

Visualization of Simulation

10 Mai 2012

1. Computer Simulation

- A computer simulation, a computer model, or a computational model is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system. Computer simulations have become a useful part of mathematical modeling of many natural systems in physics (computational physics), astrophysics, chemistry and biology, human systems in economics, psychology, social science, and engineering. Simulations can be used to explore and gain new insights into new technology, and to estimate the performance of systems too complex for analytical solutions.
- Computer simulations vary from computer programs that run a few minutes, to network-based groups of computers running for hours, to ongoing simulations that run for days. The scale of events being simulated by computer simulations has far exceeded anything possible (or perhaps even imaginable) using the traditional paper-and-pencil mathematical modeling: over 10 years ago, a desert-battle simulation, of one force invading another, involved the modeling of 66,239 tanks, trucks and other vehicles on simulated terrain around Kuwait, using multiple supercomputers in the DoD High Performance Computer Modernization Program; a 1-billion-atom model of material deformation (2002); a 2.64-million-atom model of the complex maker of protein in all organisms, a ribosome, in 2005; and the Blue Brain project at EPFL (Switzerland), began in May 2005, to create the first computer simulation of the entire human brain, right down to the molecular level.

2. Simulation versus Modeling

- Traditionally, forming large models of systems has been via a mathematical model, which attempts to find analytical solutions to problems and thereby enable the prediction of the behavior of the system from a set of parameters and initial conditions.
- While computer simulations might use some algorithms from purely mathematical models, computers can combine simulations with reality or actual events, such as generating input responses, to simulate test subjects who are no longer present. Whereas the missing test subjects are being modeled/simulated, the system they use could be the actual equipment, revealing performance limits or defects in long-term use by these simulated users.
- Note that the term computer simulation is broader than computer modeling, which implies that all aspects are being modeled in the computer representation. However, computer simulation also includes generating inputs from simulated users to run actual computer software or equipment, with only part of the system being modeled: an example would be flight simulators which can run machines as well as actual flight software.
- Computer simulations are used in many fields, including science, technology, entertainment, and business planning and scheduling.

3. Computer Simulation in practical contexts

- Computer simulations are used in a wide variety of practical contexts, such as:
- analysis of air pollutant dispersion using atmospheric dispersion modeling
- design of complex systems such as aircraft and also logistics systems.
- design of Noise barriers to effect roadway noise mitigation
- flight simulators to train pilots
- weather forecasting
- Simulation of other computers is emulation.
- forecasting of prices on financial markets (for example Adaptive Modeler)
- behavior of structures (such as buildings and industrial parts) under stress and other conditions
- design of industrial processes, such as chemical processing plants
- Strategic Management and Organizational Studies
- Reservoir simulation for the petroleum engineering to model the subsurface reservoir
- Process Engineering Simulation tools.
- Robot simulators for the design of robots and robot control algorithms
- Urban Simulation Models that simulate dynamic patterns of urban development and responses to urban land use and transportation policies. See a more detailed article on Urban Environment Simulation.
- Traffic engineering to plan or redesign parts of the street network from single junctions over cities to a national highway network, for transportation system planning, design and operations. See a more detailed article on Simulation in Transportation.
- modeling car crashes to test safety mechanisms in new vehicle models

... 3. Computer simulation in practical contexts

C10

- The reliability and the trust people put in computer simulations depends on the validity of the simulation model, therefore verification and validation are of crucial importance in the development of computer simulations. Another important aspect of computer simulations is that of reproducibility of the results, meaning that a simulation model should not provide a different answer for each execution. Although this might seem obvious, this is a special point of attention in stochastic simulations, where random numbers should actually be semi-random numbers. An exception to reproducibility are human in the loop simulations such as flight simulations and computer games. Here a human is part of the simulation and thus influences the outcome in a way that is hard if not impossible to reproduce exactly.
- Vehicle manufacturers make use of computer simulation to test safety features in new designs. By building a copy of the car in a physics simulation environment, they can save the hundreds of thousands of dollars that would otherwise be required to build a unique prototype and test it. Engineers can step through the simulation milliseconds at a time to determine the exact stresses being put upon each section of the prototype.[5]
- Computer graphics can be used to display the results of a computer simulation. Animations can be used to experience a simulation in real-time e.g. in training simulations. In some cases animations may also be useful in faster than real-time or even slower than real-time modes. For example, faster than real-time animations can be useful in visualizing the buildup of queues in the simulation of humans evacuating a building. Furthermore, simulation results are often aggregated into static images using various ways of scientific visualization.
- In debugging, simulating a program execution under test (rather than executing natively) can detect far more errors than the hardware itself can detect and, at the same time, log useful debugging information such as instruction trace, memory alterations and instruction counts. This technique can also detect buffer overflow and similar "hard to detect" errors as well as produce performance information and tuning data.

4. Visualization

- Visualization is any technique for creating images, diagrams, or animations to communicate a message. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of man. Examples from history include cave paintings, Egyptian hieroglyphs, Greek geometry, and Leonardo da Vinci's revolutionary methods of technical drawing for engineering and scientific purposes.
- Visualization today has ever-expanding applications in science, education, engineering (e.g. product visualization), interactive multimedia, medicine, etc. Typical of a visualization application is the field of computer graphics. The invention of computer graphics may be the most important development in visualization since the invention of central perspective in the Renaissance period. The development of animation also helped advance visualization.
- The use of visualization to present information is not a new phenomenon. It has been used in maps, scientific drawings, and data plots for over a thousand years. Examples from cartography include Ptolemy's Geographia (2nd Century AD), a map of China (1137 AD), and Minard's map (1861) of Napoleon's invasion of Russia half a century earlier. Most of the concepts learned in devising these images carry over in a straight forward manner to computer visualization. Edward Tufte has written two critically acclaimed books that explain many of these principles.
- Computer graphics has from its beginning been used to study scientific problems. However, in its early days the lack of graphics power often limited its usefulness. The recent emphasis on visualization started in 1987 with the special issue of Computer Graphics on Visualization in Scientific Computing. Since then there have been several conferences and workshops, co-sponsored by the IEEE Computer Society and ACM SIGGRAPH, devoted to the general topic, and special areas in the field, for example volume visualization.

