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

ARC Collaborative Research Seminar Series
Winter-Spring 2005

January 12th, Wednesday (9:00-10:30am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 3:
Reliability- And Possibility-Based Design Optimizations Using Performance Measure Approach
Prof. Kyung K. Choi, The University of Iowa
(click here for abstract)

February 9th, Wednesday (9:00-10:30am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 5:

An Efficient Approach for Reliability and Robustness in Engineering Design
Prof. Zissimos P. Mourelatos, Jinghong Liang, Oakland University

Reliability Optimization Involving Mixed Continuous-Discrete Uncertainties
Subroto Gunawan, Prof. Panos Y. Papalambros, University of Michigan

Click here for more abstracts.

March 9th, Wednesday (9:00-10:30am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 1:

Modeling Key Uncertainties in a Vehicle's Exogenous Enviornment
Prof. Huei Peng, Prof. Tim Gordan, University of Michigan
Prof. Andreas Koschan, University of Tennessee
Click here for abstract

March 23th, Wednesday (9:00-10:30am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 4:
Overview and Status of 2005 Projects in the Area of Advanced and Hybrid Propulsion
Prof. Naiem Henein, Wayne State University
Prof. Dennis N. Assanis, University of Michigan

Dual-Use Engine Injection Strategies for Improving the Performance - Emissions Tradeoff
Prof. Dennis N. Assanis, Zoran Filipi, C.A. Chryssakis, J.R. Hagena, A. Knafl, V.D. Hamosfakidis, University of Michigan

Total Engine Friction Model

Prof. Dinu Taraza, Wayne State University

Click here for abstracts

April 27th, Wednesday (9:00-10:30am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 2

Overview of Human Centered Vehicle Design Issues
Chaffin

Biodynmic Feedthrough Modeling
Gillespie, Sovenyi

Reach Hand Trajectory Modeling
Rider

Reach Neuro-muscular Coordination Modeling
Martin

Modeling Truck Driver Reach Space
Reed, Parkinson

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Abstracts for Winter-Spring 2005

January 12th, Wednesday (9:00-10:30am)

Presented by Thrust Area 3:
Reliability- And Possibility-Based Design Optimizations Using Performance Measure Approach
Prof. Kyung K. Choi, The University of Iowa

When the input data contain sufficient information to characterize statistical distribution, the design optimization that incorporates the probability method is called a reliability-based design optimization (RBDO). It involves evaluation of probabilistic output performance measures. The enriched performance measure approach (PMA+) has been developed for efficient and robust design optimization process. This is integrated with the enhanced hybrid mean value (HMV+) method for effective evaluation of non-monotone and/or highly nonlinear probabilistic constraints. When sufficient information of input data cannot be obtained due to restrictions of budgets, facilities, human, time, etc., the input statistical distribution is not believable. In this case, the probability method cannot be used for reliability analysis and design optimization. To deal with the situation that input uncertainties have insufficient information, a possibility (or fuzzy set) method should be used for structural analysis. A possibility-based design optimization (PBDO) method is proposed along with a new numerical method, called maximal possibility search (MPS), for fuzzy (or possibility) analysis and employing the performance measure approach (PMA) that improves numerical efficiency and stability in PBDO. The proposed RBDO and PBDO methods are applied to two examples to show their computational features. Also, RBDO and PBDO results are compared for implications of these methods in design optimization.

Return to Seminar Page

February 9th, Wednesday (9:00-10:30am)

Presented by Thrust Area 5:

An Efficient Approach for Reliability and Robustness in Engineering Design
Prof. Zissimos P. Mourelatos, Jinghong Liang, Oakland University

Mathematical optimization plays an important role in engineering design, leading to greatly improved performance. Deterministic optimization however, can lead to undesired choices because it neglects uncertainty. Reliability-based design optimization (RBDO) and robust design can improve optimization by considering uncertainty. In this talk, we will describe an efficient design optimization method under uncertainty, which simultaneously considers reliability and robustness. A mean performance is traded-off against robustness for a given reliability level of all performance targets. This results in a probabilistic multi-objective optimization problem. Variation is expressed in terms of a percentile difference which is efficiently computed using the Advanced Mean Value (AMV) method. A preference aggregation method converts the multi-objective problem to a single-objective problem, which is then solved using an RBDO approach. Indifference points are used to select the best solution without calculating the entire Pareto frontier. Examples illustrate the concepts and demonstrate their applicability.

Reliability Optimization Involving Mixed Continuous-Discrete Uncertainties
Subroto Gunawan, Prof. Panos Y. Papalambros, University of Michigan

Engineering design problems frequently involve a mix of both continuous and discrete uncertainties. However, most methods in the literature deal with either continuous or discrete uncertainties, but not both. In particular, no method has yet addressed uncertainty for categorically discrete variables or parameters. This article develops an efficient optimization method for problems involving mixed continuous-discrete uncertainties. The method reduces the number of function evaluations performed by systematically selecting the discrete factorials for reliability analysis based on their importance. The importance of a discrete factorial is assessed based on the spatial distance from the feasible boundary and on the probability of the discrete components. A demonstration is given for a numerical and an engineering example. Results show that the method is very efficient with only small errors.

