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**A NEW ENTROPY-BASED STRATEGY FOR THE INVERSE DESIGN OF A RADIO INTERFEROMETRIC ARRAY**

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**Abstract -** Radio interferometric arrays measure the Fourier transform of the sky brightness distribution in a finite set of points that are determined by the cross-correlation of the different pairs of antennas in the array. The sky brightness distribution is reconstructed by the inverse Fourier transform of the sampled visibility. The quality of the reconstructed images strongly depends on the array configuration, since it determines the sampling function. This work proposes a new optimization strategy for the array configuration that is based on the entropy of the response function in both the Fourier and spatial domains. A stochastic optimizer, the Ant Colony System, employs entropy information to iteratively refine the candidate solutions. The proposed strategy was developed for the Brazilian Decimetric Array, a radio-interferometric array that is currently being developed for solar observations at the Brazilian Institute for Space Research (INPE). Configurations results for an optimized configuration are presented and compared to the results obtained using a standard configuration approach.

## 1. INTRODUCTION

A radio interferometric array measures the Fourier transform of the sky brightness distribution in a finite set of points that are determined by the cross-correlation of the different pairs of antennas in the array. Each pair measures a specific Fourier component, according to the distance between the antennas, the frequency of observation and incident angle. The sky brightness distribution is reconstructed by the inverse Fourier transform of the sampled visibility, i.e. the set of sampled points. The quality of the reconstructed images strongly depends on the array configuration, since it determines the sampling function. The optimization of the array configuration has exponential complexity. Several strategies are found in the literature [1-3] in order to improve the quality of the final image. This work proposes a new optimization strategy for the array configuration that is based on the entropy of the response function in both the Fourier and spatial domains. A stochastic optimizer, the Ant Colony System, employs the entropy information to iteratively refine the candidate solutions. The criterion adopted for the optimization is to obtain a set of sampling points in the Fourier domain that provide a coverage as uniform and complete as possible for the given set of antennas. A further criterion for image quality is to obtain a beam with a narrow high-intensity main lobe and low-intensity side lobes from a point source in the zenith of the sky. The proposed strategy was developed in the scope of the Brazilian Decimetric Array, a radio-interferometric array that is currently being developed for solar observations at the Brazilian Institute for Space Research (INPE). Configuration results for an optimized configuration are presented and compared with those obtained using a standard approach. The resulting coverage in the Fourier domain, the beam corresponding to a point source (point spread function), and some simulations using Solar image data from the Nobeyama radioheliograph (Japan) are shown.

## 2. RADIO INTERFEROMETRY

A radio telescope is an instrument that allows observation of the radiation signal intensity generated by astronomical sources in the sky. It provides data related to the variation of the signal intensity in function of time, frequency and/or angular position of the source. The angular resolution of a radio telescope is given by:

$$R \approx \lambda / D \tag{1}$$

where $\lambda$ is the wavelength of the electromagnetic wave plane, and $D$ is the diameter of the antenna dish. In order to improve this resolution the diameter of the antenna must be increased. However, there are practical limitations to construct large dishes in radio astronomy. An alternative for improving this resolution is to use a radio interferometric array, which is composed of two or more radio telescopes that simultaneously observe the signal from astronomical sources. Henceforth, it will refer to each radio telescope of the radio interferometric array as being an antenna.

A radio interferometric array measures the Fourier transform of the sky brightness distribution, the source image $I(x,y)$, producing a set of points in the Fourier domain $(u,v)$ that can be expressed by the visibility function $V(u,v)$ defined as follows [4]: