Invited Paper

Bioinspired Engineering of Exploration Systems for NASA and DoD

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The intent of "Bio-inspired Engineering of Exploration Systems", is to distill the principles found in successful, nature-tested mechanisms of specific "crucial functions" that are hard to accomplish by conventional methods, but accomplished rather deftly in nature by biological organisms. The intent is not just to mimic operational mechanisms found in a specific biological organism but to imbibe the salient principles from a variety of diverse bio-organisms for the desired "crucial function". There by, we can build explorer systems that have specific capabilities endowed beyond nature, as they will possess a mix of the best nature tested mechanisms for that particular function. Insects (for example honey bees and dragonflies) cope remarkably well with their world, despite possessing a brain that carries less than 0.01% as many neurons as ours does. Although most insects have immobile eyes, fixed focus optics (no range info) and lack stereo vision, they use a number of ingenious strategies for perceiving their world in three dimensions and navigating successfully in it. We are distilling some of these insect inspired strategies to obtain unique solutions to navigation, hazard avoidance, altitude hold, stable flight, terrain following and smooth deployment of payload. Such functionality can enable a reach to otherwise unreachable exploration sites for much sought for endeavors. Furthermore, recent biological studies have confirmed that representations of each different characteristic of the visual world is formed in parallel, and embodied in a stack of "strata" in the retina. Each of these representations can be efficiently modeled in Cellular Nonlinear Networks (CNN). Many of the biological image processing operations, when translated into CNN image processing operations, constitute algorithmic cornerstones, useful in practical image processing missions. Recent breakthroughs on exploring the feasibility of incorporating these success strategies of bioinspired navigation and visual search/pattern recognition/image understanding into our biomorphic flyers for future missions will be described.

Specifically our results demonstrate the novelty of our approach in adapting principles proven successful in nature to achieve stable flight control, navigation, visual search/recognition to enable overall a robust architecture for reliable image data return in application scenarios where only a limited telecommunications or navigational infrastructure is available. We will also describe a few future Mission Scenarios for Mars exploration, uniquely enabled by these newly developed biomorphic flyers. Terrestrial applications of these biomorphic flyers in co-operative surface/aerial exploration scenarios include: aerial/surface distributed measurements of meteorological events,

storm watch, seismic monitoring, reconnaissance, biological chemical sensing, search and rescue, surveillance, autonomous security/protection agents and/or delivery and lateral distribution of agents (sensors, surface/subsurface crawlers, clean-up agents).

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