A Multi-participant motion-based simulation framework for transportation planning, safety, and design

Abstract

This position paper describes the development of a Cyber-Physical System in the form of a Motion Simulation Framework (MSF-CPS), intended primarily for ground-vehicle transportation. We will implement a Serious Game approach to emulate existing multi-participant networked computer games for real research purposes. Our end goal is to create a forum for allowing multiple participants to remotely interact within the same driving environment – a capability lacking in most research-based simulators. Such a simulation will allow for the analysis of true inter-participant interactions that is not possible with conventional simulators that implement artificial traffic models. Participants who may not be co-located geographically will be allowed to interact within our network-based simulation framework.

Requirements of an MSF-CPS

Our motion simulation framework embodies many of the characteristics of a so-called "Cyber-Physical System" [1]. Namely, our framework "integrates control, computing, communication, and storage capabilities with physical and engineered entities that possess physical-world dynamics." The centerpiece of our MSF-CPS is an electrically actuated Motion Platform with vehicle cabin, capable of 6 degree-of-freedom (D.O.F.) actuation. The motion platform (red) interfaces with a 3-screen, 180 degree visualization system (blue), a 2.1 stereo sound system (green), and high-performance computational and graphics processing (gray) all embedded within a real-time framework. See Figure 1.

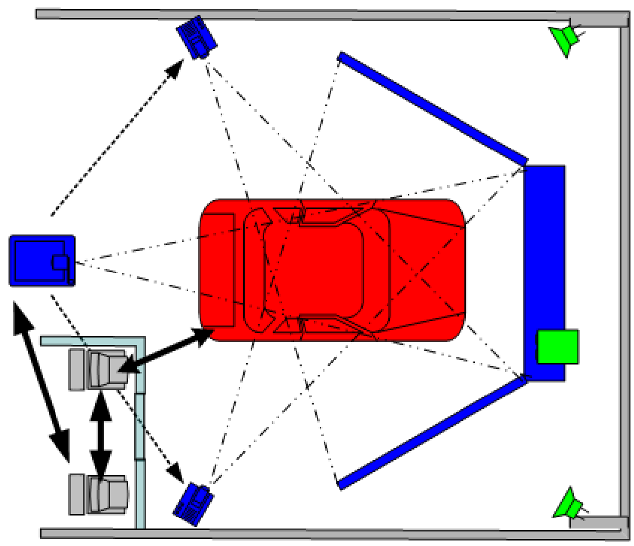

Figure 1 – MSF-CPS process flowchart

Figure 2 – Left to Right: "Skid Pad", "Millersport", "Indoor Karting"

Promising Directions: To date, our MSF-CPS has made significant strides in providing a "Serious Game" [2], simulation-based driving environment for single-user, on-site driving applications. See Figure 2. Our "skid pad/test track" was generated as a means for Road Vehicle Dynamicists to be able to experientially observe the performance impact of changes to seminal vehicle settings, such as CG location and tire properties. Our "Millersport" simulation was generated to analyze the suspension component to a virtual vehicle amidst an obstacle course of roadway speed bumps. Our "Indoor Karting" simulation is being developed specifically to provide a "closed" environment for analysis of collision events (e.g. Kart-to-kart, Kart-to-wall) within a "networked" multi-user simulation. This is a major technical challenge associated with the development of a simulation-based CPS, as is described in the next section.

Technical Challenges associated with development of an MSF-CPS

At present, a major feature lacking in our simulation, and indeed most driving simulators, is a simultaneous, multi-user capability. For a user to drive in a virtual environment among agent-based or "drone" traffic can be of limited use when trying to analyze the impact of driver decisions based upon the actions of others (e.g. a driver swerving into another drivers lane, Vehicle-to-Vehicle/Vehicle-to-Intersection studies, multiple drivers simultaneously circumnavigating a novel roadway feature like a roundabout, etc.) Such an environment will allow for transportation planning to be performed with a higher degree of certainty earlier in the design process, ideally resulting in a safer transportation infrastructure, at a lower cost.

<u>Promising Directions:</u> We envision a network of users all participating within the same simulation environment, by way of TCP-IP [3] and UDP [4] network communication. Such a simulation will allow for the analysis of true inter-participant interactions that is not possible with conventional simulators that implement only artificial (agent-based) traffic models.

See Figure 3. As depicted in the diagram, users (clients) separated by geographic distance across a computer network will participate within the SAME virtual driving environment, controlled by a central server that will keep track of all users positions/orientations, and other event triggering such as weather/climate conditions and driver obstacles.

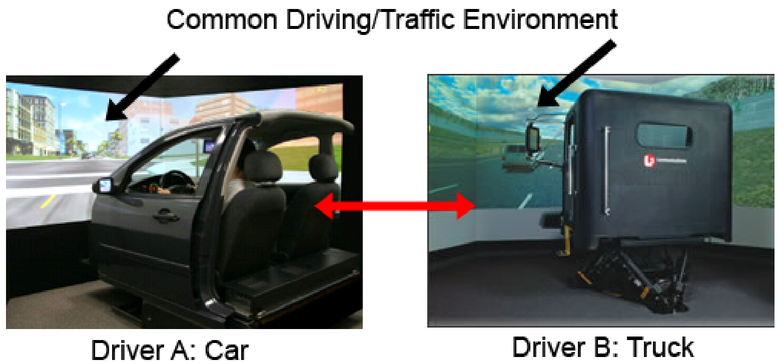

Figure 3 – Remote, multi-participant real-time motion-based vehicle simulation

References

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Author Bios

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Dr. Hulme has served as Research Associate at NYSCEDII for over 8 years, and is currently the technical lead in NYSCEDII's Motion Simulation Laboratory. He has numerous years of experience with various tools required to construct a real-time motion-based driving simulation, including: motion platform cueing strategies and washout filtering, scene graphics development, programmatic audio cues, parallel/distributed computing, network programming via TCP and UDP sockets, multi-threaded applications (Posix Threads), and HID input capture.

Recent Publications

- Hulme, K.F. Kasprzak, E., English, K., Russo, D.M., and Lewis, K., "Experiential Learning in Vehicle Dynamics Education via Motion Simulation and Interactive Gaming", International Journal of Computer Games Technology, submitted for review, September, 2008.
- English, K., Hulme, K., and Lewis, K. "Engaging High School Women in Engineering Design Using CyberInfrastructure." ASME International Design Technical Conferences, Symposium on International Design and Design Education, New York City, August, 2008.

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Dr. Lewis is a Professor in the Department of Mechanical and Aerospace Engineering at UB, and has extensive research experience in the development of decision support tools for designing complex engineered systems. His interests are in the design of large-scale engineering systems, like transportation systems, which are capable of indefinite change, growth, and development over time and are designed by a number of distributed designers or design teams who have to evaluate complex tradeoffs over multiple criteria. He is also involved with a number of cyberinfrastructure-related initiatives, including advanced visualization, system simulation, reconfigurable systems, and repository implementation, including a national product dissection cyber-collaboratory for engineering education.

Recent Publications

- Ferguson, S.F., Kasprzak, E.M., and Lewis, K., 2008, "Design of a Family of Reconfigurable Vehicles Using Multilevel Multidisciplinary Design Optimization," Structural and Multidisciplinary Optimization Journal, accepted.
- Gurnani, A., Ferguson, S.F. and Lewis, K., 2008, "Investigating the Interaction between Reconfigurability and System Mass Using Multidisciplinary Design Optimization," 49th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Schaumburg, IL, AIAA2008-1803.