



Automotive Research Center

A U.S. Army Center of Excellence for Modeling and Simulation of Ground Vehicles
led by the University of Michigan

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[Software](#)

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ARC Collaborative Research Seminar Series Winter 2007

January 24th, Wednesday (9:30-11:00am)

University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presenting:

Thrust Area 2 – Human Centered Modeling and Simulation

Toward Adaptive Estimation of Biodynamic Transmittance

R. Brent Gillespie, Taeyoung Shin

Steering or tracking commands delivered unintentionally (because of vehicle jostling) can be removed from the manual interface signal if the transmittance of the driver's body is known. Our previous estimations of the transmittance, (the transfer function from vehicle acceleration to interaction force at the manual interface) were constructed off-line. Yet the transmittance is certainly time-varying. We know that transmittance depends on posture, grip force, and muscle co-contraction, among other factors. We are now exploring the performance of on-line estimation schemes using our previously recorded acceleration/interaction force data, and we are using simulation studies to assess the benefit of adaptive algorithms for biodynamic feedthrough cancellation.

Application of the Virtual Driver: Convoy Following with Secondary Tasks

Omer Tsimhoni, Matthew Reed

The Virtual Driver combines two U-M human modeling frameworks into an integrated system for simulating cognitive and physical driving behavior. The linkage between the Queuing Network Model Human Processor, running in ProModel, and the HUMOSIM Ergonomics Framework, running in the Jack human modeling system, has been established using a custom protocol over TCP/IP. The cognitive model commands actions (reach, gaze) by the human motion simulation system and monitors state, such as the the current vision target and body posture. In this seminar, we'll outline our plan to apply our modeling approach to a real world problem. We will use the integrated system to examine the effects of driver interface design for secondary tasks on performance in a convoy-following scenario. The driver's performance will be evaluated while performing secondary communication tasks with two alternative interfaces that differ in their physical and cognitive requirements.

Development of an active biodynamic model for vehicle design: a study of ride motion effects on seated in-vehicle reach performance

Bernard J. Martin, Heon Jeong Kim

Vehicle ride motion produces a dynamic response of the seated operator, which disturbs the intended fingertip trajectory during reach activities. This perturbation induces deviations that must be corrected to successfully complete the reach. Two approaches are undertaken to predict these vibration-induced alterations. First, visual and/or proprioceptive information are necessary to detect these deviations and provide feedback to the controller of the neuromuscular system. In an attempt to predict movement alterations and adjustments under whole body vibration exposure, a trajectory planning and feedback controller was developed using split sample data from a series of reaching experiments on a six degrees of freedom motion platform. Another approach consists in identifying changes in the transfer function as a function of movement phases and trajectory. This latter approach is being evaluated. The model will be implemented using "Madymo" (biomechanical model of the human body) in order to facilitate the integrations of the human response with the modeling of vehicle mechanical structures.

February 21st, Wednesday (9:30-11:00am)

University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presenting:

Thrust Area 4 – Advanced and Hybrid Powertrains

Characterizing Transient Diesel Engine Behavior with Cycle-Resolved In-Cylinder Measurements

Jonathan Hagen, Zoran Filipi, Dennis Assanis (U. of Michigan)

A Model for Diesel Spray Behavior under Supercritical Conditions

A. Bhattacharyya, N. A. Henein and W. Bryzik (Wayne State U.)

Transient Fluid Flow and Heat Transfer in the EGR Cooler

Radu Florea, Dinu Taraza, Walter Bryzik (Wayne State U.)

The Effect of High-Sulfur JP-8 on the Diesel Engine System

Mike Smith, Michael Mosburger, Jerry Fuschetto, Zoran Filipi, Dennis Assanis (U. of Michigan)

Abstracts are not available as this time.

March 14th, Wednesday (9:30-11:00am)

University of Michigan, Lurie Engineering Center, Level 4, GM Room

Thrust Area 5 – Vehicle System Integration, Optimization, and Robustness

Development Of A Design Adaptation Methodology For Dependable Vehicle Mission Performance In Unknown Environments

Michael Kokkolaras, Panos Papalambros, And Zissimos Mourelatos

Simulation-Based Design Validation For Increased Virtual Vehicle Testing, With Emphasis On Safety

Harshit Sarin, Michael Kokkolaras, Panos Papalambros, And Greg Hulbert

Optimal Thermal System Design For Heavy Off-Road Vehicles With Electric-Hybrid Powertrains

Andreas Malikopoulos And Michael Kokkolaras (Joint Work With Sungjin Park And Dohoy Jung)

March 28th, Wednesday (9:30-11:00am)

University of Michigan, Lurie Engineering Center, Level 4, GM Room

Thrust Area 1

Advanced Cooling Strategies for Internal Combustion Engines - Concept, Configurations, and Power Savings

M. Salah, T. Mitchell, J. Wagner, and D. Dawson, Clemson University

Modeling, Configuration Design, and Control Optimization of the Power-Split Hybrid Electric HMMWV

Jinming Liu and Hwei Peng, University of Michigan

An Approximate Similitude Design Methodology for Dynamic Systems

Burit Kittirungsi, Hosam K. Fathy, and Jeffrey L. Stein, University of Michigan

April 25th, Wednesday (9:30-11:00am)

