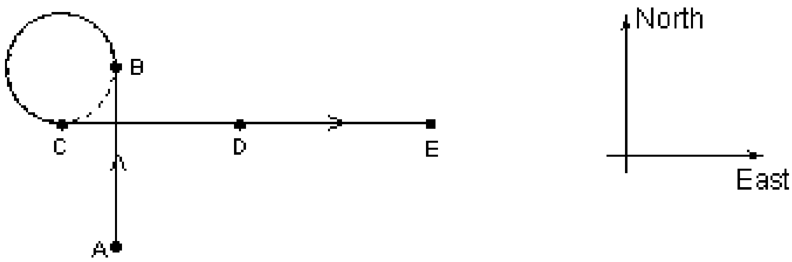
Sistemas de Controlo de Tráfego 2018-19

Project 1 – Receiver positioning in GPS

The project consists of implementing a simulator of an aircraft trajectory with the following major tasks:

- Generation of a GPS satellite constellation for a given pre-defined time with the use of almanacs obtained, for instance, in Celestrak.com.
- Determination of the satellites in view (N_{view}) from a selected location on the Earth surface.
- Determination of the optimum sub-constellation for a certain number of satellites N selectable (with $N_{view} \geq N \geq 4$) using minimization of the PDOP parameter.
- Implementation of the least-squares and extended Kalman filter (EKF) algorithms (models PV and/or PVA) using the pseudoranges with imperfect ionosphere/troposphere corrections as observations.
- Estimation of the receiver's position (latitude, longitude and altitude), velocity (and acceleration for PVA model) using the least-squares and the EKF. Consider the following trajectory ABCDE:



where:

$\overline{AB}$ – Uniformly accelerated motion with acceleration $a = 1\ \mathrm{m}/s^2$ and initial velocity $v_0 = 50\ \mathrm{m}/s$: duration=100 seconds (use mask angle=10 degrees);

$\overline{BC}$ – Circular motion with constant angular speed for 50 seconds (use mask angle=10 degrees);

$\overline{CD}$ – Uniform motion for 50 seconds (use mask angle=10 degrees);

$\overline{DE}$ – Uniform motion for 50 seconds (canyon scenario);

- Performance comparison of the estimation algorithms. Repeat the simulations $N_{sim} = 100$ times with independent Gaussian pseudorange

additive noises and determine the rms values of the receiver's position and velocity estimation errors for each sampling time. Note that, in the least-squares algorithm, the velocity estimates may still be obtained from the adjacent position estimates although with large estimation errors.
If applicable, compare the performance achieved with the least-squares algorithm and the Kalman filtering.

Algorithms to be implemented

- For groups with 1 student
  a) Least-squares algorithm

- For groups with 2 students (optional for groups with 1 student)
  a) Least-squares algorithm
  b) Extended KF (model PV)

- For groups with 3 students (optional for groups with 2 students)
  a) Least-squares algorithm
  b) Extended KF (model PV)
  c) Extended KF (model PVA)

Notes:

The pseudoranges are updated (sampled) at the rate of 1 Hz.

The receiver's initial position (A) has the following coordinates: 40 degrees North, 9 degrees West and altitude h=2000 m. The motion is performed in the horizontal plane.

The path $\overline{DE}$ represents the trajectory in a canyon scenario where only the $N_{view} = 4$ satellites with the higher elevation angles are in view.

The receiver's clock is a quartz temperature compensated oscillator. The clock time errors should be simulated with the usual 2-state model.

The corrected pseudoranges (range and clock drift) of the satellites in view are disturbed by independent, zero-mean, additive Gaussian noises, $n_m(t), m = 1, \dots, N_{view}$, with common variance σ_{noise}^2 (selectable) and by offsets due to the ionosphere equal to $\rho_{iono,m} = 10/\sin\varepsilon_m$ meters that depend on the satellite elevation angle ε_m. That is, the total noise that affects each pseudorange is $n_m(t) + \rho_{iono,m}$.

Analyse the effect of decreasing number of satellites in view on the position and velocity estimates in path $\overline{DE}$, provoked by the canyon, by repeating the simulations but considering now that the angle mask is equal to 10 degrees in the path $\overline{DE}$ (absence of canyon).

Analyse the effect of the ionospheric errors on the position, velocity (and acceleration) estimates, by repeating the simulations with $\rho_{iono,m} = 0$.

Bibliography:

F. Nunes, SCT Notes, IST, 2018.

E. Kaplan, C. Hegarty, “Understanding GPS. Principles and Applications”, second edition, Artech House, Boston, 2006.