Paper ID: 59099
oral
student

48th STUDENT CONFERENCE (E2)
Student Conference - Part 1 (1)

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REAL TIME SPACE OBJECT TRACKLET EXTRACTION FROM TELESCOPE SURVEY IMAGES WITH MACHINE LEARNING

Abstract

One of the most demanding tasks in surveying space objects with optical telescopes is the need of real time image processing to quickly perform follow-up observations and acquire additional images in the visibility window. This is instrumental to performing sufficiently accurate initial orbit determination that allows to schedule additional measurements with other sensors. Nowadays, the state of the art for the tracklet extraction is mainly associated with segmentation techniques characterized by a processing time not suitable for quick sensor tasking. In this paper, a novel approach based on Machine Learning techniques is proposed to process in real time images coming from an optical telescope, with the aim of extracting the tracklet information. The proposed approach is based on the U-Net: a deep neural network belonging to the CNN family, aimed at object segmentation. As in all the other machine learning applications, a series of steps is required to obtain a working system: dataset creation, pre-processing, training, testing and post-processing. The dataset creation and pre-processing steps are needed to properly prepare the training step, while the post-processing one is applied to refine the output of the trained network. In order to succeed in the learning process, a sufficiently vast dataset composed by a set of images coupled with a label is needed. In this case labels represent the desired output of the network and are bicolor masks where black is the background and white is the tracklet. In order to be general, 250 realistic synthetic images and labels have been generated. Subsequently, images are rescaled (to speed up training) and normalized. The learning phase is the most time consuming as the weights of the different layers are tuned to reduce a defined loss function, while the testing (and therefore operations) is much faster since it is a simple function evaluation. The trained network is tested against a set of scaled synthetic and real images. Images are filtered to reduce vignetting and to level out the background brightness, downconverted to 8 bit and normalized. The post-processing step performs a centroid identification and estimates the object right ascension and declination by knowing the passage ephemeris time and the observation pointing. The results are promising as the average processing time per image is 4 s (running the Python code on a 2014 machine with an i7-4710HQ and 16 Gb of RAM) and bright trails are easily recognized with a validation accuracy of 99.9%.