Abstract

With the increase in space traffic in recent years, precise monitoring of space debris is necessary for its potential removal. The removal can be done by intentional deorbiting of the object. In that case, an object falls to Earth in a process called the reentry event. However, currently we are not able to precisely predict the risks caused by the falling object, motivating further research. The thesis focuses on solving four problems using machine learning. The first two engage in the light curve inversion process in pursuit of object characterization and attitude estimation. Observations in the form of photometric light curves provide us with information about an object's physical properties, including shape, size, surface materials, and rotation. Publicly available databases and synthetic light curve generators account for a large number of light curves that can serve as training data for machine learning models and help solve open problems in object characterization and attitude estimation using the data-driven approach. We contribute a methodology for database-independent rocket body classification and introduce RoBo6, a standardized dataset for rocket body classification. The third problem regards light curve modeling, augmentation, and preprocessing, where we propose a system for synthetic light curve generation from 3D models. Additionally, we provide two technical contributions: the MMT_snapshot dataset to facilitate efficient access to light curve data and LCDC (Light Curve Dataset Creator), a Python package for light curve processing suitable for both scientific analysis and machine learning applications. The last problem addressed is 3D reentry event reconstruction from video recordings. We propose two possible ways of solving this problem using traditional computer vision techniques and graph neural networks. The contributions are summarized in the Results chapter, following the methods proposed in the Project of Dissertation.

Keywords: space debris, light curves, machine learning, object characterization, attitude estimation, classification, synthetic data generation, reentry events, deep learning, neural networks.