

## International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

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Vol. 8, Issue 8, August 2019

# Scalability Structural Health Monitoring Sensor Placement with Synchronization Using Clustering

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**ABSTRACT:** Wireless Sensor Networks are becoming relevant technology for Structural Health Monitoring (SHM) applications for easy deployment of sensors than the Wired Sensor Networks. SHM is the process of implementing the damage detection (health) and characterization strategy for engineering structures (bridges/dams). However, the constraints e.g., communication distance, energy of WSNs must be considered before their deployment on structures. The faults in the Wireless sensor communication such as errors, unstable connectivity affect the performance of sensor while monitoring the health of the structure. In existing system, the sensor location is adjusted according to the engineering and computer science requirements, such adjustments leads to missing of some optimal location. In proposed system, Critical Middle point SHM (CMSHM) is introduced to make resilient WSN faults. CMSHM checks for the distance and guaranteed that the WSN for SHM remains connected in the event of faults, thus prolonging the WSN lifetime under connectivity and data delivery constraints.

**KEYWORDS:** Wireless Sensor Networks, Structural Health Monitoring, Repairing point, faults.

### I. INTRODUCTION

A network is a cluster of two or more computer systems connected together. There are two types of computer networks. They are wired and wireless networks. The topology, protocol and architecture are the important characteristics of the networks. In wireless networks, the computers or any wireless devices are connected to form a network without wires. A wireless network is any type of computer network that uses wireless data connections for connecting network nodes. Each system may also acts as nodes or as sensors. Here comes a sensor networks. When sensor devices form a network is called a sensor networks.

Wireless Sensor Network (WSN) are commonly distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, vibration, etc. and to pass their data through the network to base station. Wireless Sensor Networks (WSN) consists of a large number of sensor nodes. The sensor nodes can be deployed either inside or very close to the sensed phenomenon. A sensor is the device which converts a physical phenomenon and also sound phenomenon to the electric signals e.g. heat, light, motion, vibration etc. The more modern networks are bi-directional, also used for control the sensor activity. The development of wireless sensor networks was motivated by some applications like military such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial procedural monitoring and control, structural health monitoring, and so on. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the

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sensors. The topology of the WSNs can vary from a trouble-free network to an advanced multi-hop wireless mesh network.

WSNs should self-configure and be robust to topology changes (e.g., death of a node). It also maintains the connectivity between sensor nodes and the base station. It also ensures connectivity over certain range. Some of the characteristics of the sensor networks are:

- a. Requirements: small size, large number, tether-less, and low cost.
  - i. Constrained by energy, computation, and communication
- b. Small size implies small battery
- c. Low cost & energy implies low power CPU, radio with minimum bandwidth and range
- d. Ad-hoc deployment implies no maintenance or battery replacement
- e. To increase network lifetime, no raw data is transmitted

Wireless sensor networks (WSNs) are becoming a prevalent technology for Structural Health Monitoring applications that are more relevant than wired networks.

Structural health monitoring (SHM) is emerging as a vital tool to help engineers to develop the safety and maintainability of critical structures. SHM combines a variety of sensing technologies with an embedded measurement controller to capture, log, and analyze real-time data.

The developments in sensors technologies make wireless sensor networks (WSNs) more effective and more economically-viable solutions for a wide variety of applications, such as structural monitoring, scientific exploration, and target tracking. Civil structures that are bridges, buildings, tunnels, aircrafts, and nuclear plants are complex engineering systems that ensure society's rich prosperity. Structural health monitoring (SHM) is one of the major systems are implemented for these structures to monitor their health status. WSNs are becoming a flexible technology for SHM that are more rampant and more easily deployable than wired systems. Examples include the Golden Gate bridge in the US and Guangzhou new TV tower (GNTVT) in China. The objectives of SHM are to monitor health status (i.e., damage) of a structure, provides long-term monitoring, rapid analysis in response to unusual incidents in structures. In real, it is difficult to achieve these objectives in WSN-based SHM, due to requirements of SHM and limitations of WSNs.

The WSN deployments are not covered by the engineering-like requirements, placement of sensor nodes can be planned to extend network lifetime by guaranteed connectivity and reliable data delivery. The fact of SHM is that once a set of sensors are implemented and analysis of structural properties is carried out by a base station (BS), data from each sensor location must be collected for SHM are sent to the base station. There are several constraints in Wireless sensors are such as error-less communication, fault tolerance, energy, bandwidth, etc.

There are more chances that the deployed WSN for SHM is prone to faults for various reasons: 1) physical structural modeling constraint 2) irregular communication; 3) distant between the sensors; 4) quick energy depletion of some sensors; 5) irregular communication distance that is transmitting data from a sensor to another sensor, or the BS over large structures is not reliable.

