

Machine Learning and Super resolution for radio astronomical data analysis

INAF AI SCHOOL, Naples
14th-17th April

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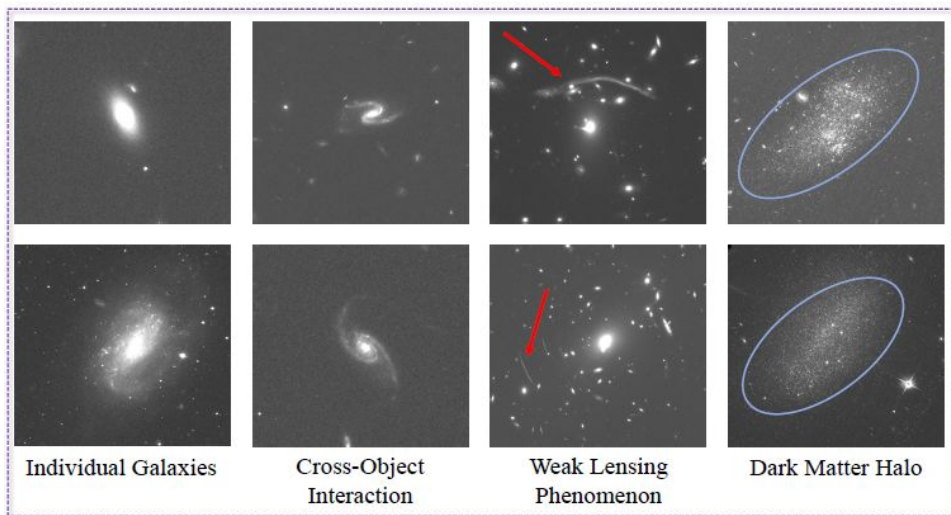


Overview

1. Big Data in astrophysics and HPC
2. Machine Learning models for Super resolution tasks
3. 3D Visualization

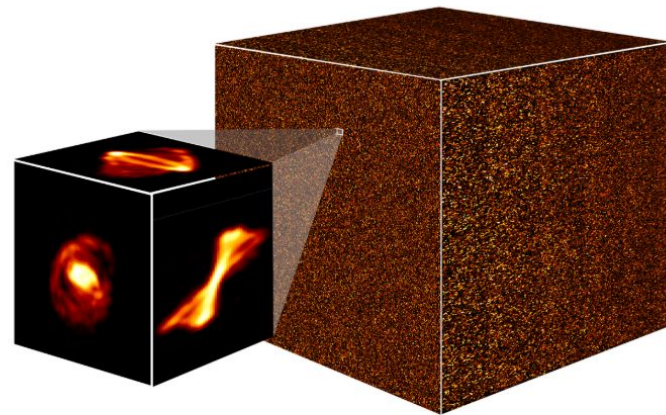


Radio astronomical data



(b) STAR Dataset Examples

Wu, Kuo-Cheng, et al. "Star: A benchmark for astronomical star fields super-resolution." *arXiv preprint arXiv:2507.16385* (2025).



3D Data cube from SKA Data challenge 2.

Machine Learning models for Super resolution tasks: 2D case

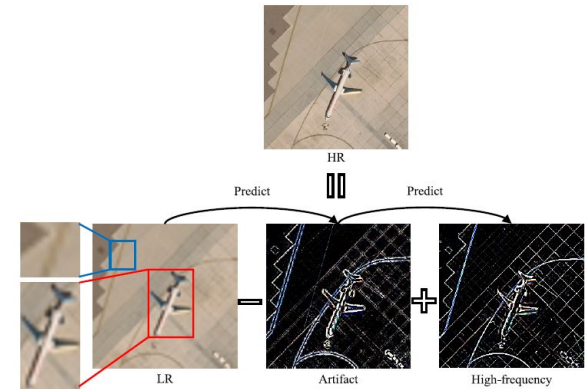
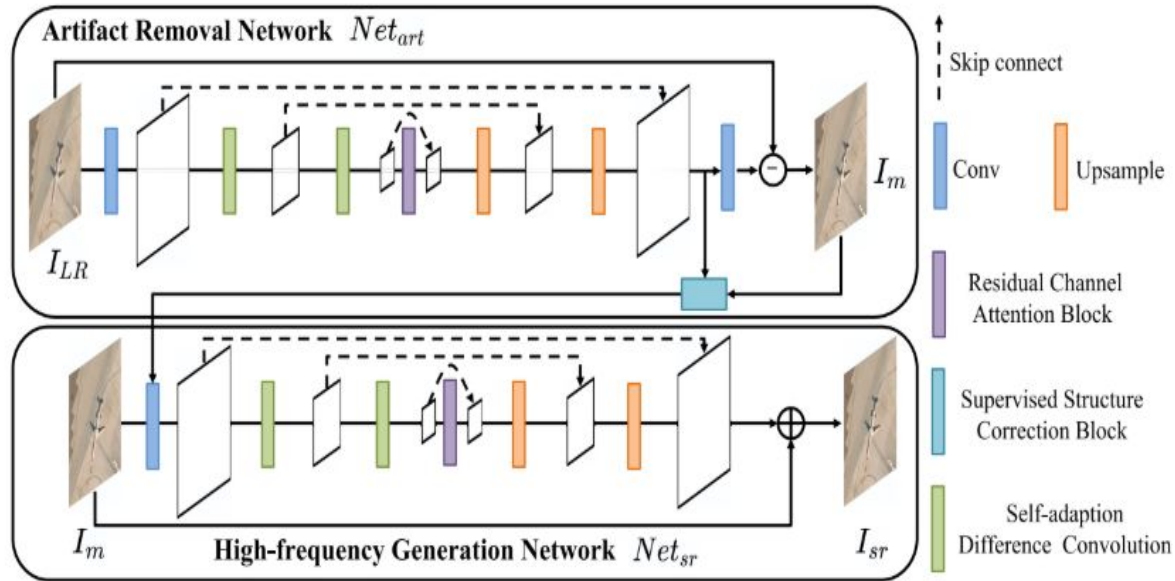


