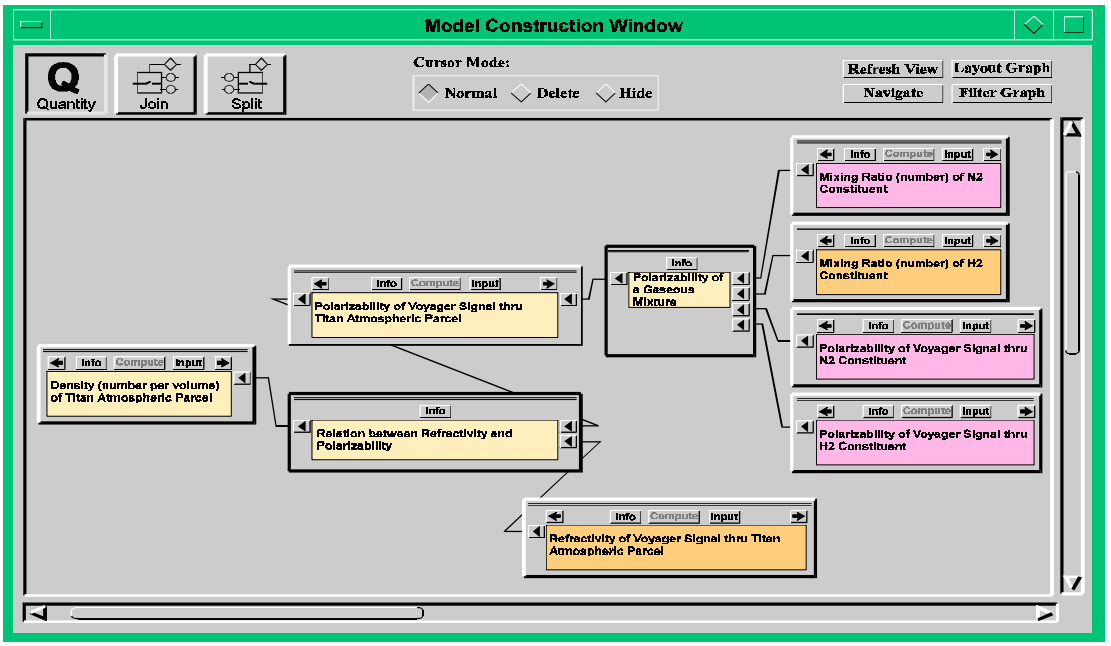
NASA TECHNOLOGY TRANSFER
Commercial Applications of Aerospace Technology

Scientists' Intelligent Graphical Modeling Assistant (SIGMA)
General Purpose Model-Building Tool

The National Aeronautics and Space Administration (NASA) seeks to transfer a general purpose modeling tool into commercial use as an effective mechanism for prototyping scientific models. Researchers at the Ames Research Center have developed the Scientists' Intelligent Graphical Modeling Assistant (SIGMA) system, which has been used to create modeling codes that support several different scientific analyses. NASA is seeking a company to incorporate this tool into existing engineering and scientific software products.



SIGMA Model Construction Window

Product Profile

SIGMA is an interactive, knowledge-based, graphical software development environment that helps scientists to rapidly prototype their scientific models. The SIGMA tool is intended to simplify construction, modification, and reuse of modeling software, and to provide a supportive computational environment for exploratory model building. Despite the importance of modeling in the overall scientific process, scientists have little computational support available to help them perform this specific task. Recognizing this need, scientists at NASA have used representation and reasoning techniques from artificial intelligence to provide intelligent computational support for the modeler. Within the SIGMA environment, users create scientific models by configuring graphical building blocks that correspond to entities within a scientific model: equations, quantities, and datasets. The model itself is represented as a data dependency graph that illustrates how each derived model parameter is calculated from input parameters via a series of application equations.

In contrast with more conventional model building, using SIGMA is simple and intuitive. SIGMA accelerates the scientific model building process and improves the accuracy and clarity of the scientific models produced. Rather than producing obtuse, low-level modeling code, SIGMA users construct high-level graphical structures that capture the essential scientific content necessary to understand a model. By interpreting these high-level structures in terms of its extensive background scientific knowledge, SIGMA can generate modeling results.

SIGMA's use of a high-level model specification language has many advantages. Peer review of scientific theory that is specified using SIGMA's language is much easier. Similarly, sharing of model fragments becomes more fea-

Technology Opportunity

sible when the scientific content of those fragments is readily understood and their modeling assumptions are clearly identified.

Conventional scientific modeling can be extremely labor intensive, and staffing in scientific labs is often insufficient to provide for extensive programming assistance to accomplish the necessary work in a reasonable timeframe. In addition, many scientific endeavors involve generating code that incorporates sophisticated numerical analysis techniques and other advanced programming methods that some scientists may not be equipped to handle. The high level graphical language provided by SIGMA enables the scientist to avoid these problems and to build the model without the need for learning and implementing low level code.

SIGMA incorporates a knowledge base of both general purpose and domain-specific modeling concepts that helps scientists to more efficiently specify model structure. This unique feature has been developed to allow reuse by other scientists. It is also designed to allow users to add different modeling concepts that are appropriate to modeling of problems in their own scientific investigative areas. The NASA SIGMA knowledge base currently incorporates over 1000 concepts that encode a variety of types of knowledge:

- information about scientific equations,
- physical quantities,
- constraints,
- conversion factors for scientific units,
- numerical programming methods,
- scientific domain concepts, and
- bibliographic citations.

Benefits

SIGMA's knowledge-based model development scheme offers scientists a high level graphical data flow tool for specifying scientific models. Advantages of this approach include:

- modeling is easier and faster;
- models are easily understood by others;
- scientists can share common features of different models; and
- the knowledge base feature reduces the need for recreating the same information and concepts.

The Technology

SIGMA was developed to give scientists an assistant system that would share a common set of knowledge about the scientific domain and the model-building process. It was deemed critical to the success of the system to capture an understanding of how and when certain scientific equations and principals could be applied. Only with access to this type of knowledge could the modeling system help the user by intelligently applying equations and principles. SIGMA uses its scientific background knowledge to support various inferencing, retrieval, and user interface requirements associated with model building.

The capabilities of the current version of SIGMA are quite impressive:

- models are developed interactively with a specialized graphical user interface, using a high-level visual specification language;
- many domain-specific modeling resources are available;
- scientific unit conversions are handled automatically during model execution;
- modeling consistency and coherency checks are built-in; and
- graphical user interface makes it easy to maintain the knowledge base, to provide model information and to visualize results

SIGMA is currently being used to model and analyze planetary atmospheres. It is also being applied to prototype an ecological model that tracks carbon, water, and nitrogen cycles in a forest ecosystem over time.

Technology Transfer Status

The concept of applying knowledge-based software to model scientific problems has been amply demonstrated. A sizable knowledge base has been developed, much of which is quite general and useful for modeling a variety of problems. The SIGMA system can also be enhanced and developed as a standalone modeling tool, available to help scientists attack many different types of problems. Expanded knowledge and specific domain data would be required for new applications.

The SIGMA system is currently designed as a rapid prototyping tool. NASA seeks a company which will use SIGMA to enhance existing scientific software.

Contact

If your company is interested in the SIGMA system or you desire additional information, please contact:

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