Any fault types occur in WSNs, two problems may occur: how to continue monitoring information and how to guarantee sensor fault tolerance in SHM. The fault tolerance problem has been studied promptly in different applications of WSNs by researchers in the computer science (CS) community. This can be ignored in the SHM applications.

This paper is organized as follows. In Section 2, discusses related work. Section 3 the proposed CSMHM algorithm. The Results and discussions are given in Section 4. Finally, Section 5 concludes this paper.

## II. RELATED WORK

WSNs are progressively becoming relevant for SHM applications, focusing on trustworthy collections of raw signals at relatively high synchronization [1], [3], [5], and [6]. Here, only discussing the sensor deployment view.

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Various best possible sensor deployment methods from engineering domains have been used for wired network systems [10], [13], [15], and [16]. Some WSN devices are used and verified with an interest in knowing whether a wireless sensor device is best suitable for SHM [1]. These are also not very alarmed with the effects of sensor faults, transmission faults, WSN separation, etc., on a deployed WSN on a structure.

Based on the sensor deployment feasibility, a remarkable work on WSN deployment, SPEM [13], is suggested and is also verified. Bo Li et al. [13] proposed the sensor placement on the civil requirements and on the computer science requirements. It provides the placement quality of the candidate locations of the sensors in step by step manner. Then optimize the system performance, by considering networking connectivity and data routing issues; with the objective on energy efficiency. For this, this process leads to the introduction of the new method called Sensor Placement using EFI method (SPEM). The deployment of the sensors must be in Effective Independence EFI [13] method and not be in regular forms (i.e.) grids or tree form. The Effective Independence placement method gives the appropriate location of the sensors. It shows the topology control, data routing and energy efficiency which can be integrated with the SHM framework. But it has some drawbacks, is that the computer requirements constraints should be adjusted with the civil placement quality constraints which leads to missing of some optimal locations in the structure. It also fails to recover from fault in wireless sensors while monitoring.

It can be seen that wireless sensor deployment for monitoring a structural shape (e.g., damage, crack, etc.) is not as simple as in other applications. Because, the spatial information to report the sensitivity of a structural shape is not sufficient at many locations. For example, existing system with grids [15] are not suitable for SHM requirements.

Ziqiu Yun et al. [16] proposed the deployment patterns of wireless sensor to achieve full coverage and k-connectivity under different proportions of the sensor communication range. For the deployment introduces the polygon-based methodology to prove the best deployment patterns to attain 3-connectivity, 4-connectivity, 5-connectivity and 6-connectivity under all ranges. When k is above the range of 6-connectivity range ( $k > 6$ ), this patterns are complicated and cannot construct the networks that is disjoint union of the atomic deployment polygons. The k-connectivity patterns based on the constraints are coverage constraints and connectivity constraints. The coverage constraints are the area of atomic Polygons and the connectivity constraints are embodied in the polygons edge length. The deployment of sensors is the collection of individual deployment polygons, which form a tessellation over a region. The tessellation is the biggest area with the number of vertices constructing polygons. In this method there is the chance of missing some region when the placement of the sensors which leads to the communication error among the sensors. It may affect the performance of the sensor while monitoring the health status.

Kenan Xu et al. [15] proposed sensor deployment issue in WSNs. The number and positions of sensors and traffic also determine the usability of a system in terms of coverage, connectivity, lifetime, cost, etc. Here, the impacts of random device deployment on connectivity and lifetime in a large-scale heterogeneous WSN. The deployment of the RNs can have a significant impact on connectivity and lifetime of a WSN system. The former solely aims at balancing the energy consumption rates of RNs across the network, thus extending the system lifetime. The Relay Nodes which are away from the Base Station will dissipate energy faster than the RNs closer to the BS due to the larger transmission distance. The reason is because traffic is built up on RNs closer to the BS as it is relayed from far to near. The idea is to deploy a set of sensors, which collect sensing data and another set of sensors, to relay the data from the sensors in the first set to the BS. They may not satisfy distance constraints among the placement of sensor.

The proposed CMSHM attempts to overcome the distance problem and to deploy the sensors for monitoring the structure using wireless sensor networks, thus extending the lifetime of the sensors.

### III. PROPOSED SYSTEM

In this section, consider critical middle point as a repairing point to communicate among sensors. While placing sensors in the structure for health status monitoring, the sensors are arranged according to the sensing range. These arrangements may affect the distance between two sensors while communicating the health status of the structure.

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Let consider,  $p$  be the primary sensors and  $b$  be the backup sensors. Place the primary sensors and arrange them for communication among the sensors. The sensors can be placed at the repairing point of critical middle point.

