Computation of GNSS Satellite Coordinates

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Since satellites have their specefic coordinate system(CRS) and users are intersted in using fix coordiante(TRS) that is why demanding algorithm to trnsport from ECI to ECEF in geodesy. Computing of the satellite coordiante from the navigation messages of GPS is provided as follows.

1 Computation of GPS, Galileo and Beidou Coordinates :

by extracting ephemeris parameters the computing of satllite in epoch coordinae is started. The ephemeris parameters in table 1 and the algorithm are given as follows. **The algorithm**

Parameter	**Explanation 2**
t_{oe}	Ephemerides reference epoch in seconds within the week
$\sqrt{a}$	Square root of semi-major axis
e	Eccentricity
M_0	Mean anomaly at reference epoch
ω	Argument of perigee
i_0	nclination at reference epoch
Ω_0	Longitude of ascending node at the beginning of the week
Δn	Mean motion difference
$\acute{i}$	Rate of inclination angle
$\acute{\Omega}$	Rate of node's right ascension
C_{uc}, C_{us}	Latitude argument correction
C_{rc}, C_{rs}	Orbital radius correction
C_{ic}, C_{is}	Inclination correction
a_0	Satellite clock offset
a_1	Satellite clock drift
a_2	Satellite clock drift rate

Table 1: Ephemeris parameters.

:

1- Compute the time t_k from the ephemerides reference epoch t_{oe} (t and toe are expressed in seconds in the GPS week):

$$t_k = t - t_{oe}$$

if $t_k > 302400s \rightarrow t_k = t_k - 604800s$

elseif $t_k < -302400s \rightarrow t_k = t_k + 604800s$

2- Compute the mean anomaly for t_k :

$$M_k = M_0 + (\frac{\sqrt{\mu}}{\sqrt{a^3}} + \Delta n)t_k$$

3- Solve (iteratively) the Kepler equation for the eccentric anomaly E_k :

$$M_k = E_k - e \sin E_k$$

4- Compute the true anomaly vk :

$$v_k = \arctan(\frac{\sqrt{1-e^2}\sin E_k}{\cos E_k - e})$$

5- Compute the argument of latitude u_k and the radial distance r_k and the inclination i_k with their correction :

$$u_k = \omega + v_k C_{uc} \cos 2(\omega + v_k) + C_{us} \sin 2(\omega + v_k)$$
$$r_k = a(1 - e \cos E_k) + C_{rc} \cos 2(\omega + v_k) + C_{rs} \sin 2(\omega + v_k)$$
$$i_k = i_0 + \acute{i} t_k + C_{ic} \cos 2(\omega + v_k) + C_{is} \sin 2(\omega + v_k)$$
$$\lambda_k = \Omega_0 + (\acute{\Omega} + \omega_E)t_k - \omega_E t_{oe}$$

6- Compute the coordinates in the TRS frame, applying three rotations :

$$\begin{bmatrix} X_k \\ Y_k \\ Z_k \end{bmatrix} = R_3(-\lambda_k) R_1(-i_k) R_3(-u_k) \begin{bmatrix} r_k \\ 0 \\ 0 \end{bmatrix}$$

The resualt is :

(a) ECEF.

(b) ECI.

Figure 2: ECI(b) and ECEF(a) for all GPS satellite.

And in the end if we want to know that our work is true we compare sp3 with navigation by subtracting navigation from sp3 then we can calculate the norm and the resault is given as follows :

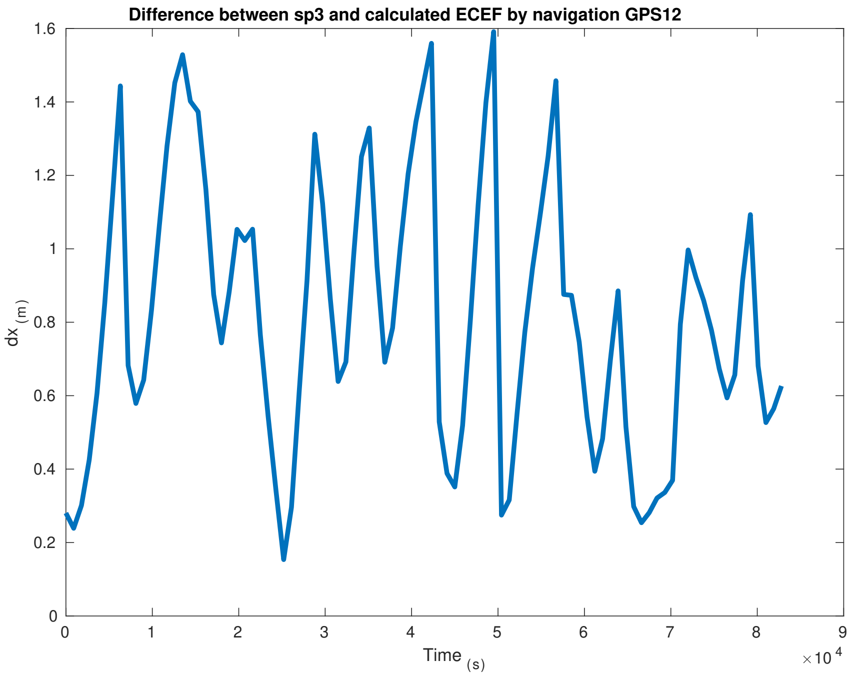

Figure 3: $\sqrt{(SP3^2 - Navigation^2)}$.