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Node Placement for Efficient Coverage in Heterogeneous Wireless Sensor Networks

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***Abstract*-- Coverage problem is an important and fundamental issue in sensor networks, which reflects how well a sensor network is monitored or tracked by sensor. Connectivity and coverage problems are caused due to the limited communication and sensing range. The solution to these problems lies in how the sensors with respect to each others are positioned. A good sensor deployment algorithm gives us minimum intersection of sensor's range and maximizes the total area covered by sensors. The paper founds a fact that heterogeneous sensors are deployed removing the intersection between the sensors, so that, a maximum area got covered using the sensor nodes.**

***Keywords*-- wireless sensor network, coverage, sensor nodes, deployment, heterogeneous sensors.**

I. Introduction

Wireless sensor networks (WSNs) are a particular type of ad hoc network which consists of number of sensor nodes deployed in an unsupervised environment with the capabilities of sensing, wireless communications and computations (i.e. collecting and disseminating environmental data). Sensor networks are composed of nodes with sensing capabilities which perform distributed sensing task [5]. Wireless sensor networks allow real time data processing at a minimal cost. Wireless sensor networks (WSN's) are useful for military, environmental, and scientific applications such as vehicle tracking, habitat monitoring, forest surveillance, earthquake observation, biomedical or health care applications and building surveillance, monitoring, disaster recovery, home automation and many others [1],[2]. A Wireless Sensor Network can be composed of homogeneous or heterogeneous sensors, which possess the same or different communication and computation capabilities, respectively. Fig 1 shows the heterogeneous sensor network.

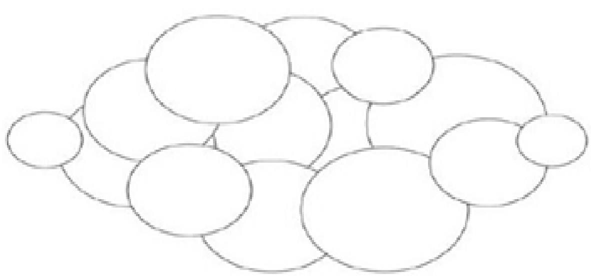

Fig.1 Heterogeneous sensors [8]

Although some works consider heterogeneous sensors, many existing works investigate node placement in the context of homogeneous WSNs. In homogeneous networks all the sensor nodes are identical in terms of battery energy and hardware complexity. On the other hand, in a heterogeneous sensor network, two or more different types of nodes with different battery energy and functionality are used [1].

II. Proposed Algorithm

The central idea of the paper is to develop such algorithm that provides maximum area covered by the sensor nodes by removing intersection between the sensors range. Sensors are firstly deployed using the initial co-ordinates provided and then new co-ordinates are generated using the initial co-ordinates to remove intersection and get maximum area coverage.

A. Sensor Deployment Algorithm:

- The data file is an excel file contains initial deployment co-ordinates of sensors and radius (range) of sensors.

- Sensors of varying sensing range are used i.e.
  - Heterogeneous Sensors.
- Initially sensors are deployed according to the given co-ordinates.
- After deploying sensors, intersection between sensors is calculated and removed using mathematical expressions as described in algorithm.
- Main objective behind the algorithm is to remove intersection of range of sensors and get maximum area covered by the given number of sensors.
- The new co-ordinates of deployment are calculated by: x_1 and y_1 are kept constant and x_2 is incremented by 2 i.e. x_2+2 and y_2 by the formula given in Step3 of the algorithm.

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Algorithm:

Step 1 The data file is taken as input and a table of x, y and r is formed.

Step 2 Sensors are deployed initially with (x, y) co-ordinates as centre and r as radius (range).

Step 3 Intersection between sensors is removed using:

$$y_2 = \sqrt[2]{[(r1+r2)^2-(x2-x1)^2} + y1$$

Step 3 is repeated until whole intersection is removed.

Step 4 Intersection between the sensors is determined using distance formula:

$$D = \sqrt[2]{[(x2-x1)^2+(y2-y1)^2}$$

Step 5 After removing intersection, sensors are deployed again on the co-ordinate axis with new co-ordinates (x_1, y_1) and (x_2, y_2).