5. Applications of visualization

- **Scientific** visualization is the transformation, selection or representation of data from simulations or experiments, with an implicit or explicit geometric structure, to allow the exploration, analysis and understanding of the data. It's a very important part of visualization and maybe the first one, as the visualization of experiments and phenomena is as old as Science itself. Traditional areas of Scientific Visualization are Flow Visualization, medical visualization, astrophysical visualization and chemical visualization. There are several different techniques to visualize scientific data, with isosurface reconstruction and direct volume rendering being the more common. hhhh
- **Educational** visualization is using a simulation normally created on a computer to create an image of something so it can be taught about. This is very useful when teaching about a topic which is difficult to otherwise see, for example, atomic structure, because atoms are far too small to be studied easily without expensive and difficult to use scientific equipment. It can also be used to view past events, such as looking at dinosaurs, or looking at things that are difficult or fragile to look at in reality like the human skeleton, without causing physical or mental harm to a subjective volunteer or cadaver.
- **Information** visualization concentrates on the use of computer-supported tools to explore large amount of abstract data. The term "information visualization" was originally coined by the User Interface Research Group at Xerox PARC and included Dr. Jock Mackinlay. Practical application of information visualization in computer programs involves selecting, transforming and representing abstract data in a form that facilitates human interaction for exploration and understanding. Important aspects of information visualization are dynamics of visual representation and the interactivity. Strong techniques enable the user to modify the visualization in real-time, thus affording unparalleled perception of patterns and structural relations in the abstract data in question.

... 5. Applications of visualization

- **Knowledge** visualization. The use of visual representations to transfer knowledge between at least two persons aims to improve the transfer of knowledge by using computer and non-computer based visualization methods complementarily. Examples of such visual formats are sketches, diagrams, images, objects, interactive visualizations, information visualization applications and imaginary visualizations as in stories. While information visualization concentrates on the use of computer-supported tools to derive new insights, knowledge visualization focuses on transferring insights and creating new knowledge in groups. Beyond the mere transfer of facts, knowledge visualization aims to further transfer insights, experiences, attitudes, values, expectations, perspectives, opinions, and predictions by using various complementary visualizations.
- **Product** Visualization involves visualization software technology for the viewing and manipulation of 3D models, technical drawing and other related documentation of manufactured components and large assemblies of products. It is a key part of Product Lifecycle Management. Product visualization software typically provides high levels of photorealism so that a product can be viewed before it is actually manufactured. This supports functions ranging from design and styling to sales and marketing. Technical visualization is an important aspect of product development. Originally technical drawings were made by hand, but with the rise of advanced computer graphics the drawing board has been replaced by computer-aided design (CAD).
- Visual **communication** is the communication of ideas through the visual display of information. Primarily associated with two dimensional images, it includes: alphanumeric, art, signs, and electronic resources. Recent research in the field has focused on web design and graphically oriented usability.
- Visual **analytics** focuses on human interaction with visualization systems as part of a larger process of data analysis. Visual analytics has been defined as "the science of analytical reasoning supported by the interactive visual interface". Its focus is on human information discourse (interaction) within massive, dynamically changing information spaces. Visual analytics research concentrates on support for perceptual and cognitive operations that enable users to detect the expected and discover the unexpected in complex information space. Technologies resulting from visual analytics find their application in almost all fields, but are being driven by critical needs (and funding) in biology and national security.

6. Visualization techniques

The following are examples of some common visualization techniques:

- Constructing isosurfaces
- direct volume rendering
- Streamlines, streaklines, and pathlines
- table, matrix
- charts (pie chart, bar chart, histogram, function graph, scatter plot, etc.)
- graphs (tree diagram, network diagram, flowchart, existential graph, etc.)
- Maps
- parallel coordinates - a visualization technique aimed at multidimensional data
- treemap - a visualization technique aimed at hierarchical data
- Venn diagram
- Timeline
- Euler diagram
- Chernoff face
- Hyperbolic trees
- brushing and linking
- Cluster diagram or dendrogram
- Ordinogram

7. Related research areas:

- Statistics, statistical package, multivariate statistics
- Forecasting, technical analysis
- Data Mining, also known as knowledge-discovery in databases (KDD)
- GeoVisualization, short for Geographic Visualization
- Graph Drawing
- Scientific modeling
- Cave Automatic Virtual Environment
- Morphological Modeling
- Information graphics
- Knowledge management
- Knowledge transfer
- Concept maps
- Morphological analysis
- Formal concept analysis
- Conceptual graphs

... 7. Related research areas: C10

- Information graphics
- The Information visualization reference model for construction of Information Visualization systems. Similar to the 'Model view controller' software engineering architectural pattern.
- Music visualization
- Statistical graphics
- Configurator visualization
- Graph drawing
- Graphic design
- Edward Tufte
- Human-computer interaction
- Rendering (computer graphics)
- Illustration
- Imaging
- New Epoch Notation Painting
- Representation (arts)
- Representation (psychology)
- Many Eyes Public, web-based visualizations
- [VIEW Conference on Computer Graphics]
- Prefuse Java Toolkit for Interactive Information Visualization
- Starlight Info Vis System, R&D 100 winner
- VisIt, R&D 100 winner
- VisTrails
- ParaView
- Tulip C++/Qt framework for navigation, graph drawing, clustering and edition of huge graphs.

