State Sensing and Awareness for Fly-by-Feel Autonomous Vehicles
by
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Bio-inspired multifunctional materials are highly “intelligent” materials that constitute the future generation of composites for aerospace applications. They have the ability to carry mechanical loads and detect external stimuli and material degradation, providing data to mitigate or avoid potentially hazardous situations. Multifunctional materials are capable of enabling high-resolution sensing capabilities, similar to biological systems, utilizing large numbers of embedded sensors, and allowing the implementation of advanced feedback control systems that would enable levels of agility and reaction not possible by the materials currently employed.

Towards this end, the current research goal is the development of technologies that will lead to the next generation of autonomous UAV systems that can (i) sense the environmental (temperature, pressure, etc.) and operating (dynamics, damage state, performance degradation, etc.) conditions, (ii) effectively interpret the sensing data to achieve real-time state awareness and implement appropriate diagnostics, (iii) make optimal decisions in an unsupervised mode under uncertainties in complex operating environments, and (iv) enable the use of advanced multi-modal feedback control techniques. In recent years, extensive research has been performed related to the design of bio-inspired multifunctional materials from nano/micro scale to macro scale integration and deployment. The design of such materials involves several multi-disciplinary technologies related to micro/nano sensors and stretchable networks, built-in electronics (processors, wires, etc.), and composite fiber matrix materials.

The goal of this presentation is to provide a concise overview of the main research developments that constitute a “conceptual leap” to overcome the current limitations and realize the full potential of multifunctional composites, thus enabling their integration into “intelligent” structures and actual deployment for aerospace applications. The current focus is the extension of these approaches for the design, integration, and implementation of the next generation of autonomous UAV systems.