### 3.1 Sensor placement at the repairing point.

In this section, describes the Sensor Placement at the place of repairing point. The critical middle point [11] considered as repairing point. A middle point between two sensors in the region of the sensor placed is an RP which is the longest and irregular transmission distance between the sender and receiver. In order to achieve balance in distance and to receive data packets reliably and continuously place a backup sensor between sender and receiver.

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#### Algorithm 1: Finding the critical middle point

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**Input:**  $n$  number of primary sensors

**Output:** Placement of the backup sensors

1. for each pair of sensors  $u$  and  $v$  do:  
    check distance  $(uv) > t$   
    if available such distance  $(uv)$  then  
        Step 2
2. if available RP then  
    if  $B > 0$   
        call search and place  
    else  
        discover the nearby RP at one hop  
    end;

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Above algorithm describes that, find such RP (repairing points) in each sensor region placed.

Let,  $u$  consider as a sender and  $v$  consider as a receiver. Scan for the repairing points, if the distance between the pair of sensors is greater than the threshold value ( $t$ ), then move to the second step that is search and place the backup sensors. If there is no repairing point between the pair of sensors then move to the neighbor hop to find the critical middle points.

After placing backup sensor in the proximity of the middle points on the line between  $u$  and  $v$ , the communication between the pair of sensor by  $u$  to  $b$  and  $b$  to  $v$ ; the chance of data packet-loss is reduced.

### 3.2 Search and Place algorithm.

In this section, this is an algorithm which is called after repairing point called critical middle point [11] having found. After founding this repairing point backup sensor  $b$  is placed through this search and place algorithm. Here, possible locations are found according to sensor range and sensors are placed using EFI [13] value.

Search and replace algorithm checks for possible locations. After the deployment of each sensor, the algorithm sorts rest of the location according to the sensor range.

The optimal locations are selected around repairing points. If there are several locations available along with an RP, then the location with the more vibration is a better choice to place a sensor.

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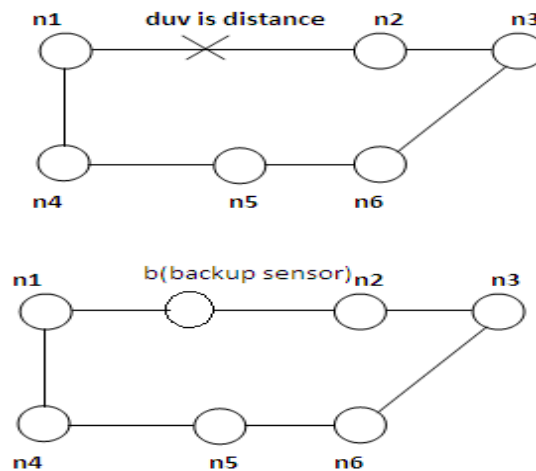


Fig. 3.1. Placing backup sensor in repairing points

Then the locations nearby the RP are found. The locations can be zero to many, which means that there is a chance of having more than one location, or no locations available around the repairing points. If there is a backup sensor available near that location, but no location near an RP, the algorithm places a backup sensor at the same sensor location.

Using this algorithm, the critical middle point's backup sensors are placed.

This algorithm [11] is used by critical middle point repairing points for placing the backup sensor effectively.

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## Algorithm 2: Search and place algorithm

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**Input:** Rest of the location

**Output:** Placement of the backup sensors at optimal location

find the remaining location after placement sensors

while found remaining sensors

    sorts the locations according to vibration frequency

    find the repairing points (RP) with larger vibration frequency

    for RP locations  $\epsilon$  neighbor location within distance (uv) do:

return location

if (b>1) then //available location

    if available location

        place the backup sensors at each RP

end;

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In order to achieve reliable data packets by placing a backup sensors at the optimal repairing point locations.

## IV. RESULTS

The simulations are carried out for detailed analysis of the proposed method. The simulation method is by network simulator ns-2. This paper clearly points out some of the shortcomings about the existing literature work for the placement of the sensors, by analyzing the sensor placement of various existing approaches. Another two approaches [14], [15] when tested show low quality. The proposed approach when tested shows more optimal results.

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Here, observe that the placement quality decreases as the number of sensors increases. In CMSHM, in the case of backup sensors, the placement performance is better than the SPEM [13]. Another two approaches, REALY [15] and TARD [14], show low location quality. Their poor performance proves that deployment should satisfy application demand from SHM, although they both require a minimum number of iterations. CMSHM is still robust under such a sensor fault rate.

The proposed system is compared with the existing instances and it proves to be more robust in sensor placements and thus increases the packet delivery ratio up to 80% and also end to end delay, because of the backup sensor placement has reduced to 15%.