... 4. Visualization

- Most people are familiar with the digital animations produced to present meteorological data during weather reports on television, though few can distinguish between those models of reality and the satellite photos that are also shown on such programs. TV also offers scientific visualizations when it shows computer drawn and animated reconstructions of road or airplane accidents. Some of the most popular examples of scientific visualizations are computer-generated images that show real spacecraft in action, out in the void far beyond Earth, or on other planets. Dynamic forms of visualization, such as educational animation or timelines, have the potential to enhance learning about systems that change over time.
- Apart from the distinction between interactive visualizations and animation, the most useful categorization is probably between abstract and model-based scientific visualizations. The abstract visualizations show completely conceptual constructs in 2D or 3D. These generated shapes are completely arbitrary. The model-based visualizations either place overlays of data on real or digitally constructed images of reality, or they make a digital construction of a real object directly from the scientific data.
- Scientific visualization is usually done with specialized software, though there are a few exceptions, noted below. Some of these specialized programs have been released as Open source software, having very often its origins in universities, within an academic environment where sharing software tools and giving access to the source code is common. There are also many proprietary software packages of scientific visualization tools.
- Models and frameworks for building visualizations include the data flow models popularized by systems such as AVS, IRIS Explorer, and VTK toolkit, and data state models in spreadsheet systems such as the Spreadsheet for Visualization and Spreadsheet for Images.

8. Books

1. Interactive Data Visualization: Foundations, Techniques, and Applications (Hardcover) by Matthew Ward, Georges Grinstein, Daniel Keim (May, 2010).
2. Marty R. Applied Security Visualization. [Pearson Education](#), 2008.
3. Visualization Handbook (Hardcover) by Charles D. Hansen, Chris Johnson, [Academic Press](#) (June, 2004).
4. The Visualization Toolkit, Third Edition (Paperback) by Will Schroeder, Ken Martin, Bill Lorensen (August 2004).
5. Thomas, James J, and Cook, Kristin A, Ed. (2005), [Illuminating the Path: The Research and Development Agenda for Visual Analytics](#), Los Alamitos, CA.: IEEE Computer Society
6. Globus, Al. Eric Raible. "Fourteen Ways to Say Nothing With Scientific Visualization". Computer. July 1994. pp. 86-88
7. Kravetz, Stephen A. and David Womble. ed. Introduction to Bioinformatics. Totowa, N.J. Humana Press, 2003.
8. Nielson, Gregory M. ed. Computer. Vol. 22, No. 8, Aug 1989. Special issue on scientific visualization.
9. [Edward R. Tufte](#) (1992). The Visual Display of Quantitative Information
10. Edward R. Tufte (1990). Envisioning Information.
11. Edward R. Tufte (1997). Visual Explanations: Images and Quantities, Evidence and Narrative.
12. Wong, Pak Chung. R. Daniel Bergeron. "30 years of Multidimensional Multivariate Visualization". Scientific Visualization Overviews Methodologies and Techniques. [IEEE Computer Society](#) Press, 1997.

9. Information Visualization Papers

1. Bederson, Benjamin B., [Shneiderman, Ben](#). *The Craft of Information Visualization: Readings and Reflections*, Morgan Kaufmann, 2003, [ISBN 1-55860-915-6](#).
2. Mackinlay, Jock D. (1999). *Readings in information visualization: using vision to think*. [Card, S. K.](#), Ben Shneiderman (eds.). Morgan Kaufmann Publishers Inc. pp. 686. [ISBN 1-55860-533-9](#).
3. Cleveland, William S. (1993). *Visualizing Data*.
4. Cleveland, William S. (1994). *The Elements of Graphing Data*.
5. Schirra, Joerg R.J. (2005). *Foundation of Computational Visualistics*, Wiesbaden: DUV [ISBN 3-8350-6015-5](#).
6. [Spence, Robert](#) *Information Visualization: Design for Interaction (2nd Edition)*, Prentice Hall, 2007, [ISBN 0-132-06550-9](#).
7. [Colin Ware](#) (2000). *Information Visualization: Perception for design*.
8. [Andrew Vande Moere](#) (2008). *Form Follows Data*.
9. Wilkinson, Leland. "The Grammar of Graphics", Springer [ISBN 0-387-24544-8 \[1\]](#)

10. External links

1. [Amer. Soc. of Information Science and Technology \(ASIS&T SIGVIS\): Special Interest Group in Visualization Information and Sound](#)
2. [IEEE Visualization Conference](#)
3. [National Institute of Standards and Technology](#)
4. [Verifiable.com - Free site where users can upload, join, manipulate, visualize and share data](#)
5. [Second Life Data Visualization](#) Data visualization using Second Life
6. [Second Life Chemistry](#) Using Second Life to visualize chemistry concepts
7. [Scientific Visualization Tutorials, Georgia Tech](#)
8. [Scientific Visualization Studio \(NASA\)](#)
9. [Many Eyes](#) Free IBM site where users can experiment with 15 types of visualizations
10. [Visual Complexity](#) A visual compendium of techniques for displaying networks
11. [Graphic Organizers Index](#)
12. [Overview of Various Visualization Methods and Tools](#)
13. [Periodic Table of Visualization Methods](#)
14. [Educational Particle Image Velocimetry \(e-PIV\) - resources and demonstrations](#)
15. [Duke University Friday Forum - Visualization Engineering Seminars](#)
16. [JSXGraph - data visualization library](#)
17. [Makai Ocean Engineering - 4D/5D Visualization Software](#)

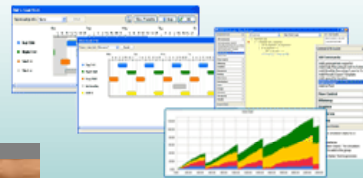
5. Software tools for Simulation

Introducing SIMUL8 2010

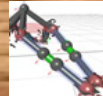
Making the complex simple.

SIMUL8 2010 makes the complex simple with great new features to build models faster and let you make the right decisions, first time.

