RESEARCH MASTER INTERNSHIP

Department of Aerodynamics, Energetics and Propulsion

Department of Mathematics, Computer Science, Control

Superviser :

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INTERNSHIP DESCRIPTION

Domain : control, fluid mechanics

Title : **LEARNING TO FLAP, ADAPTIVE CONTROL OF A FLAPPING WING DEVICE**

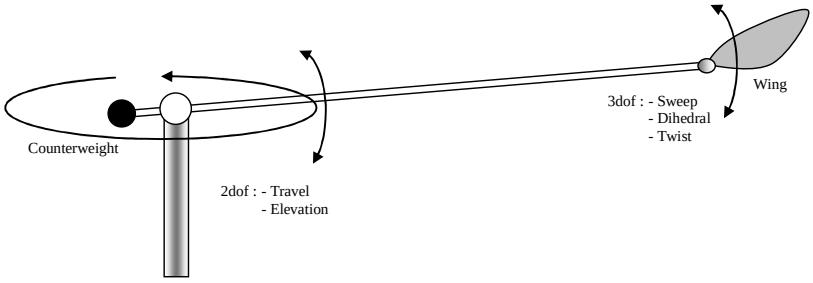

fig 1 : Learning To Flap experiment.

Context

Most mini and micro UAV (Unmanned Aerial Design) use conventional designs: either fixed wings or rotary wings (helicopter, contra-rotating, quadric-rotors, etc…). The technological solution of flapping wing has been chosen by Mother Nature after a very long process of evolution (several million of years!). Simple observation shows one first advantage of this solution: large flight envelop (slow speed, fast speed, agility). Some more complex investigations also has demonstrated the very good performance of birds in energy saving for a given flight speed. For this reasons flapping wing designs is a challenge for future mini and micro UAV designs: we expect good flight quality and low power consumption.

The flight mechanics of birds have been investigated by many researchers. But there is still a gap between the understanding (that is now quite good) and the capacity to reproduce bird's flight.

ISAE is developing an experiment called "Learning to Flap". The design (mass, dimensions, inertias) is inspired by the pigeon (Columba livia). In order to have an easier experimentation only one wing is mounted on a rotating mast, balanced by a counterweight. The three degrees of freedom of the wing are actuated by servomotors: Sweep, Dihedral and Twist. The rotating mast is free around two degrees of freedom: Travel and Elevation. These two angles are measured via optical encoders. Measurement and control are done through Matlab/Simulink.

A full simulation model has been already developed under Scilab and Matlab/Simulink.

The experiment was built in 2006 with basic mechanical concepts. Good results were obtained and several optimal criteria were investigated.

Student's work

Common for two students:

1. Bibliography (flapping wing dynamics, control of flapping wing, biomimicry, adaptative control).
2. Some design and engineering is still required for the experiment. Objective will be to be able to measure the torque to have access to the aerodynamic power.
3. Compare model A & B with the experiment. Validation and power consumption.

Separate work for two students:

A: black box approach

1. Model identification. A simulation model based on simple aerodynamical assumptions is available. The goal will be to fit the simulation model to experimental results.
2. Transient response, dynamic model.
3. Flight control. Investigation on performance, trajectory tracking and perturbation rejection criteria. Flight parameters

optimization (Sweep, Dihedral and Twist).

B: Aerodynamic approach

1. A full Unsteady Navier-Stokes model is available. The goal will be to develop the interfacing with the complete flight model. This part will probably not be done in real time.
2. Model identification as in part A with the new aerodynamical model

Methods: code de calcul des équations de Navier-Stokes en déséquilibre chimique, programmation en fortran

30 % Theoretical Research	20 % Applied Research	50 % Experimental Research

Possibility to go on a Ph.D.: o Yes o No

APPLICANT PROFILE

Knowledge and required level:

Control, fluid mechanics, basic Matlab skills

Applications should be sent by e-mail to the supervisor.