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Machine Learning based Cosmological Radio Source Detection

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Radio astronomy is undergoing a data revolution, with advancements in instruments like LOFAR, MeerKAT, MWA, and ASKAP yielding unprecedented insights into the universe. The massive volume of data generated demands efficient processing and analysis, including tasks like source detection, segmentation, and classification. Artificial Intelligence (AI), particularly Machine Learning, offers a promising solution. In our prior studies, we have applied (AI) to radio astronomy data, using Convolutional Neural Networks (CNNs) for automated source detection and U-Net architectures for segmentation of diffuse radio emission, with promising results.

Building on this, our research explores the use of Vision Transformers (ViTs), a cutting-edge development based on the Transformer architecture, originally pioneered for natural language processing. Unlike CNNs, which focus on local pixel patterns, ViTs treat images as patches and use self-attention mechanisms to understand the relationships between these patches. This approach is being exploited in the framework of the Innovation Project HaMMon, funded by the National Center for HPC, Big Data and Quantum Computing (ICSC), for the assessment of the impacts of extreme natural events on the Italian territory. The ViT is proving to be effective also for tasks like source detection and segmentation in radio astronomy. The ViT approach has been combined with the U-Net architecture in order to enhance the performance of the traditional method for semantic segmentation.

We first present the main results from applying the U-Net model to LOFAR Two Metre Sky Survey observations. Then, we highlight the improved network performance and the preliminary outcomes achieved with this new approach.

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