- <http://www.simul8.com/home>

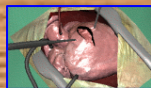


<http://www.maplesoft.com/products/maplesim/>
Automatic 3-D animation and visualization

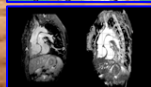


Interactive 3-D Model Construction

Medical Visualization and Simulation -Project- <http://www.cavi.dk/projects/medicalvisualization.php>



- Surgical Simulation



- 3D MRI Acquisition and Visualization



- Virtual Morphological Modelling

References

1. Computational Visualization and Simulation of Diesel Engines, Valve Lift Performance Using CFD, Semin, Rosli Abu Bakar and Abdul Rahim Ismail, Automotive Focus Group, Faculty of Mechanical Engineering, University Malaysia Pahang, Locked Bag 12, 25000 Kuantan, Pahang, Malaysia, American Journal of Applied Sciences 5 (5): 532-539, 2008, ISSN 1546-9239, © 2008 Science Publications, <http://www.scipub.org/fulltext/ajas/ajas55532-539.pdf>
2. SMOOTH BRUSHING FOR FOCUS+CONTEXT, VISUALIZATION OF SIMULATION DATA IN 3D, Helmut Doleisch and Helwig Hauser, VRVis Research Center in Vienna, Austria, [mailto: Doleisch, Hauser@VRVis.at](mailto:Doleisch.Hauser@VRVis.at), <http://www.VRVis.at/vis/http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.18.2536&rep=rep1&type=pdf>
3. Visualization and Simulation Tool for Automated Stowage Plan Generation System, Win Cho Aye, Malcolm Yoke Hean Low, Huang Shell Ying, Hsu Wen Jing, Liu Fan, Zeng Min, http://www.iaeng.org/publication/IMECS2010/IMECS2010_pp1013-1019.pdf
4. 3D visualization and simulation of fronto-orbital advancement in metopic synostosis, Rodt T., Schlesinger A., Schramm A., Diensthuber M., Rittierodt M., Krauss J.K., <http://www.slicer.org/publications/item/view/1513>
5. SiPaViS -A Toolkit for Scientific Visualization and Simulation, Fernando P. Birra, Manuel J. Prsospéro, Computer Science Department, New University of Lisbon, P-2825 Monte Caparica, Portugal, emails: fpb@di.fct.unl.pt, Journal for Geometry and Graphics, Volume 3 (1999), No. 1, 47{55, ps@di.fct.unl.pt, http://www.heldermann-verlag.de/jgg/jgg01_05/jgg0304.pdf
6. Algorithms for the Visualization and Simulation of Mobile Ad Hoc and Cognitive Networks - A Thesis Submitted to the Faculty of Drexel University – by Daniel Hennessey in partial fulfillment of the requirements for the degree of Master of Science in Computer Science, June 2009, http://idea.library.drexel.edu/bitstream/1860/3028/1/Hennessey_Daniel.pdf
7. From robotic hands to human hands: a visualization and simulation engine for grasping research, A. Miller and P. Allen, V. Santos, and F. Valero-Cuevas, <http://www.cs.columbia.edu/~allen/PAPERS/industrialrobot.pdf>

Three-dimensional visualization of mechanical simulations

Three-dimensional visualization is used for interactive animation to make possible analysis of simulation results.

- An OpenGL-based environment for dynamic visualization of simulation results, MVIS
- Cult3D-based visualization tool for WWW publishing and presentations

- **Paper:** Vadim Engelson, Håkan Larsson, Peter Fritzson, [Design, simulation and visualization environment for object oriented mechanical and multi-domain models](#) .- early paper describing the structure of the tools.

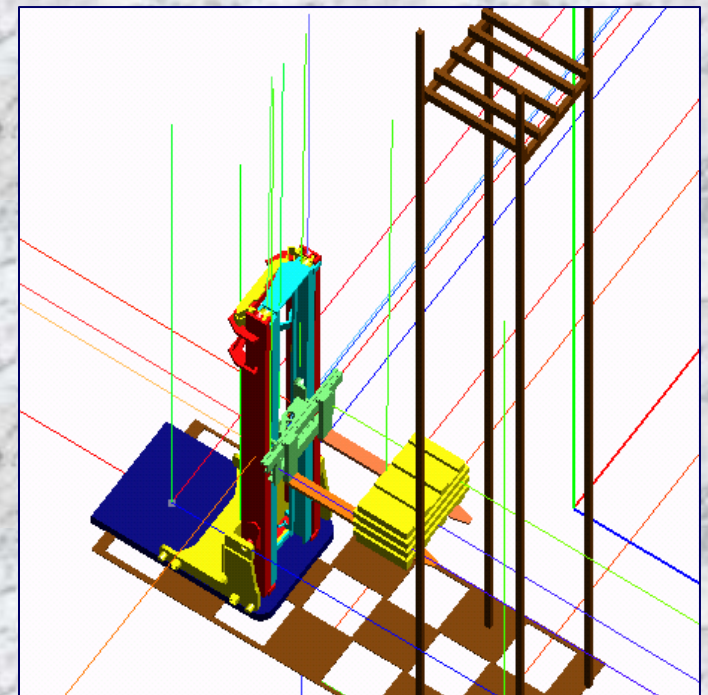
- **Ph.D. Thesis:** Vadim Engelson, **Tools for Design, Interactive Simulation, and Visualization of Object-Oriented Models in Scientific Computing**, [Ph.D. Thesis](#) . See Chapter 5 for detailed description of the tools and their applications..

- **Report:** Daniel Larsson: [A remote Modelica simulation visualized with EAI VRML](#) .

