Multifrequency Point Source detection with Fully-Convolutional Networks: Performance in realistic microwave sky simulations

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Abstract

Point Source (PS) detection is an important issue for future Cosmic Microwave Background (CMB) experiments since they are one of the main contaminants to the recovery of CMB signal at small scales. Improving its multifrequency detection would allow to take into account valuable information otherwise neglected when extracting PS using a channel-by-channel approach.

Our approach (Casas et al., submitted A&A) is the improvement of PoSeIDoN (Bonavera et al. 2021), a single-frequency method based on Neural Networks and consist on developing an Artificial Intelligence method based on Fully Convolutional Neural Networks to detect PS in multifrequency realistic simulations and compare its performance against one of the most popular multifrequency PS detection method, the matrix filters. The frequencies used in our analysis are the central channels of the Planck mission, i.e 143, 217 and 353 GHz and we impose a Galactic cut of 30 degrees.

To do that, we produce multifrequency realistic simulations of the sky by adding contaminating signals to the PS maps as the Cosmic Microwave Background, the Cosmic Infrared Background, the Galactic thermal emission, the thermal Sunyaev-Zel'dovich effect and the instrumental and point sources shot noises. These simulations are used to train two neural networks called Flat and Spectral MultiPoSeIDoN. The first one considers PS with a flat spectrum and the second one is more realistic and general because it takes into account the spectral behavior of the PS. Then, we compare the performance on reliability, completeness and flux density estimation accuracy for both MultiPoSeIDoN and the matrix filters.

Using a flux detection limit of 60 mJy, MultiPoSeIDoN successfully recover PS reaching the 90% of completeness level at lower flux densities than the matrix filters. To reduce the number of spurious sources, we use a safer 4σ flux density detection limit for the matrix filters, which does not help much to improve these results. With respect to photometry, the recovering of the flux density of the detections is also better for the Neural Networks.

In conclusion, based on our results, Neural Networks are the perfect candidates to substitute

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filtering methods to detect multifrequency PS in future CMB experiments, such PICO or LiteBird.

Slides: PDF
Video: https://youtu.be/nMJem2_mYYg

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