ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

Distributed Structural Health Monitoring By Cyber-Physical Codesign

Gowri G[1], L S Jayashree[2], Pradeep G[3]

P.G. Scholar, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India.

Professor & Dean, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India.

P.G. Scholar, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India.

ABSTRACT: In these decades the civil infrastructure has been facing crucial challenges for long term structural health monitoring for detection and localization of damage. In the earlier research the design of wireless sensor network has been commonly separates from structural Engineering algorithm. In this paper we propose Cyber-physical code sign approach in wireless sensor network for monitoring the structural health of the civil infrastructure. Here we integrate two approaches i) Flexibility based damage localization methods that allows a Trade-Off between number of sensor nodes and resolution of damage localization. ii) Energy Efficient, hierarchical multi-level computing architecture designed to multiply its ability for the multi-resolution features of flexibility-based approach. The system has been implemented on the Intel Imote2 platform. The system implements the demonstration of energy efficiency and damage localization.

KEYWORDS*:* Cyber-Physical system, Structural Health Monitoring, Wireless Sensor Network.

I. INTRODUCTION

The downturn of our civil infrastructure is an evolving problem both in the US and throughout the world. For example, during their lifespan the bridges affect from environmental corrosion, never-ending traffic, wind loading, severe earthquake occurrence, material aging and more, which is unavoidably result in structural insufficiency. Almost more than 26% of the bridges are either structurally deficient or outdated functionality from the survey of American Society for Civil Engineers in 2009 report of American's infrastructure. At present most of these structures are not being observedcontinuously, because of the wired sensor infrastructure.

Nowadays there is a growing interest in SHM based on Wireless Sensor Networks (WSNs) for the sake of low installation. WSNs allow a heavy deployment of measurement points on an existing structure, to make accurate and fault-tolerant recognition methods without the requirement of wired infrastructure. Several SHM systems have been proposed in literature that leverages WSNs to collect raw sensor data. These systems are normally planned to support standard centralized SHM methods, with special observation to the certain bandwidth and energy supplies that are not available below a standard system of wired sensors.

Though, by behaving SHM as simple data collection methods for maintaining centralized SHM methods, the out coming systems basically affected from high energy utilization and extended detection latencies. Let us consider, a state-of-art system installed at the Golden Gate Bridge needed 9 hours to accumulate a single circular of data from 64 sensors, out coming in a system lifespan of 10 weeks while using four 6V beacon batteries as a power origin. This method's high inactivity and comparatively short lifespan emerge from the fact that the priming SHM method was planned dividedly from the WSN system. Specially, the SHM method needed the WSN to definitely deliver the whole raw sensor dataset to the base station for centralized approaching, inherently positioning a high network load on the WSN system.

10.15680/ijircce.2015.0302089

What is required is a basically distinct cyber-physical method which thinks both the limitations of the basic WSN system (the cyber components) and the SHM specification (the physical components) in its statistical approach. This can be attained by leveraging the progressively potent processing ability of wireless sensor "motes" to partly process

II. RELATED WORK

In the existing system, in order to detect the damage localization in the wireless sensor network different methods are suggested.

A new method is developed which provides services for reliable multihop transmission of raw sensor data, using run-length encoding to compress the data before transmission. These centralized approaches suffer from two fundamental limitations. First, data may only be collected from a limited number of nodes in a reasonable time frame, which would allow the system to only detect the most severe (and probably visually apparent) damages. Second, such systems are inadequate for timely detection of structural failures resulting from extreme events (e.g., earthquakes) due to the prolonged time needed for collecting and analysing data.

A low-cost and rapid-to deploy wireless structural monitoring system on a long span cable-stayed bridge is developed in Taiwan. The full-scale test was conducted by collecting ambient vibration data of the bridge and analysing it in situ by two modal identification methodologies, the stochastic subspace identification method (SSI) and frequency domain decomposition method (FDD). Modal ID results led to the determination of a total of 10 modal frequencies and corresponding mode shapes within a frequency range of 0-7 Hz.

Also implemented an automated modal identification by optimizing output-only modal methods (FDD with peak picking) for a distributed wireless sensor network. The distributed implementation, tested in a balcony of a theatre, used a parallel data processing and reduced communication scheme to ensure scalability and power efficiency in the WSN. Their implementation proposes three network topologies to yield a two-node based data sharing chain. This implies the partial mode shape identified from each pair of nodes has to be recombined to recreate the complete mode shape necessary for damage detection. This strategy would potentially amplify the recombination error, if any one of the sensor nodes is unreliable.

