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By Ulrich Gebhardt

Abstract

In the area of research on Synthetic Aperture Radar (SAR), bi- and multistatic constellations of radar transmitter and receivers become more and more important. The spatial separation of transmitting and receiving antenna opens a wide field of new applications, e.g. the use of cheap and less complex receive-only systems with third party's transmitters or forward looking SAR.

The first topic of this work is the complete geometrical description of a bistatic radar experiment involving the TerraSAR-X satellite as illuminator and an airborne radar system as receiver. The challenge of this configuration is the high difference between the platform velocities (app. Factor 80) as well as the fact that the transmitter geometry is ellipsoidal and the earth rotation has to be taken into account, while the receiver geometry is described in Cartesian coordinates.

The idea is to use azimuth antenna steering for the spatial and temporal synchronization of the transmitter and receiver antenna footprints. To compensate for the high velocity difference, the transmitter antenna is operated in a sliding or staring spotlight mode while the azimuth velocity of the receiver's antenna footprint is increased by using inverse sliding spotlight mode.

As a first step, the geometry of both the transmitter and the receiver is described under the assumption of a flat earth and a Cartesian geometry. The goal is to obtain a possibility to calculate the antenna steering angle rate for both platforms. Then the transmitter geometry is modified with respect to the consideration of the earth rotation and the WGS84 ellipsoid to obtain a more realistic description.

The result is used to produce raw data of simulated point targets for a further analysis of parameters like expected azimuth bandwidth and the bistatic range history. Thus, data for testing new bistatic SAR processors is provided.

In the second part of this work, a model based orbit tracker and predictor is introduced. Basis for this algorithm is a linear Kalman filter. A state vector that consists of the satellite's position, velocity, acceleration and higher derivatives of the acceleration in Cartesian coordinates is propagated via a state transition matrix during the prediction cycle of the Kalman filter. The state transition matrix corresponds to a Taylor series of the equation of motion. In the update cycle, the predicted state vector is corrected using weighted measurements. The gradient of a gravitation model evaluated at the predicted position represents an acceleration measurement. Further measurements like e.g. position and / or velocity measurements are included and weighted according to their standard deviation.

This algorithm has the potential to enhance the accuracy of GPS based orbit measurements by a factor of app. 7. For the case that measurements fail for a particular time interval, the missing values can be interpolated using only the information from the gravitation model. Also a short-term prediction can be performed, which is of special interest for the airborne / space borne experiment described above.