DEVELOPMENT OF ALGORITHM FOR DYNAMIC RESPONSES IN CIVIL STRUCTURES USING WIRELESS SENSORS

[1] M.S.THARA DEVI, [2] R.JAYASHREE, [3]S.SELVANAYAKI
[1, 2] M.E Student, [3]Assistant Professor
[1, 3] Vel Tech Multi Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai, Tamil Nadu, India,

ABSTRACT- *Civil structures, subject to external excitation, are prone to damage and deterioration during their service lives. Structural Health Monitoring (SHM) has been proving to be a suitable application domain for wireless sensor networks, whose techniques attempt to autonomously evaluate the integrity of structures, occasionally aiming at detecting and localizing damage. To ensure structural integrity it is desirable to monitor these structures to detect the existence, location, and severity of any damage in real time.. In this work, an algorithm is proposed in multi-programming languages, which works in frequency domain, supported by multilevel information fusion techniques to enable detection and localization of damage using the raw dynamic response data acquired using suitable wireless sensor network.*

key terms- Structural health monitoring, multilevel information fusion techniques,structural integrity.

1, INTRODUCTION

1.1 OBJECTIVE

In recent years, wireless sensor network in the area of structural health monitoring is gaining more popularity due to its remote tracking, continuous monitoring and less man power. The ability of wireless sensors to autonomously collect, store, and communicate data has led to these devices being labeled as “smart” sensors. The densest dynamic data, huge continuous data, collected from the wireless sensors is to be communicated to a nearest server. The objective of the work is to,

- Propose a data processing algorithm using MATLAB for analyzing the dynamic response of the structures for damage identification.
- Validation of the proposed algorithm from the measured data during monitoring using wireless sensor networks.

1.2 SCOPE

The scope of this thesis is confined to the conditions given below.

- Literature review on various wireless sensor platform and algorithm for dynamic responses.
- Development of algorithm is done primarily using MATLAB.
- An algorithm proposed is primarily focused on analyzing the dynamic response of the linear elastic structures, non-linearity is not considered.
- Effectiveness of the algorithm was verified through the real-time experiments carried out using data acquired from a WSN used for structure health monitoring at laboratory level.
- The work is extended further in developing the code in multiprogramming language such as C, C++ and C#.NET.

1.3 OVERVIEW

Structural health monitoring (SHM) is defined as the computational paradigm used to quantify a structure’s health and well-being over its operational life. Application of SHM concepts to a diverse set of structures, ranging from aircrafts to traditional civil structures, has tremendous benefit in assessing safety and remaining operational life. While still in its infancy, researchers in the SHM field have produced a variety of algorithms for the identification of damage in structures. To date, methods developed for damage detection can be classified as frequency-domain or time-domain approaches.

The earliest damage detection methods correlated damage to changes in structural stiffness. The methods use finite element models and linear modal parameters, such as natural frequencies and mode shapes, to identify the existence of damage and in some cases, even damage location and severity (Doebling et al 1996). Modal properties, like natural frequencies of a structure’s modes, are observed in the healthy structure. If major changes are observed in modal properties over a structure’s operational life, the changes could be attributed to damage.

The extraction of modal parameters from frequency response functions derived from vibration-based test data. Classified as frequency-domain approaches, these methods had success in identifying large levels of damage in a structure.

2. SYSTEM ANALYSIS

2.1 EXISTING SYSTEM

A wireless sensor network consists a collection of tiny device are called sensor node. This technology provides the engineering community with an affordable method of obtaining rich sets of measurement data from large, spatially diverse networks of sensing devices. Now a days, wireless sensor network in the area of structural health monitoring is gaining more popularity due to its remote tracking, continuous monitoring and less man power. The ability of wireless sensors to autonomously collect, store, analyze, and communicate data has led to these devices being labeled as “smart” sensors. The densest dynamic data, huge continuous data, collected from the wireless sensors is to be communicated to a nearest server. The densest dynamic data, huge continuous data, collected from the wireless sensors is to be communicated to a nearest server; this large amount of data communication is very expensive and also chances of data getting disturbed during communication process is very high. Thus, an attempt should be made to minimize the amount densest dynamic data through communication as much as possible.It is well known that communicating 1 bit over the wireless medium at short range consumes far more energy. Thus, an attempt should be made to minimize the amount densest dynamic data through communication as much as possible.

