Earthstation

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P. Williamson, Kriegsdaten

Viele weitere Personen haben mitgeholfen, daß das Projekt in so kurzer Zeit realisiert werden konnte. Es ist unmöglich, sie alle hier namentlich anzuführen, wir können lediglich generell unseren Dank aussprechen.

The EarthStation project is intended to express a vision of a future, in which modern information and computer technology can help us to control our impact on the global "Gaia" ecosystem in such a way that we shall be able to support a sustainable world. In order to reach that goal we have to learn to know our planet, understand the complex interactions between its many subsystems, and find a way to anticipate the consequences of our policy decisions on the global ecosystem so that we can live in a dynamic balance with all the subsystems of this planet which make the earth inhabitable.

The EarthStation project consists of two major connected parts:

- Interactive graphic representation of the state of the earth.
- Simulation and visualization of nonlinear dynamical models of global systems.

The first part should show how modern communication and computer technology can help us to obtain an image of our complex world with an accuracy and detail that was unimaginable only a few years ago. The second part should suggest how we can approach the concept of an EarthStation from a reconstructive perspective: How we can rebuild certain facets of "Gaia" in the artificial reality of computer simulations.

We want to show that the global "Gaia" system is not limited to primary ecological questions in the traditional sense. We also have to take into account economic, political, military, and population issues, and be aware that this list is not by any means complete.

(I) INTERACTIVE GRAPHIC REPRESENTATION OF THE STATE OF THE EARTH

The basic framework of this installation consists of a virtual reality interface (Fractal Boxes by Gideon May) which is designed for the interactive exploration of complex relationships between the different data bases:

We enter the virtual world through an entrance hall which contains a suspended globe, the map of the earth on the far wall, textual information on the left wall, and a schematic representation of the network of constituents of Gaia on the opposite wall. We can move freely in this hall and enter the globe, revealing the complicated network of structures which have to work together to provide us with a life-sustaining environment. These factors are organized in a hierarchical structure and represented as a self-similar (fractal) nested set of 3-dimensional boxes. Each box carries labels on its outside indicating the contents (text, graphics, photo images), and has text, images, and diagrammatic information on its inside wall with information about the specific issue. Also, each box contains a characteristic sound environment, played through the computer network simultaneously on the NeXT computer in CD stereo quality. The diagrams on the inside walls represent the location of the user, as on a "subway map". On this diagram the viewer will be able to identify the problems areas directly related to the problem (s)he is currently viewing. This can uncover counter-intuitive long-range connections. These boxes within boxes can be entered through the walls and the whole process repeats on a lower level up to the complexity limits of the data base.

The following is a (growing) list of objects, that can be accessed through the fractal boxes interface:
Computer images from NASA/NOAA satellites of atmospheric data (C02, Ozone, CI oudtop/Ocean /Land temperatures)
Overlay of

- Geographic information systems population, economical, political, and military data
- General environmental data from World Resources 1990–1991 (World Resources Inst, Washinghton, DC)
- US temperature and precipitation data (1918–1987) (C02 Info Center)
- World Food and Agriculture data (FAO of the UN, Rome)
- World demographic data (WHO, Geneva)
- Atmospheric ozone data, (World Ozone Data Center)
- World Earthquakes
- El Nino Wind and Temperature Oscillations
- World Bio-Habitat Sound Samples (D. Dunn)

- Arable Land dependence on sealevels

and other data bases from Earthwatch, WHO, Batelle, City Corp, Reuter, CIA. Emphasis will be placed on the global implications of the gulf war: spread of the smoke clouds as seen from satellite and as experienced on the ground, statistics on economic, agricultural, ecological, etc. consequences. Another timely topic will be some graphical display of statistics related to the economic implications, impact on health care, and social/legal systems of drug usage.

The geographic displays will be interactive (on SGI and/or NeXT platforms using different types of software packages) in the sense that we have a color coding of the different areas on the globe according to specific topics.

Among those are LinkWinds (Bud Jacobson, JPL) for statistical analysis and correlations of atmospheric data based on satellite data and VDL for data base visualization.
Besides more traditional databases, we also plan to install an interactive news data base: By pointing and clicking into an area of the world map we can extract graphical, sound, and video information on a specific topic at this specific geographical location.

