SpaceMaster Diploma Thesis Review
- supervisor -

Name of student: Eswarmurthi Gopalakrishnan

Thesis topic: QUADCOPTER FLIGHT MECHANICS MODEL AND CONTROL ALGORITHMS

CTU Supervisor: Doc. Ing. Martin Hromčík, Ph.D., DCE FEE CVUT in Prague

Eswar is a Round 9 SpaceMaster student at CVUT. His student's project was assigned in autumn 2014 within a then-starting joint students' activity with the VZLU research institute to which I have been invited. Eswar did not perform satisfactorily and his thesis submitted in Spring 2016 was rejected by the State Examination Committee with a recommendation to extend he scope and re-write the manuscript.

I must confess that Eswar since that time has worked intensively on his diploma project and has brought it to a state I can acknowledge. He kept coming regularly for consultations and was showing progress. Technically, I appreciate that realistic models of actuators are now included in the design and validation simulation case studies in this revised version of the thesis, the linear analysis is executed correctly, and the PID and LQ control laws are designed correctly and show satisfactory performance. On the other hand, since the pace of progress of Eswar was not as fast as would be appropriate for an excellent student and excellent thesis, there was not space to explore any further issues that would be interesting and important (trajectory planning issues, dynamics of sensors and their compensations, ..).

Based on the above arguments, my suggestion is

grade C

in accordance to ECTS.

2017/09/06

Date

Signature

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CTU Diploma Project Review
Kiruna, June 7 2017

CTU Diploma Project review- 2nd reviewer's evaluation of master thesis with title "Quadrocopter flight mechanics model and control algorithms laws " by Space Master student Eswarmurthi Gopalakrishnan.

I find that the *goal* of the thesis project fulfils the requirements of a master thesis in space technology. The work concerns development a quadrocopter flight mechanics nonlinear model in MATLAB/Simulink. A set of both basic and advanced control laws for stabilization and guidance should be validated for the model. Also, the thesis shall include a literature survey related to the thesis topic.

A rich source of documents concerning quadcopter modelling and control exists, many of which stem from amateurs and not from research project. Some of these documents are nevertheless very informative and in some cases also advanced. For the litterature survey it is of importance to include trustworthy litterature and present this in a consistent way for the reader.

Only a few sources are included for each "submodel" in the thesis. Mathematical models are presented more or less word by word from these sources and not in a consistent way. There is no part that really shows how to put together all "submodels" into a final full model. The sensor models are assumed to be ideal, i.e no noise or dynamics, and this is not commented on. There are also other important assumptions that are not commented on, for example the basic assumptions leading to a SISO controller approach with no crosscouplings (Ixy, Iyz etc).

The control laws and models are only "validated" by a sanity check using visualisation. The transfer functions and blockdiagrams for the systems are generally not explicitly given and the results are not compared to analytical solutions for the linear or linearized cases. The final value theorem could for example have been used in order to validate the 3 degree steady state error mentioned on p.54.
It is not always clear if transfer functions are from reference to output or from disturbances to output (noise transfer functions are not considered at all). The discussions regarding the presented results (graphs) are shallow and results that should be discussed (for example fig 10 relation between angular velocity and position) are not commented on.

The controllers are designed ad hoc (probably by manually varying model controller paramerters) but goodnes parameters are not evaluated, i.e does the system meet given design constraints.

The thesis as a whole is of low quality and in order to approve the thesis with grade E the student has to complement the written thesis during the oral presentation and defence and fill in the shortcomings.

This review serves solely for the purposes of the diploma project defense at CTU. LTU official evaluation for the SpaceMaster double degree will follow the thesis defense and may differ from this review report and suggested grade.

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