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A Comparison of Algorithms for Deployment of Heterogeneous Sensors

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Abstract – Wireless Sensor Networks are most commonly used networks. The deployment of sensors has several issues like connectivity, coverage and life time. In this work we propose an algorithm for heterogeneous deployment of the sensors so that th study e range of sensors do not overlap. Also the sensors are within the boundary of the region. Here we deploy sensors having different radii and study the various types of deployment in terms of number of sensors deployed and are covered.

Keywords - *Sensor networks, Connectivity, circle packing, deployment.*

1. Introduction

Wirteless Sensor Networks are the networks of nodes. The nodes can sense change in environment like temperature, light, pressure sound etc. The information is stored in nodes and then transmitted to a central sink. The is connected to a computer which further processes the information. Wireless Sensor networks are used in the fields of volcanoes, battlefields and military applications.
Wireless sensor networks suffer from problems like coverage and life time.

In this work we propose and algorithm for deploying heterogeneous sensors of at least three different range. So that the sensors are not overlapping and lie within the boundary of the region. Also we compare the two variants of the algorithm i.e. center and corner packing deployment and make a comparison between them.

2. Related work

The idea of coverage was introduced by Chvatal where the deployment problem was similar to AGP (Art Gallery Problem) [12]. In this problem we try to minimize the number of guards and increase the area of monitoring. AGP involved a lot of combinatorial optimization. When the monitored field became very large.

In [13] an incremental deployment algorithm was proposed in which the nodes were deployed in such a way that the coverage is maximum and line of sight is maintained. In this work prior knowledge of environment is not required.

In [10] the authors proposed an algorithm to achieve range and connectivity. In this range and connectivity was studied for different deployment patterns. Also a comparative study was made for different patterns like lattice triangles etc.

A sequential packing algorithm was used was used to order to maximize the coverage of the monitored field and connectivity of the deployed sensors. This algorithm used un-equal circles and also considered overlapping of circles. It used greedy approach to maximize the are covered. [3]

3. Ideation

In this paper we introduce a circle packing algorithm in such a way that:
1) No two circles overlap with each other
2) All the circles are placed within the boundary of the region.
3) The circles should different radii.

The problem can be mathematically stated as follows.
Let S be set of the number o to be deployed in the field F.

Our aim is to cover the area of the field without over lapping of the sensor range.

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Let L be the length of the field and W be the width of the field. Let r be the range of communication of the sensor. Let i and j be the two sensors to be deployed in the field F. The coverage area of the two sensors i and j can be represented by circles c_i and c_j respectively with centers $C_i(x_i, y_i)$ and $C_j(x_j, y_j)$ respectively.

The problem can stated as follows

$$MAX\left(\sum_{i \in s} \left(\frac{\pi r_i^2}{lw}\right) \right) \quad (1)$$

Such that:

$$Min(c_i, c_j) \le \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

$$i \neq j \quad i,j \in S \quad (2)$$

$$xi - r_i \ge 0 \quad i, \in S \quad (3)$$

$$l - xi - r_i \ge 0 \quad i, \in S \quad (4)$$

$$yi - r_i \ge 0 \quad i, \in S \quad (5)$$

$$w - yi - r_i \ge 0 \quad i, \in S \quad (6)$$

Equation (1) represents our main objective of the work
Equation (2) ensures that the sensors are connected to each other.
Equations (3) to (6) take cares of the conditions that the sensors are deployed within the monitored field.

4. Proposed Work

Algorithm for heterogeneous deployment of WSN is as follows

Algorithm
1) Feed the range of sensor length and breadth of the field under consideration.
2) Let x and y represent the centre point from where sensor is to be deployed.
3) Place the first circle with radius r1 (which represents the sensor).
4) Determine minimum distance dmin= 2r1;
5) Determine the centre of new circle using the relation.
xc=x+dmin+r1*cosα
yc =y+dmin+r1*sinα
where x and y are the co-ordinates of the centre of the circle deployed in step 2.
6) Using the centre computed in step 5 calculate the circum points of the circle as follows
X1=xc+r1*cosβ
Y1=yc+r1*sinβ
7) If X1 and Y1 are within the field and are not overlapping with other circle then increment β go to step 6.
8) Increment α and go to 6 as overlapping or out of field points are detected.
9) If condition 8 is satisfied for all values of β (from 0 to 360)
10) If Area remains uncovered in the field then repeat steps 4 to 9 until the circles with the given range r can be deployed.
11)Repeat the above steps for two different radii r2 and r3.

In this case the deployment is heterogeneous i.e. all the sensors have the different range of communication as shown we accept the dimensions of the monitoring field F then we accept the maximum range of sensor communication r1 (step 1). We accept the starting point for which the first sensor is to be placed. The starting point of deployment can be either centre of the field or from the corner of the field depending upon user input.

