Aerodynamic Shape Optimization of a Morphing Micro Air Vehicle Wing for Roll Control

Moustafa Ramadan Ahmed Nabawy
Dr. Mohamed M. Abdelrahman, Dr. Gamal Mahmoud S. El-Bayoumi and Dr. Mokhtar Malek El-Nomrossy

Abstract

Morphing is considered as a mean to adapt an air vehicle to changing mission requirements or flight conditions. The concept of wing morphing presents several opportunities either for mission adaptation or for flight control involving primarily, small, continuous adjustments in the shape of the wing and/or surrounding flow field to maneuver the aircraft during flight. This thesis presents a newly developed process for the design of the anti-symmetric twist distribution that should be imposed for the roll control of a Micro Air Vehicle (MAV) wing instead of using conventional ailerons. It starts with discussing the implementation of wing morphing for roll control on the conceptual design phase. The use of Response Surface Modeling (RSM) to construct a twist constraint function applicable to a MAV conceptual design stage is investigated. The aerodynamic design optimization of a morphing MAV wing for roll control is then presented. The obtained aerodynamic results are compared and validated using experimental (wind tunnel measurements) and numerical (Panel and CFD) methods. The static and dynamic stability of the MAV are then discussed. Both longitudinal and lateral control modes as well as the MAV frequency response are studied. Finally, direct and inverse simulations are performed using the complete nonlinear six degrees of freedom equations of motion.

***Keywords*:** Morphing wing; Micro air vehicle; Aerodynamic optimization; Lifting line theory; Modified feasible directions algorithm; Response surface methodology; Wind tunnel experiments; CFD.