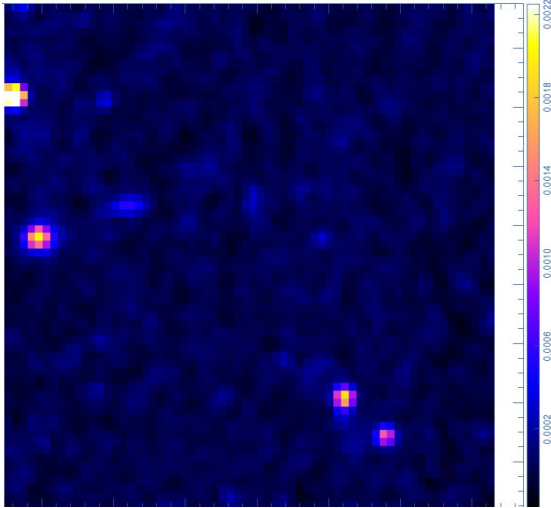
Fig. 1. Proposed SR strategy. We decompose information from a HR image into LR information, artifact information, and high-frequency information. Note that the artifact map and the high-frequency map are similar in structure and complementary in detail.

Machine Learning models for Super resolution tasks: dataset

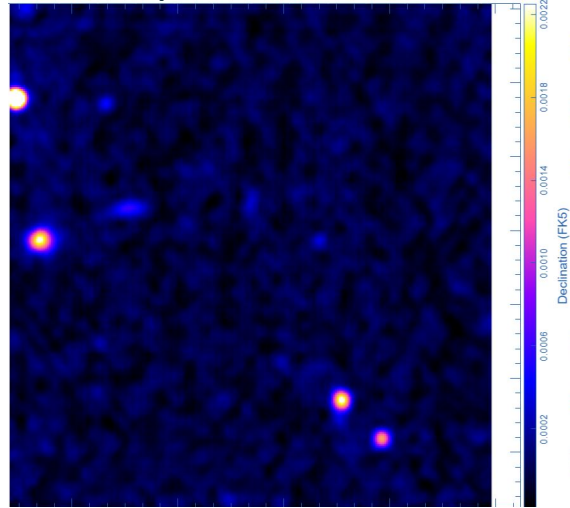
	Train set	Test set	Resolution
Original dataset (.tif)	1890	210	256x256
Astro dataset 1 (.fits)	1890	210	256x256
Astro dataset 2 (.fits)	1100 (data augmentation)	100	not fixed
Astro dataset 3 (.npy)	1890	110/110 (validation/test)	256x256

