REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Predictive control of an unmanned aerial vehicle with a time-variable mass**
Author's name:	**Diego Alejandro Saikin**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Ing. Martin Gurtner
Reviewer's department:	Department of Control Engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

Evaluation of thesis difficulty of assignment.

The thesis deals with designing and tracking a trajectory for a quadcopter with time-varying mass. The trajectory should be such that the quadcopter starts with a specific load attached, follows a trajectory which gets it to a state from which it can recover only if the load is detached. Furthermore, this task should be solved in a receding control horizon fashion by a model predictive controller (MPC). This definitely poses an interesting control problem.

Satisfaction of assignment **fulfilled with major objections**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

Unfortunately, I can see a few deviations from the original assignment in the thesis. First of all, the trajectory is planned offline and tracked by a controller which is barely mentioned in the thesis and which is definitely not an MPC (as it was required in the assignment). Since MPC is mentioned explicitly in the assignment, it should have been either tested (at least) in simulations or some arguments why it is impossible to use an MPC-like controller in this scenario should be provided. Furthermore, there is a requirement on comparing the approach where the change in mass is considered to an approach where the mass is considered constant. This part is missing as well. Although, I must mention that the proposed controller was tested on a real hardware, which, in contrast, was not required.

Method of conception **correct**

Assess that student has chosen correct approach or solution methods.

My main objection is that the way the author proceeded is not well argued and documented. For instance, the goal is to design a trajectory for a hybrid model, a model consisting of several models which are switched depending on some events. The way the author approached this problem—multiple shooting + fixed-length stages + variable sampling time for each stage—is quite natural and apparently works. Nevertheless, a research of applicable methods should have been conducted and reported. This way, it looks like the author randomly chose a method which, luckily for the author, worked.

Technical level **C - good.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The comment from the previous section applies here as well. It is not clear why the author proceeded the way he did.

Formal and language level, scope of thesis **C - good.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The author has a very good command of English. The thesis is rather readable. Nevertheless, I have some formal objections. The math formulae are not properly set. The author denotes multiplication by '*' (equation (3)). Function names and text in equations should be set in an upright font not in italics (equations (3) and (19)). Subscripts with text should be set in an upright font as well (i.e. m_{UAV} not m_{UAV}). Some figures are enormously large and some are not properly labeled; some axes lack physical units (e.g. figure 7), some does not have any label at all (e.g. figure 5). Symbol ∇ usually denotes a differential operator, not a vector as such, hence $\nabla_{terrain}$ is a peculiar way of denoting a vector. Table 2 does not fit to the page (at least, in the printed version of the thesis).

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Selection of sources, citation correctness **C - good.**
Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.
I have already made the point, the author did not sufficiently work with available literature. Nevertheless, with the exception of software framework CasADi, what is used is also properly cited.

Additional commentary and evaluation
Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.
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III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

My main objection mentioned in almost all sections above is that the author did not argue well enough why he proceeded the way he did, why he chose the tools he used. Furthermore, the assignment is fulfilled only partly. Also, the visual aspect of the thesis is rather poor. Nevertheless, I must also take into account and emphasize that the author verified functionality of the proposed approach in field tests.

Therefore, I evaluate handed thesis with classification grade **C - good.**

Questions:

1. Why did you use discs as the load to be released? You modelled the load as a mass point and thus one would expect using a spherical object instead of a disc.
2. Why did you consider individual components of the heading vector as decision variables? This way, you have more decision variables and you have to constrain the norm of the heading vector to one. Instead, you could model the heading vector as $[\cos(\psi), \sin(\psi)]^T$ and use ψ as the decision variable.
3. Does the trajectory tracking controller take into account that the load was released hence the mass of the quadcopter changed?
4. Warm starting (or hot starting) is mentioned at several places in the thesis. How do you choose or get the initial values of the decision vector when warm starting is used?

Date: **13.6.2018** Signature: