

Increasing persistence of UAVs and MAVs through thermal soaring

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ABSTRACT

This work looks to harness atmospheric energy through thermal soaring to optimise the flight persistence of Micro Air Vehicles (MAVs) and Unmanned Air Vehicles (UAVs). There are two key challenges when considering thermal soaring, the first being the locating of thermals and the second being the extraction of the maximum potential energy from the thermals. Thermal location is by no means an exact science with experienced glider pilots needing to consider many factors to improve the probability of encountering a thermal. As thermals are caused by the uneven heating of the Earth's surface it is, however, possible to predict likely thermal locations. With the application of a suitable guidance algorithm which considers these 'hot spots' it is possible to increase the likelihood of encountering a thermal. Once a thermal is found it is important to attempt to extract the maximum energy from the thermal. To do this the vehicle needs to move quickly to the centre of the thermal. There are many potential techniques for thermal centring, some of which appear to be entirely contradictory to each other, the crucial factor determining the success of such a technique has been found to be the response time of the onboard sensors. This paper considers the many aspects of thermal soaring such as locating thermals, thermal detection and thermal centring. Five different thermal models are presented which are used to demonstrate the thermal centring techniques. Finally a commercial glider simulation package is used to demonstrate the control architecture and simulate a fully autonomous flight.

NOMENCLATURE

ϕ	bank angle (rad)
E	total energy estimate (J)
J	cost function
P_n	constant
T	time (s)
V	airspeed (ms^{-1})
X_i	thermal hotspot x position (m)
Y	thermal hotspot y position (m)
a_n	free variable
d	deviation from straight line (m)
g	gravitational constant (ms^{-2})
h	altitude (m)
p	distance to closest hotspot (m)
s	laplace operator
w	user defined weighting function
x_0	initial position (m)
x_T	final position (m)
x	trajectory coordinate (m)
y	trajectory coordinate (m)

1.0 INTRODUCTION

The objective of the 'Harnessing atmospheric energy' strand of the micro air vehicle programme is to investigate means to increase the persistence of small unmanned vehicles.