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# AI-BASED SPACECRAFT FORMATION AND COORDINATION APPROACH FOR DISTRIBUTED SPACE SYSTEMS AND DECISION MAKING

**Abstract**

Artificial Intelligence (AI) has made steady progress in space systems research and this technology is becoming increasingly more important to address the challenges of automated decision making for trusted autonomy in space. The level of autonomy achievable using AI and Machine Learning (ML) techniques allows for a wider range of space missions freeing humans to focus on tasks for which computers are better suited. In some cases, autonomy and automation are critical to the success of a mission. Additionally, deep space exploration would typically require more autonomy in the spacecraft, as communication with ground operators is sufficiently infrequent to preclude continuous human monitoring for potentially hazardous situations.

The concept of satellite formation flying and coordination is emerging as an attractive alternative to traditional monolithic spacecraft for a variety of applications. This approach has been experimented in many satellite systems however, the need for coordination and distributed decision making is critical for missions deploying a fleet of on-board sensors orbiting Earth. The challenge in achieving the desired outcome for collaborative teaming resides in the ability to coordinate the formations effectively and efficiently. Effective coordination and cooperation require resources to be shared across systems and the assignment of roles and responsibilities to minimize the coupling between agents while still ensuring coordination to satisfy the higher-level mission goals. This needs a more directed and predictive approach allowing for higher levels of automation, autonomous decision making and improved situational awareness.

This paper proposes new AI/ML mission concept devoted to distributed spacecraft formation and coordination based on the utilization of an ad-hoc formation strategy for small and cooperative spacecraft which can minimize the limitations of on-board resources. Specifically, the proposed architecture comprises multiple spacecraft working in synergy and optimising their overall mission performance in detecting and tracking Resident Space Objects (RSOs). This leads to a substantial reduction in ground communication requirements as well as enhancements in human interactions, maximising promptness, and effectiveness in the identification of possible threats in space. Constraints imposed by the space environment as well as requirements for on-board sensors for decision making are factored in the proposed system architecture, with a view towards trusted autonomy. Simulation results relative to a network of Distributed Space Systems (DSS) is provided along with the optimised formation strategy, showing the robustness of the proposed architecture for effective spacecraft formations, enhanced decision making and performance both in terms of promptness and accuracy in the accomplishment of the required RSO tracking tasks.