SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advanced Space Communications and Navigation Systems (7)

Author: Dr. Martin Espana
National Space Activities Commission (CONAE), Argentina

Mr. Juan Carrizo
Universidad de Buenos Aires (UBA), Argentina
Prof. Juan Giribet
Universidad de Buenos Aires (UBA), Argentina

SENSABILITY AND EXCITABILITY METRICS APPLIED TO NAVIGATION SYSTEMS ASSESSMENT

Abstract

While assessing the performance of an integrated navigation system, the designer may find that certain state components do not converge or their covariances remain large. When implementation errors may be excluded, the lack of accuracy has to be searched both, on the sensors' performance and on the quality of the information embedded in the innovations over a given trajectory stretch. The latter depends on the instrumental configuration, but also on the vehicle's maneuvers.

A sensability measure searches to evaluate the instantaneous accuracy of each component of the augmented state vector (ASV). From a singular value decomposition of the state covariance matrix a "practically sensable" (PS) subspace and its orthogonal complement, the "practically non-sensable" subspace (PNS) are established. The orthogonal projection of each component over the practically sensable subspace becomes its sensability measure.

The excitability analysis aims to quantify the information embedded into the innovations over any trajectory stretch into consideration. This is done off line using a synthetic trajectory determined out of actual flight data. Linearized models of the state deviations and the innovations, referred to the synthetic trajectory, are used for a principal component analysis of the innovation signals. This allows decomposing the starting state space into a practically observable subspace (POS) and its orthogonal complement the practically non-observable subspace (PNS). The orthogonal projection of each component of the starting ASV over the POS becomes a measure of its "excitability" over the considered stretch.

These concepts were applied to CONAEs first navigation and control experiment on board the VS30 suborbital rocket carrying a loosely coupled navigation system integrated with a Motion Pack SD IMU and a GPS.

As expected, position and velocity were practically sensable and excitable along the flight. Since, as shown, the attitude vector's POS and PS both remained orthogonal to the propulsion direction, innovations don't carry information of the attitude component parallel to the propulsion. Moreover, once the latter is turned off the attitude becomes practically non-sensable and non excitable. Similar analysis of the IMU's bias and scale factor induce the conclusion that such a flight requires a high performance UMI with highly stable biases and scale factors or else, include a direct attitude measurement such as a star or a Sun tracker. More conclusions drawn from the experiment are discussed in the paper.