III. PROPOSED ALGORITHM

In the proposed system, a hierarchical decentralized SHM system is presented that implements flexibility-based damage identification and localization. Flexibility-based methods accurately identify and localize damage on a wider range of structures than previous decentralized algorithms like DLAC, by explicitly correlating data across multiple sensors. The hierarchical system organizes nodes into clusters using a novel multilevel search approach that incrementally activates sensors in the damaged regions, allowing much of the network to remain asleep. By leverage the Intel Imote2 platform's computational power to perform in-network processing, nodes save energy and bandwidth by only transmitting the intermediate results related to the flexibility calculation. In this work, the following contributions are:

1. A cyber-physical architecture is designed that efficiently maps flexibility-based damage identification and localization methods onto a distributed WSN.
2. An implementation of this architecture is used on top of the Tiny OS operating system and ISHM services tool suite.
3. This implementation is evaluated on a simulated truss structure and a real, full-scale truss structure, successfully localizing damage on both structures to the resolution of a single element. Latency and power consumption data collected during these experiments demonstrate the efficiency of this approach.

A. Design Considerations:

- Collecting Sensor data
- Compute the FFT
- Compute the CDS and SVD matrix

- Flexibility-based method
- Performance Evaluation

B. Description of Proposed Algorithm

Collecting sensor data

In this section, once participating nodes are selected, they are each assigned one of three roles: cluster member, cluster head, and base station. A node's role determines what data it handles as well as its level in the network hierarchy. All nodes in a cluster simultaneously collect D vibration samples using their on-board accelerometers. D's size depends on structural properties (like its complexity and material) as well as the modes are interested in, and is typically hundreds or thousands of samples. Based on these roles, the system operates as follows: The cluster members collect raw vibration samples from their on-board accelerometers.

Compute the FFT

Each node independently performs a Fast Fourier transform (FFT) and power spectrum analysis on the vibration data, transforming it into magnitudes in the frequency domain.

Compute the CDS and SVD matrix

The cluster head nodes aggregate the extracted power spectrum data from their cluster members. There, the CSD and SVD are carried out to extract the structure's mode shape vector. CSD and SVD are necessarily computed on a single node with access to all the other cluster members' data, and the prior steps all have very large outputs (hundreds or thousands of points). To achieve truly energy-efficient behaviour, must optimize the FDD algorithm's data flow to promote an efficient mapping onto wireless sensor networks. To leverage an optimization proposed that adds a peak picking stage to FDD. To illustrate this optimization, note that most of the computations in the FDD routine do not contribute to the final results. The CSD step normally requires the cluster head to pool D data points from each of its cluster members. This data are processed into D CSD matrices, which the SVD routine further processes into D outputs and discards all but the P corresponding to the structure's natural frequencies (note that $P << D$). A key observation about this procedure is that the ith CSD matrix is only constructed using the ith power spectrum data point from n each cluster member. Moreover, only the P CSD matrices corresponding to the structure's natural frequencies contribute to the FDD stage's final output.

Flexibility-based method

The cluster heads then transmit the mode shapes to a single base station node, which calculates the structure's flexibility. The flexibility is then used to identify and localize any structural damage. This will identify two adjacent sensors surrounding each damage location on the structure. In the next round of the multilevel search, the system activates additional sensors in the region of interest and repeats the entire procedure. This second round subsequently localizes the damage to a smaller region than the first round. The system may repeat this drill-down procedure to achieve even finer-grained results until the desired resolution is reached.

Performance evaluation

To validate the system, implemented and deployed the multilevel damage localization system on three representative structures. Experimental results demonstrate that this system is able to accurately localize damage at the member-level. Moreover, latency and energy consumption data collected during the experiment illustrate the efficiency of this decentralized approach. Preliminary results collected in-situ on a real truss structure also validate the approach.

IV. RESULTS AND DISCUSSION

To validate this system, the multilevel damage localization system is deployed and implemented on three representative structures. Firstly, describe an experiment carried out by injecting data from a simulated truss structure into a test bed of real Imote2 nodes. Experimental results demonstrate that this system is able to accurately localize damage at the member-level. Moreover, latency and energy consumption data collected during the experiment illustrate the efficiency of the decentralized approach. Preliminary results collected in-situ on a real truss structure also validates the approach.

