A Prototype for Real-Time RFI Mitigation for Single-Dish Radio Telescopes

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Radio Frequency Interference (RFI) is a profound obstacle for radio astronomy, corrupting otherwise useful observations. The increase in wireless technologies only serves to exacerbate this issue. Single-dish radio telescopes are especially vulnerable to RFI in comparison to interferometers, which inherently due to the spatial separation of their antennas have less susceptibility to interference. In this paper, we present and prototype a real-time RFI mitigation strategy for complex raw voltage time samples streaming from single-dish radio telescopes. Impulsive RFI is mitigated in the time domain. For narrowband RFI, we perform a Fourier transform, and mitigate in the frequency domain. We use a combination of techniques, include a "robust recursive power" estimator, coupled with strong and weak Bernoulli detectors; median absolute deviation determination and outlier detection; and spectral kurtosis. Corrupted voltage samples are replaced with random Gaussian noise. The prototype successfully mitigates broadband RFI in the time domain and narrowband RFI in the frequency domain.

The astronomical consequences of real-time RFI mitigation are investigated. To conduct the study, 1.28TB of L band 0.16μs complex voltage samples were obtained from the GUPPI backend of the Green Bank Telescope. These observations are of the millisecond pulsar, Pulsar J1713+0747. Preliminary analysis indicates that the RFI-mitigated data produces improved pulsar residuals, compared to both unprocessed data and the current RFI mitigation post-processing software.

The promising results encourage development from prototype to real-time implementation. The Python prototype runs 95x slower than real-time, as it does not utilize any parallel programming. A CUDA implementation wrapped in the Hybrid Task Graph Scheduler software is rapidly being created to exploit parallel structures in the data. Expected speed increases will reduce runtime to real-time.