University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presenting:**Thrust Area 3 – High Performance Structures and Materials****Reliability Based Design Optimization with Dependent Input Variables Using Copulas***Yoojeong Noh, K.K. Choi, and Liu Du, University of Iowa*

For the performance measure approach (PMA) of RBDO, a transformation between the input random variables and the standard normal random variables is required to carry out the inverse reliability analysis. Since the transformation uses the joint cumulative density function (CDF) of input variables, the joint CDF should be known before carrying out RBDO. In many industrial RBDO problems, even though the input random variables are correlated, they are often assumed to be independent because only marginal distribution and covariance are practically obtained and the joint CDF is very difficult to obtain. With the assumption of independent input variables, it is easy to construct the joint CDF, and Rosenblatt transformation, which transforms the conditional CDF of input variables into the standard normal distribution, has been used for RBDO. However, when input variables are correlated, Rosenblatt transformation cannot be directly used because it is hard to obtain the joint CDF of correlated variables. On the other hand, Nataf transformation can be used for correlated input variables because it only requires marginal distribution and covariance. However, since Nataf transformation uses Gaussian copula, which joins multivariate normal and marginal distributions, it cannot be used for input variables with non-Gaussian joint distribution. In this paper, a new transformation that uses a non-Gaussian copula, such as Clayton copula, as the joint CDF of correlated input variables, which is then followed by Rosenblatt transformation, is proposed for non-Gaussian correlated variables. In addition, it is shown that the correlation coefficient between input variables significantly affect RBDO results and different transformations such as Nataf transformation using Gaussian copula and the new transformation using non-Gaussian copula (Clayton copula) provide different RBDO results.

Dimension Reduction Method (DRM) Based RBDO for Highly Nonlinear Systems*Ikjin Lee, K.K. Choi, and Liu Du, University of Iowa;
and David Gorsich, US Army RDECOM/TARDEC*

There are two commonly used reliability analysis methods: linear approximation - First Order Reliability Method (FORM); and quadratic approximation - Second Order Reliability Method (SORM), of the performance functions. The reliability analysis using FORM could be acceptable for mildly nonlinear performance functions, whereas the reliability analysis using SORM is usually necessary for highly nonlinear performance functions of multi-variables. However, SORM requires the second-order sensitivities, and thus, the SORM-based inverse reliability analysis is very difficult to develop. This seminar proposes an inverse reliability analysis method that can be used for multi-dimensional highly nonlinear systems to yield very accurate failure rate calculation without requiring the second order sensitivities and an RBDO method using the inverse reliability analysis result. For this purpose, the univariate dimension reduction method (DRM) is used. Since the FORM-based reliability index (β) could be inaccurate for the most probable point (MPP) search, a three-step computational process is proposed to carry out the inverse reliability analysis: constraint shift, reliability index update using DRM, and MPP search using the updated reliability index. Using the three steps, a new DRM-based MPP is obtained, which estimates the failure rate of the performance function more accurately than FORM and more efficiently than SORM. The DRM-based MPP is then used for the next design iteration of RBDO, and thus yields an accurate optimum design even for highly nonlinear system. Since the DRM-based RBDO requires more function evaluations, the enriched performance measure approach (PMA+) with new tolerances for constraint activeness and reduced rotation matrix is used to reduce the number of function evaluations

High-Frequency Shock Analysis for Composite Vehicles*Nick Vlahopoulos, University of Michigan*

In an effort to make Army vehicles more lightweight for increased fuel efficiency, composite materials can be used for their construction. However, composite vehicles or vehicles with composite components are more vulnerable than conventional vehicles to shock loads because they are more flexible. This presentation will cover recent work on developing a simulation capability that will allow assessing the high-frequency shock response and damage of a lightweight composite

vehicle due to a shock induced by a projectile impact, from a blast load, from operating loads when traveling at high speeds over rough terrain, or from firing the vehicle's gun. This new effort utilizes the technical foundation offered by the Energy Finite Element Analysis (EFEA) developments completed in previous ARC research. EFEA allows very fast computations at high frequencies because the primary variables of the formulation are energy-based. Thus, in contrast to traditional, displacement-based FEA, a relatively coarse mesh with a small number of finite elements is sufficient for analyzing even large structures at high frequencies. However, currently EFEA can only model structures made out of metal. The new developments are focused on methods for prescribing the shock loads in EFEA, modeling components made out of composite materials, and providing the results in a manner meaningful for assessing vehicle damage and equipment failure.

Efficient Response Predictions for Structural Systems Subject to Uncertainties, Design Changes, and Damage

Keychun Park and Matt Castanier, University of Michigan

For reliability and design studies, the structural dynamic analysis of a vehicle must account for local parameter variations due to uncertainties and component design changes. These variations affect not only the local vibration and stress levels, but also the system-level response. This presentation will cover recent developments in parametric reduced-order modeling (PROM) techniques aimed at rapidly predicting the response of a structural system subject to component parameter variations. Extensions to the PROM approach that allow a component finite element model to be changed, remeshed, and systematically reincorporated into the global reduced-order model will be shown. In addition, methods for modeling the response of a structure that suffers local damage will be briefly highlighted.