ARC Collaborative Research Seminar Series
Winter-Spring 2003

February 10, Monday

"Quantitative Vehicle Product Development and Assessment"
Presented by Thrust Area 5 - UM Team
Abstract

March 10, Monday

"Reliability-Based Design Optimization of Mechanical Systems"
Presented by Thrust Area 3 - Prof. K.K. Choi (CCAD, University of Iowa)
Abstract

March 31, Monday

Topic: Alternative Vehicle Systems
Presented by Thrust Area 1

"Pose Estimation for Sweeping Laser Rangefinders in Mobile Robot Obstacle Negotiation and Map-building Applications "
Presenters: Dr. Johann Borenstein, Dr. Cang Ye
Abstract

"Enhanced Mobility Through Cooperation - Progress Report: "
Presenter: Prof. Jonathan Luntz
Abstract

April 7, Monday

Topic: Advances in Research on Diesel Engine Combustion, Tribology and Controls
Presented by Thrust Area 4

"Development of Diesel Engine Emissions and Performance (DEEP) model for the engine in vehicle simulation"
Presenter: Dr. Dohoy Jung (University of Michigan)
Abstract

"The Impact of Exhaust Gas Recirculation on Heavy-Duty Diesel Engine Performance and Heat Rejection"
Presenter: Timothy Jacobs (University of Michigan)
Abstract

"A New Model for Combustion and Emissions Formation in Small-Bore HSDI Diesel Engines"
Presenter: Prof. N. A. Henein (Wayne State University)

"Engine Tribology Research at WSU"
Presenter: Prof. Dinu Taraza (Wayne State University)

"Hydraulics Simulation of the Advanced High-Pressure Injection Systems"
Presenters: Prof. Ming-Chai Lai, Prof. N. A. Henein (Wayne State University)

April 28, Monday

Topics by Thrust Area 1

"Model Partitioning for Improved Simulation-Based Design"
Presenter: Geoff Rideout (The University of Michigan)
Abstract

"Range of Validity of Simulation Models subject to Uncertain Inputs"
Presenter: Bryon Sohns (The University of Michigan)
Abstract

"Fuel Cells with Short Transients and Long Life: A Control Vignette"
Presenter: Assoc. Prof. Anna G. Stefanopoulou (The University of Michigan)
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"Data-Based Human Driver Modeling and Evaluation of Collision Warning and Avoidance Algorithms"
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ARC Collaborative Research Seminar Series
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February 10, Monday

"Quantitative Vehicle Product Development and Assessment"
Presented by Thrust Area 5 - UM Team

We look at the entire product development process and bring in as many analytical/quantitative tools as we can to assess how a (set of) product(s) will meet user and producer needs. The idea is to extend the concept of using engineering simulation in support of product development to include organizational, market, financial, and investment simulations. The effort is motivated by the increased awareness that engineering considerations alone are not sufficiently convincing for product investment or procurement decisions. At the same time, making such management decisions without full understanding of how they impact the actual product decisions leads to lower quality and more costly products.

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March 10, Monday

"Reliability-Based Design Optimization of Mechanical Systems"
Presented by Thrust Area 3 - Prof. K.K. Choi (CCAD, University of Iowa)

In this presentation, new advanced RBDO and probability analysis methodologies are proposed for multidisciplinary design optimization of large-scale problems. The conventional RBDO method involves evaluation of probabilistic constraints by using the first-order reliability method (FORM) to obtain the reliability index for each design constraint. This is called the reliability index approach (RIA). However, it has been noted by the authors that RIA converges slow or even diverges for some problems. To alleviate this problem, a performance measure approach (PMA) is proposed for robust and efficient reliability analysis in the RBDO process. In PMA, the inverse problem of FORM is solved. For the numerical solution of this inverse problem, the advanced mean value (AMV) method can be used. However, it is found that AMV behaves very poorly for concave constraint functions, although it is effective for convex constraint functions. To overcome difficulty of the AMV method, the conjugate mean value (CMV) method is proposed for the concave constraint function in PMA. Thus, hybrid mean value (HMV) method is developed by combining CMV and AMV. The proposed method is demonstrated by applying to large-scale durability problems and future research direction is discussed.

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March 31, Monday

Topic: Alternative Vehicle Systems
Presented by Thrust Area 1

"Pose Estimation for Sweeping Laser Rangefinders in Mobile Robot Obstacle Negotiation and Map-building Applications "
Presenters: Dr. Johann Borenstein, Dr. Cang Ye

All mobile robots require obstacle negotiation capabilities in order to move around safely. The foremost problem in the implementation of this capability is that current sensor technology is very expensive, typically requiring 3-DOF laser rangefinder and fast computer vision systems costing over $100K.

The project presented here aims at developing a system capable of producing accurate elevation maps for

obstacle negotiation, but using only a much more affordable 2-DOF laser rangefinder. One essential requirement for this cost-effective approach is that the rangefinder's momentary position and orientation (collectively called "pose") be known at any time and with good accuracy. The focal points of our project are thus

- The development of elevation maps from 2-DOF laser rangefinders during motion
- The integration of a pose estimation system with the laser rangefinder and the isolation of this system from motion-induced disturbance

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"Enhanced Mobility Through Cooperation - Progress Report: "
Presenter: Prof. Jonathan Luntz

The project objective is to develop the scientific basis and a set of distributed control algorithms to allow multiple vehicles to cooperate physically to increase their mobility capabilities.