Machine Learning models for Super resolution tasks: astro dataset 1

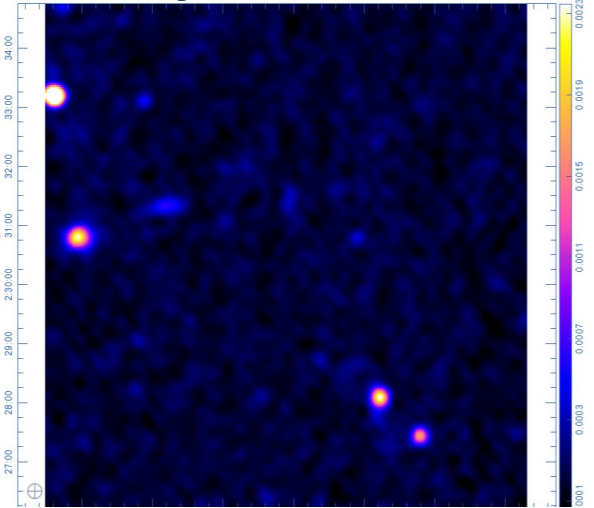
Low Resolution



Super resolution



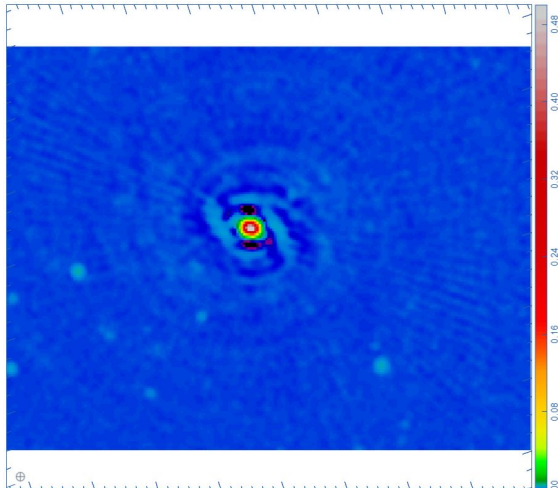
High resolution



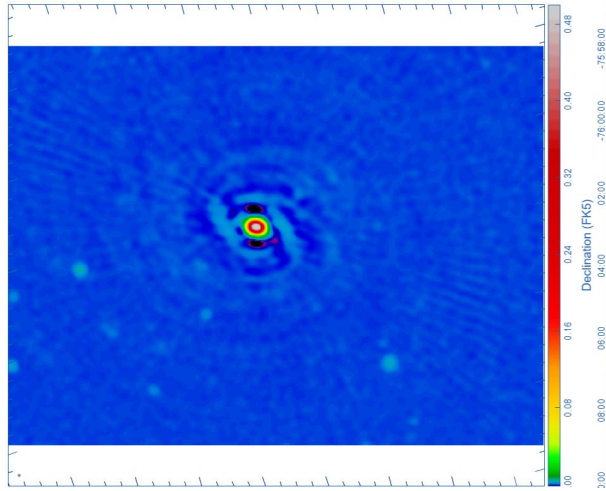
Source ASKAP EMU project. Patch size = 256x256.

