CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

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Project Number

S1427

Project Title

Characterizing the Optimal Flight Time of a UAV Helicopter, an Odyssey through Numerical Simulations

Abstract

Objectives/Goals

This project deals with optimizing the flight operation of a UAV (Unmanned Aerial Vehicle) helicopter. I intended to characterize the optimized minimum flight time to hover between two end points. My goal was to develop a relationship for estimating the minimum flight time without using the complicated optimization method.

Methods/Materials

The tools I used for this project include an optimization program and a UAV helicopter model. MATLAB was used in data analyses. The optimization program applied to the nonlinear helicopter model resulted in a solution optimized for minimum flight time for two given end points. In this process, initial guesses of controls and state variables were fine tuned in search for an optimization solution. Solutions were obtained for some sample end points with various linear distances. I analyzed these results and established an empirical relationship between the minimum flight time and the distance using least square linear regression method. I validated this relationship using independent samples from the full optimization process. I further examined the effects of the number of nodes in the optimization process on my results.

Results

I found that the optimal flight time is best described as a linear function of the distance even though the optimized flight trajectory is rather complicated. My regression results show very small bias and standard error when compared to the full optimization solutions. The function is also applicable over an extended range of distances. The number of nodes may change the flight trajectories, but it does not significantly affect the total flight time.

Conclusions/Discussion

I obtained an empirical function between the minimum flight time and the linear distance between the two end points for a UAV helicopter. This relationship was found to be accurate and robust.

Summary Statement

This project is about defining the optimal operation envelop of a UAV helicopter without using the computationally intensive optimization process.

Help Received

Professor Wei Kang provided me with the optimization program (snOpt) and the nonlinear helicopter model developed by the National University of Singapore.