ARC Collaborative Research Seminar Series
Fall 2006

September 20th, Wednesday (9:30-11:00am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 3
New Technology Development for Improved Safety of Military and Commercial Vehicles

There is currently great demand to provide vehicles with lighter body weight for improved fuel efficiency, transportability, and mobility. At the same time, safety remains a central concern for both military and commercial vehicles, with blast protection in particular being a major factor in the development of new military vehicles. As a result, innovative structural and material design concepts are needed to develop vehicle structures that can do more with less: achieve high safety requirements while reducing weight. On the other hand, up-armoring military vehicles can lead to significant increases in total weight and dramatic changes in mass distribution. This reinforces the need to develop better vehicle dynamics modeling and simulation technology, including off-road tire-terrain interaction models, to ensure that vehicle control, stability, and mobility targets are achieved. In this seminar, three Thrust Area 3 projects are presented that directly address these challenges to improving vehicle safety.

Part 1: A Magic Cube (MQ) approach for crashworthiness and blast-protection design
Zheng-Dong Ma, The University of Michigan

An approach to design for crashworthiness and blast protection is presented that consists of three major dimensions, each with three layers, to form a 27-element magic cube. For example, the Approach dimension has three layers. (1) The time decomposition yields a sequence of sub-crash processes based on the major scenarios in the crash process. (2) The space decomposition decouples the overall vehicle crashworthiness design problem into parallel subsystem design problems. (3) The scale decomposition decouples the design processes into those at the structural level and at the material level, so that both the structure and material can be optimized. A crashworthiness or blast-protection design problem can then be solved by employing corresponding elements in the magic cube. Examples will be given to demonstrate the proposed approach and its application in vehicle design problems, including a HMMWV model under landmine explosions.

Part 2: An "Inflatable Morphing Body" Concept for Improved Vehicle Safety
Noboru Kikuchi, The University of Michigan

A new inflatable body concept is presented for improved vehicle safety. The proposed system has several components, including a bumper, airbags, springs, explosives, and energy absorbing materials. The following fundamental issues will be addressed: 1) feasibility of the novel concept, 2) methodology used to design such inflatable body, 3) effectiveness of the system, and 4) general design guidelines. Example simulation results will be given to demonstrate the effectiveness and potential energy absorption capability of a proposed active crash-protective device. Major design variables and design guidelines/procedures will also be introduced. For the next step, a design model will be developed based on a full vehicle model, along with an explosive airbag model for optimizing the inflatable body design, in order to significantly improve crashworthiness of the vehicle system. The advanced design methodologies developed in this research can be further extended for development of other innovative structural and material concepts in advanced military and civilian vehicles.

Part 3: Physics-Based Modeling of Pressure-Sinkage for Tire-Snow Traction Prediction
Jonah Lee, University of Alaska Fairbanks

One of the most important areas in the performance of off-terrain vehicles, such as stability and control, is the understanding of the traction between a tire and deformable terrain, especially for low-friction surfaces such as ice and snow. In this talk, we first present a new physics-based approach to model the pressure-sinkage relationship using only the geometry of the domain and fundamental properties of the material with no empiricism. This approach is applicable to both semi-infinite and finite-depth domains, and thus has the potential to replace Bekker's and Wong's equations for a wide range of terrains. We conducted finite element analysis of punch indentation, static tire indentation and rolling tire indentation against fresh snow of different depths. The results indicate that the pressure-sinkage relationship for the plate indentation test is similar to that for static tire indentation. Three deformation zones have been identified for these tests using pressure-sinkage and density-sinkage data: an elastic zone (Zone I), a propagating hardening plastic zone (Zone II) and a densification (finite depth) zone (Zone III). Although the rolling tire indentation shows similar maximum contact pressure to a static tire indentation, the pressure-sinkage relationship is drastically different. Also the pressure profile for the rolling tire is asymmetric; consequently the length of the contact patch is shorter. The differences result from the fundamentally different motions between a rolling tire indentation and a static tire indentation. We also conclude that, for a tire on snow, the tread pattern increases traction and decreases motion resistance, and hence increases the drawbar pull.

October 4th, Wednesday (9:30-11:00am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 2:

Comparative Evaluation of Biodynamic Feedthrough Counter-measures: Motorized Cancellation, Passive Cancellation, and Armrest
Taeyoung Shin and R. Brent Gillespie, University of Michigan

Estimation of Body Links Transfer Functions in Vehicle Vibration Environment: Preliminary Analysis
Heon-Jeong Kim and Bernard Martin, University of Michigan

Linking Cognitive and Physical Human Models: Progress Toward the Virtual Driver
Omer Tsimhoni and Matthew Reed, University of Michigan

October 25th, Wednesday (9:30-11:00am)
University of Michigan, Lurie Engineering Center, Level 4, GM Room

Presented by Thrust Area 1:
System Identification for Real Vehicles and Their Environments:
Necessary Tools for Vehicle Safety Improvement

Efficient Parameter Identification for Large Multibody Dynamics Models Using an Activity-Guided Stochastic Search Algorithm
Bryon Sohns, Hosam K. Fathy, and Jeffrey L. Stein (The University of Michigan)

Robust Online Vehicle Mass and C.G. Height Estimation for Adaptive Active Vehicle Safety Control
Dongsoo Kang, Hosam K. Fathy, and Jeffrey L. Stein (The University of Michigan)

Stochastic Modeling of Terrain Profile and Soil Characteristics
Corina Sandu (Virginia Tech)

Advanced Semi-Active Control Methods for HMMWV Primary Suspensions
Steve Southward (Virginia Tech)

November 29th, Wednesday (9:30-11:00am)

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

Presented by Thrust Area 4

Energy Initiative at UM
Dennis Assanis, ARC Director

Overview of Area 4 Research Activities at WSU
Naeim Henein and Ming-Chia Lai, Wayne State University

Modeling and Optimization of the Thermal Management System for an Electric Hybrid Vehicle
Zoran Filipi and Dohoy Jung, The University of Michigan

December 13th, Wednesday (9:30-11:00am)
University of Michigan, Lurie Engineering Center, Level 3, Johnson Rooms B & C

Presented by Thrust Area 5

Real-Time, Self-Learning Optimization of Powertrain Systems
Andreas Malikopoulos (presenter), Panos Papalambros and Dennis Assanis

The continuously growing number of requests for better performance and fuel economy on the one hand and very restrictive emission standards on the other have promoted research in advanced internal combustion engine technologies. These advanced technologies, have not only increased the number of accessible variables of an engine, but have also enhanced our ability to control them. The optimal set-values of these variables are controlled through static correlations (look-up table-based maps) by the Electronic Control Unit (ECU) of an engine in a way to coordinate optimal performance of several specified indices, e.g., fuel economy, pollutant emissions, engine performance. We present a novel approach incorporating a theoretical basis and a learning algorithm that allows the engine to learn the optimal set values of these accessible variables in real time while running a vehicle. Through this approach, the engine progressively perceives the driver's conventional driving style and, eventually, learns to operate in a manner that optimizes the specified performance indices. The effectiveness of this approach is demonstrated through a simulation of a Spark Ignition (SI) engine model; while the engine is running it learns to optimize fuel economy with respect to spark timing.

Design and Simulation Toolkit for Army Ground Vehicles: Fusion of Models and Experiments
Geunsoo Ryu, Youngwon Hahn, Zheng-Dong Ma and Greg Hulbert

No abstract available.

Optimization under Uncertainty using Time-Dependent Metamodels. Application to Driveline Dynamics and Engine Torque Management for Clunk Disturbance
Zissimos P. Mourelatos and Daniel Wehrwein

No abstract available.