III. Experiment and Result

When sensor nodes are deployed according to the initial co-ordinates provided, there exists some intersection between the range of the sensor nodes and a lot of sensors got wasted as many sensors deployed senses only a limited(same) area. This increases our cost of deploying sensor nodes. So, intersection have to be removed so that the given sensors can sense more area then the initial deployment and the cost can also be reduced and also wastage of sensor nodes can also be overcome.

In the following Figures, Fig.2 and Fig.3 shows the initial deployment and initial co-ordinates of the sensor nodes respectively. As, we can see in Fig.2, there exist a lot of intersection between the sensor range. So, new co-ordinates are to be calculated so that there no intersection will be there.

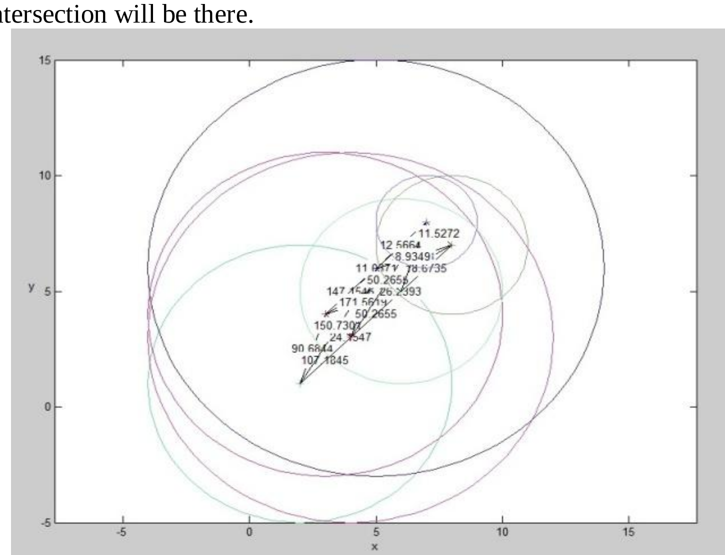


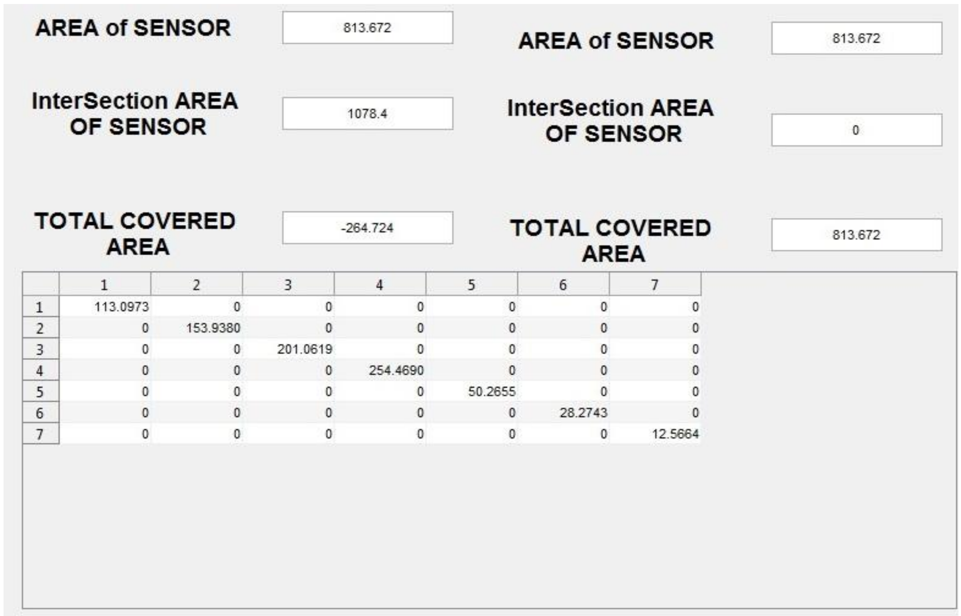
Fig.2: Initial deployment

AREA COMPONENT

	X	Y	R
	2	1	6
	3	4	7
	4	3	8
	5	6	9
	6	5	4
	8	7	3
	7	8	2

Fig.3: Initial co-ordinates

Fig.4 shows the area under the sensors after initial and final deployment. As, we can see in the first column that after the initial deployment the intersection area of sensors is a large quantity and the total area covered by the sensor nodes is too small. So whole of the sensor nodes are getting wasted as there is a large intersection. So, this intersection is to be reduced. Second column shows the area of sensors after final deployment. Intersection area of the sensors has become null. This shows that no intersection exists after the final deploying of the sensor nodes.



