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Development and Evaluation of a GUI Based Tool for Deployment of Sensors in a WSN using Genetic Algorithm

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Abstract— *Wireless sensor networks are presently a growing area as they form a platform for many applications associated to surroundings monitoring, fitness and wellbeing, supervision and military surveillance. One of the major design aspects of Wireless Sensor Network (WSN) is the sensor node deployment strategy. The deployment strategy is vital because it can affect the performance of the network. A Graphical User Interface (GUI) based tool was created using Matlab for deployment of sensors in a WSN. The GUI uses a GA to deploy the sensors in order to achieve the maximum coverage. The GUI allows the user to choose the dimension of area where sensors need to deploy, number of nodes need to deploy, radius of the sensors nodes, etc. It uses the Binary Detection Model for evaluating the coverage*.

Keywords— *GUI, sensor deployment, binary model, genetic algorithm, area coverage*.

I. INTRODUCTION

Wireless sensor network (WSN) comprise of several number of energy-constrained nodes that are deployed for observing various phenomena of interest. A sensor node consists of a sensing unit, a process unit, a radio transceiver and a power management unit. An important objective of sensor networks is to effectively monitor the environment, detect, localize, and classify targets of interest. The position of sensors affects coverage, communication cost, and resource management. The effective deployment of sensor nodes is the main concern while considering WSN. The sensor nodes in a particular region must be deployed in such a way that they efficiently covered all the targets in surveillance region.

Area coverage is a vital issue in WSN. It suggests that however well a vicinity of an area of interest is being monitored. In random deployment, for the reason that of the randomness of the sensors, generally an effective coverage cannot be obtained. That's why Genetic Algorithm helps in efficient sensor deployment. Graphical User Interface (GUI) presents a platform where it is easy to understand and work as comparison with the text-based interfaces.

II. RELATED WORK

Zou [1] mentioned the potency of cluster-based distributed sensing element networks depends to a large extent on the coverage provided by the sensing element deployment. Two sensing models binary detection and probabilistic were discussed. He planned a virtual force algorithmic program (VFA) as a sensing element deployment strategy to boost the coverage once a preliminary random placement of sensors. For a mere variety of sensors, the VFA algorithmic program tries to maximize the sensing element field coverage. A smart combination of engaging and repulsive forces was accustomed conclude virtual motion methods and therefore the rate of movement for the randomly-placed sensors. Once the effective sensing element positions were recognized, a one-time movement with energy thought incorporated was distributed, i.e., the sensors were redeployed to those positions. He additionally planned a unique probabilistic target localization algorithmic program that was executed by the cluster head. The localization results were employed by the cluster head to question solely a number of sensors (out of these that report the presence of a target) for a lot of elaborated info. Simulation results were given to demonstrate the effectiveness of the planned approach.

Yoon et al. [2] proposed that coverage is that the most important performance metrics for detector networks and they projected the utmost coverage preparation downside in wireless detector networks and analyze the properties of the matter and its answer house. They explained that random preparation is that the easiest way to deploy detector nodes however could cause unbalanced preparation and so, they thought that they have a lot of intelligent method for detector preparation. Supported this property, they projected a well-organized genetic algorithmic rule by means that of a completely unique standardization methodology. A Monte Carlo methodology was adopted to style a competent analysis operate, and its computation time was diminished while not loss of answer quality employing a technique that starts from a little range of random samples and bit by bit will increase the amount for future generations. The projected genetic algorithmic rules may well be any increased by combining with a well-designed native search the performance of the projected genetic algorithm is shown by comparative experimental study. The projected algorithmic rule was compared with random preparation and existing strategies.

Wang et al. [3] mentioned that sensing coverage and network property are two of the foremost essential problems to confirm effective environmental sensing and sturdy digital communication in an exceedingly WSN application. They had given the essential studies on the sensing coverage and therefore the network property from mathematical modeling,

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theoretical analysis, and performance analysis views. Each lattice WSNs that follow a pattern-based preparation strategy and random WSNs that follow a random preparation strategy were well thought-out. The aim of their analysis was to deliver a scientific study on the basic issues in WSNs and supply pointers in choosing important network parameters for WSN style and execution in observe.

