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Effect of Modified Harmony Search towards the Area Coverage in Wireless Sensor Network (WSN)

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***Abstract*—Wireless Sensor Network (WSN) have attracted many researcher to dig deeper of their abilities and specialty in carrying sensing duty. A lot of improvements have been done from day to day in many aspects including crucial issues such as energy and area coverage. Modified Harmony Search (MHS) is an improvement from basic Harmony Search (HS) method. All HS method will undergo the same step which are initialization of parameter, initialization of Harmony Memory (HM), improvisation, HM update and criterion checked. MHS undergo improvisation at the third step where the selection criteria is referring to the node placement in the memory. In this paper, we are implementing Modified Harmony Search algorithm (MHS) for node deployment purpose and the performance index such as area coverage is observed.**

***Index Terms*—Area; Coverage; Harmony; Modified; Wireless.**

I. INTRODUCTION

Node deployment is one of the most crucial issues in wireless sensor networks (WSNs). An appropriate node deployment scheme can help to reduce the complexity of problems in WSNs as, for example, routing, data fusion, etc [1]. Techniques of sensor node deployment can be classified on the basis of the placement strategy, usage and deployment domain as shown in Fig 1. Based on the figure, one of the node deployment techniques is based on placement strategy which include deterministic deployment and randomly deployment.

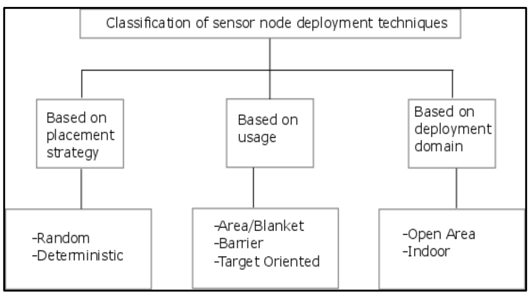

Figure 1: Classification of sensor node deployment techniques

The static deployment chooses the best location according to the optimization strategy, and the location of the sensor nodes has no change in the lifetime of the WSN [2].

II. LITERATURE REVIEW

There are various problems related to coverage issue such as area coverage, k-coverage, m-connected k-coverage problems. Area coverage problem is defined as a set of sensors are given and distributed over a specific region to monitor a given area. An area coverage problem is to find a minimum number of sensors to work such that each physical point in the area is monitored by at least a working sensor. The definition of k-coverage is an area is k-coverage if each physical point in the area is covered by at least k ($k \geq 1$) working (or active) sensors. M-connected is the communication graph of a given set of sensors M is m-connected if for any two vertices in M, there are m vertex-disjoint paths between the two vertices. An equivalent definition is, after the removal of any k-1 vertices in M, the resulted graph is still connected. M-connected k-coverage problem defines a set of sensors are given and distributed over a geographical region to monitor a given area, an m-connected k-coverage problem is to find a minimum number of sensors to work such that each physical point in the area is monitored by at least k active sensors and the active sensors form a m-connected graph.

In Wireless Sensor Network, it is very crucial to make sure all sensors can communicate with each other. The connectivity of the sensor determines the performance quality of the deployment strategy. Besides ensuring the connectivity of each nodes, node deployment strategy ensuring the percentage of sensing area coverage. Hence, an optimum node deployment strategy is a node deployment that gives optimum connectivity of the nodes with broad sensing area coverage [4]. In Wireless Sensor Networks (WSNs), the coverage is a fundamental problem that has attracted considerable research concern. Generally speaking, coverage answers the questions about the quality of service (surveillance) that can be provided by a particular sensor network [5].

The author introduces an idea for barrier coverage which is implement for railway environment monitoring system. The author proposes a method that includes three kinds of nodes which are sensor nodes, sink nodes and relay nodes. The location of each node is alternated [7]. A layered model which can be categorized as planning deployment have been introduced by Baidya & Bhattacharyya in their paper. Layered model with respect to connectivity and Layered model with respect to coverage is being implement. The result shows that layered model with respect to coverage gives higher percentage of area coverage [8].

Figure 2 shows the connected network that ensure the transmission of the data along the network [8].

