Realtime 3D visual analysis of very large models at low cost

Rick Hall

Computer based visualisation of 3D models in architecture has been possible for 20 years or more, and the software technology has steadily improved during this time so that now incredibly realistic images can be generated from any viewpoint in a model, and impressive fly through sequences can bring a model to life in ways previously not possible. Virtual reality is with us and multi-media enables us to present a finished design in increasingly seductive ways.

However, these forms of output from a 3D model offer much more limited benefits during the design process and particularly on large complex models because they are so computing intensive and it often require many hours to produce just one image. Anything other than a small and relatively simple model cannot be viewed dynamically in real-time on a desktop P.C. of the type commonly used by architects in a design office. Until now the solution to this problem has meant investing in expensive design review hardware and software with its inherent need for trained, skilled labour. As a result, design review products are often viewed as a luxury or costly necessity.

Background

The need for a tool which can provide a totally flexible means of visualising large models in real-time on a desktop P.C. has long been the unattainable Holy Grail. To be able to visually analyse models at any time during the design process, rather than simply being able to view them, substantially enhances the interactivity of the design process so that more informed design decisions are made at an earlier stage, thereby saving time and cost as well as improving the quality of the product. In addition if such a tool was to be capable of being used without having had any training and without having any existing CAD skills then the architect can involve other members of the design team in the analysis and decision making process who would otherwise be excluded. The project manager, client or any other member of the design team could use such a tool remotely from the architect's office and thereby be kept closely involved at all stages in crucial design decisions.

Introduction

Such a tool now exists. NavisWorks Roamer has been developed by LightWork Design based in Sheffield, and allows users to navigate smoothly in real-time through models with hundreds of thousands, even millions, of polygons - with no slowdown in frame rate. The problem with earlier software coping with very large models, is that viewing the model is either too slow or jerky or must rely on pre-defined paths through

the model. NavisWorks allows the freedom to roam the model using a range of navigating tools controlled by the mouse and a few simple key presses. In addition, many software products require extensive authoring. Designers must create multiple models of the same project, trading off detail and resolution in each model. Most often this is done at the end of the design process when it is too late to make use of the information viewed in modifying the design. NavisWorks can take data directly from a live database, eliminating the need for authoring. Therefore the user can view an up-to-date version of the model at any stage during its development. It has been Beta tested in the Department of Architecture in Huddersfield University, and its use will be illustrated on the overhead display in real-time using the work of a student who has created a model using Microstation then exported this as a series of DWG files for viewing analysis in NavisWorks Roamer.

The software has a number of unique algorithms and datastructure features which can be summarised as follows:

Construction of the model

A model may consist of any number of files appended to each other in any of the supported file formats. Opening a file loads a model from a file. The standard Open dialog use of Shift/Control keys allows multiple files to be selected and appended to the current set of models. NavisWorks Roamer supports multiple file formats via a plugin mechanism. In addition to its own native file formats (*.nwd and *.nwf), AutoCAD's *.dwg and *.dxf files and 3D Studio's *.3ds are supported.

Append adds a model to the current set of models. The combined set of models may be saved as a NavisWorks file (*.nwd) or as a NavisWorks file set (*.nwf).

When saving to a NavisWorks file (*.nwd) all loaded models, the scene's environment, the current view and favorite viewpoints will be saved to a single file. When saving to a NavisWorks file set (*.nwf), only a list of the files currently loaded is saved, along with the scene's environment, the current view and favorite viewpoints.

NavisWorks Roamer allows multiple models to be loaded simultaneously into the same coordinate space. Each file loaded is added to the root of the tree view. Individual files can be edited in the same way as objects within the file and can also be deleted from the set. When a *.dwg, *.dxf, or *.3ds file is loaded, NavisWorks Roamer creates a cache file (*.nwc). When the *.dwg, *.dxf, or *.3ds file is next loaded NavisWorks Roamer will read data from the corresponding cache file rather than re-converting the original data. If the original file is altered, NavisWorks Roamer will re-create the cache file when it is next loaded. Cache files speed up access to commonly used files. They are particularly useful for models made up of many files of which only a few are changed between viewing sessions. Cache options can be edited from the Options dialog box under the Edit menu.

DWG/DXF Reader: Supported Entities

The reader currently supports all surface (shaded) entities (3D faces, rectangular meshes, polyface meshes, circles, extruded lines etc.), including Proxy Graphics, but excluding ACIS based entities (3D Solid, Region). Line, point and complex entities (shapes, dimensions, text) are not supported. The structure of the drawing is preserved including blocks, inserts, AutoCAD color index, layers, views and active viewport. The NWExport plugin for AutoCAD supports the same entities including ACIS based ones.

3DS Reader: Supported Entities

All entities are supported from *.3ds files. An entity's color is taken from its material rather than its wireframe color from 3D Studio and any maps, such as texture, applied to this material will be ignored.

External References

External references are shown in NavisWorks Roamer's Tree Manager as an inserted group. NavisWorks Roamer looks for the externally

referenced files (xrefs) in the same place as AutoCAD. If the unresolved xref dialog is shown, then this link has somehow been broken and the referenced .dwg files need to be relocated to where AutoCAD would expect them to be.

