Senior Design Group #5:

Enhanced Agility of MAV's Using Adaptive Structures

Deliverable 1: Project Scope

Due: September 23, 2010

Client: Dr. Benjamin Dickinson

Advisor: Dr. William Oates

Group Members:

Joey Alessandria

Josh Webb

Mitch Jermyn

Needs Assessment

The applications for low Reynolds number (less than 10^5) micro aerial vehicles(MAV's) are essentially limitless. They can be used for surveillance, surveying, recognizance, and many other objectives. There is a lack of knowledge into the behavior of these vehicles due to their size and air speed. In order for the field to advance, better designs that will result in more stable and agile flight are necessary to increase the dependability of these vehicles. The use of smart materials is perfect for an application such as this in that they do not require the use of mechanisms to function.

Project Scope

Problem Statement

Low Reynolds number MAV's can be somewhat undependable due to the fact that their implementation is relatively cutting edge. Much is not understood about aerodynamics in the transitional phase of flow (between laminar and turbulent) such as this. In order for MAV's to prove themselves useful steps must be taken towards improving their performance.

Justification/Background

The client of this project is Dr. Benjamin Dickinson, a materials researcher for Eglin Air Force base. MAV's are still very much in the developmental stages and much is to be learned about their flight characteristics. The MAV itself will need to be agile and durable enough to navigate various obstacles and the inherent forces therein. The flight environment should be able to range from high heat conditions such as deserts to dark cold wet conditions such as caves. This project calls for the implementation of adaptive structures in order to improve flight characteristics.

Even though the field is very new there have been a number of innovations and papers published. Many studies that have already been done are modeled after natural phenomena such as avian and insect flight. Many of these solutions have worked but are strictly limited to unfixed "flapping" flight, which can be a nuisance while trying to fly through places with low clearance. Others have tried to meet the challenge by using adaptive structures to change the wing geometry resulting in increased performance. Last year a design group used an electrically actuated elastomer in order to deform the wing geometry in a advantageous way. In theory applying an electric potential across this membrane will cause the membrane to bulge out. The results of this experiment in this instance were less than desirable do to an in proper placing of the membrane. Another problem that must be solved is managing the deformation in the way that the polymer does not lose its elasticity which all membranes are subject to when put under fluctuating stresses. This can either be done by finding a material that hinders this behavior, or by implementing a quick inexpensive way to change the material out between flights.

There are a variety of adaptive materials that can be used for this project. Placing no limitations on the power source leaves the design very open ended, and allows any smart material to be used; whether it be actuated by light, electricity, or temperature.

Objective

Enhance the aerodynamic properties of fixed wing MAVs at low Reynolds Numbers (5,000 to 50,000) using adaptive structures. The ultimate goal of the project is to prove that adaptive structures integrated into an airfoil are a viable way to improve the flight characteristics of MAVs. The enhancement of MAV's can be, but is not limited to , increased lift coefficient, better flow attachment, or decreased stall speeds. It is the intention of this group to provide empirical results and new innovations with a budget of two thousand dollars.

Methodology

In order for this project to be successful, the group as a whole must understand adaptive structures and the basic flight characteristics of MAVs. Therefore the first step is to do background research in the field of adaptive structures, as well as MAVs. The group will then select the aerodynamic property or properties which will be optimized by the use of adaptive structures. Once the background research has been conducted and the flight characteristics to be modified have been selected, the group will then conduct a brainstorming session on possible designs for the airfoil. After analyzing the possible solutions, the group will select the best design with the help of the sponsor as well as the faculty advisor. A prototype will then be built and tested. The tests which will be run depend on the selected aerodynamic property to optimized, and may include flow visualization as well as lift or drag force measurements. All tests will be run with and without the adaptive structures engaged so a comparison can be made. The testing will be conducted using the facilities at either Florida State University, or the University of Florida. The design which the group selects for testing will need to be implemented as soon as possible in order to make sure that the group can get access to the testing facilities.

Constraints

There are various constraints that directly influence the enhancement of mirco aerial vehicles (MAV's).The project scale we are working with is a design with a Reynolds Number less than 100,000 and for fixed-wing flight only.

Since this project spans over the Fall and Winter months, time will be one of the largest constraints. In order for the design to be cost-efficient it must be manufactured for under $2,000. In reality, this will be easy to achieve since currently the wing platform is expected to be the most expensive component and expected to cost less than $500. However, multiple designs may be implemented and tested, raising the budget.

Expected Results

Upon completion of this project, a detailed enhancement of micro aerial vehicles should be achieved. This design must be able to be reproduced for under $2,000. The design will be efficient and be implemented to navigate in any environment at any altitude better than it could before the enhancement.