International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 3, Issue 4, April 2014 **ISSN 2319 - 4847**

Study of Sensor Placement/Location in Condition Monitoring or Vibration

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Abstract

This paper present preliminary study of Sensor Placement/Location in Condition Monitoring or Vibration Analysis. Sensor location plays important role in conditioning monitor system. Result of information capture depends upon which place sensor will be located. In this paper, we studied optimizing Sensor Location for an Enhanced Gearbox Condition Monitoring, Vibration Sensors for cooling Towers, Optimal Sensors Placements for Failures Detection and Isolation, Evaluation of Sensor Placement Techniques, Optimal Sensor Placement for Structures under Parametric Uncertainty and Evaluation of Optimal Sensor Placement Techniques for Parameter Identification in Building. In this paper, we use Initial Optimization Procedure (IOP), Accelerometers, FDI algorithms, SPARTA (Sensor Placement Algorithm for Rapid Theatre Assessment), effective independence method and Sensor Set Expansion method and also their advantages over other methods.

Keyword: Sensor Placement, vibration analysis, Condition Monitoring, Gearbox Condition Monitoring, failure detection, Placement Techniques

1. INTRODUCTION

In many machine, there is gearbox system play important role such as production machine, power plants, industrial application, automobile application etc. in this system, many parts and small assemblies like shaft, bearing, gears That work together to get desirable speed or motion. Accelerometer and sensor are applied to check condition monitoring of machine[1]. Most important thing to place accelerometer or any sensor on the gearbox or motor. So the gearbox has no. of parts of mechanical drive. FDI method is used to find the fault or improvement of the process and minimize the fault in the result. FDI method is based on comparison with real working process and standard or reference working process under normal condition. The condition monitoring is considering early stage of maintenance and design. Analytical method for finding a system and required apparatus to get the desired level of condition monitoring. In actual working condition, experimental model analysis and in particular operational model analysis are initial steps to place sensors. Apply wired or wireless methods use to locate the sensor as per requirement. There are different methods have been developed for optimal sensor placement techniques like:

1. Effective independence method
2. Fisher Information matrix
3. Energy matrix ranked optimization, etc.

In sensor location methods, there is a key issue for orbit model identification and correlation of large space structure in industry.

2. OPTIMIZING SENSOR LOCATION FOR AN ENHANCED GEARBOX CONDITION MONITORING

Sensor location plays important role in conditioning monitor system. Stability and reliability of information capture depends upon which place sensor will be located. In this paper, we try to find the vibration in gear box system. We find the relationship between sensor location and detecting fault in the system. In this paper, we operated gear box in under healthy and unhealthy condition with varying the level of effects of speed and load using factorial method. Sensor location methodology could be categorized into two groups: Fixed Position and Free Position or Indirect Sensor. Fixed position sensors located at pre-defined position. These sensors are directly mounted to the mechanical component or near to certain place to measure vibration. Free position sensors do not have specific location on machine. In this paper, we used Initial Optimization Procedure (IOP) is used to find the optimum sensor location for condition monitoring. This method consists of three steps: first step known as extreme value of parameter test. Second step known as sensor positioning optimization and final step is known as signal condition adjustment. We explain about extreme value parameter test, sensor position optimization and sensor conditioning adjustment. In this paper, we used experimental setup as show in reference paper and find the conditioning monitoring of the system.

3. VIBRATION SENSORS FOR COOLING TOWERS

In this paper, we are trying to monitoring the motor and gear box of cooling tower system. In this paper, we are using accelerometer to monitor the vibration of motor and gear box. In this paper, we located Accelerometers on the motor and gear box. In the gear box, we put two accelerometers on the input and output bearing housing to measure vibration. Vibration sensors are placed in radial as well as axial location on the system. We are using six sensor on motor in which 4 sensors are radial and two sensors are axial. We are putting same sensor on the gear box in which 4 are radial and 2 are axial, would provide maximum coverage. Radial sensors will measure vibration related to unbalance and misalignment and axial sensor will measure vibration related misalignment bearing fault and gear meshing. In this paper, we use stud mounted sensor method to mount sensor on the system

4. OPTIMAL SENSORS PLACEMENTS FOR FAILURES DETECTION AND ISOLATION

In this paper, we used the fault detection and isolation procedure. The FDI algorithms are worked on same principles comparison between the real behavior of the process and reference behavior of model under normal operation. In this paper, we used two types of method: no model based method and model based method. In no model based method, we consider the four approaches: nearer approaches, genetic algorithm, algorithm of simulated annealing and iterative algorithm of insertion/deletion. In model based method, we used analytical, structural and bond-graph for placement of the sensors. In this paper, we wrote about criteria of sensor placements. Structural analysis, the supervision specifications, and design for instrumentation system. Proposed design methodology determines the optimal set of sensor and their placements as follow:

1. Definition of the basic structure of the systems.
2. Definition of the supervision specification containing the set of minimal observable variables and list of the variables that must be redundant of degree.
3. Representation of the system with tripartite graph.
4. Construction of residual cycles, consults the specification, add a sensor and regenerate redundancy degree.