- **Report:** Johan Parmar: [Modeling an Autonomous Helicopter and its Maintenance Environment using Modelica](#)

- **Supported** by RealSim (EC) and VISP (Vinnova) projects

- **Contact:** Vadim Engelson, vaden@ida.liu.se

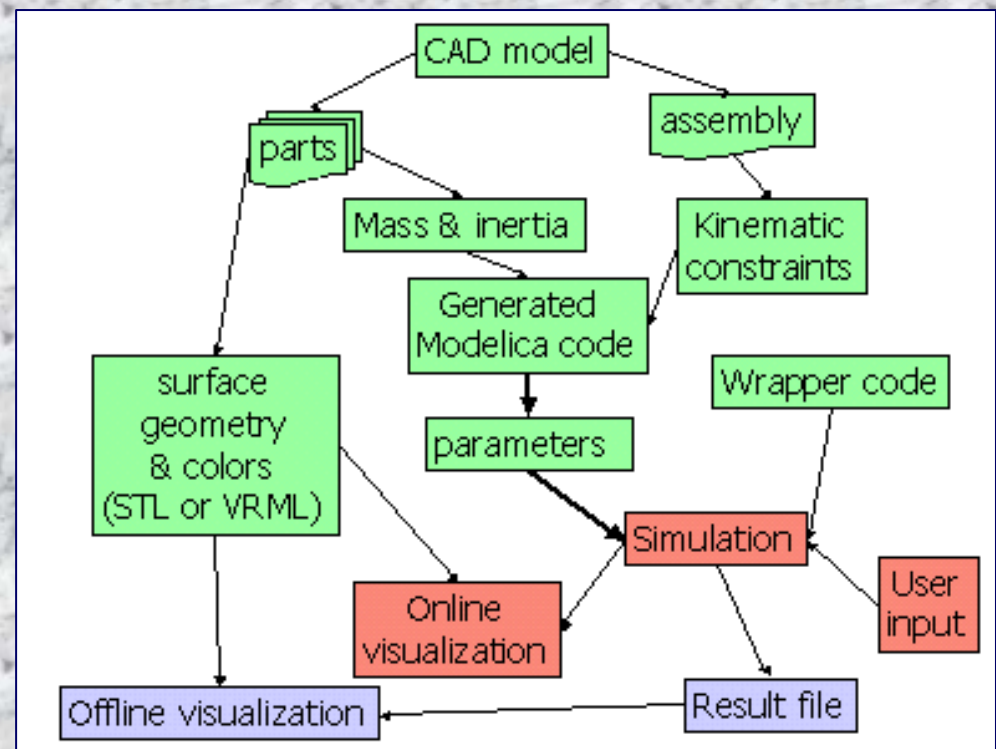


<http://www.ida.liu.se/~pelab/modelica/cad.shtml>

Modelica, CAD and visualization

Translating CAD models to Modelica

- Mechanical systems (robots, cars, aircraft components) contain complex model topology and many parameters that are difficult to specify in the model without using special tools. Three-dimensional CAD user interface is used for modeling mechanical systems in Modelica. Dynamic properties of the kinematic structure are modeled.

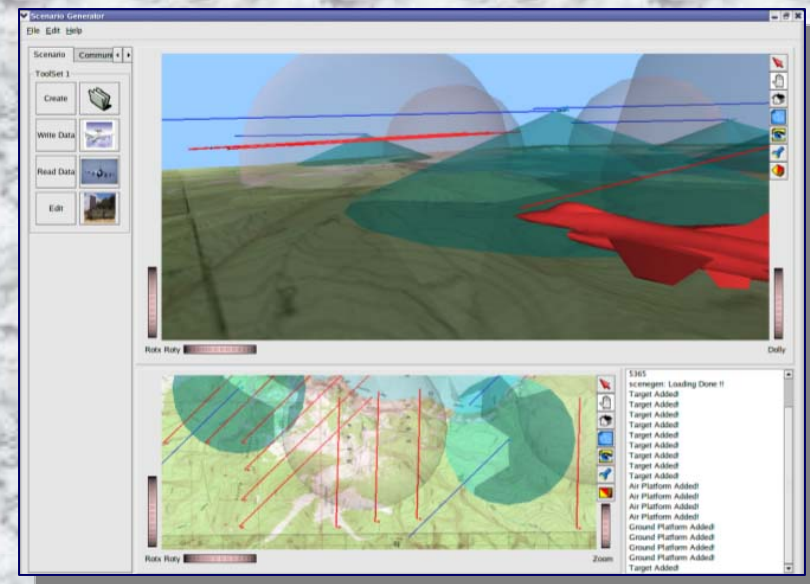
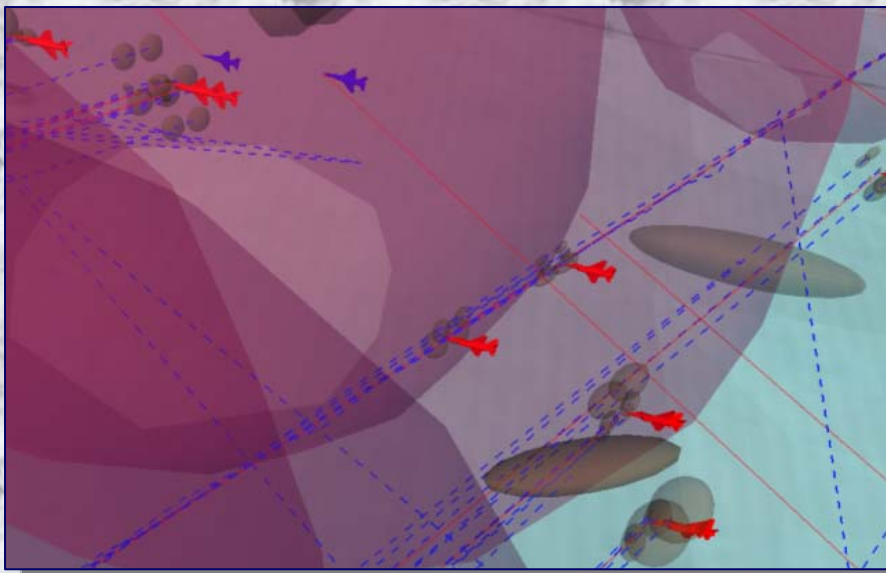


Virtual Reality Laboratory

Distributed Data Fusion (DDF) Testbed : Visualization and Simulation Support

Goal

We are a part of a multidisciplinary group working together to design and develop a DDF testbed to develop, evaluate and test algorithms to perform networking, sensor simulation, target tracking and fusion in a battlefield environment. Our contribution to this work has been providing visualization and simulation support for this testbed.