2.2 PROPOSED SYSTEM

In the proposed system, a data processing algorithm will be developed to process the densest dynamic data measured from the wireless sensors at the sensor node levelusingfrequency-domain approach, which in turn process the key data for identification of damage with greater time efficiency, and effectively transfer the processed key data which greatly reduces the data traffic, storage,etc,.Some of the advantages are

- Autonomously collects, stores & analyzes data
- Instantaneous damage identification

International Journal of Advanced Research in
Computer Science Engineering and Information Technology
Volume: 3 Issue: 3 09-Oct-2014,ISSN_NO: 2321-3337

- Effective transition
- No data interference
- Less energy consumption

3. SYSTEM DESIGN AND METHODS

3.1 SYSTEM ARCHITECTURE

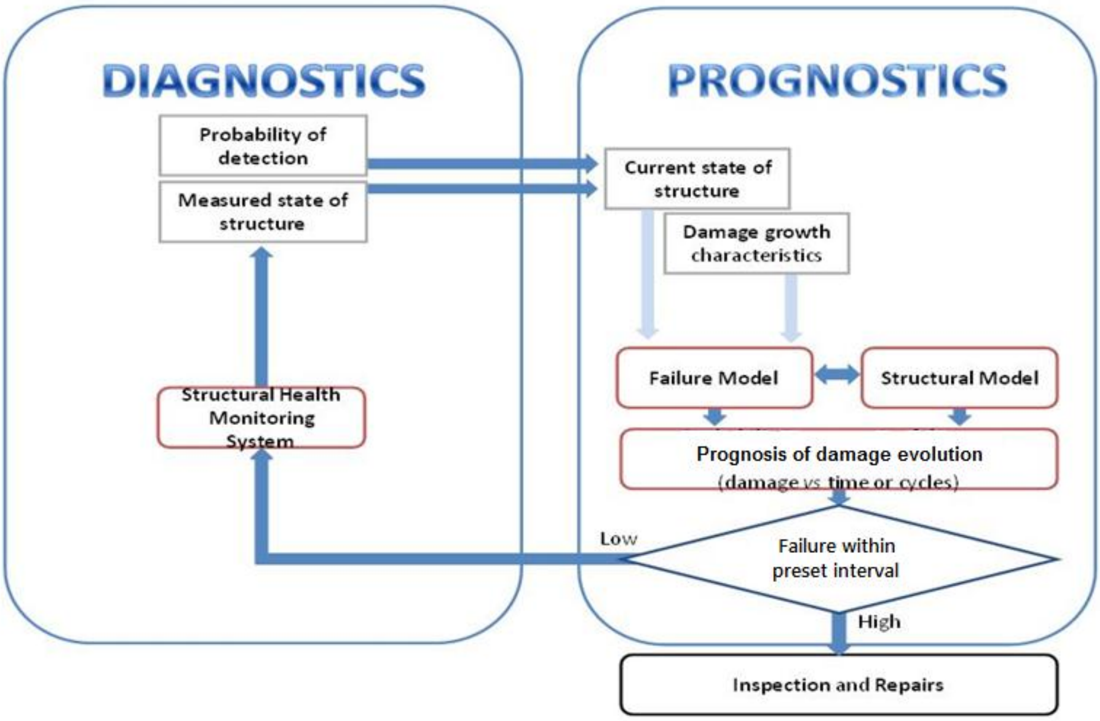


FIG 1: ARCHITECTURE DIAGRAM

Key elements of the definition of a software architectural model :

- **Rich** : for the viewpoint in question, there should be sufficient information to describe the area in detail. The information should not be lacking or vague. The goal is to minimize misunderstandings, not perpetuate them. See notes below on 'primary concern.'
- **Rigorous** : the architect has applied a specific methodology to create this particular model, and the resulting model 'looks' a particular way. Here's the test of rigorousness: If two architects, in different cities, were describing the same thing, the resulting diagrams would be nearly identical (with the possible exception of visual layout, to a point).

