Comparison of Weighted Backvalues Least Squares and NOGA Track Estimators for Airborne Remote Sensing Applications

Neena Imam Jacob Barhen David Reister

Center for Engineering Science Advanced Research
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6016
barhenj@ornl.gov

and

James Kiessling Charles Glover

Missile Defense Agency
Washington, DC 20301-7100
james.kiessling@mda.osd.mil

Submitted to:

SPIE International Symposium

Remote Sensing 2004

Canary Islands, Spain
13-17 September 2004

This work was supported by the Missile Defense Agency of the Department of Defense (NI, JB, DR) and partially by the Materials Science and Engineering Division of the Department of Energy (JB) under contract number DE-AC05-00OR22725 with UT Battelle

Comparison of Weighted Backvalues Least Squares and NOGA Track Estimators for Airborne Remote Sensing Applications

Neena Imam Jacob Barhen David Reister

Center for Engineering Science Advanced Research
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6016

and

James Kiessling Charles Glover

Missile Defense Agency
Washington, DC 20301-7100

Abstract

The rapid growth and sophistication of airborne surveillance technology have spurred intense research efforts in the development and implementation of tracking algorithms capable of processing a large number of targets using multisensor data. In this paper, a novel tracking algorithm, the NOGA tracker, is presented and compared with the more conventional Time-Weighted Backvalues Least Squares (TWBLS) estimator for accuracy (numerical and phenomenological), ease of implementation, and time performance. The latter is important, since the resolution and throughput of modern sensors can lead to substantial data processing requirements. The NOGA tracker combines model predictions and sensor measurements to produce best estimates for quantities of interest. State estimation involves a fast, nonlinear Lagrange optimization in which the inverse of a global covariance matrix is used as the natural metric for the Bayesian inference that underlies the combining process. The model used here is a simple second order auto regression. The NOGA tracker explicitly incorporates sensor and model uncertainties in the estimation process, and uses model sensitivities to propagate the associated covariance matrices accurately and in a systematic way. The algorithm produces best estimates of the model parameters and responses, while simultaneously reducing the corresponding uncertainties.

Three different sensor architectures for estimating target azimuth and elevation are discussed. First, we consider a baseline single-target-single-sensor benchmark architecture, where random observations derived from an analytical model are reported with an expectation rate of 33 Hz. Azimuth and elevation estimates as functions of time are computed for both TWBLS and NOGA. The latter is shown to exhibit superior accuracy. The second architecture is a common multisensor architecture implemented in many airborne surveillance systems. Here, the sensors are differentiated in tracking and acquisition sub-groups, with the tracking sensors possessing smaller integrated fields of view. The sensors are asynchronous and provide data to the estimators in a random order. The sensor data fusion is performed by a weighting factor that grants more weight to most recent data and data from the tracking sensors. The computational burden and the numerical accuracy of both algorithms are discussed. The third architecture is more advanced and incorporates a track fusion node where the trackfiles received from the acquisition and the tracking sub-groups are fused in one global trackfile. The track fusion technique is based on the weighted covariance fusion model. The estimation uncertainties associated with the individual trackfiles are further reduced after fusion hence providing improved tracking accuracy. The presentation of the algorithms includes description of the models, underlying mathematical assumptions, and resulting range of problems to which they are applicable. The issues of multitarget multisensor tracking in a cluttered environment and object-to-track association optimization are also addressed.