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Conditional Denoising Diffusion Reconstruction of Radio Astronomical Images

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In this work, we apply a novel approach for the reconstruction of radio astronomy images from uv-observations using guided diffusion. We use the Common Astronomy Software Applications package (CASA) to simulate data from Atacama Large Millimeter Array (ALMA). Our approach is based on denoising diffusion probabilistic models (DDPMs), which are effective at capturing the prior distribution given observations. We condition the model on the magnitude and phase of samples in the uv-space. By conditioning the model in this way, we are able to generate corresponding reconstructed images from noise realizations of the same size as reconstructed images and estimate both the localization and intensity of sources. The imaging process represents an information lossy operator, and thus the reconstruction is characterized by uncertainty. That is why, using a stochastic nature of the DDPMs, one can produce multiple realizations of reconstructed images for a given observation, which can be used for uncertainty estimation. To the best of our knowledge, this is the first time that DDPMs have been applied to radio UV data from ALMA generated using CASA. Our results demonstrate the potential of using stochastic generators for future analyses of radio astronomy data e.g., the Square Kilometer Array.

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