Challenging radio-astronomy imaging

a direct source localization from uv-plane observations

Olga Taran, Omkar Bait, Daniel Schaerer, Miroslava Dessauges,
Taras Holotyak and Svyatoslav Voloshynovskyy

Departments of Computer Science & Astronomy
University of Geneva

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Département d'informatique

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Département d'astronomie

October, 2022

Sources' localization: classical pipeline

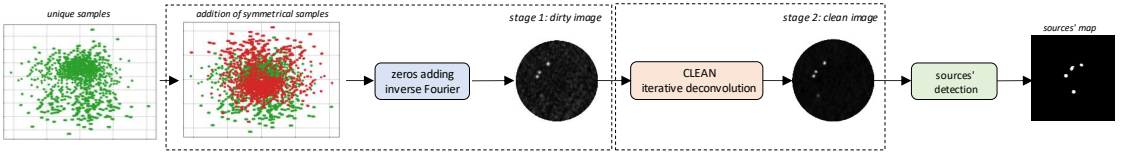
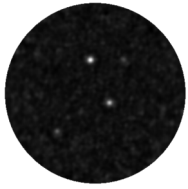


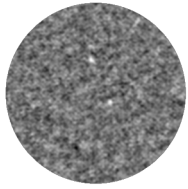
Figure: Schematic representation of the classical pipeline (CLEAN - complex and computationally expensive iterative deconvolution algorithm)

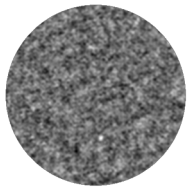
Research question

- Source localization directly from uv-plane observations omitting the sky model reconstruction (dirty & clean)
  - **?** efficiency
  - **?** time complexity

Simulated data (CASA $\rightarrow$ ALAM)





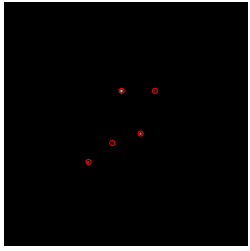


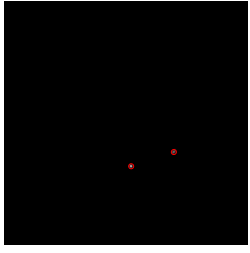
True sky models

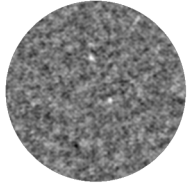
Noiselses

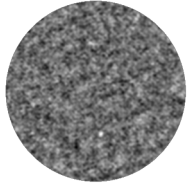
Noisy

Simulated data (CASA $\rightarrow$ ALAM)









True sky models

Noiselses

Noisy

Sources' localization: proposal pipeline

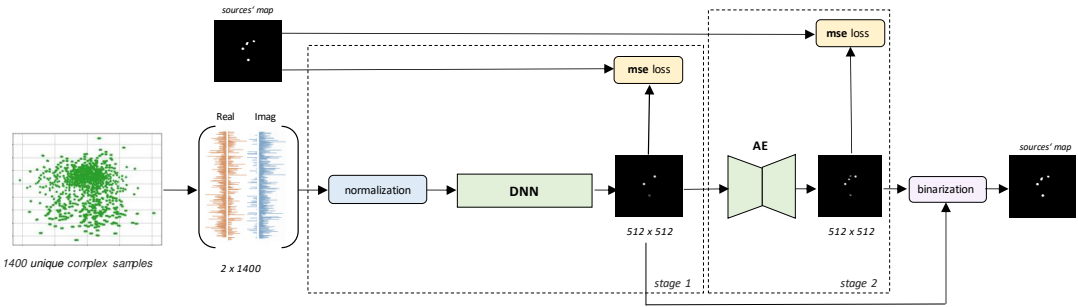
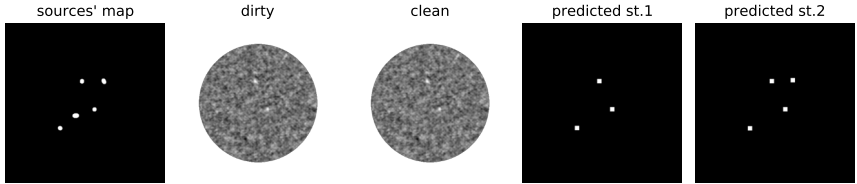
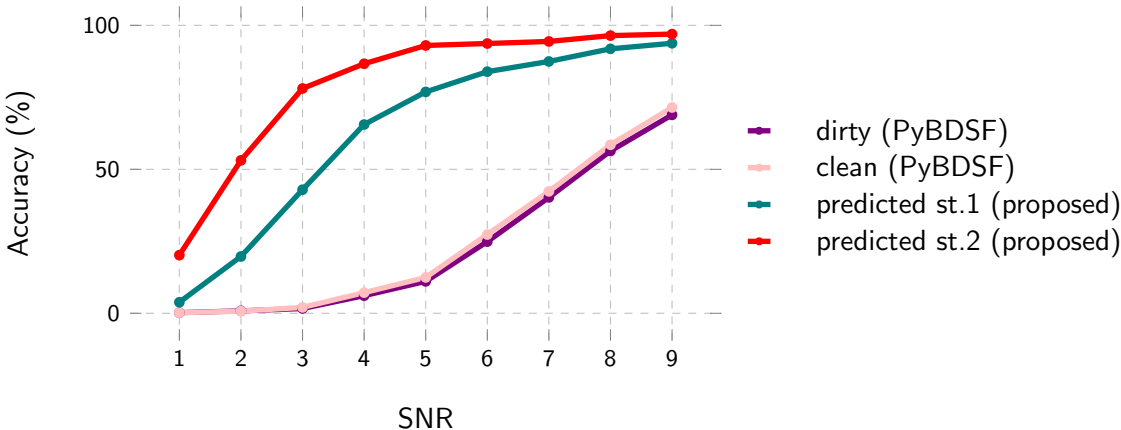


