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A fully convolutional neural network to detect diffuse sources in radio surveys

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The forthcoming generation of radio telescope arrays promises significant advancements in sensitivity and resolution, enabling the identification and characterization of many new faint and diffuse radio sources. Conventional manual cataloging methodologies are anticipated to be insufficient in fully exploiting the capabilities of new radio surveys, necessitating the integration of artificial intelligence. The analysis of radio interferometric images presents a novel challenge for image segmentation tasks due to random noise and artifacts characterized by diverse statistical properties. Additionally, the conventional workflow involves computationally expensive processes, such as a tailored subtraction of point-like sources, which is particularly challenging for large datasets.

In response to these challenges, we introduce Radio-UNet, a fully convolutional neural network based on the U-Net architecture. Radio-UNet is designed to detect faint and extended sources in radio surveys. Notably, even if it was initially developed for a distinct scientific application, our deep learning model achieves high accuracy in detecting diffuse radio sources while circumventing issues related to noise, artifacts, and point-like sources. Radio-UNet was trained on synthetic radio observations built upon cosmological simulations. To validate the efficacy of our approach, we applied Radio-UNet to a sample of galaxy clusters, where the detection of diffuse radio sources conventionally relied on customized data reduction and visual inspection.

Our results establish the applicability of Radio-UNet to extensive radio survey datasets, probing its efficiency on cutting-edge high-performance computing (HPC) systems. This pioneering approach represents an advancement in optimizing the exploitation of forthcoming radio telescope arrays and leveraging their capabilities for scientific exploration.

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