Senior Design Group #4:

Enhanced Agility of Micro Aerial Vehicles Using Adaptive Structures

Deliverable 1:
Needs Assessment and Project Scope

Due: October 6, 2011

Client: Dr. Benjamin Dickinson

Advisor: Dr. William Oates

Group Members:

William Ehlers

Daryl Montooth

Redan Reyes

Manuel Santos

Needs Assessment

Micro air vehicles play an important role on the battlefield. Whether they be used to survey an area or reconnaissance into enemy territory, micro air vehicles flight stability is crucial. The integrations of an electro-active membrane will help stabilize the micro air vehicles during flight. It is important for the application of electro-active membranes to be effective, therefore time response is vital information. Due to the size and weight of these vehicles, reliability during flight can be low under certain conditions. Finding a method that allows for these vehicles to maintain stable flight conditions would optimize the vehicle itself and allow for a wider range of uses.

Problem Statement

Micro air vehicle's reliance is relatively low considering they are fairly new. Proper research and steps are being taken to better understand their performance during flight and methods to improve flight stability. Implementations of electro-active membranes are being used to control the shape of the wing during flight. The effectiveness of electro-active membranes can be determined by measuring time response.

Background / Justification

Micro aerial vehicles (MAV) are size restricted, unmanned aerial vehicles (UAV) that are used by the military for emergency response applications that include, and are not limited to, surveillance, reconnaissance and recovery operations. MAVs allow the military to have a better understanding of the environment they plan to encounter while reducing the risk of their location being detected by the enemy. Recently, the idea of placing electro active membranes on the wings of MAVs has been of great interest to increase the agility, lift-to-drag ratio and overall flight control. The purpose of the electro active membranes is to distort the shape of the wing by running an electric potential across it while it is approaching stall, which will allow for an increase in lift when it normally would not. Carbon grease will be used to accept the electric potential. While the benefits of MAVs are plenty, it is also important to address certain aspects which could potentially alter the outcome.

One major set back to MAVs is the small size which directly affects its maneuverability and stability. MAVs are hard to manually pilot at high altitudes and are easily influenced by weather. The material that is used to make up the MAV must be able to withstand relatively high and low temperatures and constant stretching. In addition, rain and strong winds should be tolerated, but snow may be exempt due to the small size of the aircraft.

MAVs with the application of electro active membranes are still in design and testing stages, and we plan to further knowledge of effective characteristics of this field through testing at Eglin Air Force Research Laboratory.

Objective

Similar to our predecessors, the objective of this project is to enhance the aerodynamic properties of fixed wing MAVs at low Reynolds Numbers using adaptive structures. Using an electro-membrane adaptive structure, the first subjective is to analyze the time response of the structure during dynamic adaptation. The second subjective is to improve deformation for control to at least a 50% change in the first frequency mode of the dielectric membrane. The third subjective is to analyze gust alleviation based on the dynamic adaptation. Each subjective serves the purpose of empirically reaching an understanding of aerodynamic surface/fluid-structure interaction controls. The group has also discussed the possibility of building an experimental model of the MAV with the adaptive structures implemented as an additional subjective to the overall project.

Methodology

In order to achieve our objective of enhancing the aerodynamic properties of fixed wing MAVs, the existing aerodynamic properties must be known beforehand. Since research and experimentation has already been conducted to find some of these properties, these will serve at the platform which the rest of the project will be based upon. To achieve the first subjective, the fixed wing with the fluid membrane will be recreated and electrified to determine how quickly the membrane reacts to the imposed current. To achieve the second subjective, varying the application/ concentration of the membrane and electric current will be the method used. To achieve the third subjective, placing the wing behind a bluff body in a wind tunnel and experimenting with the membrane to analyze gust alleviation is the method that will be used. For the additional subjective, building the experimental model to fly or drop with removable wings will be the method for testing the flight stability with or without adaptive structures.

Constraints

The constraints imposed on our design include that the results be applicable to micro aerial vehicles of wingspan less than or equal to 6 inches. This scale could play to both our benefit and disadvantage as drastic performance changes may result from small enhancements to the design. The time available for testing will be particularly strained. Available test dates at Eglin Air Force Base will be limited, and the test environment within the wind tunnel must be constructed on site, decreasing available time even further. Therefore it will be essential to make the most of resources provided this semester to prepare efficiently, ensuring all time is used adequately. Our budget to conceptualize, construct and maintain the design is $2,000.

Expected Results

Once completed, the micro aerial vehicles to which our design is applicable will be performed with improved gust alleviation, and potentially (time-permitting) an improved capacitive sensing mechanism for “real-time” closed loop control of the MAV and electrodes. The placement of the electrodes will be optimized so as to achieve a minimum of 50% change in the first mode of the dielectric membrane.