AREA of SENSOR	813.672	AREA of SENSOR	813.672
InterSection AREA OF SENSOR	1078.4	InterSection AREA OF SENSOR	0
TOTAL COVERED AREA	-264.724	TOTAL COVERED AREA	813.672

	1	2	3	4	5	6	7
1	113.0973	0	0	0	0	0	0
2	0	153.9380	0	0	0	0	0
3	0	0	201.0619	0	0	0	0
4	0	0	0	254.4690	0	0	0
5	0	0	0	0	50.2655	0	0
6	0	0	0	0	0	28.2743	0
7	0	0	0	0	0	0	12.5664

Fig.4: Area covered after initial and final deployment

In the above figure the diagonal matrix contains the value of area of entire sensor and the entries outside the diagonal are 0. This shows that there is no intersection between the sensors. After the final deployment of sensor nodes according to the final co-ordinates generated, we can observe that in Fig.5, there is no intersection between any of the sensor node. So, we can say that after removing intersection, same number of sensors can cover a large area. Fig.6 shows the new co-ordinates generated with respect to which the sensor nodes are finally deployed.

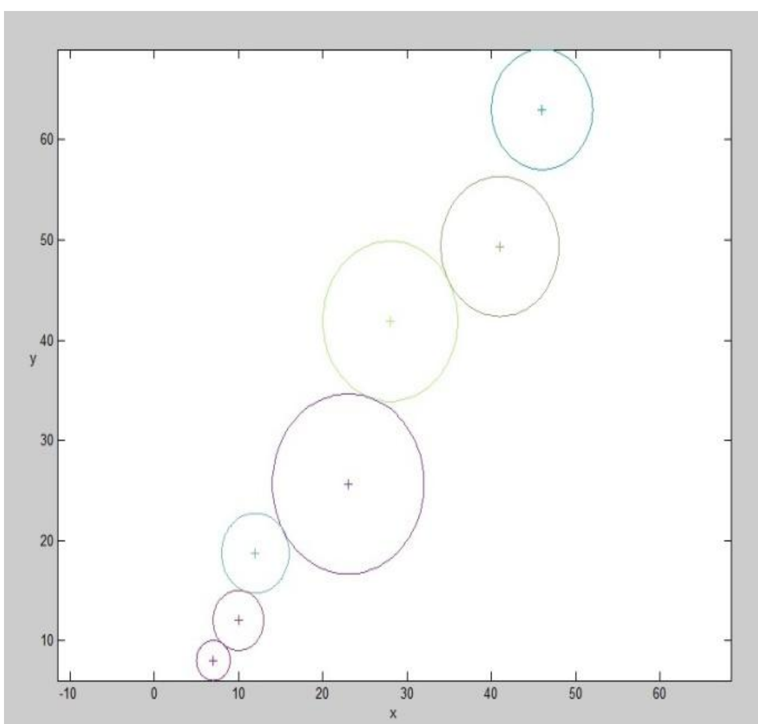


Fig.5. Final deployment

AREA COMPONENT

	X	Y	R
	46	63	6
	41	49	7
	28	42	8
	23	26	9
	12	19	4
	10	12	3
	7	8	2

Fig.6. Final co-ordinates

IV. Conclusion

An effective node placement scheme is presented which helps in efficient placement by removing intersection of the sensors range. Heterogeneous sensors are used according to the sensing area. Experimental results show that after final deployment intersection between the sensors has been removed and area under surveillance (area covered) has increased.

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