The Scientist's Expert Assistant Simulation Facility

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Abstract. In the process of developing an observing program for an observatory, the observer requires a number of inputs regarding the target and scientific instrument that need to be calculated/found/confirmed. Thus, the preparation of an observing 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, we have begun work 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 the 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) we have demonstrated SEA's Java-based visual target tuning, exposure time calculation, and visit planning capabilities. Since that time, it 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 (APT), while other observatories such as SOFIA are in initial stages of incorporation.

We are now in the new phase of SEA, building the new integrated SEA Simulation Facility (SSF). We are continuing to improve 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 help him better understand the effects of that element in the light path. At any point in the light path, the user can attach one or more visualizations, which 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 which 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 User** can use simulation to:
    1. Understand the quality and limitations of an archival image

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

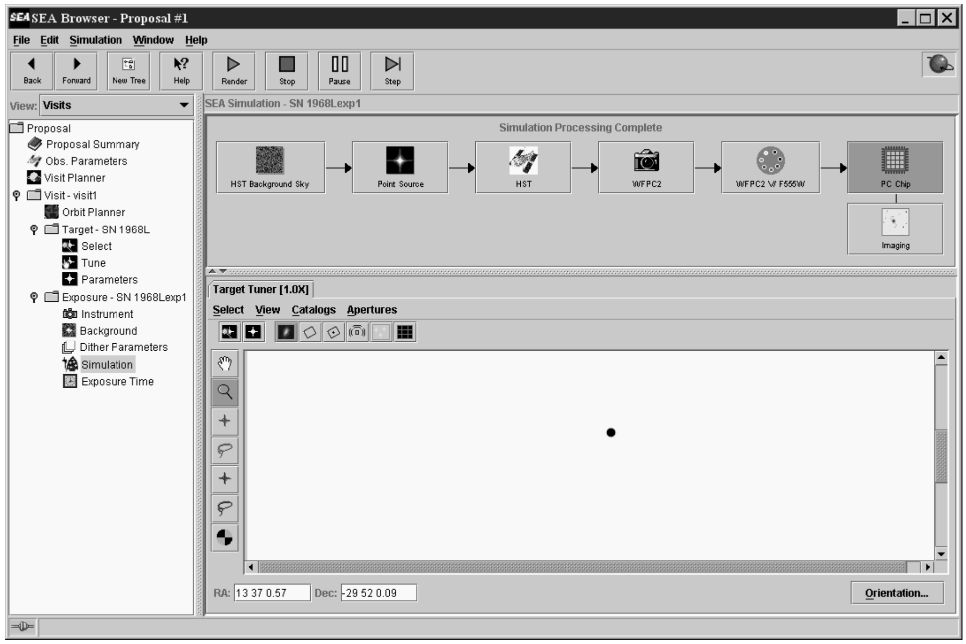

Figure 1. The SEA Simulation Facility Display

3. Highlights of the Design

Our design goals included:

- Test interactive and innovative ways to look at a proposed observation.
- The system must be scalable and support a variety of models
- Hide the simulation complexity from the user, but provide if it requested
- Emphasize scientific fidelity
- Support a variety of visualization mechanisms such as imaging and spectroscopy.

We envisioned a simulation pipeline, which models the 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** which modify the photon stream in some way, such as, adding photons, attenuating their rate of production, or some other type of distortion.
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, which can modify it, to the next EnergyModel.

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

1. **Smart EnergyDataLayers**, which optimize data storage needs by using a sparse matrix and storing double precision values rather than Wavelength arrays unless necessary.
2. **Binning**, where most of the simulation is performed on a 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

We have designed and implemented the primary framework for the SSF and are now looking at existing simulations to be incorporated into it. We are currently working on integrating the recently released simulation models from the European Southern Observatory.

In the future we plan to:

- Increase the scientific fidelity of our models
- Prototype visualization approaches and GUI enhancements

More information about the SSF can be found in a white paper available at the SEA web site identified earlier in this document.

References

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