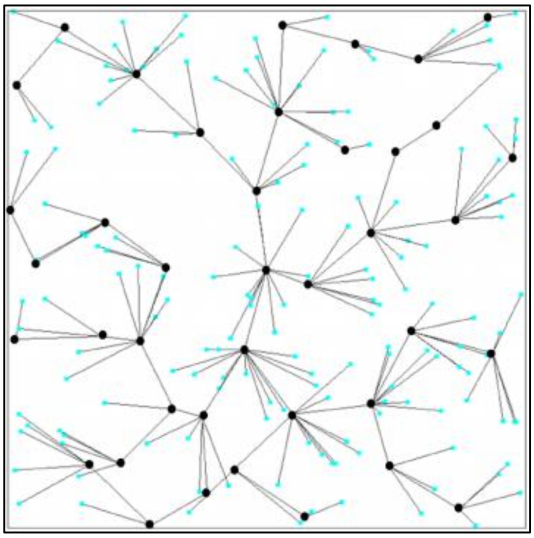

Figure 2: Connected network of sensor nodes

In this paper, we are proposing Modified Harmony Search algorithm (MHS) to be implement in node deployment strategy. Harmony Search was inspired by natural musical performance processes that occur when a musician searches for a better state of harmony, such as during jazz improvisation [6].

III. MODIFIED HARMONY SEARCH ALGORITHM (MHS)

In HSA, Harmony Memory (HM) stores the performance index such as area coverage, energy and network lifetime. When a decision variable chooses one value in the HS algorithm, it will undergo the HSA. If the new performance index is better than the worst performance index collected in HM, then the new performance index will replace the existing worst performance index in HM. Figure 3 shows the flowchart of Harmony search method. HS algorithm procedure to achieve optimization consists of five steps as shown below:

1) Initialization of parameters

Require: Harmony Memory size (HMS), Pitch Adjusting Rate (PAR), termination criterion, radius of communication (Rc);

2) Initialization of Harmony Memory (HM)

3) Improvisation

4) Harmony Memory Update

5) Terminating Criteria Checked

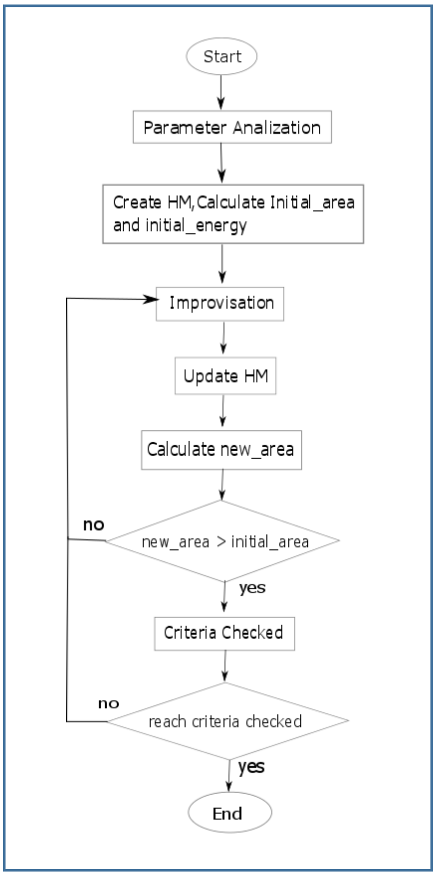

Figure 3: Flowchart of Harmony Search

IV. SYSTEM MODEL

In the proposed method, the strategy to obtain the best position to deploy the sensor nodes had been modified. There are two main factors needed to be considered which new node location are and relocate node. In our experiment, the new node location is being lodged at the region which have less coverage by the sensor. To decide which position the node should be located, a game-base theory is applied. A new position (a,b) will be created first. The intersect area of the new position (a,b) to other nodes will be calculated. If the percentage of intersect area is higher than the threshold value, another position will be created and replacing the new location. The process will be continued until a position with less intersection area is found.

However, to determine which existing location to be replaced with new node location, we implement HS in order to get the optimum result. Based on Harmony Search flowchart, the first step is to initialize the parameter such as Pitch Adjustment Rate (PAR). In our proposed method, a new parameter called Intersection Rate (IR) is introduced. IR will rate the intersection area of a sensor to another sensor. A HM will be created. The HM is consist of 15 nodes with x and y value which represents the location of each node. The nodes location will be selected randomly. At the improvisation step, a new node location will be selected. This new node will be replaced in the HM for improvement purpose in term of area coverage. The distance between the new nodes to sink node (200,200) will be calculated. To determine the relocate node, HS method is being implemented.

