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
## Fall 2003

September 15, Monday

**"A New Concept Distributed-Simulation Platform For Virtual Prototyping of Mechanical Systems"**
*Presented by Dr. Zheng-Dong Ma (University of Michigan)*
Abstract

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September 29, Monday

**"Tire and Soil Modeling, Virtual Testing, and Integration into Full-Vehicle Multi-body Dynamic Simulation"**
*Presented by Dr. Weidong Pan*
*National Advanced Driving Simulator and Simulation Center, University of Iowa*
Abstract

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October 27, Monday

**Thrust Area 1: Past, Present and Future**
**Accomplishments and Goals in Modeling and Control of Advanced Powertrains**

**Introduction and Overview**
*Prof. Jeffrey L. Stein, Thrust Area 1 Leader, University of Michigan*.

**Partitioning of Vehicle System Models for Efficient Simulation-Based Design: A Case Study with a Six Cylinder Diesel Engine**
*Geoff Rideout, Ph.D. Candidate, University of Michigan*

**Advanced Control For Improved Efficiency, Mobility And Safety Of Future Ground Vehicles**
*Assoc. Prof. Huei Peng, University of Michigan*

**Research Results and Direction in Control of Fuel Cell Systems for Military Platforms**
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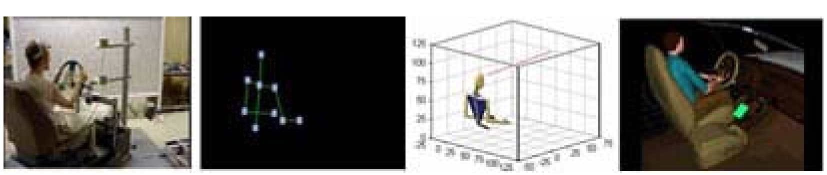
November 24, Monday

**Thrust Area 2 Presents:**
**Human Centered Design Modeling & Simulation**

To provide digital human models to improve vehicle ergonomics for soldiers operating/maintaining future combat systems.



**Human Studies Of Movements (Motion Capture)**

**Human Motions & Performance Capabilities Predicted by Models**

**Human Kinematics Modeled**

**Human Motions Simulated for Vehicle Design Simulation**

Presenters:
*Don Chaffin, The G. Lawton and Louise G. Johnson Professor, IOE and BME*
*Brent Gillespie, Assistant Professor, MEAM*
*Mathew Reed, Associate Research Scientist, UMTRI*
*Clark Dickerson, PhD Candidate, BME*
*Matt Parkinson, PhD Candidate, BME*
*Kevin Rider, PhD student, IOE*
*Szabolcz Sovenyi, PhD candidate, MEAM*

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December 8, Monday

**Thrust Area 4: Advanced and Hybrid Powertrains**

**Control Strategies For Military And Domestic Engines**
*Prof. Naeim A. Henein, Wayne State University*

**Advanced Engines For Military Application**
*Prof. Dinu Taraza, Wayne State University*

*Prof. Ming-Chia Lai, Wayne State University*

**Case Study Proposal for 2004: Clean and Controllable, Advanced Compression Ignition Engine System for Improved Power Density and Fuel Economy**
*Dr. Zoran Filipi, University of Michigan*

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## ARC Collaborative Research Seminar Series
## Fall 2003

September 15, Monday

**"A New Concept Distributed-Simulation Platform For Virtual Prototyping of Mechanical Systems"**
*Presented by Dr. Zheng-Dong Ma (University of Michigan)*

Rapid advances in software and hardware have accelerated the reliance on virtual prototyping of engineering designs in manufacturing industries. Modern simulation tools are now able to model complex mechanical systems with a large number of components, such as a full automotive vehicle. A significant change to modern business practice is that automobile manufacturers are now operating in a way that distributes the production processes across multi-layered supply chains. These supply chains, which are naturally, functionally, and geographically distributed, result in very complicated design and manufacturing systems. Even within a supplier unit, it is common practice for different groups to work on different components of the product. As a result, the component models of the design are also functionally and geographically distributed amongst different suppliers and amongst different units inside large companies. It is very difficult, if not practically impossible, to integrate all detailed component models into a monolithic, stand-alone simulation model for demanding analysis and design purposes. Hence, there is a great need for methodologies that can be exploited to simulate complex mechanical systems whose models are distributed amongst disparate production units. Such methodologies need to maintain simulation fidelity, must be efficient and must maintain the privacy of the individual component models amongst potentially competing supply chain units.

In this presentation, I will first address the need for a simulation platform that can incorporate distributed heterogeneous mechanical systems models and couple them together to perform dynamics simulations to assist the virtual prototyping process. An overview will be provided for the existent methodologies and software systems that may be used to support the distributed production activities. Related methodologies include divide-and-conquer algorithms, parallel computation and domain decomposition, substructuring methods, including component mode synthesis, and other methods. State-of-the-art software systems include Windchill (www.ptc.com), ENOVIA (www.enovia.com), iSIGHT (www.engineous.com), etc. I will discuss the capabilities and the lacks of these methodologies and systems for using them in simulating a truly distributed mechanical system.

This presentation summarizes our research towards a distributed simulation environment that meets the challenges. Three key concepts will be laid out in my following presentation, which comprise the foundation of a new concept distributed simulation platform for design and virtual prototyping of general structural and mechanical systems. First, a new gluing algorithm, denoted as the T-T method, is discussed, which enables distributed simulations (both the component model and simulation of the component) to be coupled while maintaining the independence of the separate component simulations. Second, a general and efficient model description for simulation is defined using XML. Each model is described with an XML file and stored in model database. A complete model then can be assembled based on these model descriptions. Simulation of a model is started simply by sending the model description to a simulation server. Third, a logical distributed architecture is laid out that can be implemented with one of the existing technologies for distributed computing. Interfaces between different network components have been standardized to enable extensibility of the architecture. These concepts have been incorporated into a prototype Web-based distributed simulation system that demonstrates the potential of the new techniques for solving real engineering design problems. Examples will be given throughout the presentation to illustrate this concept distributed simulation system.

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**"Tire and Soil Modeling, Virtual Testing, and Integration into Full-Vehicle Multi-body Dynamic Simulation"**
*Presented by Dr. Weidong Pan*
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This seminar describes progress towards developing technology that enables off-road vehicle simulation for vehicle mobility analysis and for generating accurate vehicle duty cycles for durability analysis. Three components of this technology are tire modeling, terrain/soil modeling, and multi-body vehicle modeling. Tire modeling is an endeavor of choosing/developing appropriate material formulation and proper model construction methodology. The latter is important as tire construction is very complex and requires proper reduction. Soil modeling is aimed at choosing/developing proper material formulations that are accurate and the parameters are easy to identify. Vehicle modeling requires use of multi-body dynamics to achieve accurate results when simulating vehicles operating in real-world environment under realistic maneuver. Integration of these three technological components is done by a systematic variational approach which leads to a set of equations of motion of tires, terrain/soil, and multi-body vehicle that is solved simultaneously, thus accounting for nonlinear coupling effects among the components. Less accurate approaches such as linking existing commercial software are also useful for some applications. Numerical results, as well as modeling and simulation tools, will be presented.

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October 27, Monday

**Thrust Area 1: Past, Present and Future**
**Accomplishments and Goals in Modeling and Control of Advanced Powertrains**

This presentation will provide an overview of the past accomplishments, current projects and future goals of Thrust Area #1, Dynamics and Control of Vehicles and Mobile Robots, with respect to modeling and control tools for advanced powertrains. Three current projects will be highlighted and include:

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