

Advanced Tools for Graphical Authoring of Dynamic Virtual Environments at the NADS

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Abstract

As driving simulation becomes a commonplace tool for various disciplines, the demand increases for easy to use tools that allow users with no specific expertise in software development to effectively program simulators. One of the most complex yet important tasks often facing a potential researcher is the overall setup of the virtual environment and the orchestration of the actions of the autonomous traffic in the simulator. Following completion of an experiment, an equally important and often as time consuming process is the analysis and verification of the data collected during the simulation. This paper describes a graphical tool that has been designed to facilitate both the pre-experiment setup of the virtual environment, and post experiment data reduction and analysis activities.

Introduction

Simulators are a very powerful research tool used in a wide variety of disciplines. Because of this popularity, the demand for software tools that can be used to better utilize simulators is also increasing. A key activity in the process of effectively using a simulator for research is the setup of the scenarios that the driver will encounter during the simulation. Generally, this setup involves the specification of several features of the physical and virtual environment of the simulator. Over the years, there has been an evolution in specifying scenarios using direct programming [], higher level programming languages [], or graphical tools []. Generally, most simulators available today provide some sort of graphical interactive tool that allows the user to setup the simulator, however, there is often great difference in the capabilities and usability of these tools.

This paper describes the scenario authoring tool developed for the National Advanced Driving Simulator (NADS), a high fidelity driving simulator currently under construction at the University of Iowa. This tool is the incarnation of the latest generation of technology in a long history of research and developments efforts in the areas of scene and scenario authoring tools. Earlier versions of similar tools have been used in various simulators in the US and Europe.

The NADS, whose completion is scheduled for October 2000, is a high fidelity driving simulator whose primary goal is safety related transportation research. Figure 1 depicts the NADS inside the facility at the University of Iowa. The NADS has several unique and distinguishing features that include a full 360 deg. wrap-around screen, a 9 degree of freedom (DOF) motion base that includes a 6 DOF hexapod, a +/- 330 degree

turntable and a 20 meter by 20 meter X-Y track, augmented by a four actuator vibration cueing system. To complement the state-of-the-art hardware implementation, the NADS is designed with a comprehensive set of software tools that facilitate scene and scenario development. The tool described here is the Interactive Scenario Authoring Tool (ISAT), that is used to author scenarios. The ISAT is unique in that it provides extensive capabilities for developing, rehearsing and re-using scenarios. In addition, the tool is tightly integrated with data reduction software and facilitates the post-experiment analysis and verification of collected data.



Figure 1 – The NADS.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the overall flow used to develop the virtual environment of the simulator. Section 3 provides a description of the ISAT with focus on special features that facilitate

NADS Development Flow

Here we describe the overall flow in developing an experiment for the NADS in order to provide the overall context within which the ISAT operates. Figure 2 illustrates a block diagram of the overall process. The Tile Mosaic Tool (TMT) is responsible for the development of the scenes that represent the static virtual environment. It uses the notion of tiles [] to facilitate the rapid development of correlated visual databases, and can re-use any of the tiles available in the NADS library. The output of the tools primarily consists of two components. One set of files represents the visual database which after some additional batch processing can be downloaded to the Image Generator (IG). The second set of files is a correlated database representing the road network,

which upon some batch processing becomes a single Logical Road Information (LRI) file. These correlated databases are collectively referred to as the static virtual environment. The ISAT, whose input is an LRI file, can then be used to author all the dynamic aspects of the virtual environment desired by the user which are stored in one or more scenario files. These files along with the correlated files are referred to as a dynamic virtual environment. The experiment builder is a tool that allows an experimenter to specify the expected number of participants in a study and associate various scenarios with each participant. The output of that tool can be used to provide the daily operational schedule of the NADS during experimentation. Upon completion of a study, numerous data is available whose reduction, analysis, and verification is supported by another tool set that is collectively referred to as the Data Verification and Visualization Workstation (DVVW).

