Project Theme Number: T6	Academic Supervisor: Prof. Yves Wiaux
Theme Title: Deep Neural Networks for imaging in radio astronomy	
Keywords: sensor arrays, computational imaging, Deep Neural Networks, optimization, radio astronomy	

General Description

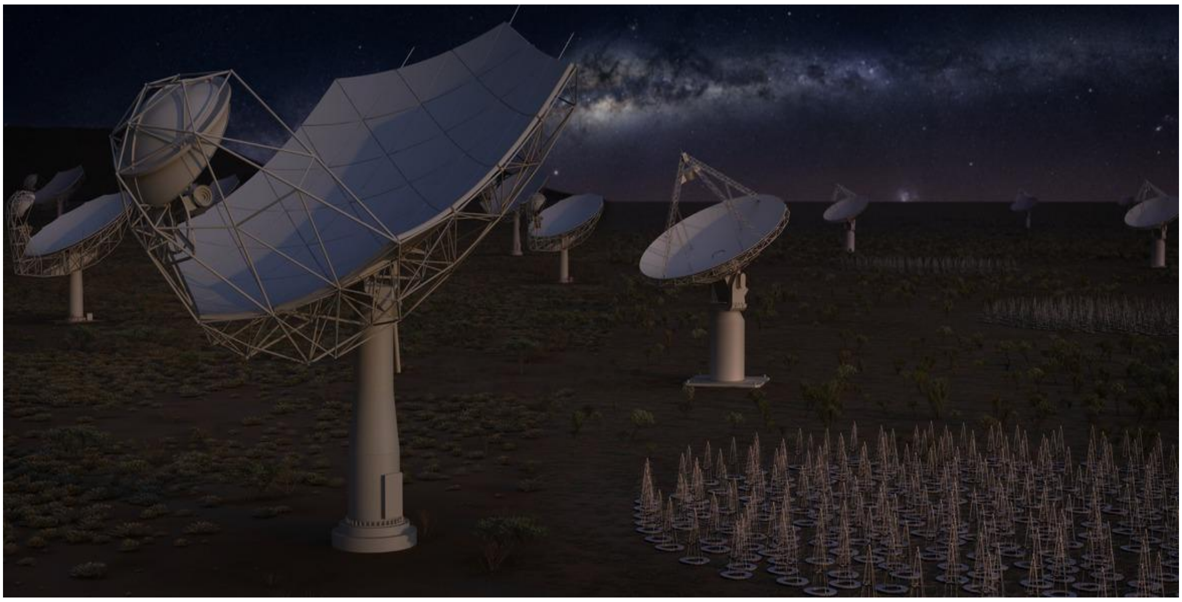

Image: SKA organisation – skatelescope.org

Important sensing modalities in science and technology rely on sampling signals in transform domains, raising an inverse problem for signal recovery and related applications. In this context, powerful computational methods are required to form images from sampled data. This is for example the case in radio astronomy, where telescope arrays can only acquire an incomplete sampling of the sky image of interest in the Fourier domain.

In order to probe new physics, future antenna arrays such as the flagship Square Kilometer Array telescope foreseen for 2023 (SKA, skatelescope.org), are however committed to drastic resolution and sensitivity improvements in a wide-band regime, leading to unprecedented data volumes. In this context, any image formation algorithm to be developed must not only provide robust imaging from highly sub-Nyquist sampling, but also be fast and scalable to extreme data sizes.

State-of-the-art approaches are grounded in the field of optimization theory. The reconstruction algorithms will aim to solve iteratively a minimization problem accounting for both the data acquired and prior information on the image of interest. In the context of extreme data volumes, faster and more scalable algorithms need to be developed, within the context of optimization, or beyond.

Recently, “Deep Learning” has shown to be a very promising framework for large-dimensional problems arising in image segmentation and classification [1]. Convolutional neural networks (CNN), in particular, have shown remarkable results for image recovery [2].

The aim of this project is to investigate the feasibility of the deep neural network architectures to provide a robust and scalable solution for the imaging problem arising in radio astronomy. The project will involve realistic simulations and a study of performance of deep neural networks, with comparison to state-of-the-art algorithms leveraging convex optimization.

References

[1] Lecun et al., “Deep learning”, Nature 521(2015) 436.

[2] Jin et al., “Deep Convolutional Neural Network for Inverse Problems in Imaging”, IEEE TIP 26 (2017) 4509.