Kumari et al. [4] planned that wireless sensing element networks were presently rising space for analysis and Development for the rationale that sensing element network represent platform for several applications concerning setting observation, health care, police work, and military. One major drawback in wireless sensing element network is coverage drawback as a result of it shows quality of the network. During this paper coverage techniques and algorithms employed in these techniques area unit studied. Coverage Techniques were classified into three groups: space coverage, point coverage and path coverage

Li et al. [5] proposed that coverage downside was very important and elementary issue in sensing element networks that reflects however well a sensing element network was monitored or half-tracked by sensing element. During this paper, they surveyed this works on coverage downside in sensing element networks. Two sorts of sensing element coverage were investigated: space coverage and target coverage. Combining with sensing element development system (deterministic, statistical) and WSN properties (e.g. network property, energy economical and fault tolerant for property and sensing etc), a spread of coverage issues are introduced and mentioned in details. They centered on the foremost representative issues in every domain and gift a comprehensive review and study of assorted existed algorithms, techniques.

Hossain [6] discussed the network coverage of wireless device network (WSN) means that however well a section of interest was being monitored by the deployed network. It depends in the main on sensing model of nodes. during this paper, they bestowed 3 kinds of sensing models viz. Boolean sensing model, shadow-fading sensing model and Elfes sensing model. They investigated the impact of sensing models on network coverage. They additionally investigated network coverage supported Poisson node distribution. A comparative study between regular and random node placement has additionally been bestowed during this paper. This study was helpful for coverage analysis of WSN.

Chakrabarty et al. in [7] conferred novel grid coverage ways for effective police work and target location in distributed device networks. They represent the device field as a grid (two or three-dimensional) of purposes (coordinates) and used the term target location to ask the matter of locating a target at a grid point at any instant in time. They initially presented an integer linear programming (ILP) solution for minimizing the value of devices for complete coverage of the sensor field. They conjointly solved the ILP model employing a representative public-domain convergent thinker and gift a divide-and conquer approach for determination giant drawback instances. They then use the framework of distinctive codes to see device placement for distinctive target location. They provided coding-theoretic bounds on the number of sensors and present methods for determining their placement in the sensor field. They conjointly showed that grid-based device placement for single targets offer asymptotically complete (unambiguous) location of multiple targets within the grid.

Ahmed et al. [8] projected the sensing capabilities of networked sensors are exaggerated by environmental factors in real readying and it's essential to possess sensible concerns at the look stage so as to anticipate this sensing behavior. They investigated the coverage problems in wireless detector networks supported probabilistic coverage and propose a distributed Probabilistic Coverage formula (PCA) to gauge the degree of confidence in detection chance provided by a haphazardly deployed detector network. The probabilistic approach was a divergence from the idealistic assumption of uniform circular disc for sensing coverage employed in the binary detection model. Simulation results illustrate that space coverage calculated by using PCA was a lot of precise than the idealistic binary detection model.

Gond [9] mentioned that one among the basic issues in wireless sensing element network is Coverage and lifelong. Since the sensing element node have a restricted battery power. Once they deployed the sensing element it's terribly tough to vary the battery power therefore energy economical preparation is extremely necessary to extend the coverage and lifelong. In some applications of wireless sensing element networks, the sensing nodes is to date faraway from base station that relaying nodes should be used to forward knowledge. Some relay nodes use their power early as a result of they need heavier traffic load than alternative nodes that affects the network period of time. During this work, they provided an analytical framework for the deployment of sensors. They also presented the formulation and solution to energy allocation of sensor node according to traffic load in every hop wireless sensor networks. The simulation results show that their preparation algorithmic program will considerably scale back the entire range of deployed sensing elements and additionally increase the period of time of wireless sensor network. They also presented an algorithm which shows that how much initial energy was required for different sensors which are deployed in different hop WSNs.