Return to Seminar Page

March 9th, Wednesday (9:00-10:30am)

Presented by Thrust Area 1:

Modeling Key Uncertainties in a Vehicle's Exogenous Enviornment
Prof. Huei Peng, Prof. Tim Gordan, University of Michigan
Prof. Andreas Koschan, University of Tennessee

Safety, robustness and reliability are key objectives in both on-road and off-road vehicle design and control. To address these issues, one needs to model the key uncertainties affecting vehicle dynamics. Some uncertainties are internal, or endogenous, to the vehicle, such as manufacturing errors. To address endogenous uncertainties, one may either attempt to reduce them directly (e.g., through six sigma manufacturing) or reduce their impact on the vehicle (e.g., through robust design, robust control, etc.). Other uncertainties are exogenous to a vehicle, and cannot be directly reduced or eliminated. Two key exogenous uncertainties that affect vehicle performance are: uncertainties in the driver model, and uncertainties in the terrain. This ARC seminar will consist of two talks addressing these two key uncertainties. In the first talk, Prof.s Huei Peng and Tim Gordon from The University of Michigan will address uncertainties in driver models, how they affect vehicle performance and safety, how they can be quantified, and how they can be accounted for in vehicle design and control. In the second talk, Prof. Andreas Koschan from The University of Tennessee will address terrain uncertainties, how they affect terrain recognition and characterization, and how kriging and other stochastic optimization techniques can be used to address such uncertainties.

Return to Seminar Page

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Overview and Status of 2005 Projects in the Area of Advanced and Hybrid Propulsion
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Prof. Dennis N. Assanis, University of Michigan

Dual-Use Engine Injection Strategies for Improving the Performance - Emissions Tradeoff
Prof. Dennis N. Assanis, Zoran Filipi, C.A. Chryssakis, J.R. Hagena, A. Knafl, V.D. Hamosfakidis, University of Michigan

Modern diesel engines manufactured for commercial vehicles are calibrated to meet EPA emissions regulations. Many of the technologies and strategies typically incorporated to meet emissions targets compromise engine performance and efficiency. When used in military applications, however, engine performance and efficiency are of utmost importance in combat conditions or in remote locations where fuel supplies are scarce. This motivates the study of the potential to utilize the flexibility of emissions-reduction technologies toward optimizing engine performance while still keeping the emissions within tolerable limits.

The effect of pilot-injection strategies on reducing pollutants from diesel combustion is investigated through a synergistic approach combining experiments and Computational Fluid Dynamics (CFD) simulations. CFD analysis is performed to model in-cylinder processes and gain further understanding of the combustion and emissions formation mechanisms from multiple injection events. Results show that benefits of pilot injection stem from improved fuel-air mixing and the reduction of the amount of diffusion combustion. Using this for guidance, the experimental study was conducted on a modern medium-duty International V-8 diesel engine with variable geometry turbocharger (VGT) and exhaust gas recirculation (EGR). The performance-emissions tradeoffs were explored using design of experiments and response surface methodology. The methodology enables optimizing the engine operation for different objectives, such as minimum emissions or maximum efficiency, and subsequent development of a "best compromise" that improves the fuel efficiency while maintaining emissions within the regulation constraints, but without the use of EGR.

Total Engine Friction Model
Prof. Dinu Taraza, Wayne State University

The simulation of an automotive diesel engine operation requires a reliable and detailed engine friction model, especially when engine transients must be simulated. Such a friction model must take into consideration all major friction components of the diesel engine i.e. piston-ring assembly, bearings, valve train and engine auxiliaries: injection system oil and water pumps and consider friction variation during the engine cycle. To make the model compatible with other simulation codes developed in the ARC Projects, the total friction model is developed in a SIMULINK environment. The development of this model requires an engine simulation model devised especially for simulating engine dynamics and transients. The engine simulation model is developed considering the characteristics of modern, common rail diesel engines and the capacity of these systems to produce multiple injections (three injections, pilot main and post have been incorporated in the model). A detailed engine dynamics model has been developed considering the stiffness and mass of each crank of the crankshaft and the nonlinearities of the crank-slider mechanisms. A first generation dynamic model of the turbocharger has been also developed. First results are shown in comparison with measurements made on the 2.5 Daimler Chrysler engine using a simplified friction model. The detailed friction model is currently under development and the piston-ring assembly friction model as been already incorporated in the engine simulation model.

Return to Seminar Page

April 27th, Wednesday (9:00-10:30am)

No abstracts available.

Return to Seminar Page