Abstract

Observations of space debris and Near-Earth objects are becoming increasingly important due to the rising number of launches and defunct satellites on Earth's orbit. Space debris objects are tracked, categorised and catalogued to extract astrometric and photometric information and prevent collisions with ongoing missions or dangerous re-entries. Slovak telescope AGO70 belonging to Comenius University in Bratislava is a relatively fresh contributor to the Space Situational Awareness programme. This thesis describes hardware and software components that allow observers at the Astronomical and geophysical Observatory in Modra to create and process space debris observations. The software is named Image Processing System, and it is a modular pipeline partially developed and fully validated during this thesis. The system can process raw astronomical images and correct common instrumental and environmental errors. Cleaned images undergo segmentation to extract light sources, and the calculated coordinates are translated to an equatorial system. The observations are correlated to produce data structures describing an object's trajectory. Finally, post-processing routines ensure that the results are clean from system-specific discrepancies. We prove that targeted improvements to hardware (better stepper motors and custom controllers) and software (increases in performance of selected modules) allow us also to handle high-speed objects on the lowest Earth's orbits. We design experimental algorithms for selected Image Processing Elements, such as a recurrent neural network, and validate the analytical solutions. We prove that the neural network is at least as successful as the analytical algorithm. We conclude that AGO70 and the Image Processing System are the first passive optical sensor and processing system in Slovakia to observe and process Low-Earth Orbit objects successfully.

keywords: image processing, algorithms, neural network, space debris, AGO, LEO