Analysis of Flapping Motion Considering Three Kinematic Mechanisms by Partitioned Iterative FSI Analysis System

Giwon Hong*,1, Tomonori Yamada†, Naoto Mitsume[2] and Shinobu Yoshimura[3]

[1,2,3]Department of Systems Innovation, School of Engineering
The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
[1]e-mail: g_hong@save.sys.t.u-tokyo.ac.jp, [2]e-mail: mitsume@save.sys.t.u-tokyo.ac.jp
[3]e-mail: yoshi@sys.t.u-tokyo.ac.jp, web page: http://save.sys.t.u-tokyo.ac.jp/

†Research into Artifacts, Center for Engineering (RACE)
The Univerisity of Tokyo
5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8568, Japan
e-mail: yamada@race.u-tokyo.ac.jp

ABSTRACT

Flapping flight is one of flight methods, which flying insects and birds adopt. By applying the flight method to a micro air vehicle (MAV), researchers have tried to make practical flapping-wing MAVs for performing various missions such as environmental monitoring and searching in hazardous areas. It is expected that the MAVs could be effective to demonstrate their aerodynamic performance at low Reynolds numbers[1].

It is still challenging to design the practical flapping-wing MAVs. Although various kinematic and geometric models have been proposed for flapping flight, the optimized models are not clear yet. So that, we can achieve the optimized design by a fluid-structure interaction (FSI), which is an unsteady and complex aerodynamic phenomenon.

To analyze the models and find out the optimized ones, we are using a three-dimensional FSI analysis system[2]. The system[3] has been developed by employing partitioned iterative coupling methods, which allow us to utilize existing solvers: a parallel FEM flow solver Front/Flow blue (FFB) and a parallel FEM structure solver ADVENTURE_Solid.

In this research, we focus on kinematics and simulate to find out optimized kinematic models, which consist of the following three mechanisms, i.e. flapping, pitching and lead-lag. At low Reynolds numbers, the design variables are changed, and then one wing follows an assigned motion by the combination of those mechanisms. Large deformation on three-dimensional meshes becomes an issue by describing the motion, so we deal with the problem by improving mesh-control techniques. Finally, we evaluate the result of parametric studies and attain knowledge to design the optimized kinematic models for flapping-wing MAVs.

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