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The Scientist's Expert Assistant Simulation Facility

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Abstract. In the process of developing an observing program for a given observatory, the planner requires a number of inputs regarding the target and scientific instrument that need to be calculated, found, and/or confirmed. Thus, preparation of a program can be quite a daunting task. The task can be made easier by providing observers with a software tools environment. NGST funded the initial development of the Scientist's Expert Assistant (SEA) to research new visual approaches to proposal preparation.

Building on this experience, work has begun on a new integrated SEA simulation facility. The main objective is to develop the framework for a flexible simulation facility to allow astronomers to explore the target/instrument/observatory parameters and to 'simulate' the quality of data they will attain. The goal is a simulation pipeline that will allow the user to manage the complex process of simulating and analyzing images without heroic programming effort. Tying this into SEA will allow astronomers to effectively come 'full circle' from retrieving archival images, to data analysis, to proposing new observations. The objectives and strategies for the SEA simulation facility are discussed, as well as current status and future enhancements.

1. What is the SEA Simulation Facility?

The Scientist's Expert Assistant (SEA)[1] is a tool designed to investigate automated solutions for reducing the time and effort involved for both scientists and telescope operations staff spent in preparing detailed observatory proposals.

At the past two ADASS conferences (VIII and IX) SEA's Java-based visual target tuning, exposure time calculation, and visit planning capabilities were demonstrated. Since that time, SEA has been embraced by a number of astronomical observatories for inclusion into their observing programs. The Space Telescope Science Institute has already incorporated SEA for production use into its Astronomer's Proposal Tool, while other observatories such as SOFIA are in the initial stages of incorporating it.

A new phase of SEA has now begun: building the new integrated SEA Simulation Facility (SSF). In improving the visualization process to give the user better insight into observation process, the SSF breaks down the observation into elements of the light path. These elements are really software models of various aspects of the light path. The models generally have a variety of parameters that the user can adjust to assist in better understanding the effects of that element in the light path. At any point in the light path, the user can attach one or more visualizations that can be used to observe aspects of the light path at that point.

2. Why a Simulation Facility?

One of the emerging efforts in the astronomical community is the Virtual Observatory (VO). The SSF is working to combine the ability to access existing archives with the ability to model and visualize new observations. Integrating the two will allow astronomers to better use emerging integrated archives of the VO to plan and predict the success of potential new observations.

The SSF provides benefits to a variety of potential users:

- **Observers** can use simulation to:
  1. Effectively determine how various parameters affect their data and scientific objectives
  2. Act as a "Phase 0" tool for the initial "framing" of the observations
  3. Validate proposed observations ahead of time
  4. Support new complex instruments that drive the need for newer visualization tools.
- **Observatory Staff** can use simulation to:
  1. Characterize their telescope, instruments, and detectors
  2. Calibrate instruments with fewer observations.
- **Archive Users** can use simulation to understand the quality and limitations of an archival image.

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[1] `http://aaaprod.gsfc.nasa.gov/SEA/`

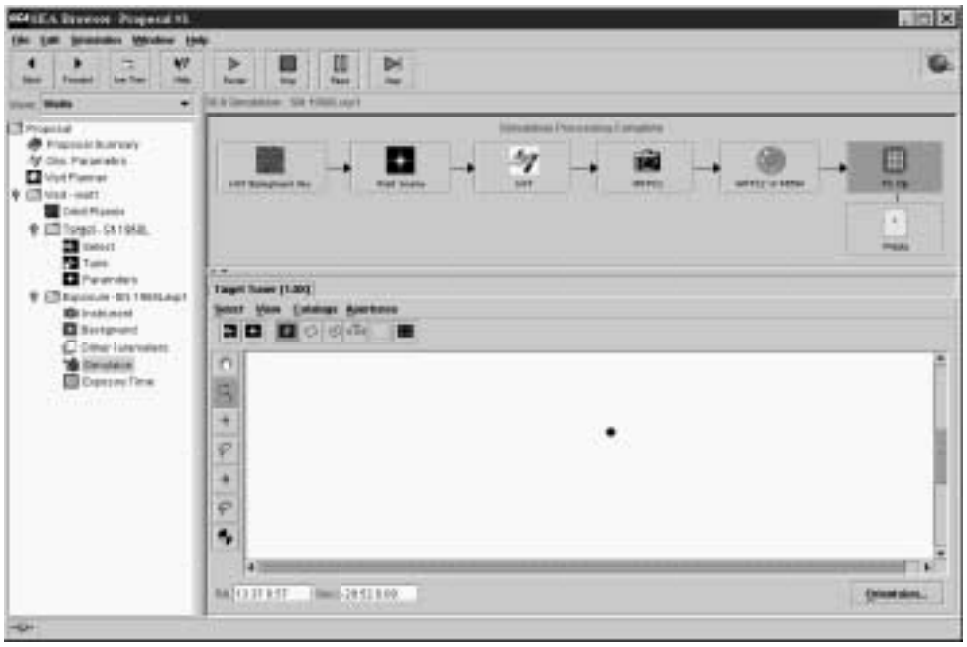

Figure 1. The SEA Simulation Facility Display

3. Highlights of the Design

Project design goals included:

- Testing interactive and innovative ways to look at a proposed observation
- Providing a system that is scalable and supports a variety of models
- Hiding simulation complexity routinely from the user (but providing it when requested)
- Emphasizing scientific fidelity
- Supporting a variety of visualization mechanisms such as imaging and spectroscopy.

The simulation pipeline was envisioned as modeling changes to the photons as they travel from one or more sources though various distortion producing effects before ultimately reaching an instrument's detector. The pipeline consists of two primary element types:

1. **EnergyModels** that modify the photon stream in some way, such as, adding photons, attenuating their rate of production, or distorting them in some other way.
2. **EnergyVisualizations** are attached to an EnergyModel. Their purpose is to visualize the data at that point in the pipeline. Astronomical archive information can also be accessed for comparison purposes.

By default, the pipeline is automatically constructed to model the components of an exposure. Model parameters for the simulation are derived from the exposure specifications. Each component models some part of the exposure's light path. For example, there will be a model representing the background emissions, a model for the observation target (a star, galaxy, etc.), and models

for the Observatory, Instrument, Filter and Detector objects defined for this exposure. The user is free to add, replace, modify, or delete EnergyModels and EnergyVisualizations as desired.

The user controls the simulation process by telling the SSF to "render". The rendering process starts at the left most EnergyModel in the pipeline (seen along the top of the display) then progresses to the right as each EnergyModel completes its processing.

What is being processed is an EnergyDataSet. The goal of an EnergyDataSet is to accurately and efficiently contain the simulation data. At the start of the render processing, the EnergyDataSet is initialized then passed from one EnergyModel that can modify it, to the next.

To minimize EnergyDataSet storage requirements and computational load while maintaining quick and easy access to data values, two solutions were implemented:

1. **Smart EnergyDataLayers** that optimize data storage needs by using a sparse matrix and storing double precision values rather than Wavelength arrays unless necessary.
2. **Binning** so that most of the simulation is performed on low resolution data and only a subset of the data is rendered at higher resolution for a more accurate simulation.

4. Current Status and Future Plans

The primary framework for the SSF has been designed and implemented and is now ready for incorporation of existing simulations. Recently released simulation models from the European Southern Observatory are currently being integrated.

Future plans call for:

- Increasing the scientific fidelity of the models
- Prototyping visualization approaches and GUI enhancements.

More information about the SSF is available in a "white paper"[2] on this subject.

References

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Grosvenor S. 2000, in ASP Conf. Ser., Vol. 216, Astronomical Data Analysis Software and Systems IX, ed. N. Manset, C. Veillet, & D. Crabtree (San Francisco: ASP), 695

[2] `http://aaaprod.gsfc.nasa.gov/SEA/papers/sea_simulation.pdf`