CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

Nathan H. Xu

Project Number

S1428

Project Title

Optimal Trajectory Planning for an Unmanned Helicopter: Bifurcations in the Presence of Obstacles

Abstract

Objectives/Goals

The main objective is to create a computer program that is capable of guiding an unmanned helicopter from point A to point B in minimum time without hitting the obstacles between them.

Methods/Materials

Different MATLAB programs are developed and validated to enable the critical capability of obstacle avoidance in the nonlinear optimal trajectory planning of an unmanned aerial vehicle (UAV) helicopter, named HeLion. Numerical simulations are performed to explore and discover the characteristics of the bifurcations in the presence of obstacles. The materials and software used in my project are as follows: a Window 7 based desktop PC; a UAV helicopter nonlinear dynamic model; a Pseudo-Spectral (PS) optimization package; a p-norm based mathematical model for obstacle avoidance; a student version of MATLAB.

Results

The results illustrate that the obstacle configuration plays a key role in determining the verifiable optimal trajectory, such as flying over or around obstacles, for the UAV helicopter - HeLion flying between Point A and B in an obstacle-rich environment. An innovative procedure designed and implemented in this project, to iteratively search for a bifurcation point (BP) in the presence of an obstacle is quite accurate. The procedure also significantly reduces the computational requirement to find the additional BPs when one needs to study the impact of various obstacle configurations on bifurcations.

Conclusions/Discussion

Based on hundreds of simulations, I conclude that the new-created computer program, using the 'inequality state constraints' of a p-norm based mathematical obstacle avoidance model, is an accurate and efficient tool for off-line UAV helicopter optimal trajectory planning with the critical capability of obstacle avoidance. The benefits from this research include but not limited to the following: (1) enabling the critical capability of the 'obstacle avoidance' for HeLion optimal trajectory planning, (2) providing a tool for the validation of the efficiency of future autopilot designs adding samples to the collection of HeLion's optimal trajectories, (3) applying the knowledge obtained from this research to optimal trajectory planning of UAVs other than HeLion.

Summary Statement

What would one do to guide an unmanned helicopter from point A to point B in minimum time without hitting the obstacles between them?

Help Received

Prof. Wei Kang of the Naval Postgraduate School (NPS) provided me with the Pseudo-Spectral (PS) optimal control package and a numerical model for HeLion. My parents provided me with a Desktop PC and bought me a student version of MATLAB.