- **Diagram** : in general, a model may refer to any abstraction that simplifies something for the sake of addressing a particular viewpoint. This definition specifically subclasses 'architectural models' to the subset of model descriptions that are represented as diagrams.
- **Standards** : standards work when everyone knows them and everyone uses them. This allows a level of communication that cannot be achieved when each diagram is substantially different from another. UML is the most often quoted standard.
- **Primary concern** : it is easy to be too detailed by including many different needs in a single diagram. This should be avoided. It is better to draw multiple diagrams, one for each viewpoint, than to draw a 'mega diagram' that is so rich in content that it requires a two-year course of study to understand it. Remember this : when building houses, the architect delivers many different diagrams. Each is used differently. Frequently the final package of plans will include diagrams with the floor plan many times: framing plan, electrical plan, heating plan, plumbing, etc. They don't just say: it's a floor plan so 100% of the information that CAN go on a floor plan should be put there. The plumbing subcontractor doesn't need the details that the electrician cares about.
- **Illustrate** : the idea behind creating a model is to communicate and seek valuable feedback. The goal of the diagram should be to answer a specific question and to share that answer with others to (a) see if they agree, and (b) guide their work. Rule of thumb: know what it is you want to say, and whose work you intend to influence with it.

3.2 ALTERNATIVE DESIGN METHODOLOGIES

Rapid Application Development (RAD)

Rapid Application Development (RAD) is a methodology in which a systems designer produces prototypes for an end-user. The end-user reviews the prototype, and offers feedback on its suitability. This process is repeated until the end-user is satisfied with the final system.

Joint Application Design (JAD)

Joint Application Design (JAD) is a methodology which evolved from RAD, in which a systems designer consults with a group consisting of the following parties:

- Executive sponsor
- Systems Designer
- Managers of the system

JAD involves a number of stages, in which the group collectively develops an agreed pattern for the design and implementation of the system.

4. SYSTEM IMPLEMENTATION

4.1 BUILDING

Implementation is merely on the system of tall and heavy weighing buildings and nowhere around. Comes in great hand with the natural and man - made disasters such as earthquakes, landslides, bomb - blast and so kind. Rail track bridges will also require this system on a large scale to determine the vibrations that will be caused when a train passes by.

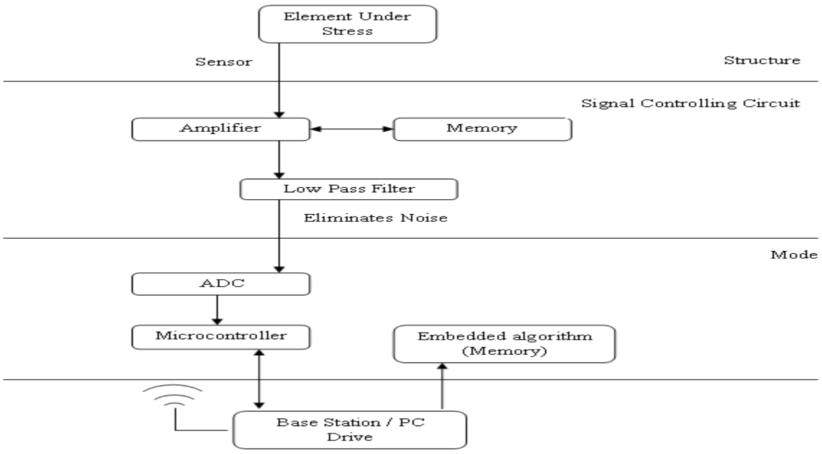


FIG 2: SYSTEM IMPLEMENTATION

4.2 REMOTE DATA TRANSFER FROM A BOX GIRDER

Structural health of one span of a pre - stressed concrete box girder fly over bridge across dumper lines has been monitored periodically. The bridge has been instrumented with vibrating wire strain gages for measurement of strains and temperature. Measurements from these gages are acquired using data acquisition system 'Datataker DT615'. Experiments were conducted using the developed scheme to acquire data from these vibrating wire gages and transmit it to the monitoring computer remotely via PSTN and GSM Network. The DT615 was triggered, data was acquired and also configurations of channels were changed from the monitoring computer. These measurements were later verified from the measurements directly acquired from the DT615 at site. For this experiment, the PXI module loaded with the developed driver files were kept at the bridge site. The DT615 was controlled by PXI, which in turn was controlled by the monitoring computer. The developed RSM scheme acquired data from the Vibrating wire gages and successfully transmitted them to the monitoring station, in real time, via GSM, and PSTN network.

