Machine Learning for Radio Interferometric Array Design

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Keywords – Radio astronomy - Astrophysics - Machine Learning

The CosmoStat group at CEA Paris-Saclay invites applications for a master student (M2) to work with Ezequiel Centofanti and Dr. Samuel Farrens on machine learning for radio interferometric array design.

CEA Paris-Saclay is located 20km south of Paris, France, in the vicinity of various universities and other research centres. The CosmoStat group is a diverse and multi-disciplinary team of researchers working on various topics in cosmology. Our group is committed to diversity and equality, and encourage applications from women and underrepresented minorities. We support a flexible and family-friendly work environment.

Context

Radio astronomy has witnessed remarkable advancements in recent decades, with radio telescopes achieving unprecedented resolution and sensitivity in deep sky observations. A key driver of this progress are radio interferometers, which combine signals from multiple antennas to achieve superior angular resolution. Unlike single-dish telescopes, where resolution is limited by antenna size, interferometers rely on the maximum separation between antennas (baselines), eliminating the need for large dish reflectors. However, this enhanced resolution comes with increased complexity in image reconstruction. The observations are affected by the array's point spread function (PSF), or beam, which depends on the physical arrangement of individual antennas. To mitigate these effects, "cleaning" methods are employed to deconvolve the interferometer's PSF from the images.

A potential approach to further improve image quality involves optimising the spatial distribution of antennas. This strategy aims to shape the array's PSF, minimising secondary lobes, reducing baseline redundancy, and tailoring the beam shape for the needs of specific scientific applications. By intelligently positioning antennas, it could be possible to enhance the effectiveness of deconvolution algorithms and ultimately improve the quality of radio interferometric observations. This project will focus on investigating the application of machine learning (ML) solutions for optimising the antenna positions for specific scientific goals.

Outline of project objectives

The internship will essentially be comprised of the following tasks and objectives:

1. Get familiarised with radio interferometric observations and deconvolution algorithms.
2. Study how the antennas placement thus, the PSF, impacts the imaging process in the context of different science cases.
3. Review the current state-of-the-art on antenna placement for radio interferometers.
4. Propose a machine learning solution for optimising the antenna distribution for specific scientific goals.

Candidate

The candidate should be a Master 2 (or equivalent) student with background in either physics/astrophysics or applied maths/signal processing/data science. Knowledge of machine learning methods would be a plus. Experience with Python is not required, but would be advantageous.

Internship

The internship will take place in the CosmoStat laboratory, under the supervision of Ezequiel Centofanti and Samuel Farrens.

- *Deadline for applications:* December 12th, 2024.
- *Contact:* Samuel Farrens (samuel.farrens@cea.fr), Ezequiel Centofanti (ezequiel.centofanti@cea.fr).
- *Duration:* 4-6 months.