Wang et a.l [10] planned the usage and development of wireless device networks will increase, issues regarding these networks are getting apparent. Dynamic preparation is one in every of the most topics that directly have an effect on the performance of the wireless device networks. During this paper, biogeography-based improvement is applied to the dynamic preparation of static and mobile device networks to realize higher performance by making an attempt to extend the coverage space of the network. A binary detection model was thought-about to induce hold of realistic results whereas computing the effectively lined space. Performance of the algorithmic program was compared therewith of the unreal bee colony algorithmic program, Homo-H-VFCPSO and stud genetic algorithmic program that also are population-based improvement algorithms. Results explained biogeography-

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based improvement will be preferred within the dynamic preparation of wireless device networks

Ma et.al [11] projected wireless device networks are composed of energy-constrained nodes. Therefore, it absolutely was essential to style routing algorithms that optimize the energy usage of nodes. Supposed at maximizing the network period, they introduced associate degree best routing formula supported the max-min model. During this algorithm, the info transmission matrix was outlined and therefore the relaying node choice mechanism is intended to stay off from potential routing loops. supported the energy consumption for causing and receiving knowledge and therefore the accessible residual energy of nodes, the mathematical programming model is intended to seek out best routing. The routing methods and knowledge volume were determined by nodes in line with the improvement of parameters within the model. Simulation results provide you with an inspiration that the formula balances the energy utilization of nodes with efficiency and extends the network period.

In this paper, the deployment of sensors is shown by using genetic algorithm. A graphical user interface was created by help of which sensors are deployed and area coverage is evaluated. The rest of the paper is organized as, where the sensing model is discussed and also the technique of deploying the sensors and evaluating the area covered.

III. Sensing Models

Generally speaking, the sensing model of a definite type of sensors is a mathematical model that describes the probability of target/event revealing of the sensor. Assuming the target or event take place at a point p_{ij} in the Region of Interest, the sensor is denoted by 'ni' that is placed at the point (x,y). Usually the parameters used are the Euclidean distance between them d_{ij}, the orientation of the sensor, various ecological parameters and sensor node hardware parameters. There are numerous sensing models found in the journalism. However, most commonly used model is binary detection model.

Binary Detection model – If the incidence of the event is within the sensing range of a sensor node then the event will be understood to be detected, otherwise not. This model ignores the dependency of the condition of the environment (obstacles such as building, plants) and the potency of the emitted signal on the task of sensing. Generally, the area covered by a sensor node is a circle with radius equals to sensing radius of the node.

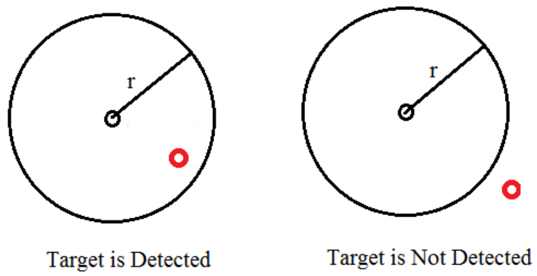

Fig. 1. Detection criteria of binary detection model.

This Equation shows the binary sensor model that expresses the coverage $C_{ij}(x, y)$ of a grid point at (i, j) by sensor s at (x, y).

$$C_{IJ}(X,Y) = \begin{cases} 1, & if\ d_{ij}(x,y) < r \\ 0, & otherwise \end{cases} \qquad (1)$$

IV. Proposed Work

In this proposed system, the work on WSNs starts with the deployment of the sensor nodes uses Graphical User Interface (GUI) in MATLAB and accurate evaluation of the area coverage using genetic algorithm.

In genetic algorithm, we have generated 10 different populations. So out of these 10, two different populations called as Parent 1 and Parent 2 is chosen and two offspring's are generated in the crossover stage. Out of these four: two parents and two offspring's, the population with maximum fitness is chosen. The best fitted population is deployed on GUI and corresponding percentage area covered is also shown.

In this system, Zou [1] dealt with 3 types of sensors by taking reference from other three authors. These three sensors are acoustic sensor, seismic sensor, and forward looking infrared radar (FLIR), which are used for surveillance in U.S. Army. The detection radius of seismic sensor is about 0.8 times that of acoustic sensor. Likewise, the detection radius of FLIR is about 0.8 times that of seismic sensor.