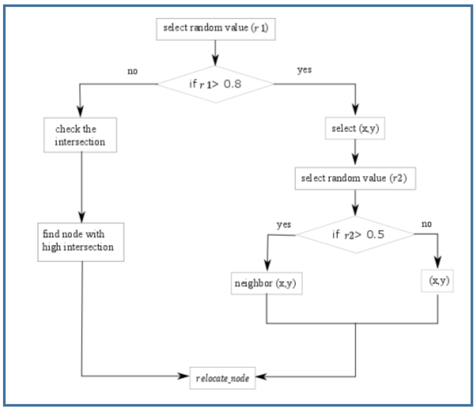

Figure 4: Improvisation flowchart

Figure 4 shows the improvisation flowchart in Harmony Search. Based on the flowchart, a random value r1 will be selected and will be the indicator to the IR value. If r1 value is more than IR value, a random element in memory will be selected and another consideration will be take count. Same as r1, another random number r2 will be selected and being compared to PAR. If the value of r2 is more than PAR, the neighbor of the selected node will be the relocate node. Otherwise, the selected node from the memory will be replaced with a new node position. However, if the value of r1 is less than IR, intersection check will be conducted. The intersection area of each node in HM will be calculated. The node with high intersection area will be selected as the relocate node. Once the relocate node is identified, the new node location will replace the relocate node in the HM. The new area coverage will be calculated and being compared to the area coverage of previous deployment. The highest area coverage will be stored as the best deployment. The process will keep going on until it reaches the stopping criterion.

Table 1
Parameters for the simulation

Parameters	Value
Data bits	250bytes
HMS	15
P random	0.1
P memory	0.6
P pitch	0.3
Rs	50
Area (width x length)	400 x 400
Sink Node position	(200,200)

V. Result

The simulation was carried out using Matlab software. The flow of the platform of the simulation is created according to the parameters mention above. The monitoring area is set to 400x400. The number of sensor nodes (HMS) is set to be 15. Each of the sensor nodes is assumed to have the same value of initial energy and the same value of sensing range. The sensing range (Rs) for each of the nodes is set to 50. For this experiment, three number of varies will be tested. The varies are number of hotspot, sink node position and size of data (bytes). The aim of the experiment is to evaluate the area coverage for existing Harmony Search and our proposed method, Modified Harmony Search for each different varies. The result between two method is then being compared and tabulate. Figure 5(a) and Table 2 shows the comparison for the area coverage of HS and MHS as the number of hotspot is increase from one to three.

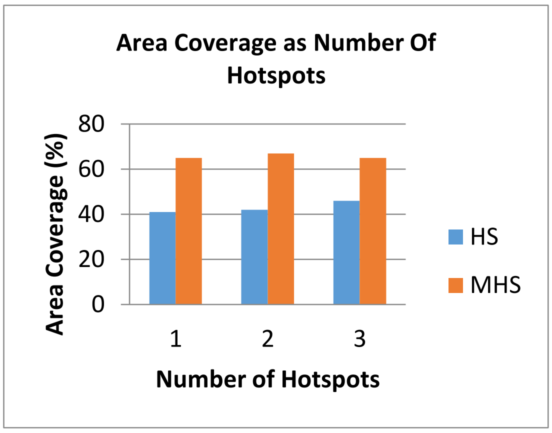

Figure 5(a): Area Coverage for different number of hotspot

Table 2
Area Coverage comparison between HS and MHS

Number of Hotspot	Area Coverage (%)	
	HS	MHS
1	41	65
2	42	67
3	46	65

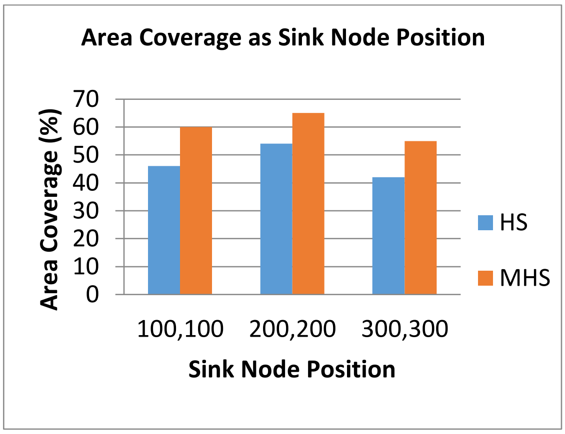

Figure 5(b): Area Coverage for different sink node position

Table 3
Area Coverage comparison between HS and MHS for different sink position

Sink Node Position	Area Coverage (%)	
	HS	MHS
100,100	46	60
200,200	54	65
300,200	42	55

