Using convolutional neural networks to identify strong lenses in Euclid and J-PAS

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Abstract

The deflection of light coming from distant astronomical sources due to the presence of massive foreground objects, such as galaxies and galaxy clusters, is called gravitational lensing. In the strong lensing regime, these extended lenses deviate the light from quasars or galaxies, resulting in multiple images of the background source. These images are also usually heavily distorted, acquiring the shape of rings and arcs. The analysis of these multiple lensed images has proven to be an extremely useful cosmological tool. The intrinsic magnification effect derived from lensing enables us to observe distant objects which would otherwise remain undetected. And the images can provide direct estimates of the dark matter distribution in the central region of galaxies and galaxy clusters or be used to constrain the value of cosmological parameters, such as the Hubble constant.
In this work we have developed several models of convolutional neural networks (CNNs) for the detection of the gravitational lensing effect in simulated astronomical images of KiDS, Euclid, and J-PAS. On the one hand, several models have trained using simulations based on the Euclid and KiDS surveys (created by the "Euclid Strong Lensing Group) in order to detect lensed systems. Various tests have been carried out in which the influence on the results of a series of factors (data pre-processing, specific selection of training data, number of bands provided to the network, the training process or the neural network architecture) was studied. The models derived have not only been tested with Euclid and KiDS simulations, but with real SDSS and DES lensed systems, and possible cases of lensing selected by volunteers in the Galaxy Zoo 2 project.

On the other hand, we have created simulations of strong lensing involving QSOs using real and mock data from the J-PAS survey. The Javalambre-Physics of the Accelerating Universe Astrophysical Survey (J-PAS) is an ongoing survey that will cover at least 8000 square degrees of the northern hemisphere extragalactic sky in approximately 5 years, using an innovative system of 54 optical narrow band filters + 2 medium band filters. This large number of photometric bands in J-PAS can be really helpful when detecting strong lensing systems, where usually faint blue background galaxies (usually with emission lines) are lensed by massive red foreground galaxies. Our simulations of lensed QSOs, together with non-lensed examples, have been used to train a CNN, yielding promising results.

Slides: in PDF
Video: https://youtu.be/McpOuYjWs_o

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