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Introduction: Enhancing Intelligence in Aerospace Systems

Aerospace technology, driven by military and civilian applications, is increasingly moving towards a new generation of sophisticated manned and unmanned systems. As warfare gets asymmetric and uncertain, and space exploration more bold and daring, the desire is for machines to emulate a human's ability to adapt quickly and effectively.

According to the U.S. Department of Defense's Unmanned Systems Roadmap 2007–2032 [1], "*the area of autonomy and control is a major research area for all unmanned systems, whether military, commercial, or academic in origin*". Furthermore, this roadmap states that "*Adaptability and learning from past experience are still at early stages of capability. Advances in these technologies for individual systems will go a long way toward enhancing the capabilities and utilization of unmanned systems collaboratively or in teamed applications with manned systems.*" Intelligent systems technologies are enabling air and space missions to exhibit an increased level of autonomy, to be more adaptable, to learn, and to have improved performance. This special issue includes a collection of papers which presents recent advances in the above three areas: autonomy, adaptability, and learning.

Autonomy refers to an important attribute of unmanned systems relating to the performance of desired tasks in unstructured and complex environments without direct and continuous human control. Autonomy may be characterized in terms of a three dimensional space which includes: (1) Missions that the system is capable of performing; (2) Environments within which the missions are performed; and (3) Human independence that can be allowed in the performance of the missions [2]. In recent times, there has been a growing appreciation for the critical role of the interface between the human and the unmanned system also referred to as human-machine interface (HMI). Since this interaction is vital to mission success, it is imperative that the HMI issues be emphasized during the design cycle. This issue contains two papers on the topic of autonomy. Dvorak et al. [3] present a goal-based approach wherein the fundamental basis of operations relies upon declarative specifications of operational intent, termed goals. The move toward goal-based operations, which has already begun in some space missions, involves changes and opportunities in several places: operational processes and tools, human interface design, planning and scheduling, control architecture, fault protection, and verification and validation. Lennon and Atkins [4] describe a software architecture which accepts both fuzzy linguistics and hard numeric constraints on trajectory performance and, using a trajectory generator provided by the user, automatically constructs trajectories to meet these specifications as closely as possible. The system is tested in a 2DOF linear and a 6DOF nonlinear domain with a variety of constraints and obstacles.

One of the salient features which contribute to the superiority of humans is adaptability and learning. These characteristics are especially important when operating in complex and uncertain environments. This issue contains four papers on the topic of adaptability and learning. Nguyen and Krishnakumar [5] present a hybrid adaptive flight control approach to improve command-tracking performance of aircraft operating in off-design flight conditions. This method is based on adaptive learning laws for on-line parameter estimation of aircraft plant dynamics in conjunction with an existing neural net direct adaptation strategy. Bosworth and William-Hayes [6] describe a direct adaptive neural-network-based flight control system developed for the National Aeronautics and Space Administration NF-15B Intelligent Flight Control System airplane, and subjected to an inflight simulation of a failed-stuck stabilizer. Formation flight handling qualities were evaluated, with and without neural network adaptation. Barber et al. [7] outline a method for using vision-based feedback to accurately land a Micro Air Vehicle (MAV) on a visually identifiable target of approximately known location. The method presented is robust to wind, capable of handling both stationary and moving targets, and capable of correcting for camera misalignment, state estimation biases, and parameter estimation biases. Kirkpatrick and Valasek[8] introduce improved Reinforcement Learning algorithms to characterize Shape Memory Alloys and verify simulation results with an experimental hardware apparatus. Results presented in the paper verify the temperature-strain major hysteresis loop simulation results, and also determine the relationships of the minor hysteresis loops.

Another important feature sought after in future intelligent systems is optimization. This issue contains two papers on the topic of optimization. An efficient optimization algorithm, called EGOMOP (Efficient Global Optimization for Multi-Objective Problems), was adopted by Jeong et al. [9] to improve the nonlinear lateral characteristics of a lifting-body type reentry vehicle using a Computational Fluid Dynamics (CFD) analysis. The results indicated that fins mounted on the Japan Aerospace Exploration Agency's (JAXA) baseline lifting-body configuration cause asymmetrical development of vortices and result in nonlinear lateral characteristics. Oyama et al. [10] apply a design exploration framework coupled with CFD to a multi-objective aerodynamic design optimization problem of two-dimensional flapping motion of an airfoil.

In summary, this special issue includes a selection of papers addressing many of the areas crucial to intelligent aerospace systems. The papers constitute a balanced mix of theory and experiments, and cover civilian and military application areas in aerospace. The paper written by Nguyen and Krishnakumar [5], "A Hybrid Intelligent Flight Control with Adaptive Learning", was selected as the Best Paper of the Conference. We hope that the reader will find this issue to be a valuable source of information on leading edge research that is aimed at enhancing intelligence in aerospace systems.

References

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