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Mask R-CNN for the Automated Detection of Bright Gravitational Arcs in Euclid Galaxy Clusters

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In the era of big data, developing robust methods for the autonomous extraction of information from vast multi-dimensional datasets is pivotal. This work focuses on utilizing a region-based convolutional neural network (Mask R-CNN) to automatically detect bright arcs produced by strong gravitational lensing in galaxy clusters, specifically for the upcoming Euclid survey. These kinds of events offer a powerful tool for probing the mass distribution of galaxy clusters and the large-scale structure of the universe. To replicate the observational conditions expected from Euclid, we used downgraded Hubble Space Telescope images of real galaxy clusters. We trained the network by simulating strong lensing events on these clusters, leveraging high-precision lensing models of 10 massive galaxy clusters within a redshift range of $0.2 < z < 0.6$. A training set of 4000 2'x2' images was generated by injecting Sersic sources near the caustic lines of each galaxy cluster. Our model achieves high completeness in the simulated test images, successfully recovering all the brightest arcs. The Mask R-CNN's training procedure involves direct processing of full-field images, circumventing the need for pre-extracted cutouts. The successful application of this method demonstrates the feasibility of using advanced neural network architectures to enhance the detection of astrophysical phenomena. Our approach is well-suited to handle the massive amounts of data expected from next-generation telescopes, showcasing the potential of deep learning to significantly advance the field of astrophysics.

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