Spatial interference filtering : advantages and limitations

Gregory Hellbourg
CSIRO Astronomy and Space Science
Sydney, NSW, Australia

The adoption of active Radio Frequency Interference (RFI) mitigation techniques is indispensable for sensitive radio frequency applications in corrupted environments like RADAR, communications or radio astronomy. Interfering signals can be of various origin : active users of the spectrum, intermodulation products, self generated RFI, etc.

Classic RFI mitigation techniques generally consist in processing the observed signals in the time and / or frequency domains. These approaches can affect the information carried by the Signal-Of-Interest (SOI). Multi-elements systems also allow the implementation of spatial filtering approaches such as adaptive beamforming or subspace projection. The spatial approach is of particular interest as it theoretically allows the recovery of uncorrupted time-frequency data when the intersection between the RFI and the SOI subspaces is empty.

The main limitations of this class of techniques is the quality of estimation of the RFI spatial signature (i.e. the response of the array on the RFI signal only), and the spatial stationarity of the data. The performance of the RFI subspace estimation mostly depends on the distinguishability of SOI and RFI and the data integration time.

The spatial non-stationarity of the data model is generally due to the relative motion between the instrument and the source of RFI (e.g. tracking instrument and moving RFI). This movement induces a phenomenon commonly termed as "RFI subspace smearing" (or "subspace leakage"), causing the dimensionality of the RFI subspace to increase analogously to the amplitude of this movement. Asymptotically, the RFI subspace can span the whole observed data vector space. In the case of "high subspace smearing", i.e. when the dimension of the RFI subspace is much greater than the number of sources of RFI, the SOI and RFI are likely to share a common subspace. An RFI subspace projection might in this case seriously impair the SOI recovery.

An obvious solution to limit the RFI subspace smearing (and improve the performance of spatial filtering) is to reduce the data integration time, reducing therefore the relative motion between RFI and instrument over a snapshot observation. An accurate analysis involving the type of instrument, the system parameters and the RFI non-stationarity allows the derivation of requirements for minimizing the SOI deterioration and maximizing the RFI rejection for spatial interference filtering.