If these xrefs are not important for the current session, then you can ignore the reference and the file will load without that xref inserted. Similarly, ignore all will load the file with all unresolved xrefs unloaded.

NWExport ARX Plug-in operation

NWExport is an AutoCAD R14 and AutoCAD 2000 plugin capable of exporting NavisWorks data files (*.nwd) and NavisWorks cache files (*.nwc) directly from within AutoCAD. NWExport adds three new commands to AutoCAD:

NWDOUT, NWCOUT, NWOPT

The plugin currently supports all surface (shaded) entities (3D faces, rectangular meshes, polyface meshes, circles, extruded lines etc.), including proxy graphics, custom entities and ACIS based entities (3D solids, regions). Line, point and complex entities (shapes, dimensions, text) are not supported. The structure of the drawing is preserved including xrefs, blocks, inserts, AutoCAD color index, layers, views and active viewport.

A partial menu called LwNw_Export.mnu is available in the same location as where the nwexport.arx file was installed. One can then use AutoCAD's menuload command to browse to this menu and load it. A NavisWorks menu will then position itself as the penultimate menu on the current menu bar and will persist across sessions until unloaded. The NWDOUT, NWCOUT and NWOPT commands are available through this menu.

Navigating the model

There are several different Navigation Modes which control movement in the main view.

These are based on the cursor keys and mouse drags with the left and middle mouse buttons. The shift and control keys modify the movement. The mouse and cursor keys perform the same sort of movements, with the mouse giving finer control. The shift key usually speeds up movement. Dragging with the left mouse button and the control key down performs the same actions as dragging with the middle mouse button (useful if you only have a two-button mouse). Right clicking on any item in the tree view or main view displays a context menu.

Modes are:Select, Pan, Walk, Orbit, Look Around, Examine, Zoom, Fly, Zoom Box, Turntable

There are also several Navigator Tools for altering, resetting or changing the type of camera.

Tools are: View All, Focus, View Selected, Perspective Camera, Section Plane, Orthographic Camera

Sectioning the model

Section Plane on the Navigation Tools toolbar displays the section plane slider control:

The section enable toggle enables and disables the section plane. When enabled, the slider controls the positioning of a section plane in the model parallel to the reference plane, and the edit box displays the distance from the reference plane. Each button on the slider bar aligns the section with a different reference plane. The first is the current viewpoint . The remaining reference planes are positioned at the origin normal to each of the axes. The model is only visible on one side of the section plane. Moving the plane through a model is a good way of inspecting internal detail.

Editing functions

Editing allows the display of selected objects in the model to be Hidden or Required. The use of the Hidden or Required editing options assists the user

to navigate more easily in a very large or complex model. When elements are neither Hidden or Required then NavisWorks Roamer decides which objects are displayed. This depends on the viewpoint at any particular frame.

Options enables Selection, Caching, 3DS and DWG/DXF global options to be edited. These options are persistent across sessions. Scene enables editing of Lighting and Culling and these are saved with each file.

Viewing analysis

This is controlled by two parts to the screen window:

Main View

Displays a 3D rendered view of the model in the right-hand part of the window.

Tree View (Tree Manager)

Displays a hierarchical view of the structure of the model in the left-hand part of the window. The currently selected object is highlighted. The selection can be changed by clicking on items in the view or the rendered image in the main view. When clicking in the main view the selection criteria under Options in the Edit menu determine which items in the tree view are selected. There are several different tree icons representing the types of element which make up the structure of a model. Each of these element types can be Hidden (gray), Unhidden (dark blue) or Required (red).

The structure of the file as shown in tree view can be expanded or collapsed as required. The named item from the open file is displayed along with an icon indicating the type of item. The name and icon is displayed in a "grayed out" form if the item has been hidden and the name and icon are displayed in red if the item has been selected as required.

The tree structure has the following hierarchies:

- A model, e.g. a drawing file
- A layer
- A group, e.g. a block definition from AutoCAD.
- An inserted group, e.g. an inserted block from AutoCAD
- An item of geometry, e.g. a polygon
- An instanced item of geometry, e.g. an instance from 3D Studio

Note that if a group is selected as hidden or required then all instances of that object will be hidden or required. If you wish to operate on a single occurrence of an object then one can make the inserted group hidden or required .

Viewing the model:

Viewing the model is controlled by selecting Viewpoint and different Rendering and Lighting options. A variety of viewpoints can be set up to view the model from known positions and alignments. These can then be saved with footnotes and listed and selected as favorites.

Rendering applies the object colors and any scene lights which form part of the model. The model can be viewed as a Shaded Render view, a Wireframe view or a Hidden Line view. If a more photo-realistic image is required from a particular viewpoint then the stored viewpoint parameters can be passed across to another application such as 3D Studio.

If there are no Scene Lights then a single Head Light or No Lights view is available and Scene Lights is disabled. The intensity of these lights can be set using the Scene options under the Editing controls.

Conclusion

In conclusion we have found, for the first time, that students and professional designers are able to use a tool like **NavisWorks** in conjunction with any of the 3D modelling systems, to interactively analyse -

visually - any combination of models, of any size, real-time on a standard P.C. This has enabled much more effective design tutoring in the department and will, I am certain, provide the design team in practice with a powerful new tool for reviewing design progress at critical stages.

Rick Hall
Department of Architecture
University of Huddersfield, UK