FIG 3. PRESTRESSED BOX GIRDER BRIDGE

4.3 RESPONSE MONITORING OF A COMMUNICATION TOWER FOR WIND LOADING

In another prototype test, an instrumented communication tower, 6m tall, located on the terrace of a building inside campus was monitored continuously for 3 days from the monitoring station situated inside the same campus using thedeveloped RSM scheme. Here GSM network was used to remotely transfer data from the communication tower to the monitoring station. The strain responses due to the wind loading, which are dynamic in nature, were monitored continuously and data was logged at specified intervals. The communication tower instrumentedwith strain gages and experimental set-up for performance monitoring of the tower under wind loading. The response of the structure was monitored in real time in the form of numerical and graphical display. Data was also acquired at the remote site directly from the sensors using conventional wires. The directly acquired data were compared with the data acquired remotely using GSM network. The data transfer was complete without any transmission loss. Even though the distance between the instrumented tower and the monitoring station in the present case is less than a kilometer, the same GSM methodology is capable of transferring data for any large distance, as long as the structure and the monitoring station has GSM connectivity.

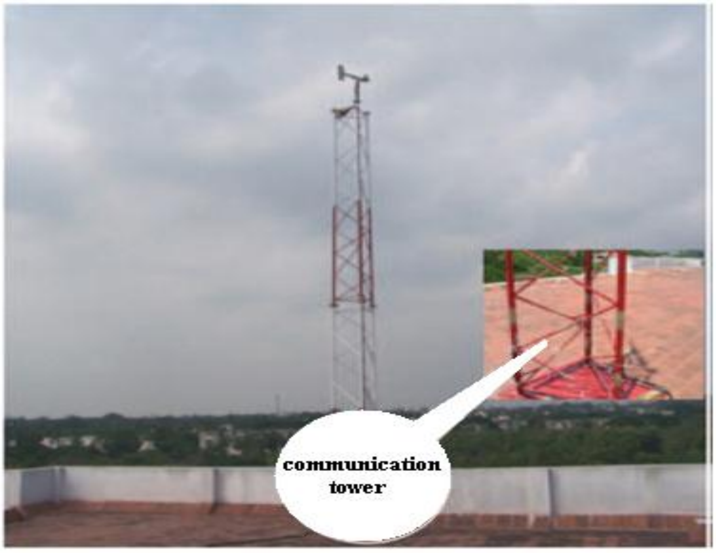


FIG 4(a) INSTRUMENTED COMMUNICATION TOWER

FIG 4(b) INSTRUMENTED CULVERT

International Journal of Advanced Research in
Computer Science Engineering and Information Technology
Volume: 3 Issue: 3 09-Oct-2014,ISSN_NO: 2321-3337

4.4 RESPONSE MONITORING OF A CULVERT UNDER VEHICULAR TRAFFIC LOAD

Trials like, change of configuration of both electrical resistance strain gages and vibrating wire sensors, sampling rate, activation/deactivation of sensors, triggering etc. were checked. The RSM system was set to run continuously and data was recorded at PXI at regular specified intervals. The movement of the vehicles also recorded at specified time intervals. The analysis of the recorded data was carried out and from the analysis of the data, it is found that, the peaks in strain values from both electrical resistance strain gages and vibrating wire strain gagesare matching well with the movement of the vehicles. It is also found that, the variations in strain values are in tandem with variations in temperature values. The SMS alarm received automatically from thesite is shown, when the monitored values were beyond the preset limits. The 'emergency alarm' feature of the developed scheme was also tested. By this, system will automatically acquire data at higher sampling rates if the monitored parameter in few channels crosses the upper/lower limits set by the user.

