Contribution ID: **120** Type: **Poster + Flashtalk**

Classification of Radio Sources Through Self-Supervised Representation Learning

Modern radio telescopes are detecting a large number of radio sources that will be impossible to analyze individually. In particular, the morphological classification of radio galaxies remains a difficult computational challenge.
In this study, we use contrastive learning to classify radio galaxies from the LOFAR Two-meter Sky Survey Data Release 2 (LoTSS-DR2) and propose a new classification procedure.
We have developed a five-step pipeline: (i) Self-supervised training of the encoder. (ii) Search for clusters or high-density regions in the representation space. (iii) Manual cluster curation. (iv) Fine-tuning of the trained encoder with the cluster labels. (v) Deep ensemble training. To ensure the morphological relevance of the representations, we have designed a new random augmentation.
Our results show that the obtained representations encode morphological properties like source extension, the number of source components, the relative intensity of radiation peaks and source bending.
Furthermore, we show that by training a deep ensemble, we are able to provide corresponding class probabilities increasing the scientific usability of the results.
Finally, we analyse the radio sources in LoTSS-DR2 with a peak flux $F_{\text{peak}} >$
$SI0.75mJy/beam$ in two different largest angular size (LAS) bins:
$SI30arcsec \leq$ LAS $\leq$
$SI60arcsec$ and LAS $>$
$SI60arcsec$. We present the morphological classes we found in both LAS bins and discuss their properties.
We demonstrate that radio galaxies can be classified in a semi-supervised manner, enabling a fast analysis and the discovery of data-driven classification schemes.

AI keywords

Representation learning; Contrastive Learning; Self-supervised Learning

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Track Classification: Inference & Uncertainty