Aerodynamic research of Flapping MAV

Background

Flapping Micro Air Vehicles (FMAVs) as the most intriguing type of MAVs family have obtained a great interest due to their outstanding efficiency and maneuverability. The flapping wings can generate both lift and thrust for an available flight. With onboard cameras and sensitive devices, these radio-controlled FMAVs are capable to implement tasks of surveillance, exploration and rescue. The inherent low Reynolds and unsteady aerodynamics caused by flapping motion results an uncomfortable aerodynamic behavior, conventional aerodynamic theories and analysis methods are no longer applicable to FMAVs. Ultimately, it is always essential to offer the designers and engineers a clear picture about the overall aerodynamic knowledge and useful tool to organize the FMAVs for specific mission objective and flight envelop.

This sub-project is now embedded in the STW project: "Insect Flight Inspired New Generation of Flapping-Wing Micro Aircraft"

Progress and Objectives

During the past period, a great deal of progress has been accomplished on the research on Flapping MAVs. Fundamental theoretical knowledge and previous research have been systematically referred. Meanwhile, staff from MAVLab provide a lot assistance on the fabrication of micro parts, which now results in other prototypes for both free flight and wind tunnel measurements.

An efficient and accurate N-S solver coupled of the ability of dynamic mesh strategies has been developed. For the inherent unsteady aerodynamics of flapping motion, two optional dynamic mesh methods are employed. Overset grid is responsible for large scale movement to guarantee the mesh quantity, while fast grid deformation based on Delaunay graph mapping will take care of small deformation, such as flexibility and Fluid-Structure interaction due to its notable computational efficiency. Such numerical tool can provide a reliable prediction and optimization of flapping motion by parametric test.

Experimental, computational and analytical methods are used in combination to further describe and investigate the characteristics. This will reveal to what extent beneficial unsteady aero-elastic phenomena are present in the current designs and how they may be further improved.

Further campaign will be conducted on the Wind Tunnel measurement on the Delfly Micro prototype which can collect sufficient data for next optimization and minimization. Also flow visualization techniques PIV (Particle Image Velocimetry) will be performed on Delfly Micro to provide a detail insight into the flow behavior around the flapping wing. Results of the experiments will provide feedback and input for further optimization. Alternatively, the data from experiments can provide specific validation data for testing the CFD method.

Certain PhD project will be especially dedicated to the further development and miniaturization of the Delfly MAV concept, along the lines of the existing Delfly Micro design. With an ambitious destination that establishing an overall FMAV design concept and its system integration.

Publications
