

Workshop/Tutorial T3 (Half Day)

UAV HEALTH MANAGEMENT ISSUES: CAN SMALL UAVS SURVIVE EXTREME DISTURBANCE ENVIRONMENTS?

Organizers and Presenters

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Tutorial Summary

This Tutorial presents a comprehensive discussion of methods, approaches and techniques, coupled with their support technologies and tools for improved UAV operational integrity under severe/extreme external (i.e., wind gusts) and internal (i.e., single and multiple failure modes) disturbances.

We currently witness an enormous proliferation of UAVs and their application to a variety of domains. Yet, significant challenges must be addressed and overcome if the aim is for the public and industry/government to accept and utilize such assets - concerns regarding safety and security of flight as just two such challenges. UAVs place significant demands to human operators who are required to make informed decisions in (almost) hard real-time, and they require significant computational resources for data and information processing. This challenge is best registered through the comment made by an Autonomous Vehicle Operator (AVO) who stated that, at times, “he’s been more overcome by the torrent of information pouring in during a drone flight than he was in the cockpit”.

Limitations in (the level of) autonomy lead to operator work-time exceeding the time of unmanned system deployment, and gains in the field of autonomy are required to reverse this current trend. The final report of the Defense Science Board Summer Study on Autonomy, June 2016, provides recommendations for “accelerating DoD’s adoption of autonomous capabilities”. Achieving these gains requires developing new and innovative methods and tools to establish “*assured and trusted autonomy*” through integrated system health management, resilient design and operation of UAVs and swarms of UAVs (and unmanned assets in general), adaptive vehicle control, safety assurance and risk assessment and management, enabling complex systems to operate across a range of functional capabilities.

The underlying technology basis to develop and eventually implement assured and trusted autonomy strategies is adoption and utilization of fundamental concepts from the field of cognitive engineering, specifically reasoning, learning and adaptation. These intelligent attributes contribute significantly to the algorithmic developments of autonomy and health management of UAVs. Learning enabled tools/methods

are essential to the establishment of a dynamic and continuously improving framework for assured autonomy, reducing the operator workload, optimizing knowledge bases and expediting processing of large databases. Prognostics and Health Management (PHM) technologies have seen significant progress towards their development, validation and transitioning on-board the targeted systems/processes. A toolset for assured and trusted autonomy is presented focusing on rigorous and verifiable data mining, Condition Indicator (CI) extraction and selection, fault diagnosis and failure prognosis software complemented with quantifiable risk, confidence and trust metrics. This rigorous framework has been applied successfully to various engineering processes and validated in extensive testing. It is implemented on-line in real-time requiring minimum computational resources.

Topics to be Covered

- *Integrated Vehicle Health Management (IVHM) practices for unmanned systems*
Accurate and robust detection of incipient faults and failures occurring in critical components or sub-systems of the overall system; accurate estimation of the Remaining Useful Life (RUL) of such failing components or sub-systems.
- *Diagnostics and Prognostic and Health Management (PHM)*
Effective diagnostics with low false alarm rates; prognostics requirements based on generation of long-term predictions describing the evolution in time and over time of a specific signal of interest or condition indicator; estimation of the RUL of a failing component or sub-system.
- *Condition Based Maintenance (CBM)*
- *Bayesian estimation techniques*
- *Particle filtering (PF), Risk Sensitive Particle Filtering (RSPF)*
- *Assured and Trusted Autonomy Foundation*
 - *Metrics*
 - *Resilience*
 - *Intelligent Vehicle Health Management (IVHM) framework*

Intended Audience

This Tutorial is suitable for graduate students, researchers, scientists and engineers, practitioners, end-users and developers interested in autonomous UAVs. The collective outcome of the Tutorial is an understanding of what autonomy entails, how UAV autonomy, robustness and resilience are measured through quantifiable metrics, and how through and integrity management framework UAV health is monitored and maintained.

Tutorial Material

Participants will receive detailed presentations and papers.