Design and optimisation of a vibrating wing insect-size air vehicle

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Abstract

This presentation covers the latest work on the optimisation of a bio-inspired nanodrone with vibrating wings. This study is part of a project led by the IEMN (Institut d'Électronique, de Microélectronique et de Nanotechnologie) and the LISPEN (Laboratoire d'Ingénierie des Systèmes Physiques et Numériques) at Arts et Métiers, which aims to get the world's smallest drone off the ground. At present, only two research teams have managed to get a nanodrone off the ground, the group of Prof. R. Wood at Harvard and the group of Prof. Y. Zou at Shangai university, but it is heavier and larger than our current prototypes. Studies carried out on insect flight have shown that the lift force on vibrating wings is efficiently produced when flapping and twisting movements are in phase quadrature (one being maximum when the other is zero). Based on this result, previous work has led to a first generation of Nano Air Vehicle (NAV) reproducing the movement of insect wings with a fully flexible structure. The drones are manufactured by micro-fabrication using lithography methods and are highly flexible structures with a weight of 20 mg and 22 mm in width. An electromagnetic actuator placed at the centre of the prototype causes it to vibrate, in order to induce a combined flapping and twisting movement of the wings. In this presentation, we will show that it is possible to design more efficient vibrating wings by replacing their entirely flexible ribs with one composed of an assembly of thin and thick members, the first one being compliant links and the second ones composing the rigid bodies. The first advantage of this concept is that the optimisation can be carried out on a simple spring/mass vibrating systems with very few degrees of freedom, which is shown equivalent to a multibody system of rigid bodies with compliant links. Another advantage is that these prototypes are more resistant because the thinness of the structure is concentrated at the compliant link. This makes it possible to obtain very large amplitude of vibration without damaging the structure.

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