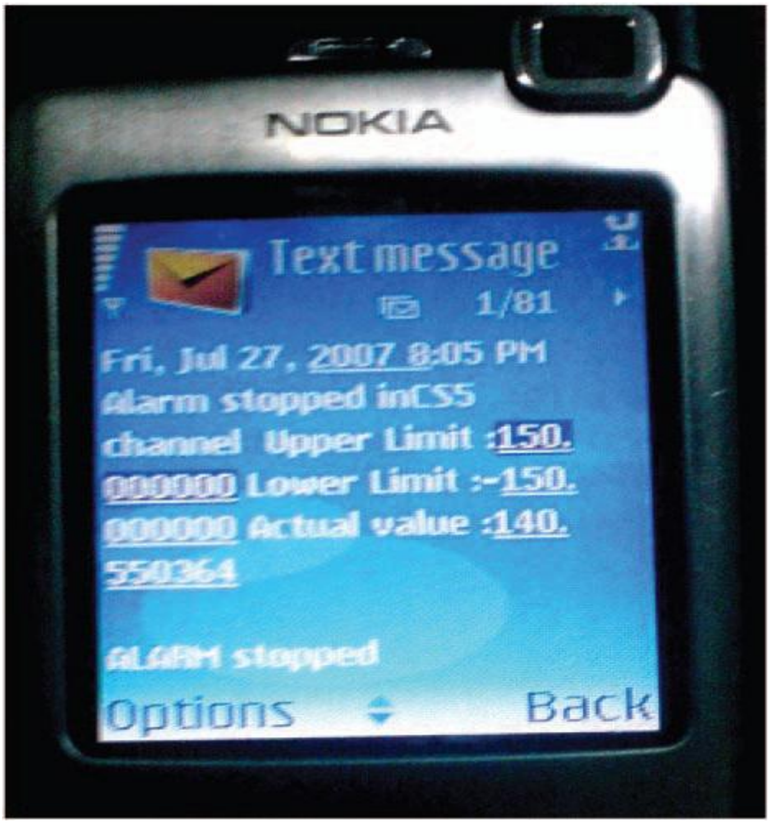


FIG 5 SMS ALARM ON THE CELL PHONE

5. CONCLUSION AND FUTURE ENHANCEMENT

International Journal of Advanced Research in
Computer Science Engineering and Information Technology
Volume: 3 Issue: 3 09-Oct-2014,ISSN_NO: 2321-3337

5.1. CONCLUSION

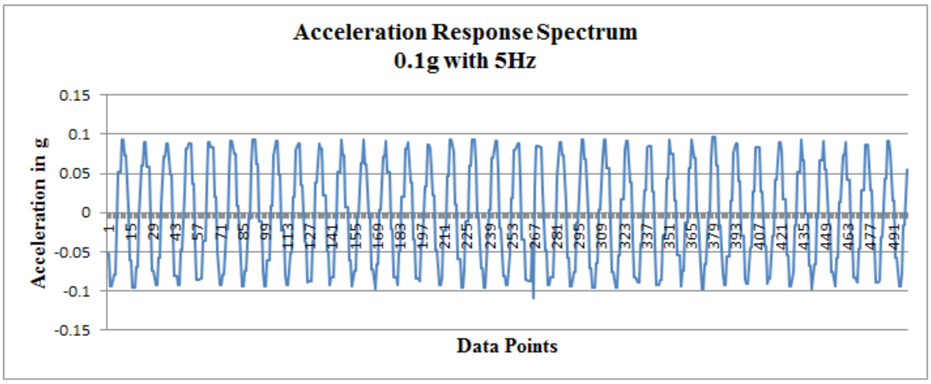
In order to get an immediate alarm from the wireless sensors for the various dynamic responses, this software is designed and loaded in the wireless device which is been mounted on the civil structures. The points are being plotted as a graph with the help of a mathematical algorithmic concept “FFT” which gives raise to a typical sinusoidal curve. This device has been put into implementation in countries which are economically forward. It is an ongoing project to be implemented on a large scale in India as well.