We deploy the first circle here (step 3). This is initial step in our algorithm all the other circles are deployed based on the deployment of this circle. We then calculate minimum distance dmin.dmin is the minimum distance to be maintained while deploying a new circle. Now we calculate the centre of the new circle (xc, yc) to be deployed as,

xc=x+dmin+r*cosα
yc=y+dmin+r*sinα

Where x and y are the co-ordinates of the circle deployed in step 3. Now we calculate the circum points of the circle to be deployed as

X1=xc+ r*cosβ
Y1=yc+y*sinβ

Every circum point X1 and Y1 should satisfy the boundary constraint and overlapping constraint, i.e it should be within the monitored field and should not overlap with other circle. This condition is checked for all values of β i.e from 0 to 360 (step 7).If these constraints are not met then the circle is not deployed at centre point (xc, yc) and new centre points are computed by incrementing the value of α. (Step 8).The circle is deployed in the field if condition 8 is met for all values of β and count of number circle is incremented. For each circle deployed steps 4 to 9 are repeated iteratively. Thus we try to maximize the coverage deploying as many circles as possible. Similarly we deploy two more circles with radii r2 and r3 for each iteration.

5. Architectural Flow

The architectural flow is as shown in Fig 5. 1 .As shown we first accept all the parameters required which includes the dimensions of the field, range of sensor, and the starting point. Depending on the input we place the first circle which can either centre or corner. Here we use a Queue (Q) which keep track of the circles which are placed. When a circle is placed in field its is entered in this queue. Now we compute the centre of the circle to be deployed by the relation given the algorithm.

$x_c=x+d_{min}+r*cos\alpha$
$y_c=y+d_{min}+r*sin\alpha$

Using this centre x_c and y_c we further compute the circum points of the circle to be deployed using the relation

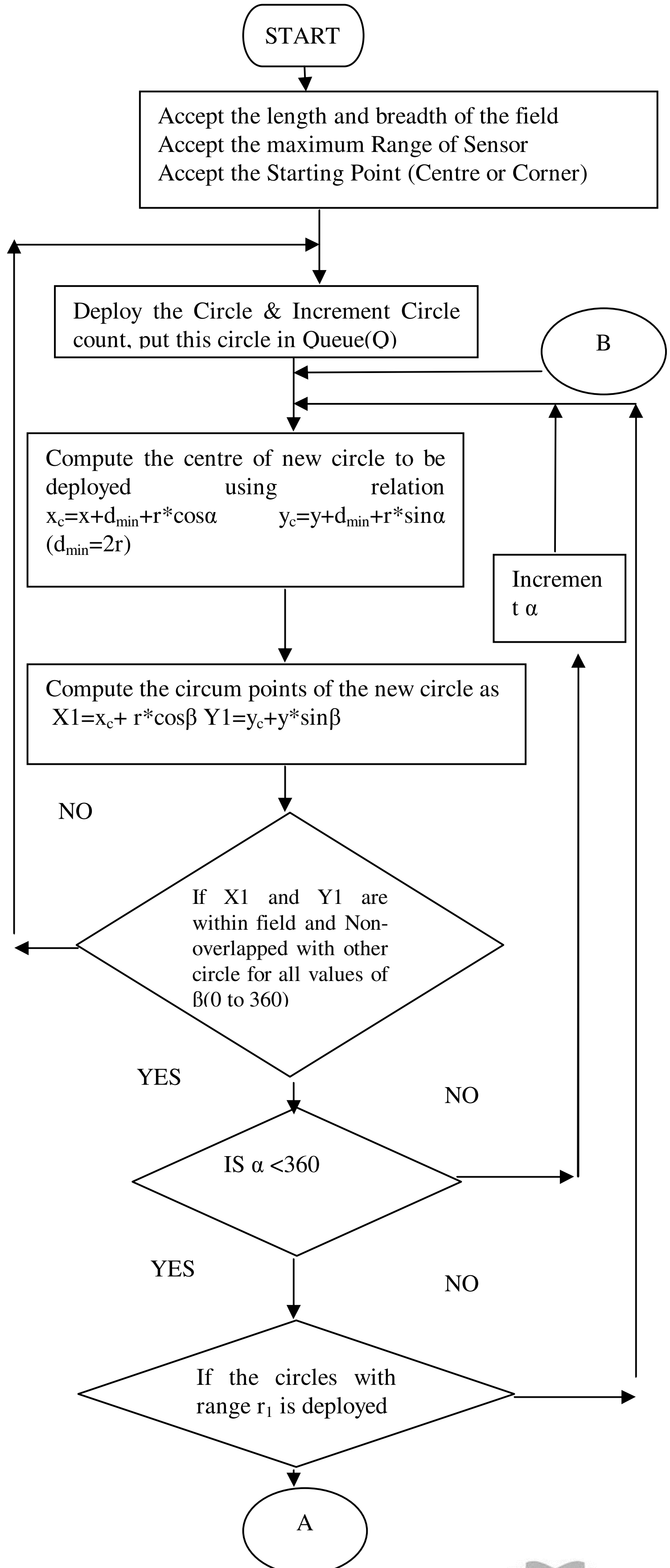
$X1=x_c+ r*cos\beta$
$Y1=y_c+y*sin\beta$