The comparison in figure 5(a) clearly shows the area coverage for MHS is higher compared to the area coverage for HS. The percentage different between both methods is about 20%. The area coverage for MHS as the number of hotspot is 1 is 65% while the area coverage for HS is 41%. As the hotspot increase to 2, the area coverage for MHS increased to 67%. The same pattern for HS where the area coverage increases up to 42%. However, as the hotspots increase to 3, the area coverage for MHS slightly decreases 2% which is 65%. Differ from MHS, the area coverage for HS increase to 46%. Even though the overall graph pattern for both methods is slightly different, MHS gives higher coverage compared to HS.

The experiment is then continued by varying the sink node position. Figure 5(b) and Table 3 shows the comparison of area coverage for second varies which is sink node position. In this experiment, we varies the location of the sink node into three positions which are (100,100),(200,200) and (300,300). Comparing among three locations of sink node position, (200,200) locations gives highest area coverage for both HS and MHS. Hence it can be conclude that, the most suitable position for sink node to be placed is (200,200). For HS method, the area coverage as the sink node is located at (100,100) is 46% while 54% for (200,200). As the node position is changed to (300,300) the area coverage is 42%. For MHS method, the percentage of area coverage for sink node position (100,100) is 60%, 65% for (200,200) and 55% for (300,300).

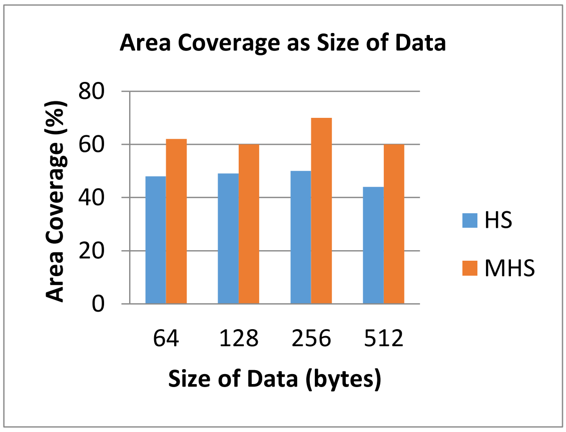

Figure 5(c): Area Coverage for different sizes of data (bytes)

Table 4
Area Coverage comparison between HS and MHS for different data sizes

Size of Data sent (bytes)	Area Coverage (%)	
	HS	MHS
64	48	62
128	49	60
256	50	70
512	44	60

Figure 5(c) shows the comparison for the third varies which is size of data sent (bytes). The sizes of data is varied to 4 sizes which are 64bytes, 128 bytes, 256 bytes and 512 bytes. For this experiment, the sink node is located at (200,200) and the number of hotspot is 1 which is the sink node position.

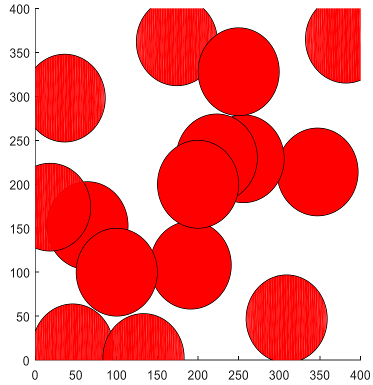

Figure 6(a): Node deployment by MHS for number of hotspot = 2

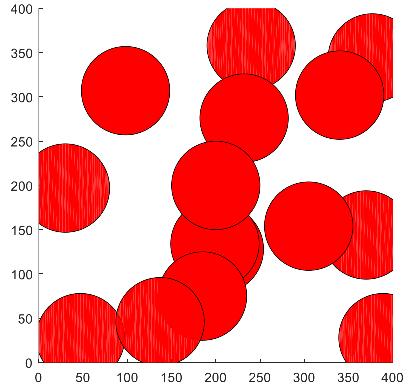

Figure 6(b): Node deployment by MHS for sink node at (200,200)