V. Experimental Setup

The experimental work is done in MATLAB as it is a great tool for testing and developing various systems.

In this system, GUI is developed and using that GUI based tool, the sensor deployment using genetic algorithm is efficiently done. Firstly, the given area is divided into two-dimensional grid and sensors are deployed in a way to cover the maximum number of grid points and thus calculating the total percentage area covered using binary detection model.

The total number of sensors is divided into 3 sets i.e. acoustic sensor, seismic sensor, and forward looking infrared radar (FLIR) and these sensors are denoted by blue, green and red color respectively. The total area covered is the sum of the area covered by the individual sensors.

The snapshots of work done are given below:

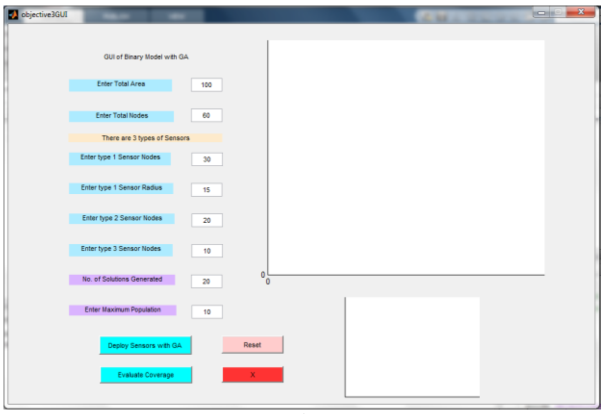

Fig. 2. Snapshot showing the values of various parameters being entered in a GUI of binary detection model using genetic algorithm.

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Figure 2 shows the snapshot of GUI in which user is free to enter various parameters by one's choice. The GUI allows the user to choose the dimension of area in which sensors need to deploy, number of nodes need to deploy, radius of the sensors nodes, etc. The user can also enter the population size and the number of iterations by one's own choice. User can easily change the values of various parameters and re-deploy the sensors.

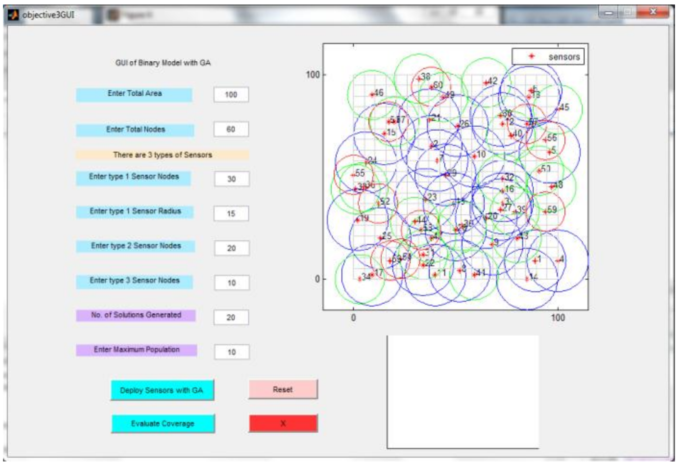

Fig. 3. Snapshot showing the Sensor deployment by binary model using genetic algorithm.

Figure 3 shows the deployment of various sensor groups of different radii. Three types of sensors are deployed. Acoustic sensors are denoted by blue circles, seismic sensors by green and forward looking infrared radar (FLIR) by red circles. In an area of 100 units, total 60 nodes are deployed where 30 are acoustic sensors, 20 are seismic and 10 are FLIR. Maximum population in GA was kept as 10 while number of iterations was 20.

