SUPERVISOR'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Mission planning for cooperative construction by a team of unmanned aerial vehicles**
Author's name:	**Jasna Petric**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis supervisor:	Martin Saska
Supervisor's department:	Department of Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment   **challenging**
Evaluation of thesis difficulty of assignment.
The assignment was challenging as it requires knowledge of task allocation and mission planning approaches, but also significant implementation works in ROS and Gazebo to enable deployment of multiple UAVs sharing their workspace.

Satisfaction of assignment   **fulfilled**
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.
All points of the assignment were fulfilled and even the HW experiment with multiple drones was implemented beyond the mandatory tasks of the assignment, which I did not expected.

Activity and independence when creating final thesis   **A - excellent.**
Assess that student had positive approach, time limits were met, conception was regularly consulted and was well prepared for consultations. Assess student's ability to work independently.
Student's activity was excellent. She worked hard and helped us in many tasks not directly related to her thesis. She significantly contributed into the video report of the MBZIRC 2020 competition, which qualified us to the finals of this challenge.

Technical level   **E - sufficient.**
Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.
It is lower mainly in the parts dealing with task planning and task allocation. Mainly the used terminology was not solid, which could be caused by the fact that student did not attend our bachelor program with the subject Cybernetics and artificial intelligence.

Formal and language level, scope of thesis   **C - good.**
Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.
The thesis is sufficiently well readable and it contains an acceptable number of typos and grammar errors. The results are well presented.

Selection of sources, citation correctness   **A - excellent.**
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.
The state of the art covers 5 pages and it includes 64 references from well recognized conferences and journals. The references are well cited following all robotic standards.

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.

Please insert your commentary (voluntary evaluation).

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation.

To sum up my evaluation, I have to highlight that student worked intensively on the thesis and was a valuable member of our MBZIRC team, where she helped also with the video report, which was beyond the thesis. The assignment was exceeded also by the HW experiments. On the other hand, the technical quality of the planning part of the thesis has lower quality and did not bring expected contribution. During the works on the thesis we decided to be focused more on communication and technical aspects of coordination of multiple UAVs, which we found more important regarding the specification of rules from the challenge organizers.

Putting these together, I evaluate handed thesis with classification grade **C - good.**

Date: **5.6.2019**   Signature:

Review of Master's Thesis: "Mission planning for cooperative construction by a team of unmanned aerial vehicles"

Author of thesis: Jasna Petrić
Reviewer: Ing. Daniel Fišer

The thesis is targeted at solving a very specific problem from MBZIRC 2020 competition, namely building a wall from colored bricks using UAVs. In the first part of the thesis, an algorithm for selecting an order in which the bricks will be placed in the wall is proposed. And the second part describes a simulation and real-world experiments with the proposed algorithm.

Although the simulation and real-world experiments seems to be satisfactory, the work on the scheduling algorithm has serious deficiencies.

The chapter on related work is rather short, it is filled with inaccurate or confusing statements, and cited literature sometimes seems to be chosen at random. For example in 2.2.1, a paragraph starts with "Graph based solution usually suffers [...] from computation complexity." and follows with "One of the ways to avoid the dimensionality problem is to use a sequence of graphs." which is the first time the "dimensionality problem" is mentioned. It is not clear why (or which) graph-based approaches suffer from computational complexity, what are "sequences of graphs", what is meant by dimensionality problem and so on. As another example in the same section, the fifth paragraph starts with defining a tree as a directed connected graph without cycles, for which three sources are cited, two relating to UAVs and LaValle's book Planning Algorithms. And immediately after that, a tree is defined again, this time as "a structure of hierarchically linked nodes where each node represents a particular state". I don't understand why these three source are cited for a standard definition of a tree and why is a tree re-defined immediately after that. It is, probably, an attempt to define a state space as a tree structure, but it is utterly confusing.

The worst part of the thesis is the third chapter. The fact that the title of the chapter reads "Cooperative wall building", but there is nothing "cooperative" in the described algorithm, is the smallest of all problems. As far as I can tell from the description of the problem, the goal was to find a sequence of bricks that will be placed in the wall so that as many bricks as

possible is placed in the wall even in a case UAVs fail to deliver the assigned brick to the right place. Before I get to the proposed solution, I should mention that the thesis does not describe what is a valid sequence of bricks. I can only guess that that was the purpose of the section 3.2 named "Tree build", because otherwise this whole section doesn't make sense to me.

On several places in the thesis, it is said that the goal is to minimize the cost (of delivering bricks to the right places) and maximize the reward (the number of correctly placed bricks). However, it is never described how exactly are these two criteria used for selecting the optimal solution or even what is the optimal solution. (I should also mention that on several occasions, the thesis mentions "less optimal" and "more optimal" solutions, which adds to the confusion.)

The cost of a brick is defined in equation (3.2) to be independent of the order in which the brick is placed in the wall. Assuming that the reward is also independent of the order, maximizing reward would, obviously, mean to place all bricks in the wall in any valid order, because the cost of all solutions would be constant. Minimizing the cost would then result in an empty wall. Since the thesis does not describe how these two opposing criteria are combined, it is impossible to assess the proposed solutions. The only thing I can say is that the method named "brute force" just generates all possible sequences and selects the best one (but again, it is unclear what that is). The "greedy" and "improved greedy" methods seem to be just weirdly described best-first search methods.

Overall, I don't think the work meets the requirements for a Master's Thesis and I grade the work with **F (failed)**.

Prague, June 3, 2019

Daniel Fišer