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Convolutional Neural Networks for Detecting Moving Objects in Wide-Field Surveys

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When not tracked by the telescope, moving objects can leave trails of light in long-exposure astronomical images as they cross the sky. These objects can either be natural (asteroids) or artificial (satellites and space debris). We discuss their detection using machine-learning methods by analysing the data of two wide-field surveys: the Zwicky Transient Facility (ZTF) and the VLT Survey Telescope (VST).
First, as almost-unchanged remnants of the assembly of the Solar System, asteroids can provide us with insights into this formation process. In addition, some of them pass close to the Earth's orbit and threaten to collide with it, causing local or even global damage. For these reasons, it is essential that we achieve a comprehensive census of these objects.
The trails left by asteroids need to be discerned from other linear features present in the images, such as cosmic rays or columns of bad pixels, which implies that traditional line-detection algorithms do not suffice.
To this end, the near-Earth object (NEO) group of the ZTF developed a pipeline that has been used to discover more than 200 near-Earth asteroids on the ZTF images, which cover an extremely large field of view (47 square degrees per exposure). However, the pipeline reports a high rate of false positives that need to be discarded manually.
This talk explores new methods to improve the precision of the current NEOZTF pipeline while maintaining the same levels of recovery rate. In particular, it analyses the application of a convolutional neural network (TernausNet) trained on both past detections and simulated asteroid data.
Second, satellites and space debris have increased exponentially over the past decade in the near-Earth environment and, as such, we must monitor their population. In this talk, we discuss the application of a convolutional neural network that includes a Hough Transform block to detect the signature tracks of these objects, which are longer than those of asteroids, in images taken with the VST.
Lastly, the developed tools will also be applicable to Euclid, LSST and a range of other satellite and ground-based surveys, setting the stage for fast and automated moving-object detection in the upcoming generation of telescopes.

Presenter: IRURETA-GOYENA, Belén Yu (École Polytechnique Fédérale de Lausanne)

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