5.2. FUTURE ENHANCEMENT

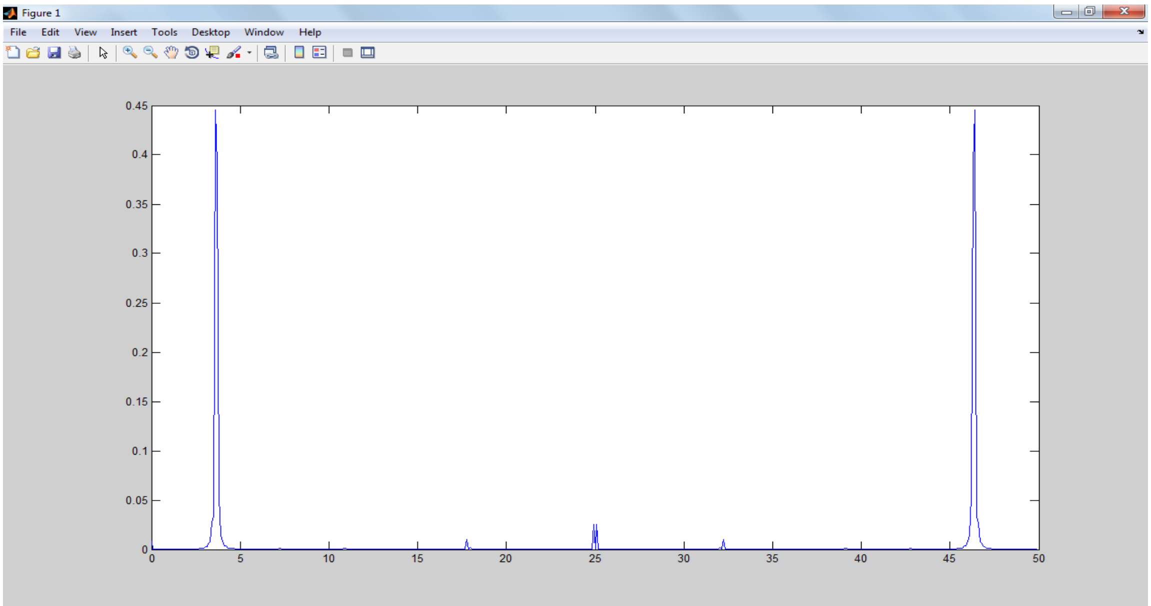
Specialization in the process of launching this wireless device on the civil structures for its utmost health to give the maximum existence. System is all about the development of this device in economically backward countries too. Very soon we would experience this health monitoring in our own house.

6. IMPLEMENTATION

6.1 INPUT



6.2 OUTPUT



REFERENCES:

1. "Smart Wireless Sensor Technology For Structural Health Monitoring Of Civil Structures" Soojin Cho, Chung – Bang Yum, Pg 267 – 275.

2. "Real Time Visualization Of Structural Response With WMS" Pai Chou, Isam Yokoi, Pg 121.

3. "Instrumentation Of Bridges For Structural Health Monitoring" Doo Kie Kim, Jong – In Kim, Pg 231 – 242.

4. "Using GPS in Structural Health Monitoring" Knecht. A Manetti, Pg 4.

5. "Structural Health Monitoring For Bridges Under Ordinary Traffic" Lee. J. W, Kim. J. D, Pg 247.

6. "FFT : Algorithms And Applications" K. R. Rao, D. N. Kim, J. J. Hwanj, Pg 78.

7. “MATLAB Primer” Timothy A.Davis, Pg 22.
8. “A Guide To MATLAB” Brian R. Hunt, Ronald L. Lipsman, Pg 255.
9. “MATLAB For Engineering” Fredrick Gustafsson, Niclas Bergman, Pg 1.
10. “The MATLAB Handbook” Eva – Part Enander, Pg 346.
11. “Introduction To MATLAB 7” William John Palm, Pg 546.
12. “A State - of - the - Art Report On Remote Health Monitoring Of Civil Engineering Structures” S. Sridhar, K. Ravisankar, S. Parivallal, K. Kesavan, P. Sreeshylam, S. G. N. Murthy, Pg 5
13. “Development of a Real-time Remote Structural Monitoring Scheme for Civil Infrastructural Systems” S. Sridhar, K. Ravisankar, P. Sreeshylam, S. Parivallal, K. Kesavan and S. G. N. Murthy, Pg 516 - 520