Multiplatform Mission Planning and Operations Simulation Environment for Next Generation Small Satellite Missions

Andrew J. O'Brien, et. al.

February 13, 2019

It is envisioned that NASA's future space systems will be composed of large, inhomogeneous collaborative networks of autonomous, small satellite platforms. Unfortunately, current and near-future inter-satellite communications are highly constrained in terms of link availability, reliability, power, and bandwidth. Although future technologies may mitigate these communication constraints, instruments will also rapidly expand in data volume and employ adaptive sensor reconfiguration. Adaptive sensor platforms must make intelligent decisions based on a model informed by the entire network. This feature introduces a complex decision space concerning the content and flow of information. Under the NASA Advanced Information System Technology program we are developing an open-source C++ library for the simulation of autonomous collaborative networks of adaptive sensors. It enables efficient network simulation with realistic constraints in communication, power, and measurements. In this work, we investigate how our simulation tools could produce large training data sets that capture the operation of the described networks. We then investigate how machine learning could utilize these data sets to train neural networks to make intelligent collaborative decisions. We report on the design and develop of a remote sensing mission simulator to support the emerging field of adaptive remote sensors and resource-constrained small satellite constellations. We provide analysis of how the current approach to performing observing system simulation experiments (OSSEs) must be changed to enable adaptive sensors for remote sensing, and present an architecture to enable their inclusion in future OSSEs. This new class of OSSEs required to utilize adaptive sensors located on multiple platforms must answer question: If the physical act of sensing has a cost, how does the system determine if the science value of a measurement is worth the cost and how should that cost be shared among the collaborating sensors? Here we propose to answer this question using an architecture structured around three modules: adapt, manage and collaborate. The adapt module is a set of routines to facilitate modeling of adaptive sensors; the manage module, will implement a set of routines to facilitate simulations of sensor resource management when power and data volume are constrained; and the collaborate module will support simulations of coordination among multiple platforms with adaptive sensors. When used together these modules will constitute an OSSE that can enable both the design of adaptive algorithms to support remote sensing and the prediction of the sensor performance.