If point (X1,Y1) satisfies the conditions of boundary and non-overlapping of other circle for all values of β (0 to 360). Then we Deploy a circle at centre x_c and y_c. This deployed circle is added in queue Q. If a circle cannot be deployed at centre x_c and y_c then new centre points are calculated using the equation as above. This procedure is followed for all values of α (0 to 360). When all the values of α are done we then consider the next circle in the queue Q. The above steps are repeated for radii r_1 r_2 and r_3.

6. Simulation and Results

Simulation of the four variants of circle packing algorithm is done on gcc compiler. Here we consider two variants of the algorithm.

1. Heterogeneous deployment when the sensors are place from centre. Here we compare the heterogeneous deployment of the sensors for various set of ranges (40,30,20) and (30,20,10) for the area of 400x400 sq units. Figure 6.1 shows the deployment pattern for (40,30,20) range.



5.1 Architectural Flow

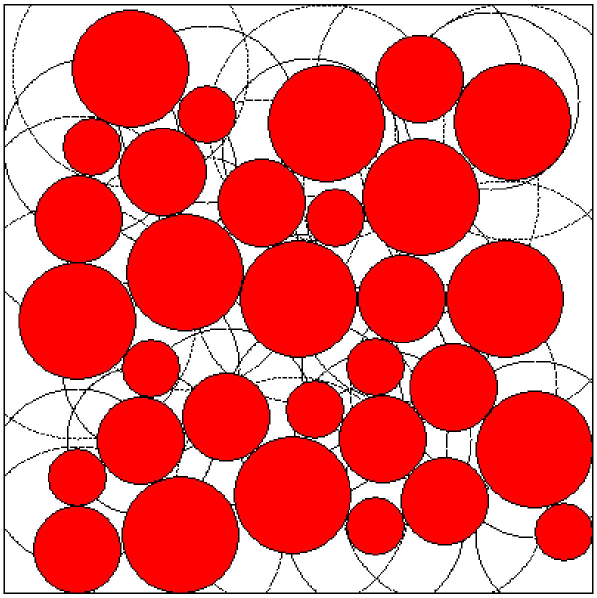


Fig 6.1 Deployment pattern for (40,30,20) range of sensors for400x400 sq units for centre packing

The area of the field was calibrated to 400x400 sq units. The total area covered by (40,30,20) was 62.6% and the number of sensors deployed were 11 for each range while (30,20,10) range of sensors covered 71.43% .

2. Heterogeneous deployment when the sensors are place from corner. Here we compare the heterogeneous deployment of the sensors various set of ranges (40,30,20) and (30,20,10) for the area of 400x400 sq units. Figure 6.2 shows the deployment pattern for (40,30,20) range.

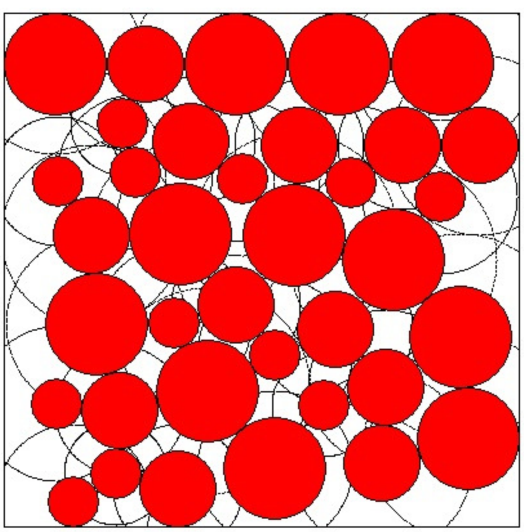


Fig 6.2 Deployment pattern for (40,30,20) range of sensors for400x400 sq units for corner packing

The area of the field was calibrated to 400x400 sq units. The total area covered by (40,30,20) was 68.29% and the number of sensors deployed were 12 for each range while (30,20,10) range of sensors covered 71.43% of 26 sensors of each range.

7. Conclusion

Here we have compared the variants of sensor deployment. The variants used corner and centre placing of the sensors. Corner placed deployment gives a better coverage then centre one. We observe that sensors having lesser range can be placed more accurately.

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