

**I. IDENTIFICATION DATA**

<b>Thesis name:</b>	<b>An Improved RRT* Algorithm for Multi-Robot Path Planning</b>
<b>Author's name:</b>	<b>Poludin Mikhail</b>
<b>Type of thesis :</b>	bachelor
<b>Faculty/Institute:</b>	Faculty of Electrical Engineering (FEE)
<b>Department:</b>	Department of Cybernetics
<b>Thesis supervisor:</b>	Tiago Pereira do Nascimento
<b>Supervisor's department:</b>	Department of Cybernetics

**II. EVALUATION OF INDIVIDUAL CRITERIA**

<b>Assignment</b>	<b>ordinarily challenging</b>
<i>Evaluation of thesis difficulty of assignment.</i>	
The thesis assignment to the student is considered ordinarily challenging. The challenge here is, despite the algorithmic contribution itself, the need to implement the contributions on real robot experiments, using real UAVs. The student must use one autonomous UAVs and perform a successful experiment in a GNSS-denied environment. This usually is very time consuming and technically demanding.	

<b>Satisfaction of assignment</b>	<b>fulfilled</b>
<i>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.</i>	
My evaluation is that this thesis meets the requested assignment. None of the required tasks from the final assignment fell short. The student considered fixed obstacles, GNSS-denied environment, performed simulation o a multi-robot scenario application, performed real robot experiments and comparisons with the state-of-the-art approaches.	

<b>Activity and independence when creating final thesis</b>	<b>A - excellent.</b>
<i>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.</i>	
My evaluation is that the student performed an excellent job in his thesis. The student was under my supervision only in this semester, so he had to come up with the work from scratch. He was able to implement two well known algorithms (RRT and RRT*), expand the approach for a 3D search, analyze the algorithms behavior with obstacle avoidance, and was able to expand the RRT* to a multi-robot application. The student always came prepared to the biweekly meeting I have with him and other students under my supervision. He was able to work independently and search for answers beyond my orientation. He also participated in a two week experimental campaign the MRS group performed in April at CVUT TEMEŠVÁR.	

<b>Technical level</b>	<b>B - very good.</b>
<i>Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.</i>	
My evaluation is that this thesis has a very good technical level.  This thesis includes a brief overview of the UAV path planning and a detailed explanation of the algorithms implemented. The implementation of the RRT and RRT* algorithms were performed and extended to handle the generation of trajectories for multiple drones. Two obstacle avoidance approaches were introduced and tested with both RRT family	

path-planning algorithms. Experiments of autonomous UAV flight in a forest-like environment were conducted in both simulation and real world. Both simulations and real world experiments were filmed. Thus, the student demonstrated good use of the knowledge in path-planning, and deployment of UAVs in a real world scenario. The comparison using the state-of-the-art RRT algorithms also demonstrated a thorough research from the literature.

### Formal and language level, scope of thesis

**C - good.**

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

The student has a good written English. However, I feel that the student could have used better notations and formulate a problem in a better manner. The final version of the thesis, however, is still good enough for a bachelor degree graduation in my evaluation,.

### 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.*

The student performed a good job on selecting the references. The student acquired 33 references. I believe he could have got more. The quality could also be improved.

### 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.*

The main objective of the thesis was achieved. The student compared and implemented algorithms from the RRT family for the exploration of GNSS-denied environments with obstacle. The student also performed real robot experiments and numerical comparisons with the state-of-the-art approach. The software used is available on Github and can be used in other projects. All the work was performed with a rigorous scientific methodology and the date is sufficient, in my opinion, for the graduation as a Bachelor.

### III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

*Summarize thesis aspects that swayed your final evaluation.*

In summary, my evaluation was due to the fact that the student:

1. Performed improvements and comparison with the RRT state-of-the-art algorithms.
2. Performed real robot experiments.

I evaluate handed thesis with classification grade B - very good.

Date: **25.5.2022**

Signature: