization methods are also known as nontraditional optimization methods. These methods are particle swarm optimization (PSO) algorithm, genetic algorithms (GA), neural networks, ant colony optimization, and fuzzy optimization [2].

The PSO algorithm (Particle Swarm Optimization algorithm) was first introduced in 1995, by Dr. Kennedy and Dr. Eberhart. This algorithm is basically learned from animal's behavior to solve optimization problems. In this algorithm, the population is called a swarm and each member of the population is called a particle. Initially start with a randomly initialized population and moving in randomly selected directions. Each particle goes through the searching space and remembers the best previous positions of its neighbors and itself. Particles of a swarm dynamically adjust their own position and velocity. They communicate the good positions and velocity is derived from the best position of all particles. When all particles have been moved the next step begins. At last, all particles moving towards better positions. This continues until the swarm move to close to optimum positions. This method is becoming very popular because of its simplicity of implementation and uses only primitive mathematical operators. It is faster, cheaper and more efficient. PSO is used to solve the non-linear, discrete, continuous, integer variable type problems.

Introduction Section is followed by Section II, which is the literature survey conducted related to the PSO Algorithm. In Section III the proposed algorithm is described and the IV Section is result analysis of experiments which is followed by conclusion.

II. EVOLUTIONARY ALGORITHM: AN OVERVIEW

There are some parameters those may affect the performance of algorithm, some of the parameters have little impact on the efficiency of algorithm, and some parameters have large affect or may have no effect [3]. The basic flow and PSO parameters are as follow:

A. Swarm size

Swarm size is the number of particles *n*. The large swarm size generates larger search space per iteration, but sometimes large number of particles may require less number of iteration to obtain a good solution. On the other hand a large amount of particles increase the computational complexity, and takes more time to obtain good solutions.

B. Iteration numbers

The number of iterations depends on the problem. Low number of iterations may stop the search process prematurely, and on the other hand large iterations added computational complexity and more time consumption [6].

C. Velocity Components

The velocity components are important to update the particle velocity. There are three terms of the particle's velocity

a) The term inertia component that provides a memory of the previous flight direction that means movement in the immediate past.
b) The term is called cognitive component which measures the performance of the particles relative to past performances.

The term for *gbest* PSO or for *lbest* PSO is called social component which measures the performance of the particles relative to a group of particles or neighbors.

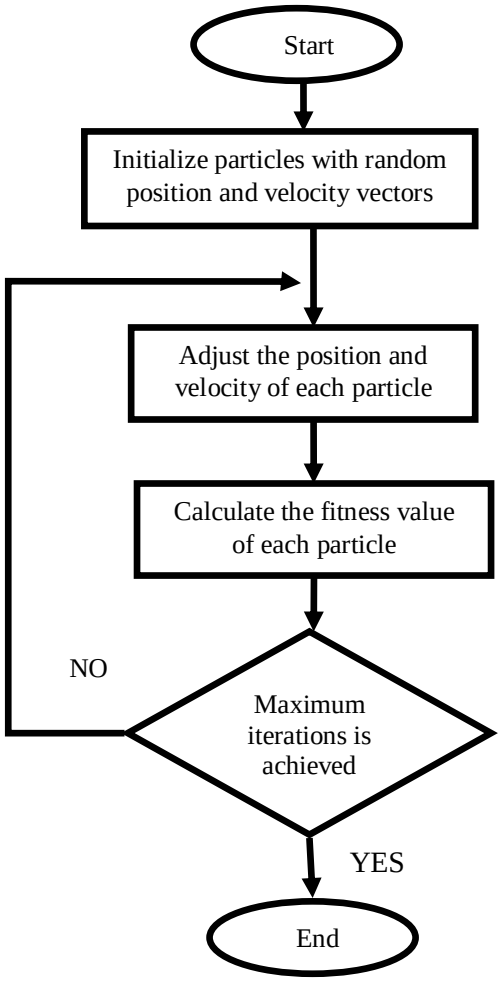

Fig.1: Flow of particle swarm optimization algorithm

III. RELATED WORK

***Sheng Wang et al. in* [4]** develop a new algorithm named as Virtual Force CPSO. It depends on CPSO algorithms and on the VF algorithm. More the one number of swarms are used to optimize the solutions for dynamic deployment. The velocity of particles is updated based on the history of previous solutions and also based on the virtual forces of nodes. The result of this paper is that Virtual PSO is more effective than other algorithms. VFCPSO gives good coverage rate and execution of time of computation. The performance of the proposed VFCPSO algorithm is stable. The placement of hybrid technique of WSNs is rapid, effective and robust.

