IAF SPACE OPERATIONS SYMPOSIUM (B6)
Large Constellations & Fleet Operations (5)

Author: Mr. Zhijiang Wen
Innovation Academy for Microsatellites, Chinese Academy of Sciences, China

Mr. Yan Liu
Innovation Academy for Microsatellites, Chinese Academy of Sciences, China
Dr. Shengyu Zhang
Innovation Academy for Microsatellites, Chinese Academy of Sciences, China
Prof. Haiying Hu
Innovation Academy for Microsatellites, Chinese Academy of Sciences, China

TASK SCHEDULING METHOD FOR LARGE EARTH-OBSERVING SATELLITE CONSTELLATION

Abstract

With the increasing demand for observations and the development of satellite technology, the scale of the earth observation satellites (EOS) constellation is growing. The planned earth observation satellite constellation contains several hundred satellites with different payloads. To make the constellation more efficient during operation, scheduling imaging tasks of large-scale constellations are imperative. Moreover, the traditional scheduling method with low autonomy involves many human interventions, which is unsuitable for the reaction of an emergency accident. The observation tasks of satellites can be divided into daily operation tasks and emergency tasks. To improve the autonomous level of the large-scale satellite constellation, we designed an integrated scheduling method for daily operations and an online scheduling task method based on deep reinforcement learning (DRL) for the scheduling of emergency tasks.

To solve the problem, we first establish detailed mathematical modelling by taking complete account of the properties and size of the constellation. The integrated scheduling method would finish the constellation task scheduling process on the ground using a benefits-first scheduling approach for the daily operation process. First, we designed an allocation strategy based on the features of the satellite and task information, and the strategy will allocate the task to ensure that each task will be assigned to the most suitable satellites for execution. Then, in the task scheduling phase, a sequence of task scheduling sub-problems on every single orbit is separately solved based on allocation result. The scheduling scheme will be evaluated by the objective function, which is decided by the satellite resource and the target information.

For in-orbit emergency observation tasks, such as space collision events and natural disasters, DRL would solve the problem of scheduling a real-time multi-satellite cooperative observation. When urgent tasks arrive, a well-trained DRL model based on proximal policy optimization (PPO) will re-schedule the single satellite's task scheme. The DRL model would ensure the satellite performs the original tasks as efficiently as possible while executing the emergency event. The re-scheduling process does not require human intervention and increases automation in the constellation operation when faced with urgent tasks.

Experiment results show that in the one-day scenario with 100 satellites and 2000 tasks, the integrated benefits-first scheduling algorithm could schedule tasks efficiently and have a good result. The results also show that the online scheduling method based on PPO is effective and could re-schedule the daily task scheme within one second.