SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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DISTRIBUTED BEHAVIOURAL COORDINATION FOR SATELLITE CLUSTERS

Abstract

Multi-platform swarm/cluster missions are an attractive prospect for improved science return as they provide a natural ability for temporal, spatial and signal separation with many more engineering and economic advantages. As the number of spacecraft increases and/or the round-trip communications delay from Earth lengthens, the traditional "remote-control" approach begins to break down as a result of the inherent communication bottleneck. It is therefore essential to push control into space; to make spacecraft more independent and autonomous.

An autonomous group of spacecraft still requires coordination, but standard terrestrial paradigms such as negotiation or stigmergy both require high levels of inter spacecraft communication, which is nontrivial and expensive in space. This paper therefore introduces a new agent-based behavioural approach that allows for infrequent coordination with decisions based on local information, and is also hierarchically decomposable for natural scalability.

An individual spacecraft behaviour can just be considered as a probability distribution (or weighting function) over the currently available tasks in a suitable resource space. Individual spacecraft run a simple genetic algorithm on-board to dynamically search for the current most effective local behaviour. Cluster supervisor agents (or the ground station) adjust the parameters of this fitness function, effectively controlling the behaviour of lower level spacecraft.

After outlining this novel system, this paper presents an analysis of some of the crucial parameters such as communications overhead and on-board genetic algorithm parameters. Multiple spacecraft scenarios are considered to quantify the emergent properties of various behaviour combinations on simplified problems utilising feedback, feedforward and inertia information. Finally more realistic cluster scenarios (such as a multiplatform remote sensing mission) are simulated to demonstrate the feasibility of such systems and how they can be dynamically adjusted to match changing mission objectives such as rapid response time, load balancing, overall efficiency etc.