***Vahe Aghazarian et al. in* [5]** describes a multi-objective optimization technique for designing of wireless sensor network. A swarm algorithm is used for optimizing the parameters of wireless sensor networks. Different operational modes are studied to minimize the consumption of energy. Clustering methods and range of sensing is also optimized. The energy consumption depends on the number of working nodes, and also affected by distances between nodes. Fitness function is the sum of values of all the parameters. In the fitness function the value of energy parameter is trying to minimize and the density maximizes. The parameters such as Spatial Density Error (SDE), Mean Relative Deviation (MRD), Sensors-Out-of-Range Error (SORE), Sensors-per-Cluster head Error (SCE), Operational Energy (OE), and Communication Energy (CE) affects the fitness. This algorithm is for homogeneous network. The sensor may operate as a Cluster Head, HSR or LSR. The primary goal is to obtain the best mode of operation for each sensor node. The sensor network designed by this algorithm satisfied all the required parameters of the network.

***W. Mohemmed et al. in* [6]** proposes a new method based on Voronoi diagram and PSO for coverage optimization. Swarm Optimization is done for the best positioning to maximize the coverage. Voronoi diagram is used to evaluate the fitness function. The results of this proposed technique gives good coverage in efficient time. The computation time is affected by the number of nodes in the network. The result of this technique is used for a large network or Region of Interest. The grid method is used for the small network. The execution time in this technique does not matter.

***Seyyed Reza Khaze et al. in* [7]** gives new hybrid method which is based on PSO and DE Algorithms. The coverage rate problem of Wireless sensor networks is discussed in this paper. PSO algorithm results are obtained by implementing it. The results of hybrid technique are compared with the results of Swarm Algorithm in similar situations. The results show that the hybrid algorithm gives long lifetime of the network as compared to PSO. The energy consumption reduces and the coverage increases. The performance of the hybrid algorithm is better than the PSO algorithm.

***Ab Aziz in* [8]** compares three algorithms to optimize coverage of mobile network. Power consumption is also studied in this paper. The algorithms are based on swarm optimization (PSO). PSO is chosen because of its good performance. The three PSO based algorithms are as: WSNPSOvor, WSNPSOper and WSNPSOcon.

The aim of these algorithms is as:

1. WSNPSOvor algorithm is to maximize the coverage.

2. WSNPSOper algorithm maximizes coverage with minimum energy cost.
3. WSNPSOcon algorithm maximizes the coverage of limited mobility network.

Mobile sensor network improves its coverage by moving the sensors, the movement consumes energy. Results showed that the algorithms are able to achieve their objective/goal.

Dr. N.Devarajan et al. in [9] develops a multi-objective algorithm based on Swarm Optimization. The fuzzy based optimization model is also studied.
The objectives of this paper are:
1. Maximized coverage
2. Network lifetime
3. Connectivity

The input parameters of fuzzy model are such as:
a) Node degree
b) Residual energy
c) Link quality.

According to the output obtained from fuzzy logic, the nodes are such as good, normal and bad. The initially good nodes are placed. The multi-objective PSO technique is applied for the remaining nodes. PSO iterations are performed to get the connectivity to one good node. The reference points are positioned such that the distance from the normal or bad node to the RN is small. The distance between the Base station and the RN is large. The fitness function is affected by the longer and shorter distances.
The results give the:
1. Better packet delivery ratio
2. Less delay and less energy consumption
3. Efficient and accurate node deployments.

Vikas Baghel et al. in **[10]** presents a new method for energy efficient WSN. The sensor nodes communicate to send their data through a high energy node which is called as relay node. Optimization of sensor is required to provide communication for a longer duration. Multi objective algorithm is developed for energy efficient layout of network. Sensors movement is performed to make a uniform network. The two objectives such as Coverage and Lifetime of network are considered to optimize. Basically combinations of layouts are obtained. It shows that the results are improved with the increase of generations of the algorithm.

Enrico Natalizio et al. in **[11]** two different versions of the newly proposed algorithm have been studied such as
1. A global version use information of the whole sensor area.
2. A local version based only on neighbourhood information.

The author implements the PSO techniques. Sensors are capable to collect data from events in the sensing field and movements are occurred based on neighborhood. The behavior of the algorithm is tested by energy consumption. The pioneer's sensors are used. The conclusion shows that these specific sensors are capable to get a remarkable coverage of the interesting zones. It also drastically reduces the energy consumption.