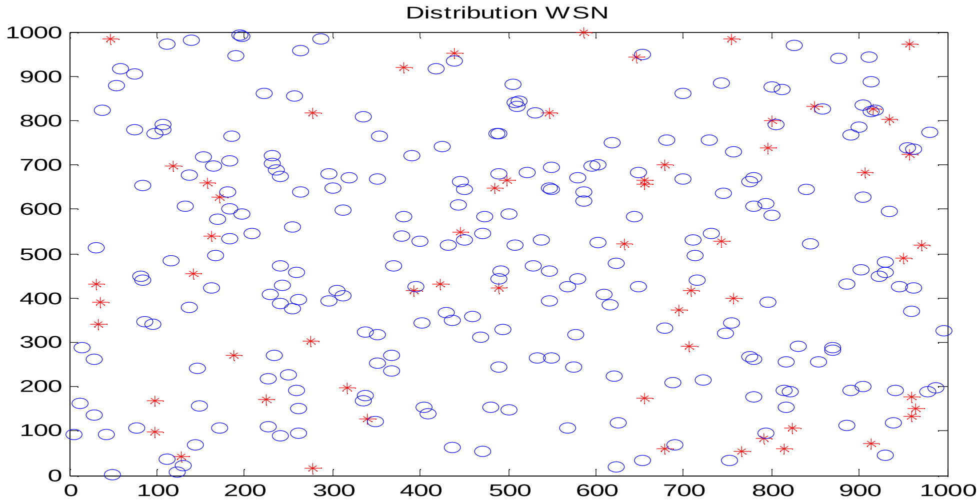

Fig: 1 Deployment WSN

In this figure, the sensor nodes are deployed in the wireless sensor network. All nodes in a cluster simultaneously collect D vibration samples using their on-board accelerometers. D’s size depends on structural properties (like its complexity and material) as well as the modes are interested in, and is typically hundreds or thousands of samples.

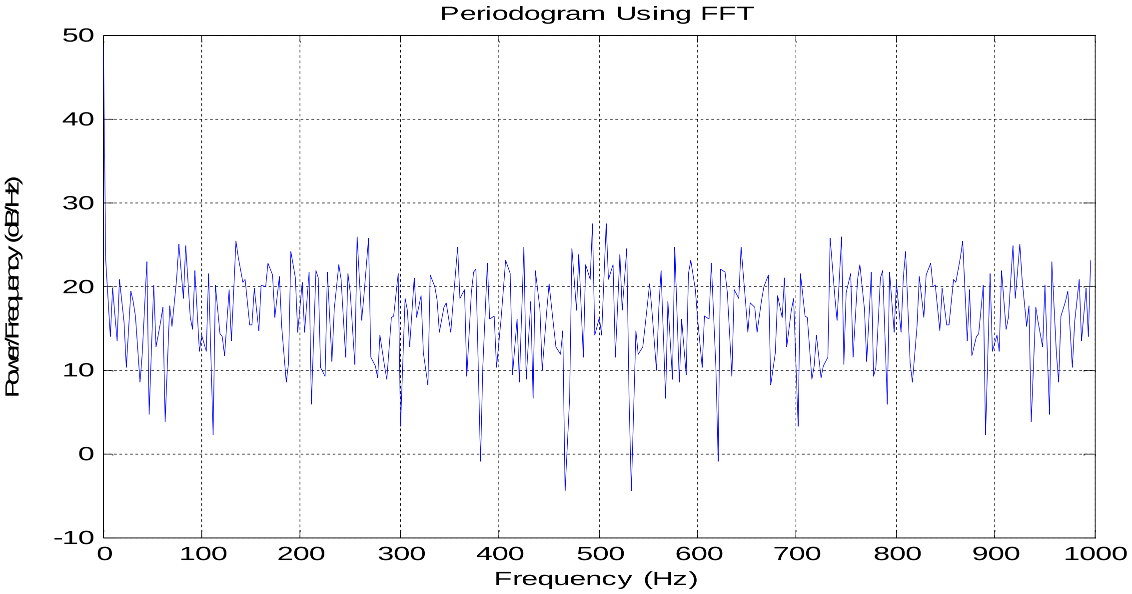

Fig: 2 Periodogram Using FFT

In the fig:2 the frequency is taken in the X-axis. The power frequency is taken in Y-axis. Each node independently performs a fast Fourier transform (FFT) and power spectrum analysis on the vibration data, transforming it into magnitudes in the frequency domain.

