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DESIGN & DEVELOPMENT OF AN OPTIMIZED SENSOR SCHEDULING & TASKING PROGRAMME FOR TRACKING SPACE OBJECTS

Abstract

The Industrial Sciences Group (ISG) and The Australian Space Environment Research Centre (SERC)collaborated on the development and analysis of mathematical models and software to perform sensor scheduling and tasking for a network of sensors over a 12-hour schedule. The program optimizes sensor utilization by producing sensor-object assignments that maximize the sensor networks information gain, determined by the reduction in object covariances, for each assignment window throughout the schedule. The program takes in a catalog of Earth-orbiting satellites, with initial state vectors and covariances, and a set of active and passive optical sensors across Australia. Each object is simulated over a 12-hour period to determine visible passes that may be tracked by each sensor. The program outputs a schedule for each sensor detailing the tracking times of selected objects over the 12-hour period. Objects are propagated forward using an unscented Kalman filter, and object selection is made using Rényi divergence as an Information Gain criterion, comparing the potential reduction in each object's covariance during an object's visible pass. If the program is running in real-time, measurements from sensors can be passed to the unscented Kalman filter which updates the states of assigned objects with live data. The program accounts for asynchronous assignment windows, computing the cumulative information gain from multiple observations, scaling the information gain for high priority targets, and adding constraints on laser measurements. The program and algorithms were successfully tested by SERC on a catalogue of 20,000 objects with 6 sensors. The assignments will used by SERC to produce daily schedules for their sensor network. The program can be scaled to maintain pace with the ever-growing number of objects in orbit. Key insights from the implementation of the program include the importance of minimising program run-time in order to be able to process a schedule in real-time, as well as memory utilisation considerations to be able to process large numbers of objects simultaneously. Future developments include, the use of optimized sampling schemes known as 'space-filling' designs as an alternative to 'brute force' Monte Carlo approach to simulate a known 'true' probability of collision. Additionally, the methodology used is adaptable and scalable to a range of complex multi-sensor/multi-object problems where optimal tasking is required. Finally, dynamic scheduling could be used to account for changes in weather effecting visibility, and target priorities.