SatNet-Shenanigans Problem Introduction

Justin Fletcher (Justin.Fletcher.14.ctr@us.af.mil)

Awareness of the space domain is instrumental to the defense of space-based national assets. The United States Space Force (USSF) establishes and maintains Space Domain Awareness (SDA). A variety of SDA sensing modalities exist, but much of the global SDA data is generated by ground-based electro-optical telescope systems. Images from these telescopes are routinely processed to produce object detections; detections are associated to form tracks, which are in turn correlated to orbits. Orbits can be used to track and predict object motion, enabling SDA.

The space environment grows more congested each day, and the possibility of great power conflict in space is no longer negligible. As such, the object detection approaches that underlie SDA must be robust to the scenarios such a conflict may entail. These scenarios include collisions, breakups, separations, and rendezvous, among others. Collectively, these events are sometimes called shenanigans. The problem of resident space object detection was formalized in terms of modern computer vision practices in [1]. This work introduced the SatNet dataset for ground-based electro-optical telescope object detection. To evaluate detector performance against shenanigans, we have build SatNet-Shenanigans.

The SatNet-Shenanigans dataset comprises 8,160 annotated, synthetic data elements. Collectively, these elements contain 1,000,000 single-channel, 512x512-2048x2048 pixel, 16-bit images divided into collections of 5-200 temporally-sequential exposures. Each collection corresponds is a dataset element and represents an observation of a single procedurally-generated shenanigan, from a procedurally-generated collector (optics, focal plane, etc.) positioned at a randomly-selected location on Earth (viewing geometry, atmospheric conditions, etc.) at a random time. Four classes of shenanigans are generated, including breakups, collisions, close rendezvous, and separations; benign scenarios are also included for comparison and diversity. Every dataset element includes single-class bounding box detection, semantic segmentation, and shenanigan class annotations.

The primary objective of a solution to the SatNet-Shenanigan problem is to provide object centroid detections with high precision and recall for every frame in a collection. Code is provided to conduct this evaluation using JSON-encoded inferences. Many alternative formulations may also be valuable. For example: a model which takes an entire collection as input and outputs only detections for the final frame, or a subset of frames, is still useful. Additionally, intermediary and aggregate representations (clusters, moment analysis, etc.) may be useful. Creative approaches and reframing of the problem are welcome, so long as they yield quantifiable insights about the underlying nature of the observed event.

All SatNet-Shenanigans data, related work, baseline model code, and evaluation code can be found on the Unified data library To access these resources: (1) create an account at unifieddatalibrary.com, (2) gain FOUO access on UDL (use CAC to login or contact admins via UDL help), (3) go to “Storefront” and click “AFRL” (this may change soon) and request access; (4) once access is granted, navigate to https://unifieddatalibrary.com/sfm/?expandedFolder=/SupportingData/MISS/. If you need help, email me (justin.fletcher.14.ctr@us.af.mil) and Zach Gazak (zachgazak@odysseyconsult.com)

[1] Justin Fletcher, Ian McQuaid, Peter Thomas, Jeremiah Sanders, and Greg Martin. Feature-Based Satellite Detection using Convolutional Neural Networks. AMOS Conference Proceedings, 2019.