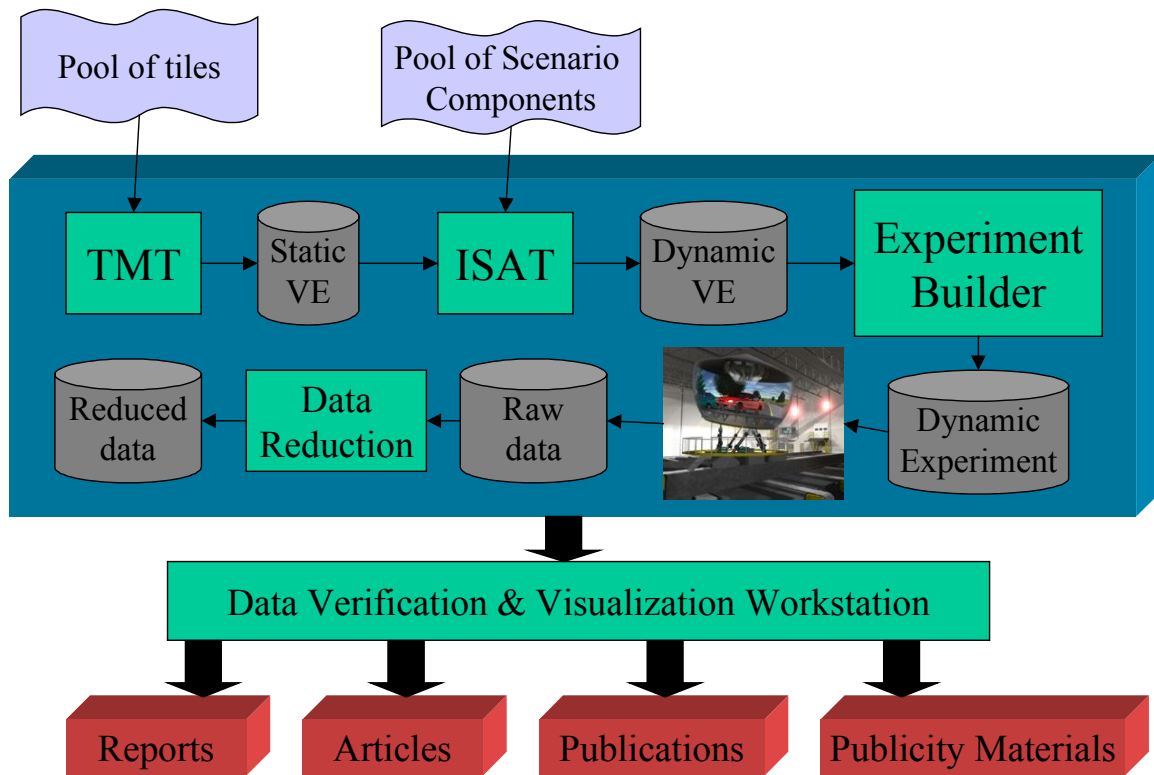
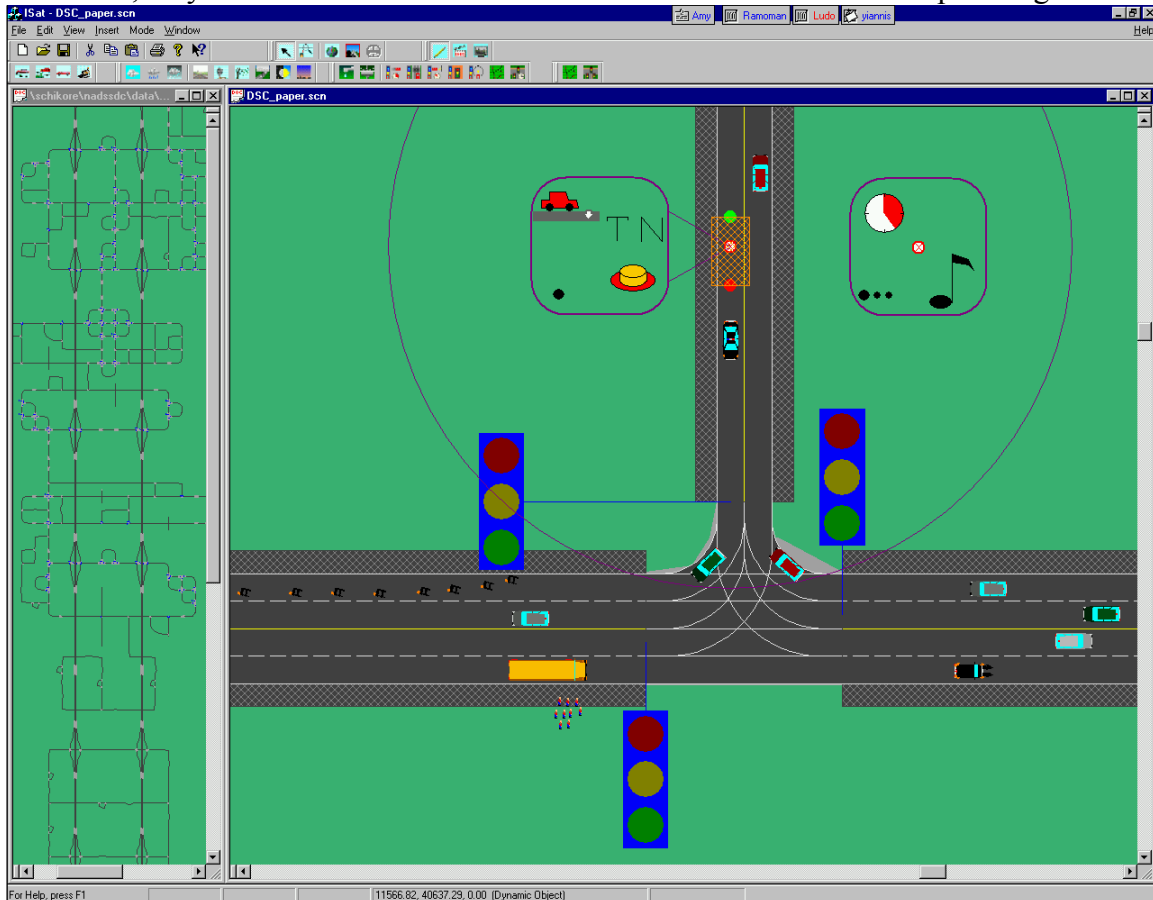