IV. PROPOSED WORK

A. Problem Statement

With time passage, the world becomes more complex that's why the decisions must be optimal one. It is optimization method to obtain best result. With the development of wireless communications, it is possible to construct cheap, small-sized and low-power sensor nodes. To operate the Wireless sensor networks more efficiently energy efficient deployment, architecture, protocols and algorithms are needed [1]. Coverage, Energy Consumption, Lifetime and efficient Routing are the major issues that causes problem for efficient performance of network. Our main concern is with the area coverage and deployment of nodes to make a network efficient with maximum coverage of area. Many techniques, algorithms and methods were developed and applied to the sensor networks. We proposed an algorithm based on combined functioning of Particle Swarm Optimization Algorithm and Genetic Algorithm to cover maximum area of network. The main role is of PSO (particle swarm optimization).

B. Objective of Study

The main objective of this work is to study the optimization techniques and implement the proposed hybrid algorithm based on swarm optimization and genetic algorithm for optimizing the efficient coverage of sensor network.

C. Methodology

At the first step the Particle Swarm Optimization Algorithm is initiated, and then the Genetic Algorithm is used to generate the Global Best and Local Best of particles. The velocity and new particle positions are updated by using PSO. Randomly, the nodes are deployed then the Total Area Coverage (TC) is calculated. The Actual Area Coverage (AC) is calculated and AC IS compared with TC. If Total Coverage is equal to or nearest to the Actual Coverage, then this coverage is the optimal coverage. If the difference between the AC and TC is more then apply the PSO to calculate new particle positions. Genetic Algorithm is used to generate global best and local best. Deploy the nodes with those coordinates as center. Calculate total area coverage.

D. Flow of Research Work

As described in the above steps the flow of working of hybrid algorithm is as follows. The following flow chart explains the steps of methodology in the form of flow.

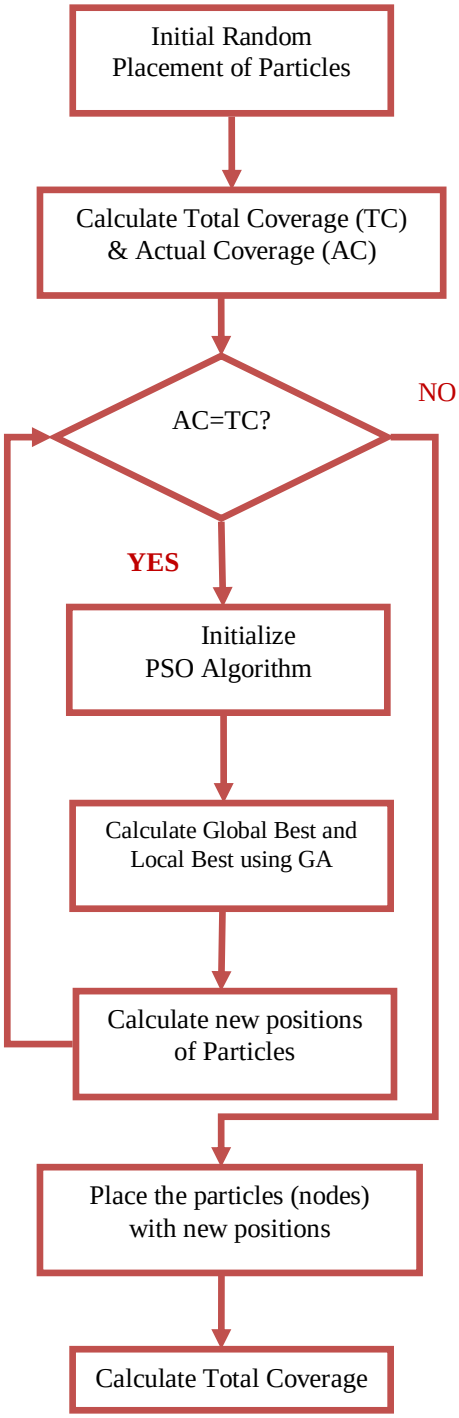

Fig.2: Flow of Proposed Algorithm

V. RESULT ANALYSIS

We started with the first step and go to last step with different input. Here the input means we conducted the test with different number of nodes at different random locations. In this paper, we had shown the test details conducted with 20 nodes. The following table represents the total area coverage and actual coverage before and after the implementation of proposed algorithm. As, we see that the actual coverage and total coverage is almost equal from which we conclude that the proposed technique gives better positions of particles where the coverage is optimal.