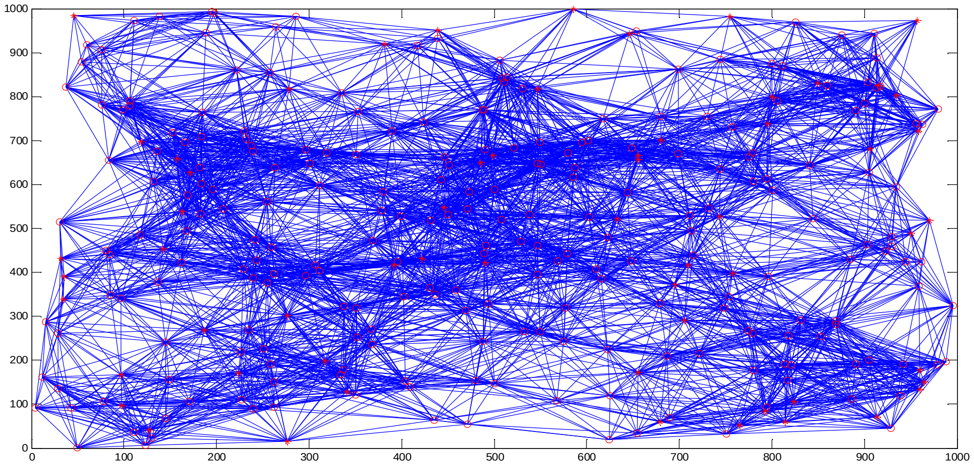

Fig: 3 Computation of cross spectral density matrix

In the above fig: 3the D magnitudes collected from each node are correlated to compute a cross spectral density (CSD) matrix.

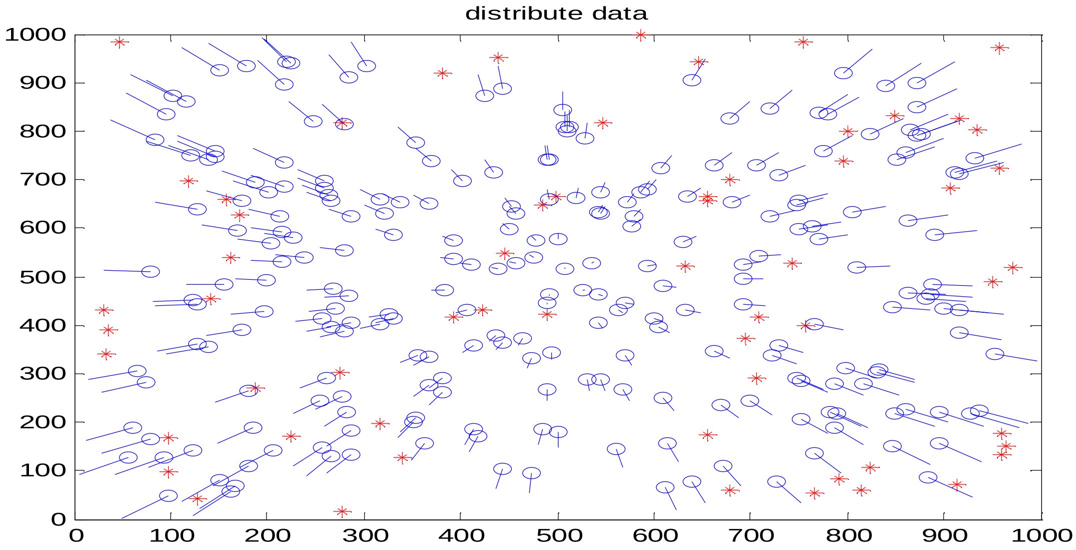

Fig 4 Distributed data

In the above fig: 4, a SVD is performed on the CSD matrix at each of D discrete frequencies. The singular value in each matrix is collected to form a vector, and the structure's P lowest natural frequencies are identified as the peaks in this vector. The corresponding mode shapes can be estimated from the first column of the corresponding left SVD matrix.