Figure 2 – The NADS Development Flow.

ISAT Overview

The ISAT utilizes graphical interface elements consistent with the Microsoft Windows operating system. The document that the ISAT edits is called the scenario file (SCN file). Each SCN file has a header and any number of scenario elements. The header includes fields such as description, global weather conditions, subject vehicle parameters, and the name of the database (LRI) used in the scenario.

Multiple scenarios can be opened at the same time. Each scenario that is open can use a different LRI or the same LRI as another scenario. If multiple scenarios use the same LRI, they will share the data associated with that LRI instead of duplicating it.



Common to all modes of operation of the ISAT is a scrollable top-down 2D view of the virtual environment. In this view, the user can add, remove, and edit scenario elements such as autonomous vehicles, deterministic vehicles, environmental conditions, traffic light timing tables, traffic managers, and elements that add, remove, or alter the properties of other scenario elements. Once a scenario has been authored, the user may execute the scenario and watch its evolution in real-time using the ISAT. The ISAT can also be used as an effective debugging tool because it provides a flexible network based interface to displaying graphics and text messages that are closely coupled to the displayed objects. Finally, the ISAT can also serve as a top down feedback window for the researcher, while the NADS is operational. In this mode, the ISAT continuously displays a top down view of the actual simulator's environment and allows the experimenter to take partial control of scenario vehicles and modify their behavior in real time. Since network lag cannot be easily controlled, the ISAT uses a set of high level commands such as "turn right at the next intersection" or "remove from the simulation" that provide a very effective means of dynamically controlling the behavior of selected traffic elements

In all modes of operation of the ISAT, there is a top-down 2D view of the virtual environment. The user can zoom in and out and scroll the view to display any location in the virtual environment. Since the virtual environment can be very large and detailed, the ISAT uses several levels of detail (LODs) to speed up its rendering. Each type of object (i.e. roads, intersections, dynamic objects) defines its own zoom levels at which the LOD changes. At a very large distance, roads are drawn as simple lines, and at a very small distance, they are drawn as polygons with solid or dotted lines dividing the lanes. This view can be scrolled via standard Windows scrollbars or via the keyboard arrow keys.

