Generalized Image Navigation and Registration Method Based on Kalman Filter

Ahmed Kamel[1], Handol Kim[2*], Dochul Yang[2], Chul-Min Park[3], Jin Woo[4]
[1]Kamel Engineering Services, US; [2]Korea Aerospace Research Institute, ROK;
[3]Korea Aerospace Industries, ltd., ROK; [4]Korea Meteorological Administration, ROK
hkim@kari.re.kr

Keyword : INR, Kalman Filter, Orbit Determination, Flight Dynamics System

Image Navigation and Registration (INR) represents a system that determines image pixel location and register it to a fixed grid frame [1]. In this paper, a generalized Image Navigation and Registration method is presented using Kalman Filter (Figure 1. and Equations (1) to (3)). The basic method is landmark-based, self-contained INR system that estimates the orbit in itself (or refines the orbit received from Flight Dynamics). Kalman Filter measurements consist of landmarks observed by the imaging instrument, maneuver delta v from ground operation (or orbit from Flight Dynamics) and attitude from spacecraft telemetry inserted in the imager wideband data. The Kalman Filter state vector consists of spacecraft attitude correction angles, constant attitude correction angle biases, spacecraft orbit position and velocity relative to ideal orbit, instrument misalignments, and constant misalignment biases. The basic method is then shown to be extended to systems using star and landmark measurements, systems using star only measurements with orbit provided by Flight Dynamics or GPS, and systems with attitude rate inserted in the imaging instrument wideband data. Simulation results of this new method are also presented.

Image Navigation Using Kalman Filter

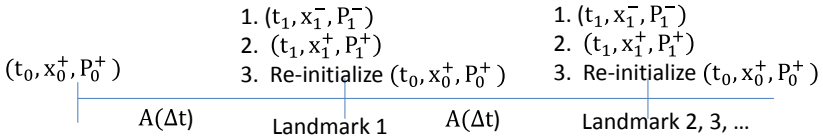

Figure 1. Kalman Filter for INR

$$x_1^- = A(\Delta t)\, x_0^+,\ P_1^- = A(\Delta t)\, P_0^+ A(\Delta t)^T + Q(\Delta t) \quad (1)$$

$$x_1^+ = x_1^- - K\Delta Z^-,\ \Delta Z^- = Z - \bar{Z} \quad (2)$$

$$K = P_1^- H^T (H P_1^- H^T + R)^{-1},\ P_1^+ = (I - KH)\, P_1^- (I - KH)^T + KRK^T \quad (3)$$

, where A is state transition matrix, P is error covariance, Q is process noise covariance, R is measurement noise covariance, K is gain matrix, and H is observation model.

Image Registration Using Resampling

Resampling of level 1A imagery pixels in the frame of image acquisition geometry to level 1B pixels in the fixed grid frame requires knowledge of the pixel time t_i and the INR state vectors $x_i$computed at t_i from the INR state vectors time series. These time series are determined from Kalman Filter time series which represent points corresponding to time at landmarks, stars, end of block, maneuvers (or Flight Dynamics orbit determination) and attitude time series from spacecraft telemetry which is at higher frequency than landmarks and stars. The resampling time can be significantly reduced by selecting few anchor points distributed over the level 1A block and transferring them to the fixed grid frame. The rest of the level 1A pixels can then be determined by linear interpolation between the selected anchor points. Level 1B pixels are obtained by resampling the level 1A pixels to the fixed grid.

References

[1] Kamel A.A.: GOES Image Navigation and Registration System, SPIE, 2812, pp 766-776, 1996.