Virtual Reality Laboratory

Distributed Data Fusion (DDF) Testbed : Visualization and Simulation Support

Abstract

The aim of this project is to develop a one of a kind, best in class simulation system which can be used to emulate a battlefield environment. In this environment algorithms for networking, tracking and data fusion can be developed, tested and evaluated. The battlespace simulation is an inherently 3 dimensional geospatial set up. The algorithmic inputs (ground truth, velocity, geo spatial information etc) and outputs (network assignments, covariance, estimates and tracks) are also 3 dimensional in nature. Most software (COTS) available to support this problem does not provide adequate 3 dimensional support. The key challenge to this problem is to provide a dedicated 3D interface for supporting the simulation and visualizing it. The simulation support tools we have developed for this purpose is divided into two modules. One module is dedicated to providing the user a 3D space where problems/scenarios of specific nature can be developed. The other module provides the viewer with an interactive 3D set up where in simulation results are displayed. The challenges for which we have provided solutions include:

- 1) Geospatial data management and display
- 2) Covariance, tracks and estimate display (Information Visualization)
- 3) Management and display of entity information
- 4) Waypoint/path specification and scenario creation for air target and ground target tracking
- 5) Real time simulation visualization
- 6) Support for simulation scaling with respect to entities, time, playground size and entity details.

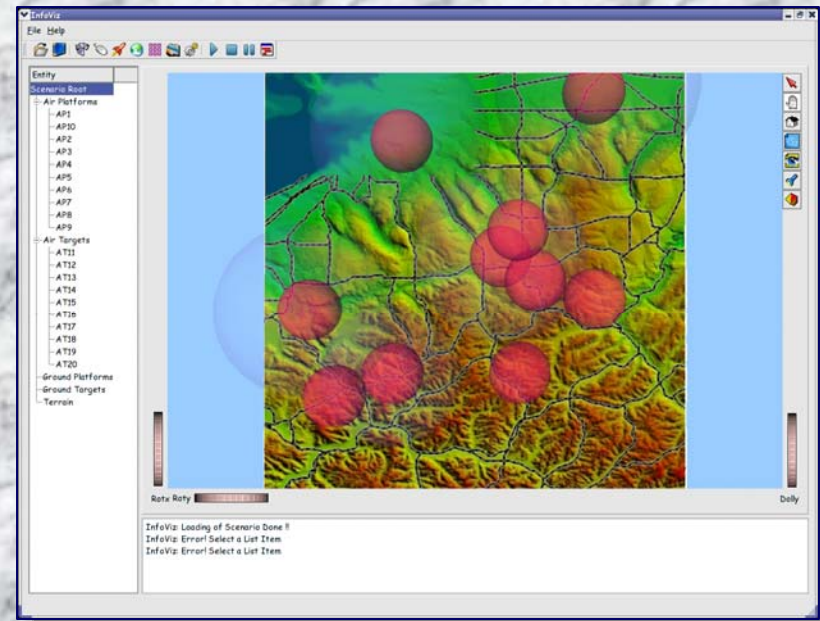
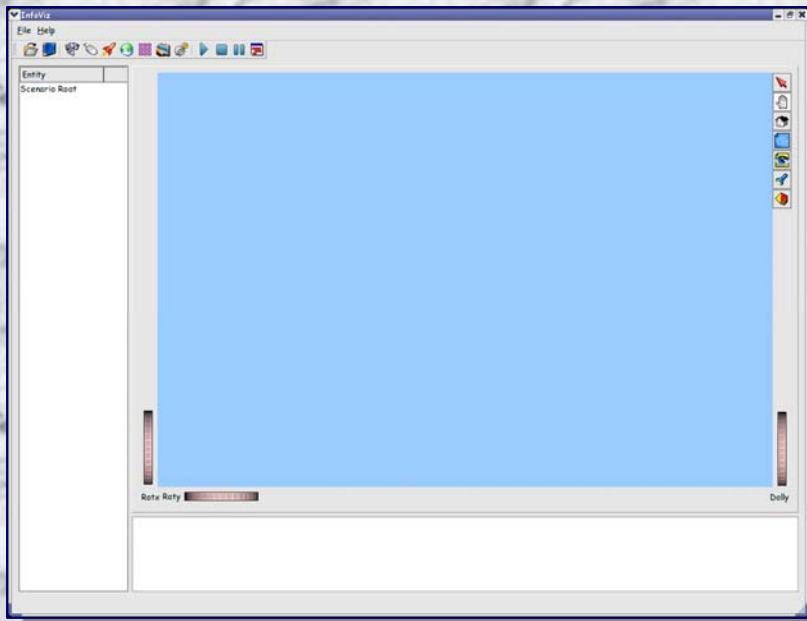
Virtual Reality Laboratory