5. EVALUATION OF SENSOR PLACEMENT TECHNIQUES

In this paper, we used chemical and biological sensors need to be positioned with care to provide maximum information to allow identification of accidental or intentional released of dangerous material. We used two main approaches to place sensor:

1. Rule based sensor placement in which sensors are placed according to heuristic rules.
2. Computational optimization which involve running multiple simulations and then using optimizer to determine best placement.

We implemented a computer optimization approach called SPARTA (Sensor Placement Algorithm for Rapid Theatre Assessment). In SPARTA tool takes as input: domain information, information on the material, treat information, sensor information, meteorological information and mitigation option. SPARTA has two main stages in its computational approach:

1. A store of possible event simulation is computed.
2. An optimizer is used to calculated best location for the sensors by comparing the results for placing different combination of sensors location.

In this paper, we wrote about currently a sequential optimizer used in SPARTA method. In the rules based sensor placement, we implemented a number of rules based method that placed sensor against prescribed rules. These include commonly used rules and sophisticated developed based on the result of the sample test cases using automated optimization technique. The rules we considered are as follow:

1. Placed sensors evenly around the perimeter of the protection area.
2. Spread the sensors evenly throughout the protection area.
3. If the threat and the protection area do not overlap, place the sensors evenly around parameter of the protection area. Otherwise separated them.
4. For chemical, the threat area and the protection area do not overlap.

6. OPTIMAL SENSOR PLACEMENT FOR STRUCTURES UNDER PARAMETRIC UNCERTAINTY

This paper examines the effects of parametric uncertainties on the optimal sensor placement methodology for model analysis of the truss bridge. In this paper, four classical sensors location methodologies are employed: two based on fisher information matrix and two based on energy matrix rank optimization. We consider young’s modulus, mass density and cross sectional dimensions as uncertain parameters. The optimal location of the sensors under parametric uncertainty assessed by the used of three criteria. In this paper, we used different methodologies for optimal sensor placement. The effective independence method based on the maximization of determinant of the fisher information matrix. The no. of sensors reduced in an iterative way by deleting degree of freedom from mode shape matrix. Energy matrix rank optimization techniques are similar to the EFI method. But in this case the main consideration to maximize the strain energy of the structure rather than the determinant of the FIM matrix. In this paper, for the sensor placement algorithms we used two concepts EFI and energy matrix ranked optimization. The calculation process is given in detain in this paper. In this paper, for uncertainty analysis was performed Monte Carlo Simulation method due to the most accurate and popular uncertainty technique. The main advantage of MCS is that uncertainty analysis can be performed without any modification of the finite element analysis program.

7. Evaluation of Optimal Sensor Placement Techniques for Parameter Identification in Building

In this paper, the applications of six different optimal sensor placement techniques are used in buildings. The techniques are Effective Independence, Optimal Driving point, Non-Optimal Driving Point, Effective Independence Driving Residue, Singular Value Decomposition and Sensor Set Expansion. The OSP techniques were first developed for aerospace structures where the stiffness and mass distribution are homogeneous throughout structure. In this paper, we explained briefly about all the techniques stated above. We took experimented on the instrumented school building to evaluation of optimal sensor techniques. We selected a three degree of freedom candidate sensors at each inspection point of axes. We used total 675 degree of freedom for the candidate sensor for the whole building. We took experiment and checked the data for all types of method and we conclude that the Sensor Set Expansion method is best and bring four important advantages over other techniques:

1. SSE predicts homogeneous sensor distribution throughout the structure.
2. The technique allows civil engineers to keep set of location in final set of location.
3. SSE technique decreases the computation time.
4. The technique is very robust against the noise in the measurement.

8. Conclusion

In these paper we studied about tha different type of position of sensor to locat and palce in optimal position.we place the sensor at that place we get minimum error in the result.we studied the different types of method to finding the optimising the sensor location in conditioning monitoring and vibration measurement.Due to advantages of SSE method mention above we conclude that the SSE method is good among all types of methods.

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