Table I: Parameters of Evolutionary Algorithms

Parameter Description	Value of Parameters
Swarm Size	20
c1	1
c2	1
r1	rand value between 0 to 1
r2	rand value between 0 to 1
Range	3
Crossover	Single point crossover
Crossover Probability	0.74
Mutation	Uniform Mutation
Mutation Probability	0.26

Table II: Area Coverage for 20 Nodes

Description	Before	After Proposed Algorithm
Total Coverage of 20 nodes by formula	565.20	565.20
Actual Coverage of 20 nodes	360.68	565.20

Table III: Initial and Final Coverage for different number of Sensors

No. of Sensors	Initial Coverage	Final Coverage
10	115.4	282.6
20	360.7	563.2
30	699.2	847.8
40	978.8	1130.4
50	1217	1413

From the above tables, it is clear that the random placement of nodes mostly causes the overlapping. But the final deployment after the implementation of proposed algorithm gives the maximum coverage of nodes. The results are represented in the following graphs.

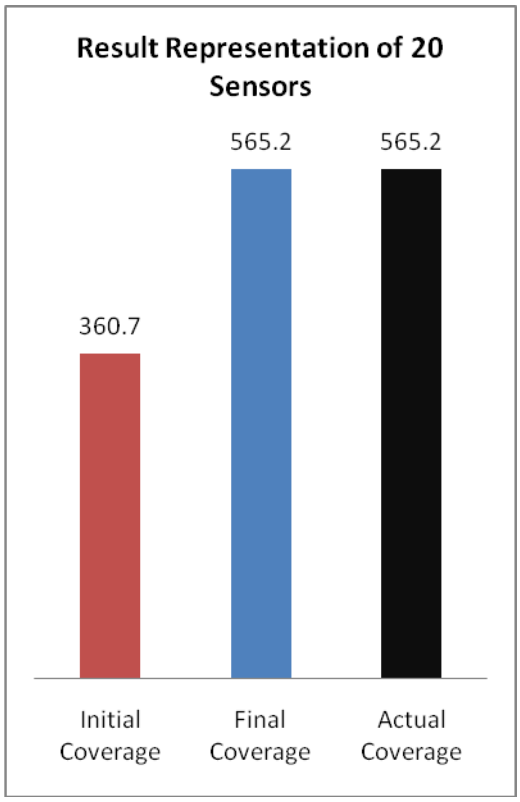

Fig.3: Representation of Coverage of 20 Nodes

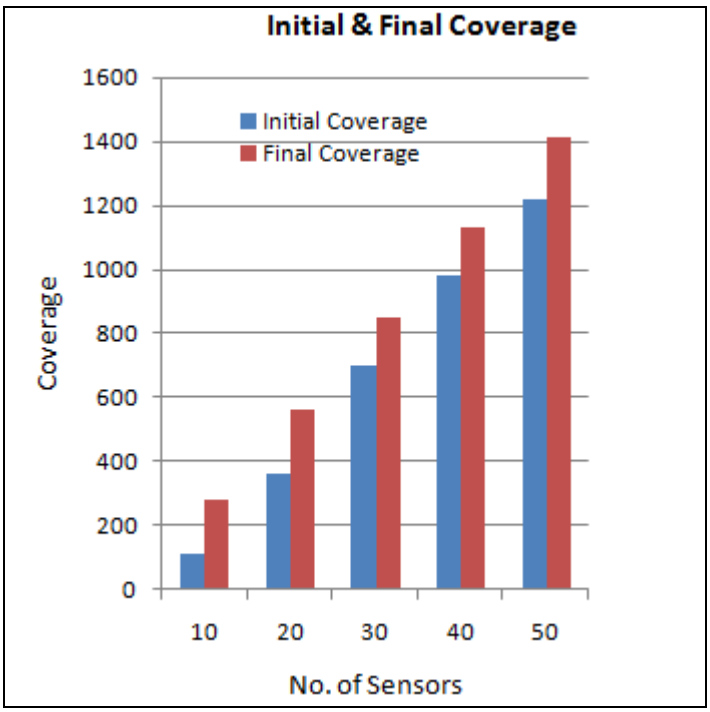

Fig.4: Result Comparisons of Initial and Final State Coverage

In the above figure 4, we see that at the initial state the total coverage is less than the actual coverage. But on the other hand the final state coverage increases. The total final coverage is the coverage which is almost nearest to the actual coverage. The coverage improves after applying the proposed hybrid technique.

VI. CONCLUSION & FUTURE SCOPE

The result analysis shows that the proposed algorithm covers area as much the actual coverage of nodes. In this paper, we had worked on coverage. The hybrid algorithm provides an efficient deployment of nodes. The same area dimensions are covered by less number of nodes in very efficient manner. In each case the coverage increases as the hybrid technique is applied. This gives better placement strategy as well as better coverage.

In future, we will do the research work on other optimization algorithms and will compare the results of this hybrid technique with other optimization algorithm.

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