ctre
Center for Transportation Research and Education

Visualization Resources for Iowa State University and the Iowa DOT: An Automated Design Model to Simulator Converter

tech transfer summary

Highway design decisions could be enhanced if designers, stakeholders, and the public were able to drive proposed designs before they are built.

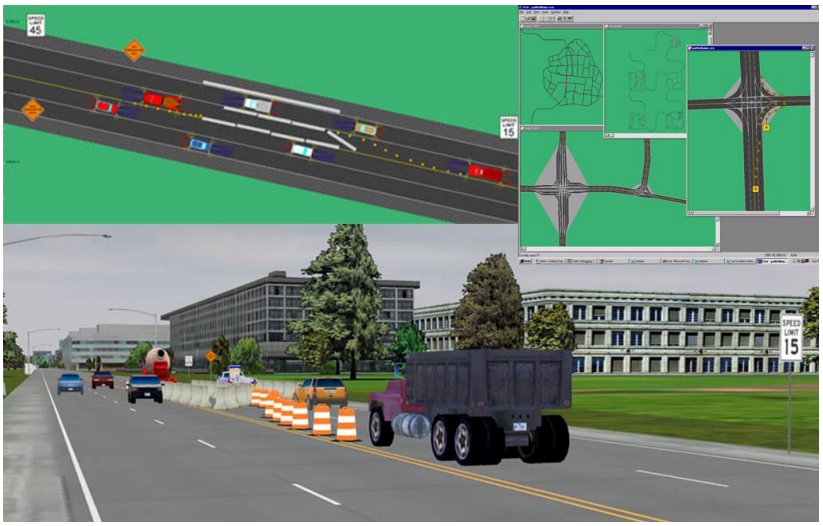
Objective

This software file converter project was designed to create a tool that facilitates the transfer of computer-aided roadway designs to interactive driving simulators.

Problem Statement

The creation of three-dimensional (3D) drawings for proposed designs for construction, re-construction and rehabilitation activities are becoming increasingly common for highway designers, whether by department of transportation (DOT) employees or consulting engineers. However, technical challenges exist that prevent the use of these 3D drawings/models from being used as the basis of interactive simulation.

Use of driving simulation to service the needs of the transportation industry in the US lags behind Europe due to several factors, including lack of technical infrastructure at DOTs, cost of maintaining and supporting simulation infrastructure—traditionally done by simulation domain experts—and cost and effort to translate DOT domain data into the simulation domain.



Scenario defined (upper left), one of various road network environment samples (upper right), and resulting simulator scene view from driver eye point (bottom)

November 2012

RESEARCH PROJECT TITLE
Visualization Resources for Iowa State University and the Iowa DOT: An Automated Design Model to Simulator Converter

SPONSORS
Iowa Department of Transportation (InTrans Project 10-376)
Federal Highway Administration

PRINCIPAL INVESTIGATOR
Omar Smadi
Director/Research Scientist
Roadway Infrastructure Management and Operations Systems
Center for Transportation Research and Education
Iowa State University
515-294-7110
smadi@iastate.edu

MORE INFORMATION
www.intrans.iastate.edu

CTRE
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103

The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

IOWA STATE UNIVERSITY
Institute for Transportation

However, as costs continue to decrease and the extent of simulation training continues to prove cost-effective value for training and research, simulators have become more widespread and available for general-purpose use. What is required for simulators to become useful for DOT design departments and contractors is the means to exploit the simulation technology in ways that do not require extensive capital outlay or extensive staff training.

The process of converting transportation design files to simulation models is currently a predominately-manual one that is also scale-dependent, requiring months of effort to translate between the design software and the driving simulator software. The larger the project, the more time required to translate between the design and driving simulator.

Changes to the source model require additional time to carry those modifications through to the simulator model. The use of a converter tool is independent of scale, automated with minimal interaction required during conversion, and does not require specialized training to use on the driving simulator beyond a working knowledge of fundamental procedures.

Background

Transportation designers face significant challenges as increasing traffic congestion, aging infrastructure, and inadequate investments in innovation compete with increasingly inadequate revenues. Meanwhile, construction costs continue to soar. Innovative designs are being developed that hold the promise of reducing construction, maintenance, and operation costs while preserving safety.

