2° Forum della Ricerca Sperimentale e Tecnologica

# Monitoring and Mitigation of RFI in Radio Astronomy Using Artificial Intelligence

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## ABSTRACT

One of the major challenges in radio astronomy is mitigating data contamination caused by radio frequency interference (RFI). RFI can originate from a variety of human-made sources, making it difficult to model this complex signal. Strong RFI, when combined with astronomical signals, can render data unusable and requires cleaning through specialized analysis software. This proposal aims to advance the field by exploring new AI-based strategies for RFI mitigation. These algorithms are particularly effective in time series analysis due to their ability to understand and store historical data distributions, which helps identify new anomalies. Additionally, they are well-suited for real-time applications, as they are generally less computationally intensive compared to traditional optimization algorithms.

## OBJECTIVES, RESULTS AND PROGRESS

### Hardware setup

A workstation dedicated to Deep Learning model training has been set up for remote usage with Jupyter/Google Colab [1]. The machine is equipped with the purchase of two GPUs to accelerate the training process. The main configuration includes:

- Linux Operating System: The workstation uses the Linux operating system for enhanced flexibility and compatibility with tools and libraries commonly used in the fields of Machine Learning and Deep Learning;
- Remote Usage with Jupyter Notebooks: Users can remotely access the workstation through Jupyter notebooks. These notebooks run in Docker containers, isolated from the operating system, ensuring a clean and separate development environment. Users can execute their machine learning code in these containers without worrying about conflicts with other applications or services running on the workstation.
- To further streamline the process, the running containers come pre-installed with common dependencies for use with the Keras/Tensorflow framework.

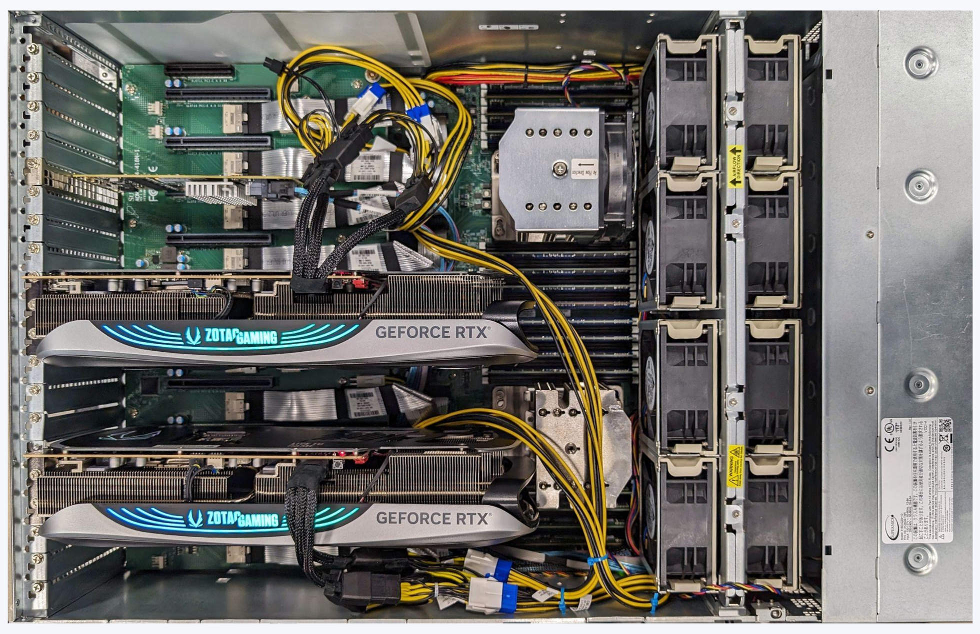

**Figure 1:** Image of the workstation with the 2 GPUs

### RFI Monitoring

In the field of RFI monitoring, an active system is already in place at the Sardinia Radio Telescope (SRT), which uses an additional antenna and a spectrum analyzer [2]. This system periodically saves the captured signal spectra from the area surrounding the radio telescope. Over time, this has enabled the creation of a dataset containing the spectral evolution measured in the vicinity of the telescope.

This dataset will be highly valuable for the development of analysis software. By applying appropriate statistical methods to the data, it becomes possible to track the evolution of the frequency spectrum of interfering signals.

The project is focusing on the study and implementation of AI-based anomaly detection systems to identify new interference in real time, allowing for timely notifications to be sent to the observatories.

In particular, the research is investigating the use of continual learning systems, which would enable the model to continuously update and adapt to changes in the baseline of spectral interference, ensuring that variations are easily accounted for and incorporated into the detection process.

