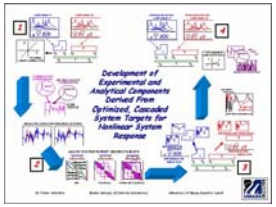
Structural Dynamics and Acoustic Systems Laboratory
University of Massachusetts Lowell

SOME RECENT STUDENT THESIS AND PROJECT WORK IN THE SDASL

RESEARCH EMPHASIS – MAJOR DEVELOPMENT FOR MULTIPLE PROJECTS

Development of Components Derived from Optimized, Cascaded System Targets



Current system models are developed from a variety of different approaches that utilize component information or are developed from one massive finite element model describing the entire system. A component mode approach (using reduced, modal, or impedance models from both test and analytical approaches) is more efficient and practical from a manufacturer/supplier standpoint. Also, the model, testing, correlation and updating procedures necessary in the development of accurate system representations work best when first performed on components.

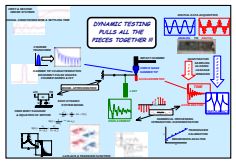
Often, the assembled system does not possess the dynamic characteristics that provide the desired response. From a design standpoint, the system characteristic mass and stiffness can be reallocated or redistributed using optimization approaches to meet the desired system level target response required. However, the effect of these adjustments needs to be identified in terms of the individual (unassembled) component descriptions in order for the supplier/manufacturer to be able to make the necessary component modifications to achieve the desired system level response. The disassembly of the adjusted system model is required to clearly identify the cascaded component target necessary to meet the desired system performance characteristics. Once disassembled, these component designs may then be adjusted to meet the cascaded component target specifications.

This research area plans to develop innovative approaches and methods for the efficient disassembly of dynamic system models with cascaded target specifications using both analytically and experimentally integrated approaches with a strong emphasis on melding the research and education components into a robust whole. This research area endeavors to integrate research and education to pioneer novel new approaches and techniques for the disassembly of dynamic system models using test and analytical components with cascaded target specifications. This effort is a larger program which can support several masters and doctoral research efforts.

EDUCATIONAL/TEACHING EMPHASIS – CHANGE OF APPROACH FOR INTEGRATING COURSE MATERIAL

NSF Engineering Education Grant EEC-0314875

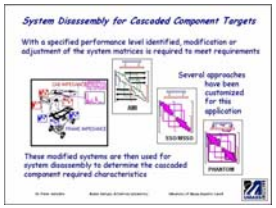
MULTI-SEMESTER INTERWOVEN PROJECT FOR TEACHING BASIC CORE STEM MATERIAL CRITICAL FOR SOLVING DYNAMIC SYSTEMS PROBLEMS



The NSF Engineering Education Division has funded a three year project for $267K on this topic. (This was the only project funded from this group in the award session of Jan 2003.) The main focus of this project is to better integrate science, technology, engineering and math (STEM) into the curriculum. The proposal cited that engineering students are taught skills in various courses but the material appears disjointed and unrelated from the students' perspective. In order to circumvent this problem, a multi-semester interwoven project is proposed. The project addresses a dynamic systems problem which is important to all engineering disciplines (electrical, chemical, civil, mechanical) and can be easily transferred to other universities. The project has a very important blend of both graduate and undergraduate students working on the project. The students are actually the best equipped to identify exactly what they do and do not understand relative to their basic STEM skills necessary for solving real-world engineering problems.

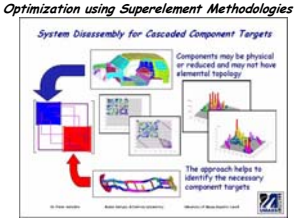
This work is directly in line with the teaching goals identified that need to be addressed. Many of these concepts in this project are already integrated into the Mechanical Engineering curriculum in the Mechanical Engineering Laboratory courses as well as in the Dynamic Systems course. These approaches have already seen very positive effects on the students' understanding and learning abilities. This NSF grant significantly helps the overall educational aspects that need to be accomplished in order to provide a well-rounded, practical engineering education.

Design Optimization by Inverting Targets



A General Motors funded project has been completed with the intent to find approaches to develop appropriate models that assist in the identification of component characteristics subjected to inverse modeling approaches. The approaches utilized the direct inversion of system matrices to accomplish these goals. The mass and stiffness optimization approaches were utilized in conjunction with a new approach, referred to as the Phantom Element technique. A journal article and several conference papers were written addressing this.

Design Optimization using Superelement Methodologies



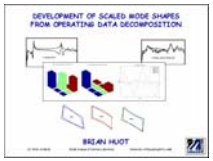
Another General Motors funded project has been completed with the intent to find approaches to develop appropriate models that assist in the identification of component characteristics subjected to inverse modeling approaches where the components are defined using a superelement topology. The approaches extended those of an earlier project to address the lack of topology definition inherent in a superelement component. A journal article and several conference papers were written addressing these efforts.