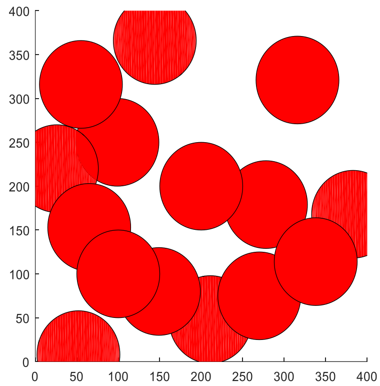

Figure 6(c): Node deployment by MHS for size of data sent = 256

From table 4, the area coverage for HS is in range of 44% and 50% while MHS, the range of the area coverage percentage is 60% to 70%. The graph pattern for both graphs is same where the area coverage is highest at the size of data sent is 256bytes. The size of data does not influence the performance of MHS in terms of area coverage. However, if the energy performance is being evaluate, the energy consumption might be effected. However for this experiment, the highest area coverage is 70% which belongs to MHS method.

Figure 6 shows the node deployment of the sensors after MHS is being applied. Figure 6(a) is the node deployment for MHS for the number of hotspot 2. Figure 6(b) is the node deployment for MHS for sink node position (200,200).

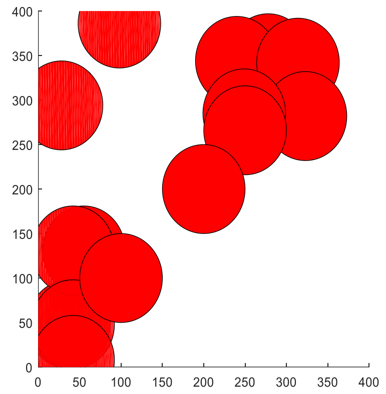

Figure 7(a): Node deployment by MHS for number of hotspot = 2

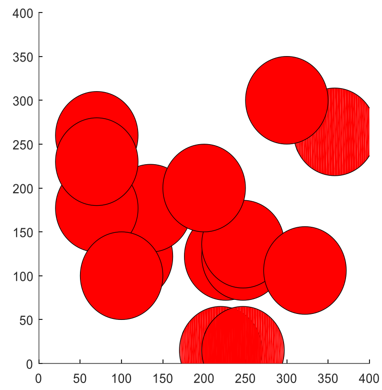

Figure 7(b): Node deployment by MHS for sink node at (200,200)

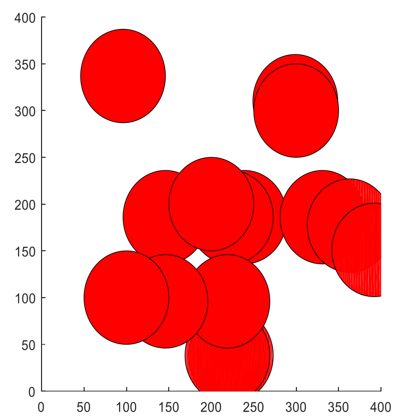

Figure 7(c): Node deployment by MHS for size of data sent = 256

Figure 6(c) is the node deployment for MHS for sizes of data 256 bytes. Figure 7 shows the node deployment of the sensors after HS is being applied. Figure 7(a) is the node deployment for HS for the number of hotspot 2. Figure 7(b) is the node deployment for HS for sink node position (200,200). Figure 7(c) is the node deployment for HS for sizes of data 256 bytes.

VI. Conclusion

Overall from the experiment, it can be concluded Modified Harmony Search performance in terms of area coverage is far away better compared to Harmony Search. The highest coverage achieved by Modified Harmony Search is 70% while Harmony Search highest coverage is 54%. There is about 16% percentage different between both methods. As the number of hotspot increase, the coverage percentage increase as well. The best sink node position is (200,200) which is the center of the monitoring area. However, for the third variable which is the size of data sent, the pattern of the coverage performance is uncertainty. This is because the size of data does not influence the performance of methods in term of area coverage. However, it might affect the result if the performance evaluate is the energy consumption. This is because the size of data sent is being considered I in energy calculation.

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