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Space Debris Detection, Tracking and Characterization - SST (1)

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USING AI TO PROCESS LIGHT CURVES FOR GEO OBJECT CHARACTERISATION

Abstract

The classification and characterisation of objects in geosynchronous orbit (GEO) is an important goal in Space Situational Awareness (SSA). Optical observations can be used to detect and identify GEO objects, while radar is generally only used to observe Low Earth Orbit due to the range limitations. Temporal variations of apparent magnitude, called a light curve, are captured by optical telescopes. Light curves contain information on features such as attitude, size, shape and materials useful for the characterisation of the object. Analysing light curves can also allow the determination of normal patterns of life, and hence the detection of anomalous behaviour during the orbit such as manoeuvres.

During this study a high-fidelity simulator for generating photometric data and light curves has been developed. Light curves produced are processed and used to train the machine learning algorithm for extrapolating common features of GEO objects. This paper details the development of the simulator, and the development and results of the machine learning algorithm.

The light curve simulator has been developed in python, using the rendering software POV-Ray, in order to generate photo-realistic images from the perspective of the ground-based observer through the use of the ray tracing technique. After a series of images has been rendered, they are processed and calibrated to determine the apparent magnitude and extract light curves. In order to assess the quality of the results and validate the simulator, simulated light curves were compared with the real observations taken by DeSS.

After the acquisition of simulated and real light curve data, an artificial neural network has been trained to identify characteristics of spacecrafts in GEO. Depending on the amount and the quality of input data available the algorithm can extract a range of features from the light curve. Initially, the algorithm looks at pattern of life, then it considers geometry, attitude and materials. This is the first step in automatic characterisation of objects. The simulator can be used to generate a full night light curve for an orbiting object. By varying the simulator inputs, many different nights, under different conditions and for different objects can be simulated. A large simulated dataset helps the algorithm to recognise a broad range of satellite types, attitudes and many other characteristics. The algorithm is then tested using separate simulated data and real data from DeSS.