EARTH OBSERVATION SYMPOSIUM (B1)
Interactive Presentations (IP)

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IDENTIFICATION AND QUANTIFICATION OF GEOMETRIC ERROR SOURCES IN SATELLITE IMAGE DATA

Abstract

Even with state-of-the-art on-board Guidance, Navigation and Control (GNC) algorithms, spacecraft pointing knowledge accuracy and performance are often limited by the error in the on-board knowledge of the spacecraft parameters (e.g. sensor, actuator and payload alignments, delays in the system, etc.). For Earth observation missions, this results in reduced raw image quality. Consequently, further on-ground processing of the data is necessary to improve the final image quality using, as references, easily-recognisable Earth features, so-called ground control points (GCPs). Although raw images of poor quality can usually be corrected on ground using geometric correction algorithms and several GCPs, this process requires time and increases the data latency between the image acquisition and its availability to the end users. Improving the quality of the raw image data delivered directly by the satellite would yield a faster and more accurate processing of the images.

The Geometric Error Source Identification and Quantification (GESIQ) study was undertaken, with the financial support of the Canadian Space Agency, to develop innovative techniques, algorithms and software, to improve the on-board and on-ground knowledge of the spacecraft parameters by identifying and quantifying the geometric error sources in the satellite and payload starting from measured geometric errors determined on ground using GCPs. This improved knowledge of spacecraft parameters would then be used to update the parameters of the on-board software (e.g. GNC software) and/or to add on-board models that can compensate on-board sources of errors, thereby improving the spacecraft pointing knowledge accuracy and performance and, hence, the raw image quality.

The GESIQ study includes two main innovations compared to existing techniques.

1. Extended Kalman Filter theory (EKF) is used for the estimation of the spacecraft parameters from the measurement of geometric errors in the images.
2. The knowledge of the geometric error sources is used to improve the on-board knowledge of the spacecraft parameters.

The paper presents an overview of the GESIQ study. First, it describes an analysis performed to determine which spacecraft parameters are observable from geometric errors in the images. Then, it presents the EKF-based algorithm developed to identify and quantify the geometric error sources. Finally, the paper highlights the main results from the demonstration of the technique by simulation including a discussion on the accuracy with which spacecraft parameters can be estimated from geometric errors and on the gain in spacecraft pointing knowledge and performance that can be achieved by using this improved parameter knowledge on board.