MASTER'S THESIS – HIROMICHI TSUJI
APPLICATION OF OPTIMIZATION PROCEDURES USING PHANTOM CONNECTIVITY TECHNIQUE

The objective of this thesis is to identify global structural differences between a finite element model and a target model defined using structural dynamic information. Optimization procedures identify the differences and adjust the system matrices of the model to achieve the target specification. Constraints of the finite element topology may be used in these procedures. In order to improve these optimization processes, a new technique is proposed. This approach (Phantom Connectivity Technique) modifies the existing topology of the finite element model to allow additional elemental connectivities in the optimization process. The use of the Phantom Connectivity Technique allows for the optimization procedures to identify the changes outside the skyline of the original finite element model in the full space model. In applications where no finite element topology exists (such as with reduced component models), the Phantom Connectivity Technique is used to generate a finite element constraint topology; this allows for the optimization procedures to identify changes in the reduced component model.

Several applications using the optimization processes along with the Phantom Connectivity Technique are investigated using component system models with simulated target information; both full and reduced finite element models are used for component definitions. Various numerical examples are used to evaluate the robustness of this proposed technique. The technique is shown to produce very acceptable results for the target model scenarios investigated.

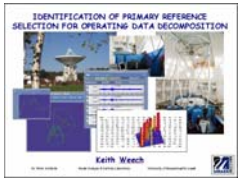
MASTER'S THESIS – BRIAN HUOT
DEVELOPMENT OF SCALED MODE SHAPES FROM OPERATING DATA DECOMPOSITION



Operating deflection shapes are extremely useful in trouble shooting vibration problems. However, operating data is not scaled so it has limited usefulness for further analytical predictions. Scaled modal data, such as that acquired from a modal test using measured frequency response function data, is required for further analytical studies such as Structural Dynamic Modification and Forced Response Simulation. Thus development of scaled shapes from operating data is desirable. Several techniques have been developed over recent years to scale operating data to modal data.

In this thesis, the application of operating deflection shape scaling techniques will be explored. A single drive point frequency response function will be used in order to scale the operating deflection shapes to mode shapes. Several different cases will be studied in order to better identify and demonstrate the limitations and advantages of this technique. A comparison of the results when compared to actual frequency response based modal data will also be performed to illustrate the similarities and differences.

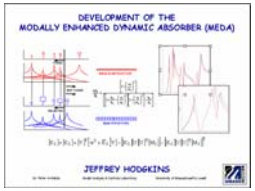
MASTER'S THESIS – KEITH WEECH
IDENTIFICATION OF PRIMARY REFERENCE SELECTION FOR OPERATING DATA DECOMSPOSITION



The definition of dynamic characteristics of a structure can be performed by numerous methods. Analytical models employing the finite element modeling technique are commonly used. However, these models at times need to be confirmed through the use of measured data. Experimental modal testing is one method for obtaining this data. However, many times it is not feasible to conduct this type of test due to inaccessibility of the structure, physical size of the structure and other problems. In these cases, operating data is collected with the system in some typical operating configuration. The dynamic responses are then collected and used for the system description. However, the selection of the appropriate reference to extract reasonably good modal characteristics is often difficult. Great care needs to be exercised to accomplish this. A rigorous mathematical approach is needed to assist in this selection process.

The Test Reference Identification Procedure (TRIP) is extended to address this application. Operating data from cross spectra measurements are used in a Singular Valued Decomposition approach to determine the best references to be used for the identification of the operating modal characteristics. Several data cases are used to validate the approach developed. Simplistic models are used for the development of the technique followed by reduction of data for a large structure. Data previously collected for the Gemini Optical Telescope and the Nobeyama Radio Telescope are used for the verification of the technique proposed

MASTER'S THESIS – JEFFREY HODGKINS
THE MODALLY ENHANCED DYNAMIC ABSORBER (MEDA)



The development of any structural dynamic model will invariably have several or many modes that produce undesirable effects in terms of performance. Often this is not determined until very late in the product development cycle. Typically, a tuned absorber is designed as a "band-aid" to remedy the situation.

This concept of the tuned absorber is extended to address multiple modes in the early design stages to de-tune multiple modes simultaneously utilizing an optimized substructuring methodology. This is referred to as the Modally Enhanced Dynamic Absorber-MEDA. The main structural dynamic characteristics are used as targets to design a substructure that has the same frequencies and mode shapes as those of the main structure. The assembly of the optimized substructure to the main structure will de-tune the modes of interest included in the optimization process. The modal detuning substructure is further enhanced through impedance modeling techniques to enable attachment of the detuning substructure at arbitrary locations on the main structure. The end result is an improved overall dynamic characteristic similar to that observed in tuned absorber applications.

