Radio frequency interference (RFI) is a problem for microwave remote sensing of Earth. Although frequency allocations are set aside for passive sensing, RFI can still degrade measurement quality. In some cases radiometer bandwidth exceeds allocated spectrum to reduce measurement uncertainty or spectrum allocations are shared, forcing microwave radiometer to co-exist with terrestrial sources. Low level RFI is particularly detrimental as it can be concealed as natural variability leading to flawed scientific results. RFI detection algorithms have been developed to address the problem. Research into other algorithms is needed to improve upon the sensitivity of existing detection algorithms to various types of RFI. The Sparse Component Analysis (SCA) has been investigated to determine its sensitivity to continuous wave (CW) RFI.

### Sparse Component Analysis (SCA)

SCA is a blind source separation method which seeks to extract $N$ unknown sources from $P$ observations where $P > N$. The sources need to have disjoint supports.

\[
x(t) = A s(t), \quad t = 1, \ldots, T
\]

- **Observations**
- **Mixing matrix** $A$
- **Sources**

\[
x(t) = a_{ij} s_j(t), \quad \forall t, \quad \text{where } j = 1, \ldots, N
\]

No RFI

\[
x(t) = a_{ij} s_j(t) + a_{ij} R_{ij} + a_{ij}^* R_{ij}^* + 2 a_{ij} R_{ij} R_{ij}^*
\]

- **Radiometer horizontal polarization**
- **Radiometer vertical polarization**

\[\tilde{V}_H = \frac{1}{T} \sum_{t=1}^{T} x(t) H \]

\[\tilde{V}_V = \frac{1}{T} \sum_{t=1}^{T} x(t) V \]

\[\tilde{R} = \frac{1}{T} \sum_{t=1}^{T} x(t) R \]

**Methodology**

- **Sources with disjoint supports**
- **Sources mixture**
- **Scatter plot of the mixtures $x_1$ and $x_2$**

Use least squares to estimate columns of mixing matrix $A$.

\[
\text{Least squares: } e_k(t) = \frac{|x(t)^H a_k|}{|a_k|} \quad \text{for } k = 1, \ldots, T
\]

**In practice the source signals are not disjoint in time. Columns of $A$ not easily determined from scatter plot.**

- **Sources with non disjoint supports**
- **Sources mixture**
- **Scatter plot of the mixtures $x_1$ and $x_2$**

### RFI Detection

- The detection criterion is the median of the absolute value of the reconstructed sources, $\tilde{S}_1$ in time.
- The output of SCA are three reconstructed sources in time, $\tilde{S}_1(t), \tilde{S}_2(t), \tilde{S}_3(t)$ where $t = 1, 2, 3 \ldots N$.
- The median of the absolute value of each reconstructed source (median($|\tilde{S}_1(t)|$), $n = 1, 2, 3$) is evaluated. If all medians are greater than a given threshold, RFI is present.

\[
\tilde{S}_1(t) = a_{ij} s_j(t) + a_{ij} R_{ij} + a_{ij}^* R_{ij}^* + 2 a_{ij} R_{ij} R_{ij}^*
\]

\[\text{IF } \text{median}(|\tilde{S}_1(t)|) > a \text{ then RFI detected.}
\]

**Dictionary**

**Sparse Domain Transform**

Represent each source by a linear combination of a few elementary signals (atoms):

\[
x(t) = A s(t) = \sum_{i=1}^{K} c_i(t) \phi_i(t)
\]

\[
|c_i(t)| \leq \tau > 0 \quad \text{quantifies the sparsity of } c_i
\]

**Ideal** $\tau$ for sparsity is 0

**Conclusion**

- Monte Carlo simulations with 1000 time samples are used, along with the structured dictionary and Orthogonal matching pursuit (OMP) algorithm for joint sparse representation, the weighted histogram for matrix estimation and binary masking for source separation.
- Figure shows the performance results of SCA for detection of CW RFI with INR ranging from -15 dB to 2.5 dB.
- The results show perfect to near perfect detection for INR greater than -12.5 dB and very good detection at -12.5 dB and -15 dB.
- Results show that detection works for relatively large INR for CW RFI.

Reference: