Satellite Orbit Computation

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0.1 Satellite Orbit Computation

The dissemination of satellite orbit prediction utilities predates GPS. See *Revisiting Spacetrack Report #3 Rev. 1* by Vallado, et. al., in the folder

`···\SatelliteOrbitComputation\DOC.`

This was achieved with a Simplified General Perturbation (SGP) model, which is a system of modified Keplerian equations that can be solved efficiently using pseudo-orbital parameters calculated from high precision orbital measurements. The necessary information is conveyed for SGP calculations via standardized sets of two-line elements (TLEs). Each element set has a specified time epoch at which the orbital predictions apply most accurately. The results deteriorate with time, but generally provide sufficient accuracy for several days of high-resolution tracking.

The MATLAB scripts in the folder

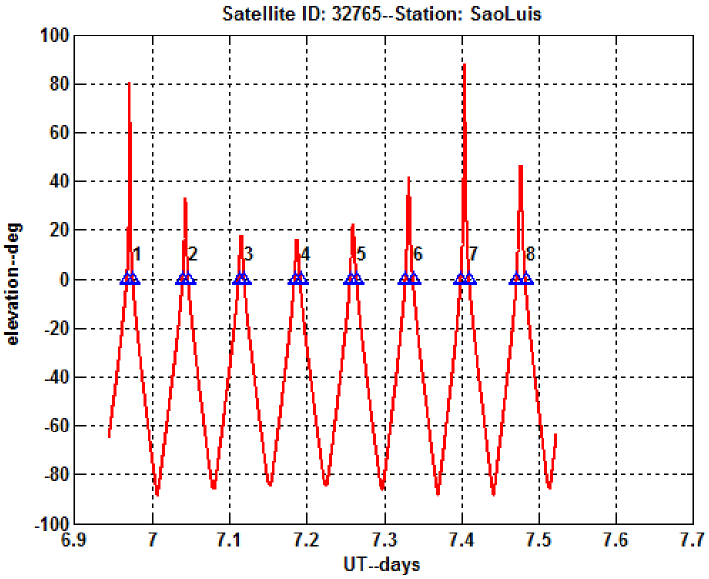
`···\SatelliteOrbitComputation\SGP4`

contains a modified version of the SGP4 MATLAB code. The modified SGP4 code provides satellite position and velocity estimates versus universal time since the TLE epoch in an Earth-fixed coordinate system (ecf). All subsequent manipulations can be performed using MATLAB GPS coordinate transformation codes that can be downloaded from the MATLAB Central file exchange

http://www.mathworks.com/matlabcentral/fileexchange/28813-gps-coordinate-transformations.

The codes have been supplemented with utilities that will calculate all the geometric computations needed to interpret transionospheric beacon satellite data. Mean magnetic field computations use a MATLAB utility that also can be downloaded from the MATLAB Central file exchange

http://www.mathworks.com/matlabcentral/fileexchange/28874-igrf-magnetic-field.



0.2 Satellite Orbit Code Examples

The folder

`···\SatelliteOrbitComputation\SatGeom_Example`

contains the MATLAB script `SetPath4SPG4,` which will place the `\SPG4` and `\utilities` folders on the MATLAB path and prompt the user to locate the `\GPS_CoordinateXforms` and the `\IGRF` folders for inclusion on the MATLAB path. Running the script

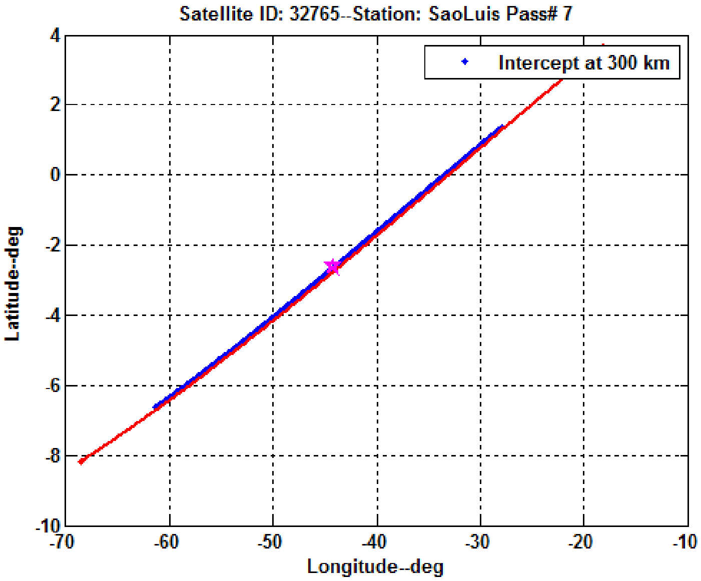
`GenerateSatelliteGeometry_DEMO`

will generate Figure 0.2, which is Figure 4.3 in the author's book *The Theory of Scintillation with Applications in Remote Sensing*