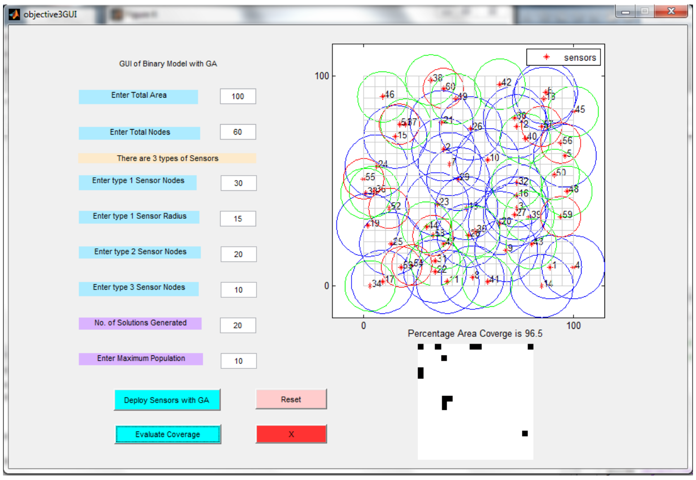

Fig. 4. Snapshot showing the sensor deployment and area coverage by binary detection model using genetic algorithm.

Figure 4 illustrates the deployment of sensors and area coverage by binary model using Genetic Algorithm. The black region shows the uncovered area while white region shows the area covered by the sensors. Area is divided into 2-dimensional grid. Out of the total grid points, sensors have to cover most of them in a manner to provide maximum coverage of the monitored area. The percentage area covered by binary model using GA was 96.5.

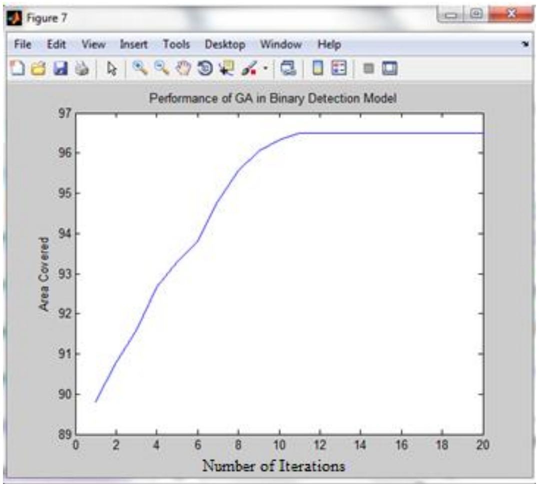

Fig. 5. Snapshot showing the performance of genetic algorithm using binary model.

Figure 5 shows the growing curve of genetic algorithm using Binary detection Model. The area covered by the sensors alongside the number of iterations is shown.

TABLE I. Showing the mean and standard deviation of the area covered by genetic algorithm using binary detection model.

Nodes (N)	Radius (R)	Genetic Algorithm	
		Mean	Standard Deviation
50	12	80.70	2.32678
50	15	91.53	1.92372
60	12	87.20	1.65831
60	15	94.96	1.15740
70	10	82.10	1.50923
70	12	91.35	1.52388
70	15	97.68	0.97930

Table I illustrates the deployment of different sets of sensor nodes having different sensing range. The mean and standard deviation was calculated for Genetic Algorithm in the case of Binary Detection Model.

TABLE II. Showing the effect of variation in Number of Iterations and Population Size on the performance of Genetic Algorithm using Binary Model.

Nodes (N)	Radius (R)	Number of Iterations	Max. Population	Percentage Area Coverage
60	15	20	10	95.25
60	15	15	12	94.75
60	15	12	15	94.30
60	15	10	20	94.37
60	15	8	20	94.95
60	15	6	25	94.60
60	15	5	30	95.39

Table II shows the effect of variation in Population Size and Number of Iterations on the performance of Genetic Algorithm in case of Binary Detection Model.

VI. Conclusion and Future Scope

In this paper, the work is presented where sensor nodes using binary detection model were deployed by using genetic algorithm. For this sensor deployment, GUI was developed and also used for evaluating the area covered.

In the Future work, we will try to achieve the maximum area coverage by using less number of sensor nodes. The concept in current scenario was that we were focused on covering the maximum number of grid points on a particular area. In the implemented work, number of sensors was not an issue; our main concern was to cover the maximum area by sensor nodes. In future, we could make a WSN in which less number of sensor nodes could able to cover the maximum region of interest and the results of Genetic Algorithm can be compared with other optimization methods.

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