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April 7, Monday

Topic: Advances in Research on Diesel Engine Combustion, Tribology and Controls
Presented by Thrust Area 4

"Development of Diesel Engine Emissions and Performance (DEEP) model for the engine in vehicle simulation"
Presenter: Dr. Dohoy Jung (University of Michigan)

A reduced multi-zone combustion model is developed to improve computational efficiency of the previously developed full size multi-zone combustion model which is based on a quasi-dimensional approach. The reduced model maintains the capability of predicting engine performance and emissions as the original model. It is modified and implemented into a SIMULINK based engine systems simulation and integrated with drivetrain and vehicle dynamics models for the transient vehicle behavior case studies.

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"The Impact of Exhaust Gas Recirculation on Heavy-Duty Diesel Engine Performance and Heat Rejection"
Presenter: Timothy Jacobs (University of Michigan)

Performance and heat rejection of heavy-duty Diesel engines have altered with the advent of exhaust gas recirculation. Introduced as a method to reduce NOx emissions, EGR inherently alters combustion with implications on power production, fuel economy, and heat losses. The following presentation highlights these alterations and uncovers some challenges to maintaining high fuel economy and low heat rejection with heavy duty diesel engines equipped with EGR.

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April 28, Monday

Topics by Thrust Area 1

"Model Partitioning for Improved Simulation-Based Design"
Presenter: Geoff Rideout (The University of Michigan)

In mature research areas, simulation-based design can often be simplified through one-way coupling assumptions, valid for a given environment and system configuration. For example, a vehicle mobility model may assume that longitudinal acceleration over smooth terrain is not affected by vehicle pitch and bounce. A point mass model without suspensions or rotational degrees of freedom may suffice. As the terrain severity increases and vehicle parameters change, however, this assumption may become invalid. Any a priori model reduction

should be tested initially and throughout the design process. An algorithm is demonstrated that automatically searches a model and identifies sets of dynamic elements, or partitions, between which little power flow occurs. The method quantitatively discovers, validates, or tracks the degradation of, one-way coupling assumptions as the system or environment change. The model partitioning algorithm also increases the scope and robustness of existing model simplification techniques. Further, optimal design of a large system is expected to be more efficient if individual partitions - reduced-order submodels - can be identified and designed independently. Vehicle dynamic applications are discussed and demonstrated.

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"Range of Validity of Simulation Models subject to Uncertain Inputs"
Presenter: Bryon Sohns (The University of Michigan)

The ability to quantify the Range of Validity of a model is essential to ensuring accurate simulation-based design. "Range of Validity" refers to a) bounds on the inputs to the system from the environment within which the model has acceptable predictive value, and b) the space of parameter values - design points - in which the model accurately predicts system behavior. An initial approach to quantifying Range of Validity with respect to inputs is presented based on an extension of earlier Thrust Area 1 work on determining model validity. Preliminary results show the feasibility of the approach as applied to an illustrative mass-spring-damper model and to an empirical nonlinear fuel cell model from a current ARC project. The results show the range within which the controller can vary fuel cell stack current for a given control system design model. Outside this range the model has quantitatively unacceptable predictive ability. If the controller is found to exceed the validity bounds then a new controller must be designed based on a higher-fidelity model, or the accuracy tolerances must be reconsidered. Future work will extend the Range of Validity to the model parameters as well as inputs, and to simulation models that must predict measured data from real systems. Connections to other ARC projects include mapping the input or design space over which model partitions exist, or ensuring that a given simulation model is valid over the expected range of variation of uncertain design parameters.

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"Fuel Cells with Short Transients and Long Life: A Control Vignette"
Presenter: Assoc. Prof. Anna G. Stefanopoulou (The University of Michigan)

This talk will take you through a control design study for a Fuel Cell Stack (FCS) system with a natural gas reformer. We show that observer-based and multivariable feedback can reduce oxygen and hydrogen starvation, and thus, extend the FCS life. The same controller regulates the temperature of the catalytic bed of the natural gas reformer, and thus, it can potentially improve the reliability of the overall system. We conclude the talk with an overview of the equipment and testing facility of the recently developed Fuel Cell Control Laboratory in North Campus. (Funding from ARC, NSF, UTRC)

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"Data-Based Human Driver Modeling and Evaluation of Collision Warning and Avoidance Algorithms"
Presenter: Assoc. Prof. Huei Peng (The University of Michigan)

Most of the past modeling effort within ARC was focused on the modeling of vehicles, vehicle component and their behavior. The "active safety" project we had since 1995 was along the same line until 2000, when it became clear an accurate driver model plays a crucial role in the design, simulation and analysis of many active safety systems.

As opposed to most other driver models developed in the literature, our approach is data-based. The driving data will be based on two databases constructed at the University of Michigan Transportation Research Institute (UMTRI): The SAVME database and the ICC FOT database. We developed a modified Gipps driver model which has been demonstrated to describe human microscopic and macroscopic behavior very well. This driver model has been used by UMTRI for their evaluation of three commercial Adaptive Cruise Control vehicles.

Recently, we start to investigate the application of our data and driver model on the evaluation of collision warning and collision avoidance algorithms. Three algorithms published in the literature were analyzed: from Honda, Mazda and the Johns Hopkins University (APL), which is later used as part of the CAMP algorithm. None of these algorithms work satisfactorily.

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