Research
Report Summary

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Distributed Simulation to Support Driving Safety Research

Over half of all crashes involve two or more vehicles. While driving simulation provides an effective way to study many crash scenarios in a well-controlled environment, it cannot capture the complex dynamics between two human drivers in the seconds leading up to a multi-car crash or safety-critical event. Examples of multi-driver simulation extend back to the 1980s in military applications, but only in the last five years have several groups begun to be active in this area to study connected and automated vehicles.

In this project, the development of a distributed simulation capability for NADS simulators was begun. The current capability provides for multiple NADS miniSim™ simulators to be networked together. However, we plan to extend this to include the NADS-1 motion base simulator as well. The vision for our distributed simulation capability will also include other non-NADS simulators.

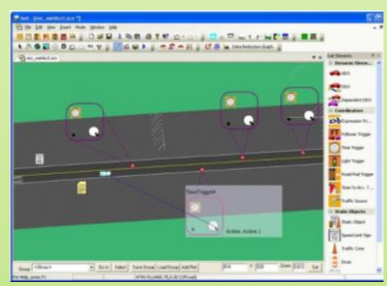
Table 1. Top five pre-crash scenarios involving two vehicles (Najm, Smith, and Yanagisawa, 2007)

No.	Scenario	Frequency	Rel. Freq.
1	Lead Vehicle Stopped	792,000	20.46%
2	Vehicle(s) Turning at Non-Signalized Junction	419,000	10.83%
3	Lead Vehicle Decelerating	347,000	8.96%
4	Vehicle(s) Changing Lanes – Same Direction	295,000	7.62%
5	Straight Crossing Paths at Non-Signalized Junctions	252,000	6.52%

NADS Simulation

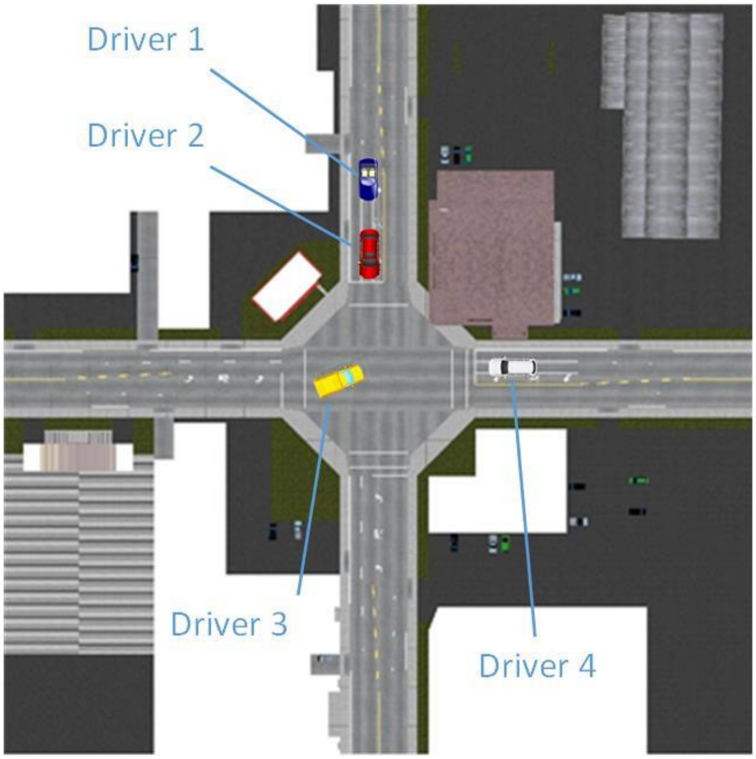
NADS PC-based simulators


NADS-1 motion base


ISAT: Integrated Scenario Authoring Tool


Rural two-lane highway

> *"What is clearly required as a next step in the process is a programmatic and sustained effort on behalf of many researchers in order to take advantage of the opportunity which dynamic, interactive simulation presents." (Hancock and Ridder, 2003)*



The four main components of the miniSim architecture are called CVED, HCSM, NADSDyna, and VisualServer. CVED contains the environment and all scenario objects (vehicles, pedestrians, etc.). HCSM executes the scenario logic and manages behavior for dynamic objects. NADSDyna is the high fidelity vehicle dynamics for the driver's car. The VisualServer glues together CVED and HCSM with visual rendering code and an interface to the driver interfaces (steering, pedals).

A peer-to-peer architecture was designed to pass information about each driver's state to other simulators. In this design, each simulator is responsible for managing its own traffic and scenario logic. In a future iteration the HCSM component will be pulled into a central server and a hybrid client-server architecture will be used.

The distributed simulation capability was tested using two miniSims and a simple scenario. A useful feature in the peer-to-peer architecture is that traffic vehicles can be placed in only one participant's scenario. Such vehicles can be used to regulate a driver's speed and ensure they arrive at a critical point at the right time relative to the other driver, all without being seen by the other driver(s).

Additional future improvements to the distributed simulation will be to create a virtual lobby to set up the initial configuration for simulations. Next a dead reckoning algorithm should be added to help compensate for larger lags that may be introduced by networking across greater distances. Finally, commercial networking products from VT Mak may be used to quickly develop cross-platform support for distributed simulations.

This capability will support next-generation simulator research at the University of Iowa and eventually benefit all miniSim customers who are interested in performing multi-driver experiments.

References

Hancock, P.A., and S.N. de Ridder. 2003. "Behavioural Accident Avoidance Science: Understanding Response in Collision Incipient Conditions." *Ergonomics* 46 (12): 1111–35.

Najm, W., J. Smith, and M Yanagisawa. 2007. "Pre-Crash Scenario Typology for Crash Avoidance Research." Final Report DOT HS 810 767. NHTSA.

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