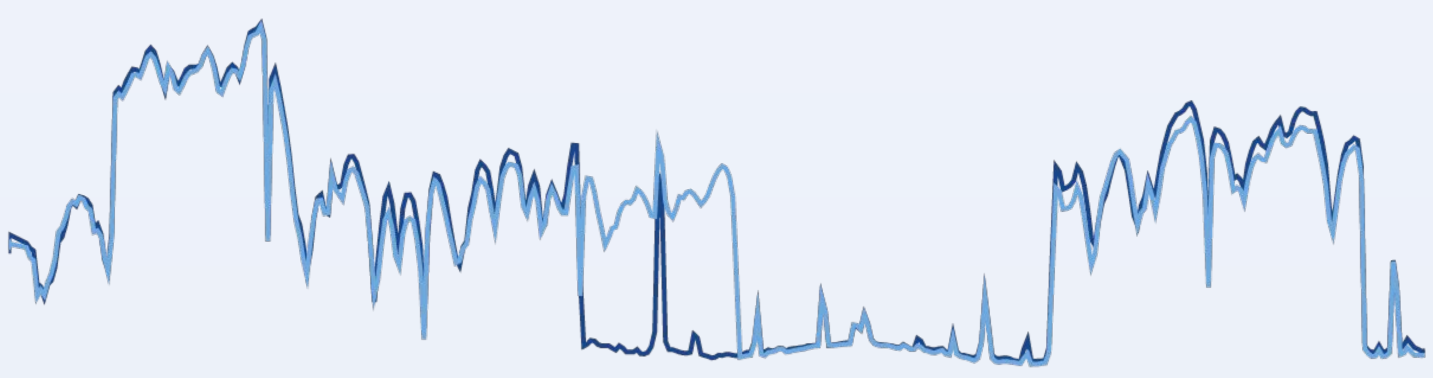

**Figure 2:** General comparison of spectra captured on different days

### Phased-Array Feed adaptive beam-forming

PAF receivers are crucial for RFI mitigation because they offer enhanced spatial filtering capabilities. Pattern synthesis algorithms, based on traditional optimization techniques, are used to determine the weights assigned to each antenna in the array to form the desired observation beam. While these methods are highly flexible, they often converge slowly towards the optimal solution, particularly for large arrays.

In collaboration with various research institutes, an AI-based module is being developed to improve RFI mitigation [3] within the beamforming algorithm. Different AI models are being compared to identify which network delivers the best performance in terms of computation time, directive loss, and interference suppression. This analysis aims to mitigate the effects of interfering signals in near real-time by continuously updating the beam pattern with enhanced performance.

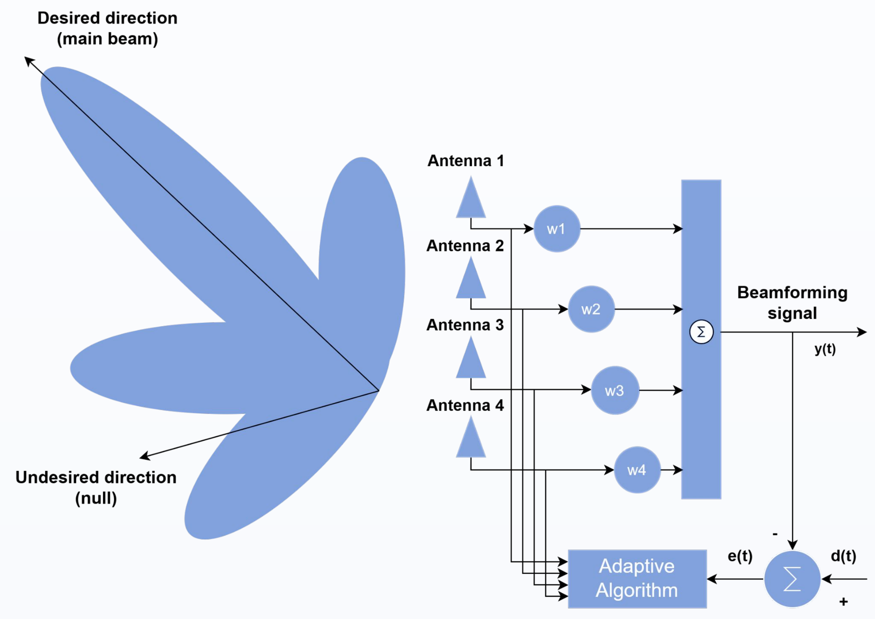


**Figure 3:** Integration of the beamformer in the PAF receiver frontend [4]

## PRACTICAL IMPLICATIONS

The project has several practical implications. The Sardinia Radio Telescope faces RFI issues across various frequency bands used for observations. As mentioned in the previous paragraphs, it would serve as an excellent testing ground for evaluating the performance of the developed formal model, especially after the recent upgrades [5]. Additionally, with the support of astronomers, an application system could be made available for real-world use. These practical implications can also extend to the other two Italian radio telescopes, Medicina and Noto. Furthermore, these systems could have applications beyond the field of radio astronomy, particularly in areas requiring spectrum management and control.

**Figure 4:** The Sardinia Radio Telescope [6]

## REFERENCES

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[6] Photograph by Mike Peel (www.mikepeel.net).

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