An “interactor” is a set of callbacks that are used to handle different user interface events, such as mouse button presses, mouse movement, and key presses. Each primary mode of operation uses one or more interactors to define how the user can interact with the main view.

When there are many scenario elements on screen, each of them displaying graphically as much information about its parameters as possible, the amount of information displayed can be quite confusing. To help alleviate this problem, the ISAT has a display filter. Using this customizable filter, the user can choose to not display certain details associated with the scenario elements or not display certain elements at all.

Editing Mode

General editing

Editing mode is used when creating or modifying scenarios. The interactor for this mode defines standard Windows functionality for the scenario elements. Left clicking on an element will select it. Right clicking on an element will pop up a context menu. Double clicking an element will activate the dialog box for editing the element’s properties. Clicking and dragging an element will move its position. Multiple elements can be selected either by shift-clicking each of them or clicking and dragging an area enclosing the elements to be selected.

Load/Save/Merge

In addition to the standard loading and saving of scenarios, there is an option to merge scenarios or parts of scenarios. Some scenario elements, such as traffic light timing tables, can be very time consuming to author. The merge capability allows the user to pick and choose which scenario elements to merge from the selected scenario into the current scenario.

Cut and Paste

When one or more scenario elements are selected, they can be cut or copied to the Windows clipboard. They may then be pasted into the same or a different scenario. When elements are pasted into a scenario, a paste interactor is used. When the mouse moves, the elements will “float” around the cursor. Since certain elements have restrictions on where they can be placed (i.e. only on a road), the elements show an indication of whether or not they are in a valid position. When the user presses a mouse

button, the elements that are in valid positions are added to the scenario and moved to the desired position. The elements that are not in valid positions are discarded.

Undo/Redo

Any adding, editing, or removing of scenario elements can be undone and then redone.

Rehearsal Mode

In this mode, the scenario that has been created is simulated on the PC. The simulation is not run in real-time, the speed is dependent on the processing power of the PC.

Repeatedly, the ISAT requests that the behaviors execute one frame, retrieves the properties of every active scenario element, and then draws the current state to the screen. This may be done as quickly as the PC is capable of, or paused and executed step by step.

Selecting an element in this mode is possible, but editing its properties and accessing its right-click menu is not possible. In rehearsal mode, the user may select an element or a group of elements and “follow” them. In this follow mode, the view will scroll to center the selected elements on the screen and zoom if necessary to accommodate all selected elements.

During the execution of a scenario on the simulator, many of the behaviors have parameters that depend on what the subject’s vehicle (the Own Vehicle) is doing. Since there is no subject in rehearsal mode, we have an Own Vehicle Mirror which all of the other dynamic objects see as a real Own Vehicle. This Own Vehicle Mirror can be made to follow the rules of the road like the other autonomous objects or it can follow a set geometric path similar to a deterministic object.

Behavior Debugging

When implementing various behaviors, one needs a simple, fast method for testing and debugging. The rehearsal mode supplies that ability. The ISAT supplies a method for the behaviors to send debugging textual and graphical elements. When executing in rehearsal mode, the user can select to show the debugging text, debugging graphics, both, or neither for any or all of the scenario elements.

Scenario Debugging

When creating scenarios for use in an experiment, a researcher must be able to test the scenarios prior to running the experiment on the simulator. Using rehearsal mode, the researcher can test the scenario and make any modifications needed based on the results. The researcher can even modify the behavior of the Own Vehicle Mirror to simulate what might happen when there is a real person driving the simulator and thus create a more robust scenario.

Monitor Mode

While a subject is driving the simulator during an experiment, there is often a need to observe and even interact with the scenario as it is running. In monitor mode, the ISAT receives data from the simulator and displays in real-time the state of the scenario.

Data reduction and verification

Conclusion