`http://www.wiley.com/WileyCDA/WileyTitle/productCd-047064477X.html.`

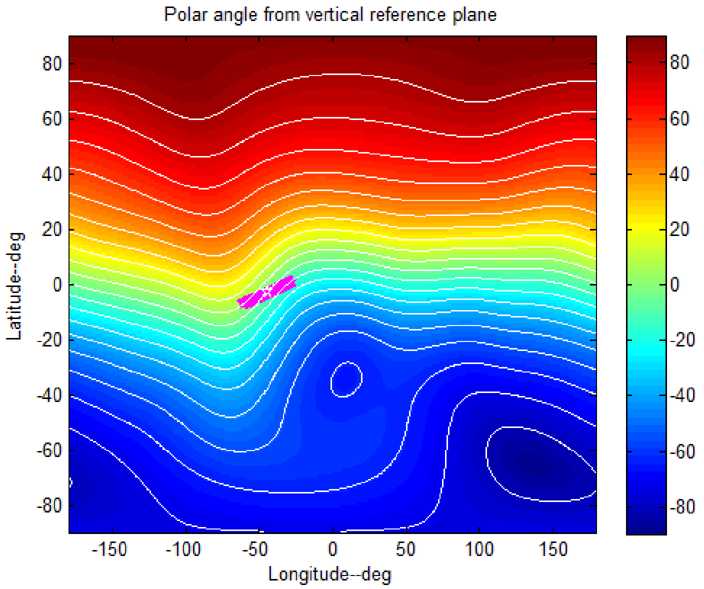
The graphic shows the visibility (as indicated by a positive elevation angle) of 8 consecutive orbits viewed from a Brazil receiving station near the geomagnetic equator. Pass 7 is selected for more detailed evaluation because it is the highest elevation pass in the sequence computed.

The subroutine `SummarizeSatelliteGeometry` will generate selected summary displays. Figure 0.2, for example, shows the longitude and latitude of the 300 km (default) ionospheric intercept point (book Figure 4.4). The magenta pentagram marks the station location. The fact that the station location



is nearly on the trajectory shows that the pass is nearly overhead, which is desirable for scientific analysis. The user can study the `GenerateSatelliteGeometry` and the `SummarizeSatelliteGeometry` to see how the GPS utilities are use to perform the various geometric translations.

Figure 0.2 (book Figure 4.5) shows the trajectory (magenta) superimposed on a map of the magnetic declination angle. Generating this figure requires the Bz300.mat file generated by the IGRF example code. The pass crosses the geomagnetic equator, but because of the changing magnetic field geometry a range of angles with respect to the magnetic field are encountered. This can be seen more directly in Figure 0.2 (book Figure 4.6), which shows the cosine of the angle between the propagation direction and the magnetic field direction (the Briggs-Parkin angle).


Polar angle from vertical reference plane
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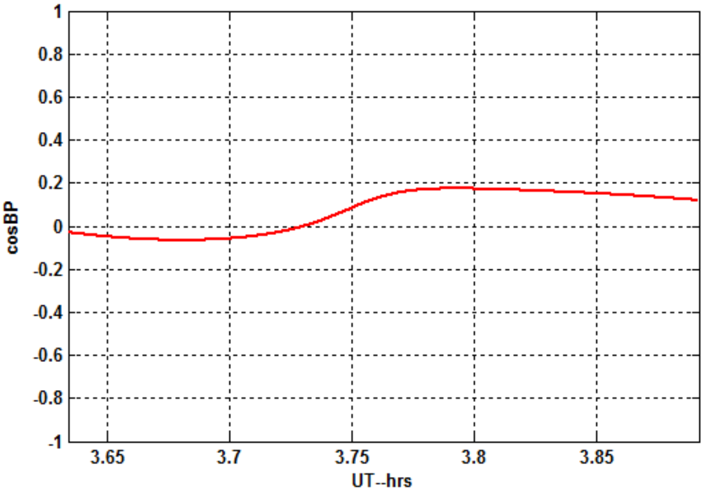
60
40
20
0
-20
-40
-60
-80
Latitude--deg
-150
-100
-50
0
50
100
150
Longitude--deg
80
60
40
20
0
-20
-40
-60
-80


1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
cosBP
3.65
3.7
3.75
3.8
3.85
UT--hrs