Interactive driving simulation provides an ideal environment for human factors related research and safety evaluations on topics such as speed selection, lane selection, gap acceptance, sign comprehension and compliance, and work-zone driving performance. Driving simulation enables these kinds of safety evaluation before construction begins and provides a test bed to compare design alternatives to each other directly without lifting a shovel.

CTRE simulator trailer

The National Advanced Driving Simulator (NADS) at the University of Iowa is home to one of the three largest motion base simulators in the world, and the largest full motion simulator in the US—the NADS-1. The technologies used to support core simulator architecture such as the visual models, supporting terrain data, behaviors to control scene objects, and authoring of events that occur during simulation, called scenarios, have been developed by the University of Iowa over the past 30 years.

Following the creation of the NADS facility, it was clear that, to advance the fields of driving simulation research and technology significantly, it would be necessary to make driving simulation accessible to a larger audience of researchers, trainers, and practitioners than was practical with the simulators housed at the facility. This was the impetus for creating the MiniSim for the Center for Transportation Research and Education (CTRE) at Iowa State University (ISU).

THE NATIONAL ADVANCED DRIVING SIMULATOR

miniSim™

The National Advanced Driving Simulator (NADS) at the University of Iowa is the host, developer, and operator of the world's most advanced ground vehicle simulator. From its inception, the mission of NADS continues to be to help our research partners save lives and reduce the costs of vehicle crashes by better understanding the impact of technology, pharmaceuticals, and other factors on driving performance.

The NADS MiniSim™ is high-performance driving simulator software designed for research, development, clinical, and training applications. The core software is based on state-of-the-art driving simulation technology that has been developed through decades of research.

The MiniSim™ core harnesses the technology found in the world's most advanced driving simulator, the NADS-1, into a smaller footprint at a lower cost. The MiniSim™ has been designed to be integrated with a variety of hardware and software components tailored to suit client requirements.

Project Methodology

The initial approach was intended to utilize generic network development algorithms to extract roadway data from the Iowa DOT design files and transform the data into a form compatible with the NADS MiniSim. Compatibility with the existing database production workflow was accomplished by following the conventions defined in the NADS Logical Road Interface (LRI) for intermediate data files.

The project ended up taking numerous development iterations to complete, given the software and extracted file issues and limitations encountered along the way. The project report details the issues encountered and resolution of those issues in reaching the project goal.

Results

The end result of this project was a converter process that can transform the sample Iowa DOT interchange design file into MiniSim-compatible data, which was then integrated into the simulator. This process was validated by using the sample data to build a simulator scenario, which included computer-controlled traffic, and, then, driving on the resulting model.

This tool enables Iowa DOT engineers to work with the universities to create drivable versions of prospective roadway designs. By driving the designs in the simulator, design problems can be identified early in the process. The simulated drives can also be used for public outreach and human factors driving research.

Conclusions

The MiniSim uses many of the core simulator technologies developed for the NADS-1 and was created to be licensed for research and training purposes. The MiniSim developed for CTRE is a three-quarter cab simulator consisting of a vehicle seat and steering wheel mounted on a fixed platform with three visual channels and a glass dash instrument panel, which is customized to each driving cab type chosen. The simulator is mounted within the trailer that can be used anywhere with electrical power to it.

A video showing the steps using the converter tool and subsequent driving in the simulator is available at www.youtube.com/watch?v=beWGea255s0&feature=youtu.be.

Simulator view inside the trailer

Future Recommendations

Although the conversion of a single, random Iowa DOT design file proved to be successful, some technical challenges remain to create a robust converter. Non-traditional designs, such as crossover lanes, dynamic lanes, and complicated interchange topologies, could prove challenging to the converter in its present form. More extensive testing and extension of the algorithm to include these additional test cases is required to provide a more comprehensive tool for automated conversion of highway designs to simulator-compatible form.

More specifically, additional development is needed to complete the following tasks:

- Create smooth transitions between road segments through junctions
- Increase algorithm efficiency to speed up data processing
- Extend the converter to work with additional simulator platforms, provided those systems use architecture that is easily accessible or well documented at the same level as the LRI/MiniSim architecture
- Generate surfaces with image textures instead of the model data present during conversion