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Spectral Kurtosis as an RFI mitigation technique for pulsar astronomy

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1 Extended Abstract

Observations of astronomical sources are the sum of many stochastic signals, which have a Gaussian distribution by virtue of the central limit theorem [1]. In contrast, periodic RFI signals have non-Gaussian distributions. Gaussian signals are entirely characterised by their mean and co-variances, which are second-order statistics. Statistics are classified as higher-order when the order is greater than second-order. Higher-order statistics (HOS) can be used to distinguish the Gaussian and non-Gaussian components of a signal. This allows one to identify the non-Gaussian components and, on the basis of this, one can mitigate the RFI.

An example of such a technique is the Spectral Kurtosis (SK) estimator which is calculated using Equation 1 as adapted from [2]. The parameters S_1 and S_2 are the sum of the power over M spectral windows and the sum of the square of the power. The thresholds are calculated using the cumulative and complementary cumulative distribution functions of a Pearson type IV probability function. These are calculated using Equations 56 to 61 in [3].

$$\begin{aligned} \widehat{SK} &= \frac{Md+1}{M-1}\left(\frac{MS_2}{S_1^2}-1\right), \quad \text{where} \\ S_1 &= \sum_{i=1}^{M} P_i, \quad \text{and} \\ S_2 &= \sum_{i=1}^{M} P_i^2 \,. \end{aligned} \tag{1}$$

In [4] the authors optimise the signal to noise ratio (SNR) of pulsars J0835-4510 and J0437-4715 as observed using the MeerKAT radio telescope at L-band. An optimised M value and upper and lower threshold combination for the SK estimator is used. The optimisation is unique to each pulsar. Further, pulsars have non-Gaussian components due to their intermittency. Therefore, the SK estimator is triggered by the pulsar and care must be taken when using it as an RFI mitigation technique. The study shows that a 125% and 116% increase in SNR can be obtained as compared to not conducting any RFI mitigation.

References

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