Adaptive Nonuniformity Correction in Focal Plane Array Sensors for Infrared Imaging

Md Saifur Rahman
3rd year, B. Tech. Student
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
West Bengal- 721302, India

Guided by
Majeed Hayat
Associate Professor
Electrical and Computer Engineering
University of New Mexico

Abstract

This report presents both calibration-based (two-point calibration) and scene-based (Kalman filtering and multiple-model adaptive Kalman filtering) techniques and their performances for nonuniformity correction (NUC) in infrared focal-plane-array sensors assuming both linear and *S*-shape detector response models. Two-point calibration performs radiometrically accurate NUC; however, it increases the weight and the size of the camera or imaging system because of the inclusion of a reference blackbody radiation source with the imaging system. Moreover, since the fixed-pattern noise drifts temporally, repeated calibration is required, which halts the normal camera operation. Scene-based Kalman-filtering technique, on the other, is a statistical approach for adaptive estimation of the gain and bias nonuniformity in infrared focal-plane -array sensors from scene data. The gain and the bias of each detector are regarded as random state variables, modeled by discrete time Gauss-Markov process. This model captures the slow and random temporal drift in the fixed-pattern noise. With the known temporal stochastic model for each detector's gain and bias, Kalman-filtering can be derived that use the detector's readout values to optimally update the detector's gain and bias estimates as these parameters drift. However, in the Kalman-filtering technique, there are uncertainties associated with nonuniformity parameters. There is need to assign initial values for the means and variances of the gain and the bias, the drift parameters, readout noise and the irradiance range. The multiple-model adaptive Kalman-filtering technique estimates the nonuniformity parameters even in the presence of uncertainties associated with the parameters of the system models. The algorithm is based on a bank of several parallel and independent Kalman filters, each of them performs their own estimation of the gain and the bias. The final estimates of the state variables are the weighted summation of all the individual estimates. The weights correspond to the maximum *a posteriori* likelihood of each model and are computed using the likelihood functions of the residuals of each filter. The weighting factors are updated iteratively between the sequences of data. Assuming an *S*-shape detector response model (recently proposed by Zhou *et al*.) the performance of the NUC techniques can be improved. First, the nonlinear image data is transformed into linear data and then normal NUC algorithms are applied. The *S*-shape

model overcomes the influence of nonlinearity of the detector’s response. Moreover, it enlarges the correction precision and the dynamic range of the response. The performances of the different nonuniformity correction techniques are demonstrated with real infrared data. In addition, the ability of the multiple-model adaptive Kalman filtering technique to adaptively estimate the system states is tested using the infrared data corrupted with simulated nonuniformity. Moreover, it is shown that the multiple-model technique is able to capture the unequal nonuniformity parameter drifts between the blocks.