Conference or Workshop Item:

Kovac, Mirko (2014) Bio-inspired Flying Robots. In: USES 2014 - The University of Sheffield Engineering Symposium, 24 June 2014, The Octagon Centre, University of Sheffield.

10.15445/01022014.31

Bio-inspired Flying Robots

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Abstract

The Aerial Robotics Lab at Imperial College London focuses on the development and testing of next generation flying robots with the vision to create swarms of robotic birds that live in the wild autonomously, are able to move in different environments and that can build their own habitats and robot communities. Within this large multi-disciplinary vision, the research emphasis is on conception, mechanical design, prototyping and testing of such aerial robots. Possible applications are manifold and range from environmental sensing, to search and rescue, industrial inspection and repair as well as autonomous water sampling after oil spills and in flooding situations.

A key design methodology that enables the development of such robots is biological inspiration because many of the required key technologies, such as morphing body structures, active skins and high-power propulsion systems that are needed for next-generation robots have already been invented by nature. However, it is crucially important to not blindly copy natural systems but to understand the underlying bio-mechanical mechanisms and implement only evaluated and functionally beneficent principles on the robots using state of the art engineering knowledge. We refer to this approach of selective bio-inspired design as the Inspire-Abstract-Implement (IAI) robot design paradigm [1] that formalizes a methodology of employing biological inspiration to build high-performance robots.

Using the IAI paradigm we have built jumping robots that perform one order of magnitude better with regards to terrain traversability compared to other similar robots (figure 1 [2]), demonstrating the applicability of bio-inspired robot design. Other previously developed robots include jump-gliding robots (figure 2 [3,4]), perching micro-gliders (figure 3 [5]) and multi-stage micro-thruster as high power-density propulsion systems for robotic insects [6]. Current research focuses on hybrid air-water locomotion of next generation flying robots, called Aquatic Micro Aerial Vehicles (AquaMAV) [7] and nest-building robots that employ swift-inspired 3D printing techniques to create structures from two-component structural adhesive [8].

Future directions will intensify multi-disciplinary interactions with biology, material science and chemistry to build flying robots that use the best of knowledge across disciplines with the goal to build high-performance flying robots for search and rescue and humanitarian applications.

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Keywords Unmanned Aerial Vehicles, Bio-inspired Design, Aerial Robotics

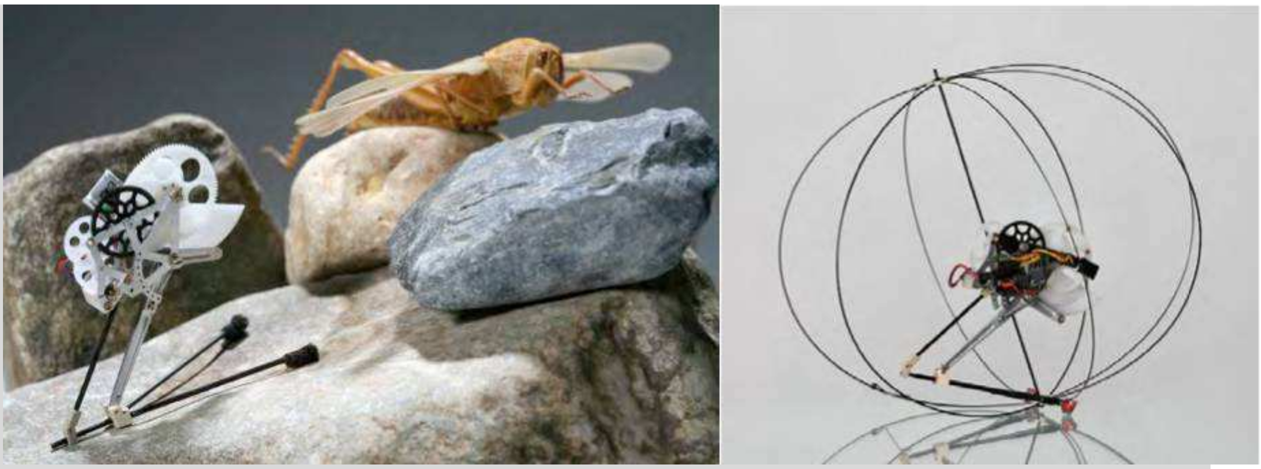

Figure. 1: Jumping robot (5cm 7grams) that is able to jump up to 1.4m in height using the same design principles as jumping insects.

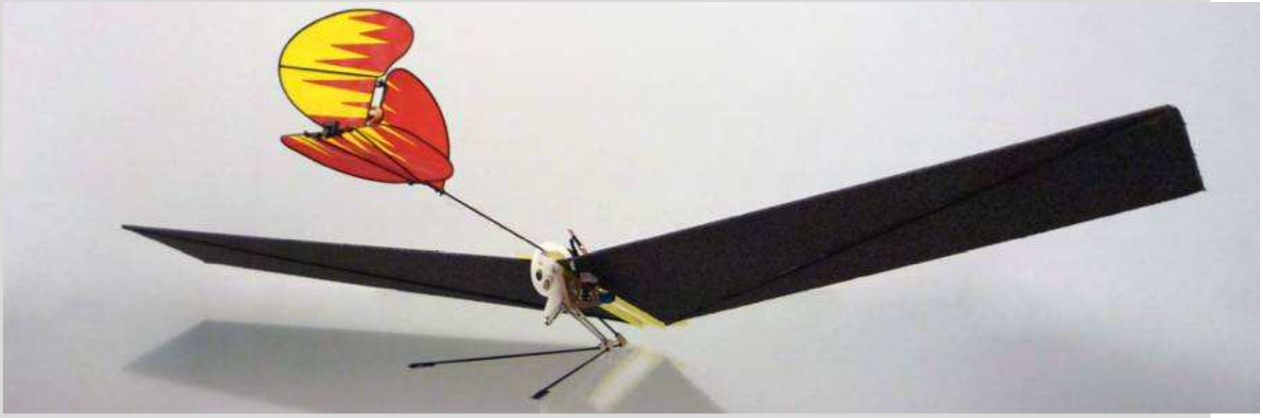

Figure. 2: Flying squirrel inspired jump-gliding robot (50cm wing span, 16.5grams) that can safely descend from elevated position such as trees or roofs of buildings using hybrid jumping and gliding locomotion.

Figure. 3: Perching micro-glider (30cm wing span, 4.5grams) that can perch to trees and buildings using mechanical intelligence that does not require any sensing or flight control for successful perching.