Distributed Data Fusion (DDF) Testbed : Visualization and Simulation Support

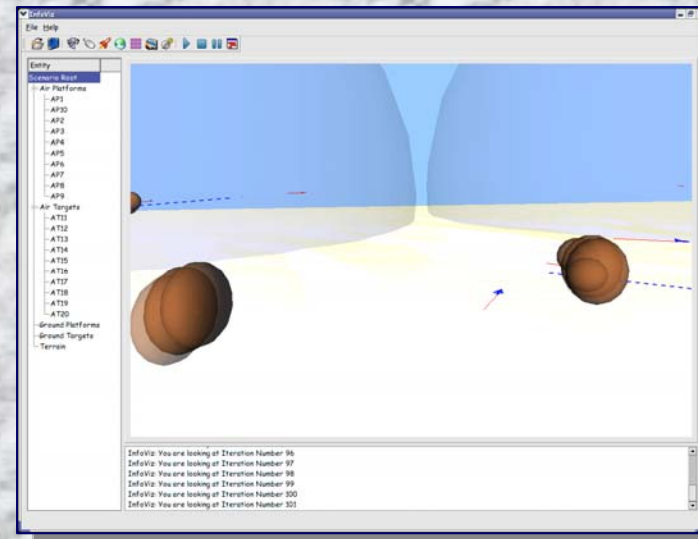
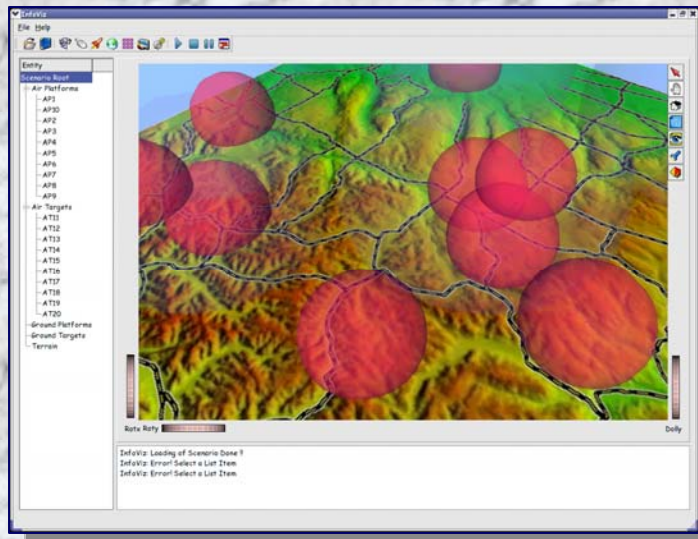
Screen Shots from VizSim

- Scenario Details:
- Batch mode scenario
- 10 Friendlies and 10 Targets
- Air tracking scenario
- Theater : Buffalo – East

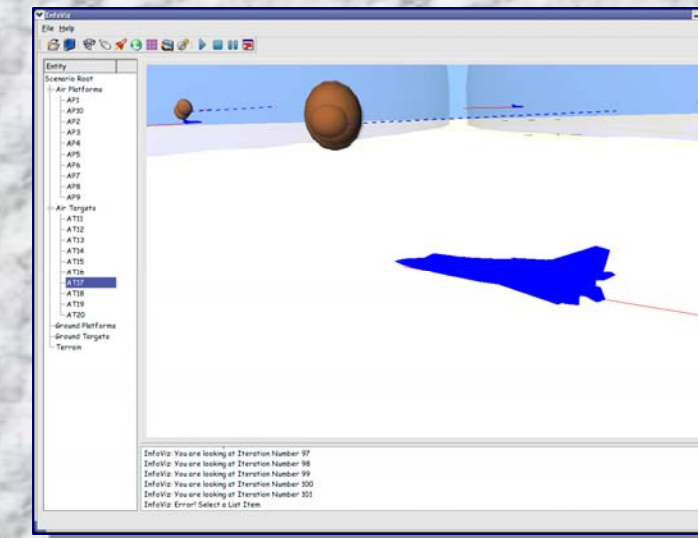
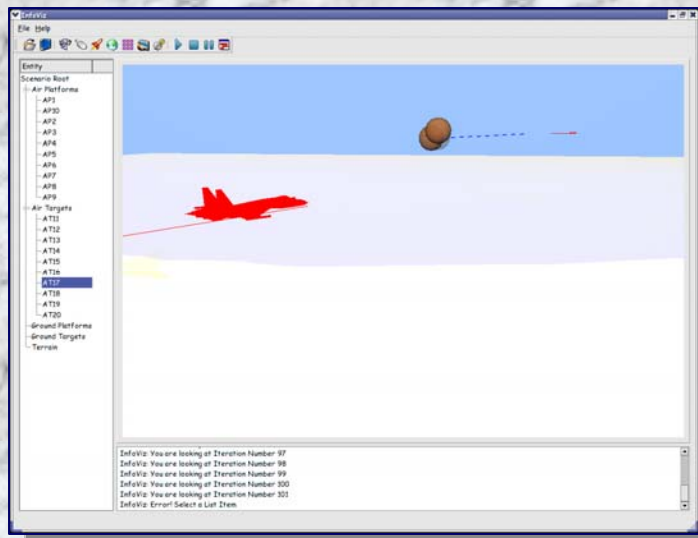
Basic Interface (left) and Buffalo-East Scenario Loaded



Buffalo-East Alternate Viewpoint (left) and Result Set 1



Result Set 2 (left) and Result Set 2



Project Summary

Design of Simulation Scenarios

- Complex & Time Consuming Process
- Requires Geospatial Information
- Sensor Target Information
- Simulation Parameters

Visualization should enable:

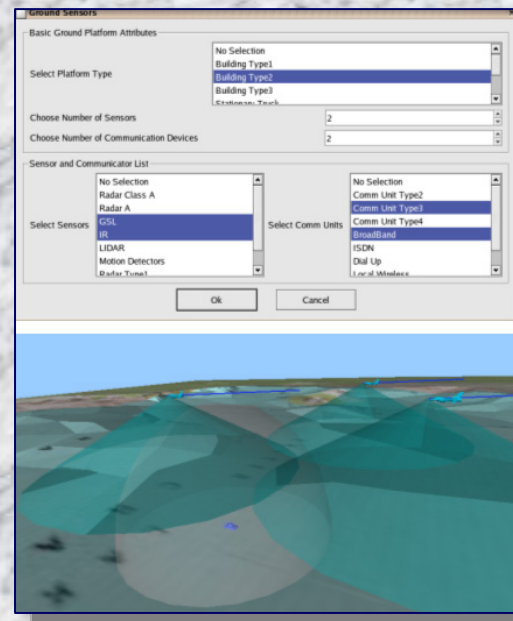
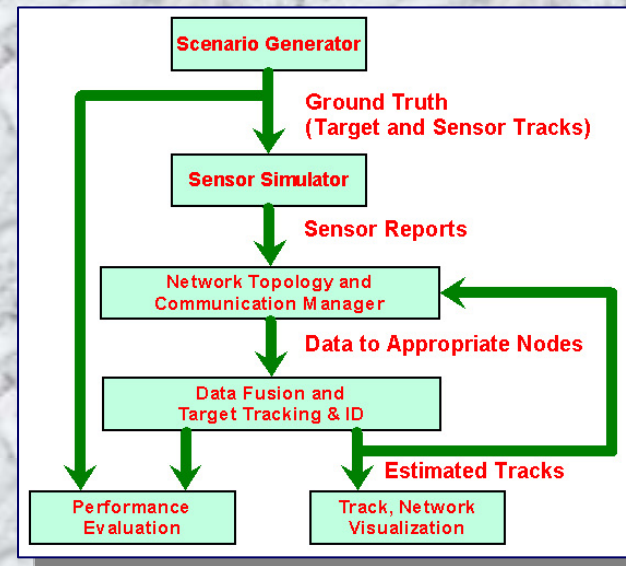
- Understanding of Simulation Output
- Intuitive Interface
- Decision Making Support

