Submission to IGARSS 2009, Capetown, South Africa
Paper No. 2879

INVERSION ALGORITHM FOR ESTIMATING RADIO FREQUENCY INTERFERENCE CHARACTERISTICS BASED ON KURTOSIS MEASUREMENTS

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Abstract

Microwave remote-sensing measurements made at L-, C-, X- and even K-Band are susceptible to man-made Radio Frequency Interference (RFI) signals (*e.g.* Li *et al*., 2004; Njoku *et al*., 2004; Njoku *et al*., 2005; Li *et al*., 2006; Ellingson and Johnson, 2006). Many analog and digital techniques have been developed that use spectral or temporal gridding to detect RFI (Niamsuwan *et al*., 2005; Guner *et al*., 2006; Piepmeier *et al*., 2008; Misra and Ruf, 2008). The kurtosis detection algorithm uses statistical techniques to identify RFI corrupted data (Ruf *et al*., 2006). The algorithm checks the normality of the incoming natural thermal emission by measuring higher order central moments of the pre-detection voltage and calculates the kurtosis by taking the ratio of the 4^{th} central moment to the square of the 2^{nd} central moment. If the ratio deviates from 3, then the data contains non-gaussian (likely man-made) interference and is tagged as being RFI-corrupted.

RFI at L-Band often originates from radars and is modeled as a pulsed-sinusoidal signal. The detectability of the kurtosis algorithm is dependant on the duty-cycle and strength of the RFI (De Roo *et al*., 2007). The kurtosis detection algorithm performs better with higher strength RFI and with low duty-cycle signals. The accumulation period over which the central moments are calculated influences both the time-average strength and the effective duty cycle of the RFI and, thus, the performance of the kurtosis detection algorithm. If the duty-cycle and strength of the RFI are known, an optimum accumulation period can be found to improve detectability. Also, the kurtosis detection algorithm is blind to RFI with a 50% duty-cycle. This handicap can be avoided by varying the sample integration time if the duty-cycle is known. Finally, knowledge of the strength of the RFI can help improve the mitigation process by eliminating only problematic RFI. For example, since soil moisture measurements require a sensitivity of approximately 1K, mitigating a 0.1K RFI biased sample is unnecessary. In addition to the above advantages, obtaining RFI parameters is a useful technique for system identification purposes.

An estimation algorithm has been developed to determine the strength and duty cycle of RFI directly from raw ADD samples. The estimator requires measurements of the central

moments, and hence of the kurtosis, at multiple integration times. A forward model has been developed which predicts the kurtosis for each integration time for a given combination of RFI signal strength and duty cycle. The forward model is inverted by the estimator. Due to the highly non-linear nature of the forward model, three separate inversion techniques were tested. Newton-Rhapson estimation, Genetic Algorithm inversion and Simulated Annealing were used to estimate the power and duty-cycle of RFI from the kurtosis. It is found that the Newton-Rhapson technique, while accurate for the most part, was sensitive to the initial conditions, whereas the Simulated Annealing inversion gave the most robust results. As a result, a combination of the two inversion algorithms is used to accurately estimate the RFI parameters.

An overview of the kurtosis algorithm for RFI detection and mitigation will be presented. A description of the separate inversion algorithms for extracting strength and duty-cycle information will be shown, followed by an analysis of the performance of a combination of the inversion techniques based on empirical data.

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