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SPACE SITUATIONAL AWARENESS TASKING FOR NARROW FIELD OF VIEW SENSORS: A DEEP REINFORCEMENT LEARNING APPROACH

Abstract

The number of objects in LEO is expected to double in the next few years. The Space Situational Awareness mission that had been carried out by USSPACECOM for decades has relied on radars and optical sensors to track and catalog these resident space objects (RSO). There have been upgrades to the US Space Surveillance Network with state-of-the-art sensors such as the Space Fence, Space Surveillance Telescope and space-based sensors such as ORS-5. There are now several commercial SSA companies providing data necessary to track the large number of RSOs. However, the number of RSOs to track is becoming much larger in comparison to the sensors and will stress the system. Scheduling the existing sensors to keep track of objects, especially those with constant low-thrust, will be key to keeping a robust catalog of RSOs. Fence-type systems with large FOVs are designed to track large swaths of the sky at any given moment and aren't tasked for any particular object in their typical CONOPS. Sensor tasking is a problem for narrow field of view (FOV) sensors, as they are only able to realistically track one object at a time and with a finite slew rate. These types of sensors include narrow field of view optical telescopes, dish radars, satellite laser ranging (SLR) sensors and imaging radars. When there are multiple objects within the field of regard (FOR), prioritizing objects to track and for how long becomes a combinatoric optimization problem where the solution search space grows exponentially to the number of RSOs. This sensor tasking problem has not been as big of a problem in the past because the number of RSOs to track with a narrow FOV system was low. With the burgeoning mega-constellations planned this is no longer the case. This optimization problem becomes even more intractable when an architectural-level planning is needed with multiple sensors which may or may not have overlapping FOR. In this study, we train a scheduler using reinforcement-learning with the proximal policy optimization (PPO) algorithm and compare its performance to a greedy scheduler. A couple of metrics are used to quantify the algorithm's figure of merit: the number of RSOs visited and the mean covariance size of the catalog objects. Scenarios comparing a few optical sensor lay-down are analyzed. No new launches or deorbits are assumed during a scenario, though the RSOs can maneuver with some pre-defined stochasticity. Future work includes characterizing multiple sensor modalities (radars, passive RF, SLR, etc) and architectural analysis of best placements of optical sensors using meta reinforcement learning.