Whirlpool Model Test/Analysis Correlation

Test/analysis correlation efforts with Whirlpool have been performed to identify the proper modeling scenarios for the development of a new clothes dryer line.

The work in this project clearly identifies that there is significant effort still necessary in order to identify appropriate modeling approaches.

Impedance Modeling Applications
SUN Computer Assembly
General Motors Camshaft

A SUN contract funded this work to identify the impedance modeling techniques usefulness for system model development of various computer cabinet peripherals. The impedance modeling approach yielded accurate system models.
A General Motors contract funded this work to identify the appropriate modeling approaches to accurately identify the dynamic characteristics of a camshaft subjected to machining operations. The identification of the natural frequencies of the system are required in order to identify potential speeds at which machine chatter would occur. The existing finite element models do not adequately address the proper boundary conditions.

Nobeyama Radio Observatory

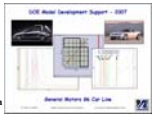
A large testing project was undertaken to test the 45 meter Nobeyama Radio Observatory in Nobeyama in Japan. This test involved the collection of a large set of experimental data to assist in the characterization of wind induced loading of large telescope structures. Graduate students were involved in the reduction of this massive database of operating data to determine design parameters for new configurations.

Gemini Optical Telescope

A large testing project was undertaken to test the 8 meter Gemini Optical Telescopes in Mauna Kea, Hawaii and Perra Cerron, Chile. This test involved the collection of a large set of experimental data to assist in the characterization of wind induced loading of large telescope structures. Both impact excitations and natural wind loading were used to assist in the excitation of the structure. Graduate students were actively involved in the collection and reduction of this massive database of operating data to determine design parameters for new configurations. Several conference papers were written regarding the testing and analyses performed.

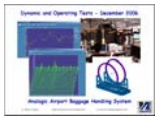
General Motors Corporation

Significant effort was expended to determine automotive structure variability effects for a massive DOE model that General Motors Corporation is developing. The effort here was to reduce dynamic measured data from six cars tested six times in three different configurations to determine the level of correlation observed for the DOE model. Students worked with GM engineers to reduce data and perform correlation studies for the abundance of data collected.



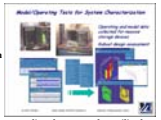
ANALOGIC Corporation

Several projects were directed towards identification and modification of a prototype airport baggage handling system. Problems exist in the current design and efforts to improve the design to correct problems and improve performance require substantial dynamic testing. An experimental modal test was performed in conjunction with collecting operating data for system spin up and steady state operations. Dynamic data was collected and operating deformations identify problem frequencies with the current design. Graduate students were actively involved in the complete test, analysis and reporting of the system characteristics using advanced analytical modeling techniques.



EMC Corporation

Several projects were directed towards the determination of operating characteristics for the improved performance of large massive storage devices. This effort was mainly initiated as a outreach program to assist in the retraining of aerospace engineers transferring to commercial industries. Funding was also obtained to support this effort. Graduate students were actively engaged in the development of experimental models using advanced analytical techniques. Conference papers were written regarding the approaches utilized

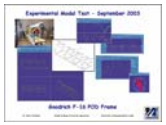


BAE Missile Testing

An experimental modal test was conducted for a BAE Salt Rocket Missile. This test utilized both impact and shaker excitation techniques for the development of frequency response functions. The purpose of the test was to confirm the frequencies necessary for the control system design. Both undergraduate and graduate students conducted this test. The practical aspects of applying course material clearly helps the students gain additional appreciation of their educational experiences.

Goodrich F16 Surveillance POD

An experimental modal test was conducted using an impact excitation approach for a BFGoodrich Surveillance POD being retrofitted to an F-16 jet. The purpose of the test was to confirm the finite element model developed. Students conducted this important test entirely by themselves. (Only supervisory support was given to assure that proper results were obtained.)



Trane Corporation Test/Analysis Correlation

A research proposal for Trane Corporation is Intended to address the test/analysis correlation of a large chiller assembly. The project involves the development of the methodology necessary for qualification of these types of large structures. The approaches identified are to be verified on alternate configurations to assure the appropriateness of the proposed techniques. This effort supports the identification of performance differences observed between similar chiller assemblies

Peter Avitabile – SD2000 Forum – April 1999

Peter Avitabile was invited to attend the Structural Dynamics 2000 Forum that was hosted by Los Alamos National Laboratory and sponsored by the US Department of Energy. The forum was developed to identify the current state-of-the-art in Structural Dynamics Technology, the challenges faced today in the field, and the major needs for the next decade.

Hardware and software tools employed

Polytec · FEMAP · LMS · PCB PIEZOTRONICS · FEMtools · Vibrant Technology, Inc. · Trilion

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