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Quantifying Radio Source Morphology

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The advent of next-generation telescope facilities brings with it an unprecedented amount of data, and the demand for effective tools to process and classify this information has become increasingly important. There have been many applications of machine learning (ML) in this context, however ML can be computationally expensive and often requires manually curated training sets. This work proposes a novel approach to quantify the radio galaxy morphology, through the development of a series of algorithmic metrics that can be applied to images in an automatic way. We introduce a series of unique metrics that quantitatively describe the structure of a single radio galaxy lobe. These metrics are intuitive in nature and are inspired by the intrinsic structural differences observed between the existing Fanaroff-Riley (FR) morphology classification system. The metrics are defined in categories of asymmetry, blurriness, concentration, disorder, and elongation ($ABCDE$/single-lobe metrics), as well as the asymmetry and angle between lobes (source metrics). We apply these metrics to a sample of 483 sources from the Evolutionary Map of the Universe Pilot Survey (EMU-PS) and 72 well resolved extensively studied sources from An Atlas of DRAGNs, a subset of the revised Third Cambridge Catalogue of Radio Sources (3CRR). We find that these metrics are relatively robust to resolution changes, independent of each other, and measure fundamentally different structural components of radio galaxy lobes. We also find that we can recover the original FR classification using probabilistic combinations of our metrics, highlighting the usefulness of our approach for future large data sets from radio sky surveys.

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