Creating a Python Framework for Simulating Satellite Geolocation

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Abstract

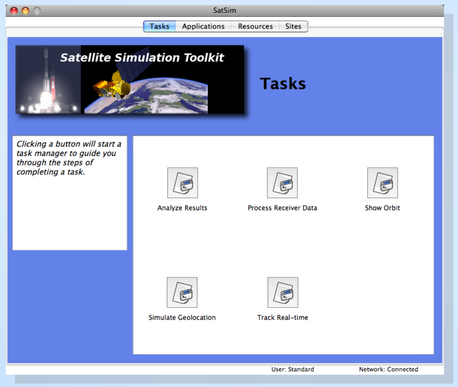
This poster illustrates a Python application for simulating satellite geolocation called *SatSim*. Using all open-source components, SatSim allows the user to explore different satellite constellations and Kalman filter designs for determining position estimates. Visual outputs show satellite and observer geometry animated on a user-customized map for a high degree of user interaction. The intent is to put in one place all of the functionality needed by the user to investigate this topic. As such it is an example of a software problem-solving environment. SatSim runs on Windows, Mac OS, and Linux.

Major Components

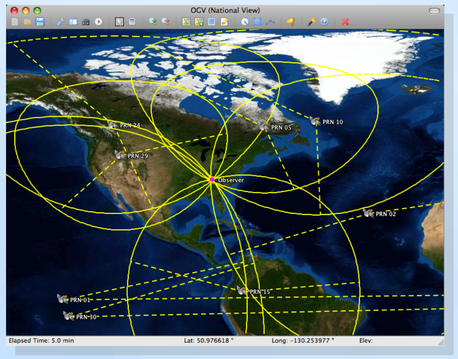
Python 2.7	Overall program control
wxPython	GUI toolkit with native OS look-and-feel
PostgreSQL	Geospatial database
psycopg2	Python DBAPI for PostgreSQL
OGV	ORNL Geospatial Viewer used for maps
GPS Babel	USB GPS device interface and data formatting
pySerial	Serial GPS device interface
NumPy	Matrix library used for Kalman filter
SGP4	Satellite propagation code (written in C)
gnuplot	General-purpose 2D and 3D plotting application

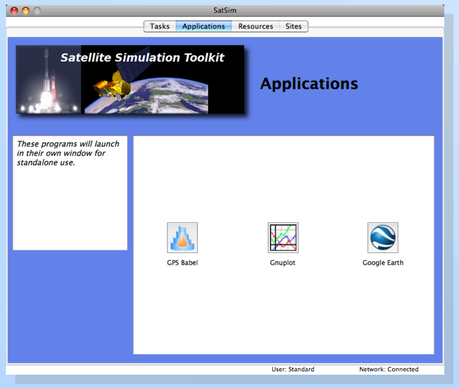
Additional information: http://www.ornl.gov/~ko5

Task buttons launch custom, domain-specific Python scripts. Each script guides a user through a sequence of steps like a software wizard.

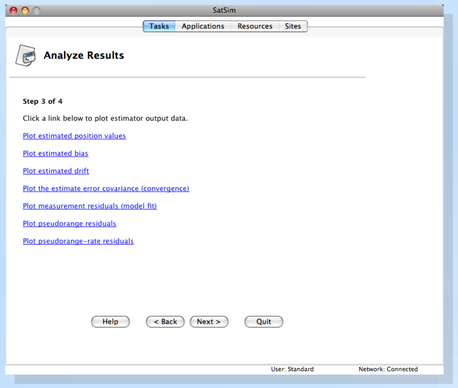


As a simulation runs, an OGV map screen shows satellite pseudorange rings converging at a location. The dashed lines represent pseudorange-rate information.



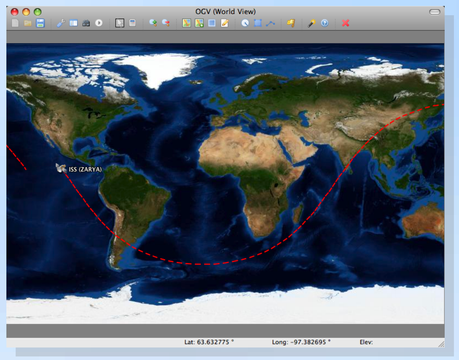


Helper application links are grouped together for quick access. A user can drag-and-drop a program onto the panel and customize its icon.



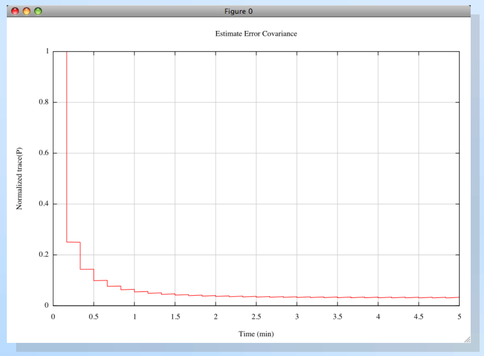
Here is an example of a wizard screen for the Analyze Results task with links for plotting various performance parameters for the Kalman filter.

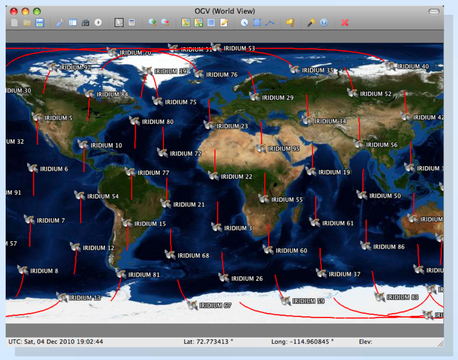
Orbit prediction for any time period is available using the SGP4 propagator with two-line element files downloaded from the web. Double-clicking a satellite icon shows numerical data about its orbit.



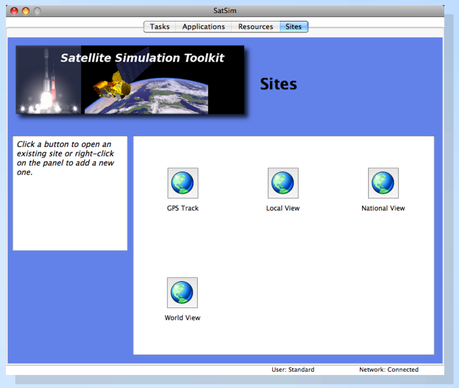
Locally-stored documents and web links form a ready-reference library. Documents may be dragged-and-dropped onto the panel. Current two-line element files may be downloaded from CelesTrak.

Plotting the error covariance matrix trace value shows convergence behavior for the Kalman filter. NumPy is used to easily implement the matrix equations describing the filter.

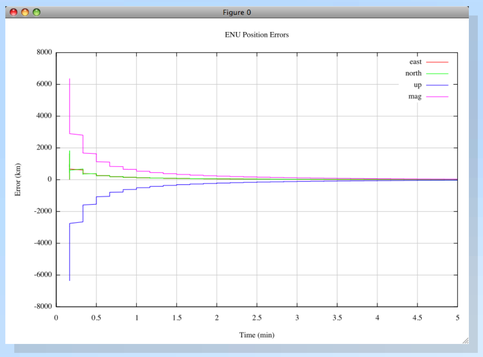




Real-time estimates of satellite positions are shown with trailing lines for the portions of the orbits traveled so far. Here, the Iridium constellation can be seen.



Sites are maps with geo-located raster and vector information from the local database and include animation capability. The ORNL Geospatial Viewer (OGV) allows the user to customize each map as needed.



The position estimation error as a function of time is shown for the observer's local frame of reference. SatSim dynamically generates gnuplot commands.

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