## V. CONCLUSION AND FUTURE WORK

The intention of this method is to demonstrate a new way of incorporating the requirements of both WSN and SHM, and to make use of traditional engineering methods in the WSN. It is found that, is worthwhile to place a small number of backup sensors around the repair points in the WSN to have a better performance. Such an idea of the backup sensor placement can also be used in generic WSN applications. The proposal of SHM algorithm exploits sensor-decentralized computing in the resource-constrained WSN. The validation shows that structural health monitoring using WSN scan be meaningless, if the requirements of WSNs (e.g., fault tolerance, energy efficiency) are not seriously considered.

The feature work is to develop a SHM-specific scheduling technique for the backup sensors that will wake up one or more backup sensors while faults in sensor.

## REFERENCES

- [1] M. Z. A. Bhuiyan, G. Wang, and J. Cao, "Sensor placement with multiple objectives for structural health monitoring in WSNs," in IEEE 9th Int. Conf. High Perform. Comput. commun. (HPCC), 2012, pp. 699–706.
- [2] M. Z. A. Bhuiyan, J. Cao, G. Wang, and X. Liu, "Energy-efficient and fault-tolerant structural health monitoring in wireless sensor networks," in Proc. IEEE 31st Symp. Reliable Distrib. Syst. (SRDS), 2012, pp. 301–310.
- [3] C. Buragohain, D. Agrawal, and S. Suri, "Power Aware Routing for Sensor Database," Proc. IEEE INFOCOM, 2005.
- [4] P. Cheng, C. N. Chuah, and X. Liu, "Energy-aware node placement in wireless sensor network," in Proc. Global Telecommunication Conf.(GLOBECOM), 2004, pp. 3210–3214.
- [5] Heo G, Wang ML, Satpathi D. "Optimal transducer placement for health monitoring of long span bridge". Soil Dynamics and earthquake Engineering 1997; 16:495–502.
- [6] D. C. Kammer, "Sensor placement for on-orbit modal identification and correlation of large space structures," J. Guid. Control. Dyn., vol. 14, no. 2, pp. 251–259, 1991.
- [7] S. Kim, S. Pakzad, D. Culler, J. Demmel, G. Fenves, S. Glaser, and M. Turon, "Health monitoring of civil infrastructures using wireless sensor networks," in Proc. 6th Int. Symp. Inform. Process. Sensor Networks (IPSN), 2007, pp. 254–263.
- [8] G. Hackmann, F. Sun, N. Castaneda, C. Lu, and S. Dyke, "A holistic approach to decentralized structural damage localization using wireless sensor networks," Comput. Commun., vol. 36, no. 1, pp.29–41, 2012.
- [9] W. B. Heinzelman, A. P. Chandrakasan, H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Micro sensor Networks", IEEE Transactions On Wireless Communications, 1(4): 660-670, 2002.
- [10] M. Meo and G. Zuppano, "On the optimal sensor placement techniques for a bridge structure," Eng. Struct., vol. 27, no. 2005, pp. 1488–1497, 2005.
- [11] Md Zakirul Alam Bhuiyan, Jiannong Cao, Guojun Wang, "Backup Sensor Placement with Guaranteed Fault Tolerance for Structural Health Monitoring", 2011 The Sixth Beijing-Hong Kong International Doctoral Forum (IDF'11)
- [12] X.Y. Li, Y. Wang, P.J. Wan, and C.W. Yi, "Robust deployment and fault tolerant topology control for wireless ad hoc networks," in ACM International Symposium on Mobile Ad Hoc Networking and Computing. June 2003.
- [13] B. Li, D. Wang, F. Wang, and Y. Q. Ni, "High quality sensor placement for SHM systems: Refocusing on application demands," in Proc. IEEE Conf. Comput. Commun. (INFOCOM), 2010, pp. 650–658.
- [14] F. Wang, D. Wang, and J. Liu, "Traffic-aware relay node deployment: Maximizing lifetime for data collection wireless sensor networks," IEEE Trans. Parallel Distrib. Syst., vol. 22, no. 8, pp. 1415– 1423, Aug. 2011.
- [15] K. Xu, H. Hassanein, G. Takahara, and Q. Wang, "Relay node deployment strategies in heterogeneous wireless sensor networks," IEEE Trans. Mobile Comput., vol. 9, no. 2, pp. 145–159, Feb. 2010.
- [16] Z. Yun, X. Bai, D. Xuan, T. H. Lai, and W. Jia, "Optimal deployment patterns for full coverage and k-connectivity ( $k \leq 6$ ) wireless sensor networks," IEEE/ACM Trans. Networks., vol. 13, no. 3, pp. 934–947, 2010.