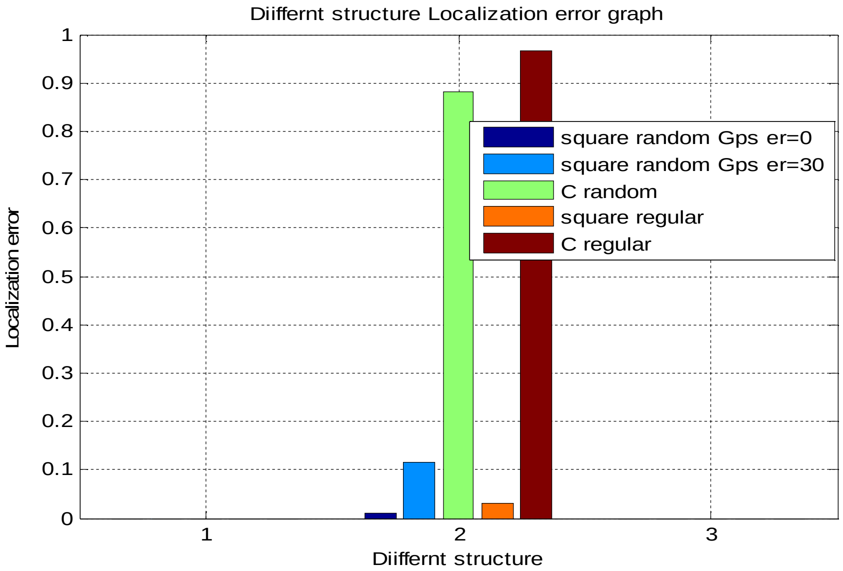

Fig: 5 Comparison graph

In this graph, different structure is taken in the X-axis. In the Y-axis localization error is taken. The structures like C random, square regular, C regular, square random GPS error=0, square random GPS erro30. From these structures, there is less localization error in the square random GPS with zero error structure.

V. CONCLUSION AND FUTURE WORK

Structural health monitoring of civil infrastructure represents an important application domain of cyber-physical systems. A novel cyber-physical co-design approach is used to structural health monitoring based on wireless sensor networks. The distributed structural health monitoring system integrates 1) flexibility-based structural engineering methods that can localize damages at different resolution and costs, and 2) an efficient, multilevel computing architecture that leverage on the multi-resolution feature of flexibility-based methods. A key feature of the approach is that it selectively activates nodes in the damaged region to achieve fine-grained localization damage localization while allowing many of the nodes to remain asleep. Experimental results show that this system is able to localize damage to the resolution of a single element on a representative simulated and real truss structures. Also demonstrate the energy efficiency of this approach through latency and energy consumption measurements. The results illustrate the promise of cyber-physical approach that considers both the architecture of the cyber (wireless sensor network) system and the characteristics of the physical (structural engineering) methods.

FUTURE WORK: But the existing method has high congestion and less fairness. Well-designed congestion control techniques allow efficient transmission of significant volumes of data from a large number of nodes along one or more routes towards the data processing centres. So, this can be considered in future.

REFERENCES

1. A. Jindal and M. Liu, “Networked Computing in Wireless Sensor Networks for Structural Health Monitoring,” IEEE/ACM Trans. Networking, vol. 20, no. 4, pp. 1203-1216, Aug. 2012.ragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.
2. B. Li, D. Wang, F. Wang, and Y.Q. Ni, “High Quality Sensor Placement for SHM Systems: Refocusing on Application Demands,” Proc. IEEE INFOCOM, 2010.
3. G. Hackmann, F. Sun, N. Castaneda, C. Lu, and S. Dyke, “A Holistic Approach to Decentralized Structural Damage Localization Using Wireless Sensor Networks,” Proc. IEEE Real-Time Systems Symp. (RTSS), 2008.

4. N. Castaneda, F. Sun, S. Dyke, C. Lu, A. Hope, and T. Nagayama, "Implementation of a Correlation-Based Decentralized Damage Detection Method Using Wireless Sensors," Proc. Int'l Conf. Advances in Structural Eng. and Mechanics (ASEM), 2008.
5. M. Ceriotti, L. Mottola, G.P. Picco, A.L. Murphy, S. Guna, M. Corra, M. Pozzi, D. Zonta, and P. Zanon, "Monitoring Heritage Buildings with Wireless Sensor Networks: The Torre Aquila Deployment," Proc. ACM/IEEE Eighth Int'l Conf' Information Processing in Sensor Networks (IPSN), 2009.

BIOGRAPHY

GOWRI G is a P.G. Scholar, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India. She received Bachelor of Engineering (CSE) degree in 2013 from Anna University, Chennai, India. Her research interests are Computer Networks (Wireless Networks) and Image Processing

L S JAYASHREE is a Professor & Dean, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India.

PRADEEP G is a P.G. Scholar, Department of CSE, R.V.S. College of Engineering and Technology, Coimbatore, India. He received Bachelor of Engineering (CSE) degree in 2013 from Anna University, Chennai, India. His research interests are Computer Networks (Wireless Networks), Data Mining, Image Processing and Cryptography.