GRIDflag : A UV plane flagging algorithm for high fidelity interferometric imaging

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We present a UV-plane based flagging algorithm called GRIDflag that enables sensitive radio frequency interferemce (RFI) flagging, and hence high fidelity imaging, in the presence of strong, persistent RFI in radio interferometric observations. RFI is becoming increasingly common, particularly for observations in the 100 MHz – 10 GHz range, due to the proliferation of new communication technologies and satellites, as well as emitters such as power lines, electric motors etc.

Given the sensitivity and science goals of both current and next-generation radio interferometers (such as JVLA, MeerKAT, leading to ngVLA and SKA) the presence of RFI presents a systematic noise floor that determines the sensitivity of the observation. Typically, the strong RFI can be identified in a straightforward manner and is routinely done. However, fainter RFI present in the data can be challenging to detect statistically, and is a systematic contaminant to the visibility data. Since the RFI is systematic, longer integration times on the target of interest will not necessarily yield a more sensitive image, since the noise floor is no longer determined by the thermal noise of the instrument, but rather by the systematic presence of faint RFI. Further, RFI also contributes to a baseline dependent closure error during calibration and self-calibration. This poses a fundamental limitation on the achievable sensitivity, as well as on the accuracy and reliability of the source morphology.

The GRIDflag algorithm operates by identifying RFI in the UV plane, rather than the more common approach of analyzing the time-channel plane of a baseline. Due to the nature of how interferometers work, for a synthesis observation there are typically redundant spacings that sample similar parts of the UV plane. Further, during the process of imaging the UV plane is “gridded” – i.e., interpolated on to a regular grid, and the pixel size of the grid is determined by the field of view. We can thus assume that every point within a single pixel on the grid samples similar spatial Fourier components.

These two insights lead us to a fairly straightforward method of identifying and flagging RFI in the UV domain. Namely, multiple baselines will sample the same UV pixel at *different times*, and typically only a fraction of the UV samples within a single pixel will be affected by RFI. However since they are all sampling similar spatial Fourier components, they should be statistically similar. Given a sufficient redundancy, the RFI affected points can be identified and flagged within a single UV pixel. In practice this is almost always feasible, given the redundant spacings and relatively long observing times (few hours or more). Flagging RFI in such a manner also has the advantage that the UV plane coverage is preserved to a large extent, thus preserving sensitivity to different spatial scales.

In this talk, we discuss in more detail the details of the GRIDflag algorithm, as well as it’s applicability to real world use cases, it’s applicability and limitations. We also discuss the efficacy and computational efficiency relative to extant flagging algorithms. Finally we discuss it’s applicability to computational technologies such as GPUs, as well as future directions to increase efficacy for future telescopes.