One of the color codings of the world map can be according to the intensity of recent political conflicts as indicated by numbers of news items in a selection of media (e.g. SCOLA news).

Besides the geographical display we are also interested in a more symbolic display of functional networks connecting different areas relevant for the global system.
Some of the data base 'visualization' will be done through synthetic sound representation (audification) of global parameters from multi-dimensional data bases.

(II) REPRESENTATION, SIMULATION, AND VISUALIZATION OF NONLINEAR DYNAMICAL MODELS OF GLOBAL SYSTEMS

In the second part of the installation we present different types of simulation tools which have been developed to create an artificial environment to study various aspects of the global Gaia system. Super computers have been used extensively to model atmospheric phenomena. We present several examples of such simulations performed at the Los Alamos National Laboratory; Results from large scale super computer simulations of global circulation models (C. Keller, G. Glatzmaier, IGPP, C. Hanson, LANL, performed on Cray super-computers).

Other models have been simulated on one of the most advanced parallel computers in the world, the Connection Machine (CM-2), a computer with 64,000 processors which all work simultaneously to compute the changes in the atmosphere.

The results from adaptive mesh simulations on the CM-2 of Los Alamos National Laboratory will be displayed with special graphics interface on an IRIS VGX in stereo vision (J. Fowler, LANL). A general problem in the study complex system is the extraction, description and modelling of patterns. Patterns can be created spontaneously, undergo a complicated evolution and dissolve or disappear, such as clouds in the sky. Among the mathematical tools to describe these irregular patterns as chaotic attractors are Fourier-, Wavelet-, and Proper-Orthogonal decompositions. The dynamical structure of the recurrence of those patterns can be represented via recurrence diagrams. All of these methods will be represented with modern computer graphical methods. Among the simulated and analyzed models are:

- Simulation of global models for special atmospheric events (e.g.: El Nino model by Geoff Vallis, UCSC)
- Simulation and representation of 9-dimensional Lorenz model simultaneously as evolving distribution of spatial patterns and in an abstract chaotic attractor representation (3 visual variables + 9 sonic representation of the dimensions). (MIDI based code currently developed by Gregory Kramer, New York, Bruce Sawhill, SFI, B. Hotchkiss, LANL, implementation for multimedia SGI by Gideon May).

Complex elements of the global Gaia system evolve according to nonlinear equations which can show chaotic behavior. The chaos of such solutions, however, can be very subtle and hard to observe. If human interference with this system introduces small perturbations, they can cause very dramatic changes. We have developed a virtual reality interface which allows an interactive exploration of sensitivities and instabilities of nonlinear models: Our codes allow the user to fly through chaotic attractors under the time evolution of nonlinear differential equations. Spaceball based controls allow the user to perturb the differential equations and experience the modified time evolution against a backdrop of the original attractor. The program shows the Lorenz attractor from an outside view (present in a screen window to indicate Phase Spaceship's current and past [through comet-tail representation] position). It also shows a perspective through the front window of the Phase Spaceship as it flies along the attractor, Spaceball controls can be used to actively control the path of the system. Simulations will also be available which will demonstrate the power (and limitations) of "auto pilots, equations for optimal control of chaotic attractors" (A. Huebler).

Modern methods from machine learning allow the exploration of strategies which can evolve into solutions of very complex problems. These principles are demonstrated using genetic algorithms in the framework of John Holland's ecomodel with an improved graphics user interface developed by Simulation Laboratories.

The classes of solutions found by either interactive exploration or through machine learning algorithms are not very useful unless the robustness of the solutions has been established. Tools from nonlinear dynamics and computer graphics allow the identification and visualization of critical surfaces in multi dimensional parameter and phase spaces. As an example we demonstrate a phase space analysis together with interactive simulations of a 3-nation generalization of Richardson models of international arms race (code written by Judy Challinger for SGI).

Other examples of simulations of nonlinear models in other fields include simulations of nonlinear economic models of learning agents (B. Arthur, SFI, Stanford Univ) and simulation and visualization of artificial life ecologies (C. Langton, SFI, LANL).

Even without technical background one can achieve surprising insights into the complexity of global systems through computer games like SimCity for city developments and SimEarth for creating and managing of new planets.