Figure: Schematic representation of the proposed approach

Results: noisy



Results: sources' localization



Summary

Conclusions:

- The proposed approach is more efficient in the presence of noise, especially for the low SNR
- At the inference stage, the proposed approach is in times faster than the classical pipeline

Future work:

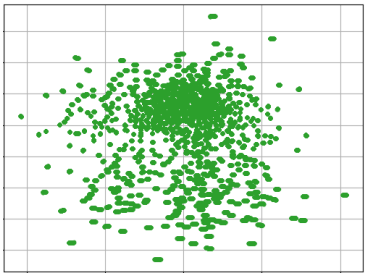
- Reinforcing of the proposed approach by more powerful networks like DDPM and investigation its abilities for the reconstruction / prediction sources' flux intensity directly from the uv-sampled data omitting dirty and clean image construction
- Investigation of optimal sampling for the tasks of true sky model image reconstruction and source localization

Thank you!

Questions?

Data simulations

- Simulation tool - CASA
- Number of antennas: 43
- Number of channels (frequencies): 240
- Total integration time: 20 mins
- Sampling time: 10 secs
- Source type: Gaussian
- Source positions: random
- Number of sources: variable 0 - 5
- Amount of data: (i) 0 sources $\rightarrow$ 1 000 sky models; (ii) 1-5 sources $\rightarrow$ 9 164 sky models
- Noise: (i) atmospheric noise (pwv = 1.796); (ii) receiver noise (expected at the frequency of 230ghz)



UV-plane sampling map

Training parameters

- Train subset: 7331 samples (80%)
- Validation subset: 917 samples (10%)
- Test subset: 917 samples (10%)

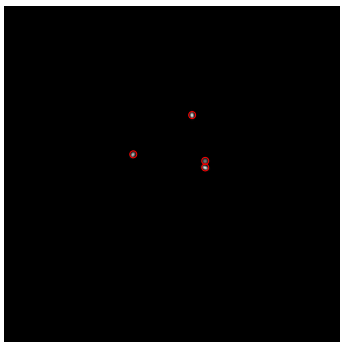
Stage 1:

- learning rate: 1e-4
- batch size: 312
- epochs: 1000

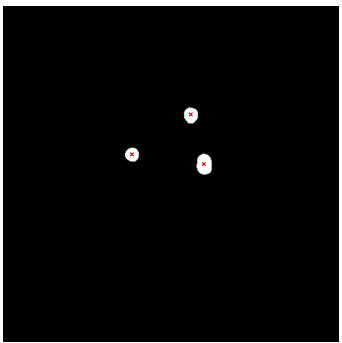
Stage 2:

- learning rate: 1e-3
- batch size: 32
- epochs: 500

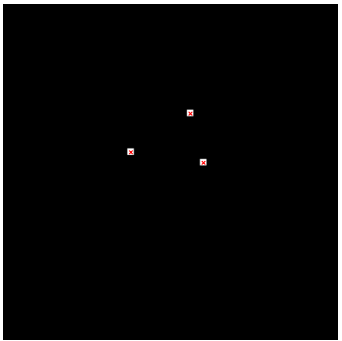
Complicated cases



True sky model



Binarized prediction



Binarized prediction wrt the beam size