User Friendly GUI & Interactivity

- Dialog based Modeling
- Mouse based spatial interaction
- Runtime generation of 3D icons

Visualization of:

- Vehicle Data Information
- Terrain Information
- Vehicle dynamics information
- Path Generation

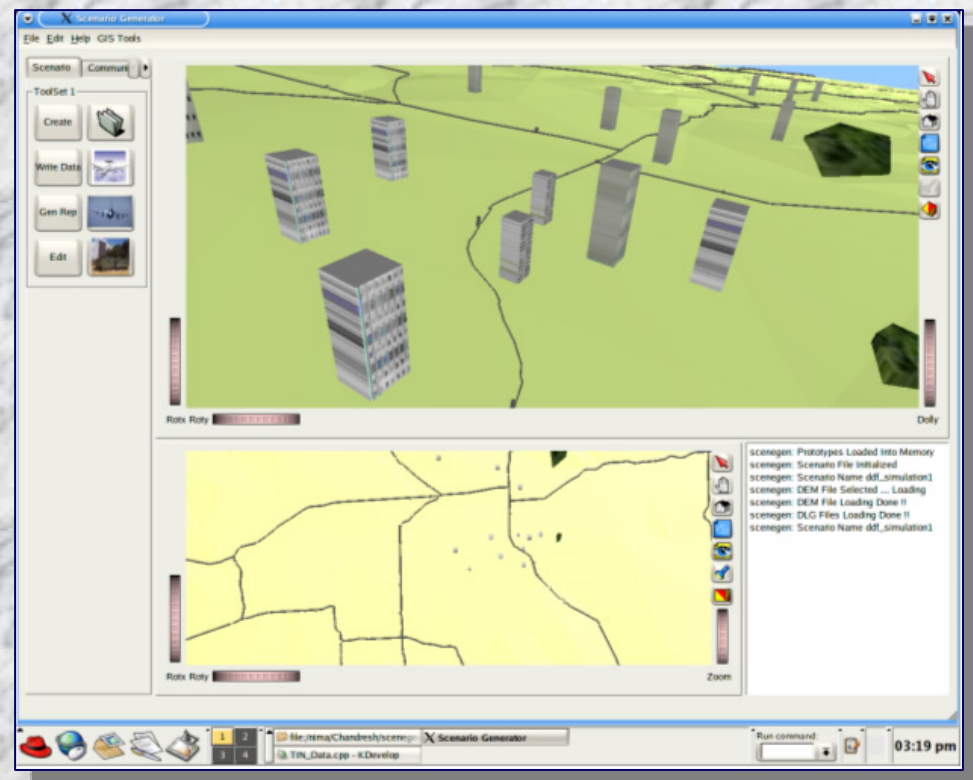


... Project Summary

Need for GIS Support:

Terrain features and cultural artifacts affect the creation of scenarios and influence the fusion algorithms during simulation. This close tie of DDF simulation with geospatial information demands adequate support for terrain database generation.

In our DDF Testbed, we use Digital Elevation Model (DEM) files for getting terrain data and Digital Line Graph (DLG) files for getting vector map data of the desired location. Data from DEM files is efficiently triangulated to compute the Triangular Irregular Network (TIN) that gives the terrain skin. The vector maps of the region providing cultural and other important data such as roads, rivers, manmade structures and foliage information are accurately draped onto this terrain to provide adequate geographic information to users for scenario creation.



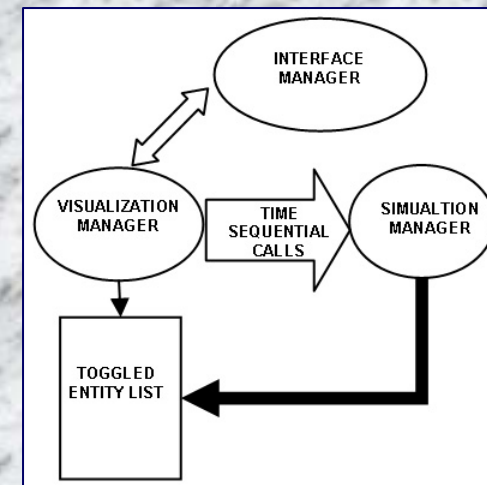
... Project Summary

Simulation Controls:

- Playback simulation control: Play or pause, Stop, Reset and Advance to desired time step
- Toggle control over properties
- Simulation input: Fusion parameters & Networking parameters
- Provisions for database management

Simulation Setup:

- Simulation runs in real time with visualization
- Optimized visualization
(Scenegraph, Render culling, Running on minimum, Interactive "4D" visualization)
- Carry out analysis



Information Visualization:

- Simulation Results
- Provide Insight into Fusion using Viz.
- Result visualization
(Tracks, Covariance, Estimates, Network connections)
- Display of results based on preference
- Interactivity