Machine Learning models for Super resolution tasks: astro dataset 2

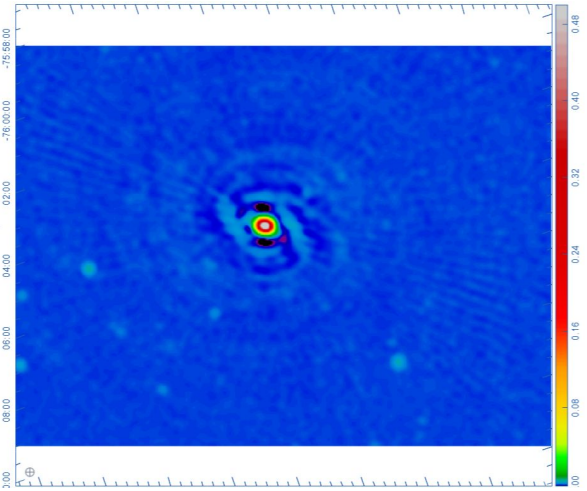
Low Resolution



Super resolution



High resolution



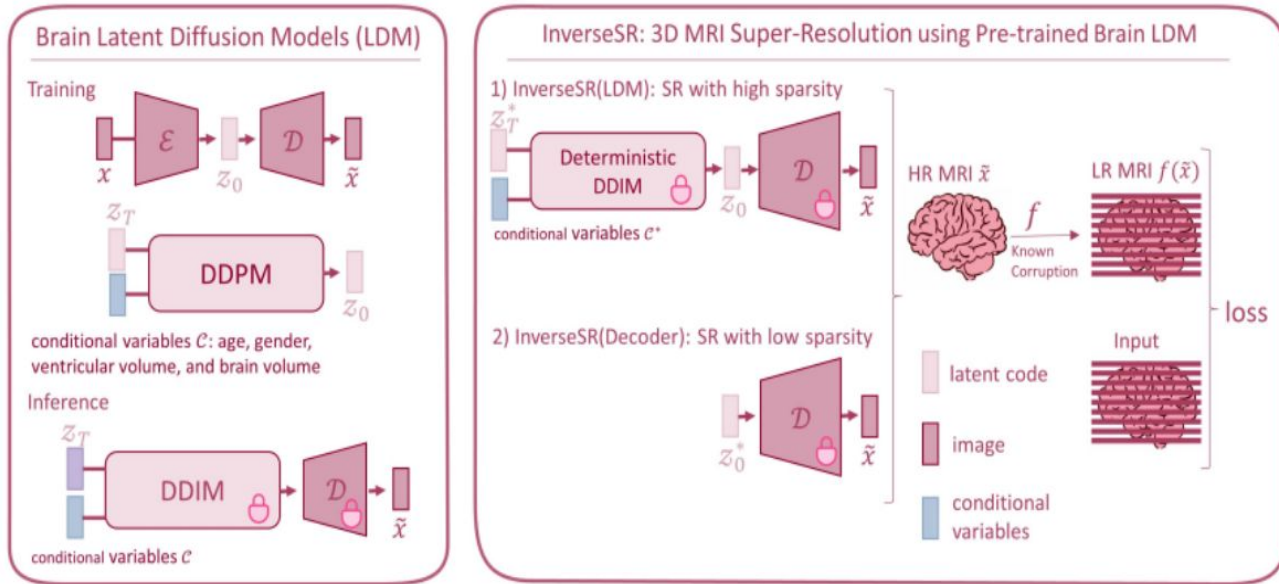
Source ASKAP EMU project.

Machine Learning models for Super resolution tasks: 2D case conclusion

dataset	ASKAP artifact manually cropped	ASKAP 256x256	STAR
epochs	1500	2000	1500
batch size	16	16	16
patch size	64	64	64
Average PSNR on 110 data	34.34 dB	33.79 dB	33.71 dB
Average SSIM on 110 data	0.7140	0.7029	0.7025

HPC resources: 1 GPU of Leonardo Booster.
Average Training Time: 5 hours

Machine Learning models for Super resolution tasks: 3D case



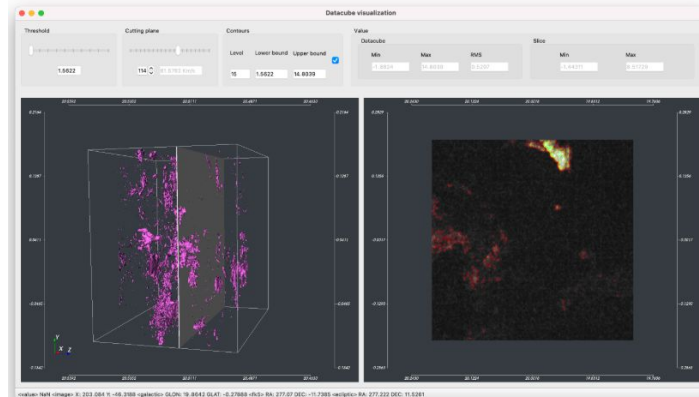
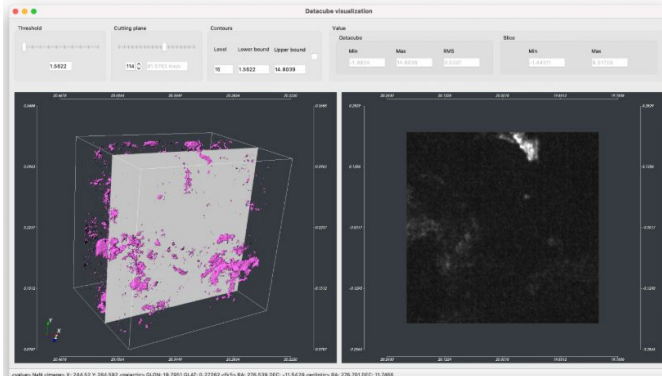
Wang, Jueqi, et al. "Inverser: 3d brain mri super-resolution using a latent diffusion model." *International conference on medical image computing and computer-assisted intervention*. Cham: Springer Nature Switzerland, 2023.

Final goal: 3D Visualization

VisIVO (<https://visivo.readthedocs.io/en/latest/>)

- **VisIVO Server** is a suite of software tools for creating customized views of 3D renderings from astrophysical data tables.
- **VisIVO Visual Analytics** is aimed at exploiting astrophysical surveys of the Galactic Plane to study the star formation process of the Milky Way. The tool combines different types of visualization to perform the analysis exploring the correlation between different data, for example 2D intensity images with 3D molecular spectral cubes.

IdaVIE (Immersive Data Visualisation Interactive Explorer): The specific goal of iDaVIE is to enable the interrogation of 3D data using virtual reality technology. (<https://idavie.readthedocs.io/en/latest/>)



Thank you for your attention!

Questions?