

## I. IDENTIFICATION DATA

<b>Thesis name:</b>	<b>An Integrated Approach to Multi-Robot Exploration of an Unknown Space</b>
<b>Author's name:</b>	<b>Vojtěch Lhotský</b>
<b>Type of thesis :</b>	master
<b>Faculty/Institute:</b>	Faculty of Electrical Engineering (FEE)
<b>Department:</b>	Department of Cybernetics
<b>Thesis reviewer:</b>	Kruno Lenac
<b>Reviewer's department:</b>	University of Zagreb, Faculty of Electrical Engineering and Computing, Department of Control and Computer Engineering

## II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b> <i>Evaluation of thesis difficulty of assignment.</i>	<b>challenging</b>
The assignment is challenging as it includes testing multiple complex components in real world scenario. SLAM is one of the crucial and most complex algorithm in mobile robotics and together with exploration algorithm it allows mobile robot to autonomously map unknown areas. Besides these two complex algorithms path planning, sensor measurement filtration and fusion has to be implemented for the entire system to work.	
<b>Satisfaction of assignment</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>	<b>fulfilled with minor objections</b>
In the thesis all the assignments were done correctly and according to the guidelines. The algorithm for exploration based on 2D polygons was successfully adapted and some clever ideas were implemented to make it better in real world environment. The only aspect of the thesis that I would like to be more extensive is the experimental verification of the exploration with multiple robots, but since hardware failures occurred which could not be predicted or solved within this timeframe it is acceptable.	
<b>Method of conception</b> <i>Assess that student has chosen correct approach or solution methods.</i>	<b>outstanding</b>
In the thesis relevant RGBD SLAM solutions implemented under ROS were tested and correct solution was chosen for the given task. Also all modifications required by the exploration algorithm were correctly identified in order to allow execution in real world. Student also developed some missing parts that complemented the entire solution and allow it to work more precisely in the real world experiments.	
<b>Technical level</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>	<b>B - very good.</b>
The scope of the thesis deals with current state of the art problems in mobile robotics: localization, exploration, map building and path planning. The knowledge gained from the literature was used to identify shortcomings of existing algorithms and to develop solutions for those shortcomings. The implemented solutions were tested in real world and proven to work correctly. Student used relevant sources and evaluated them correctly when choosing final implementation methods.	
<b>Formal and language level, scope of thesis</b> <i>Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.</i>	<b>A - excellent.</b>
The overall language quality and usage of technical terms within these thesis is excellent.	
<b>Selection of sources, citation correctness</b> <i>Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection</i>	<b>A - excellent.</b>

*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 sources within the thesis are both very well selected and cited. For example RTAB-SLAM and ORB-SLAM are currently two state of the art RGBD SLAM solutions available in ROS. Also relevant articles for exploration were correctly identified and cited. Throughout the thesis it is very clearly laid out what was newly developed, which already implemented algorithms were used and from what sources and what new modifications were made to every selected algorithm.

### **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.*

I enjoyed reading these thesis as it is very well written and easy to follow. My opinion is that all tasks were completed successfully and taking into account given time frame and difficulty of the tasks their implementation level is excellent. Also I found that student presented excellent capability to solve unexpected problems encountered when moving from simulation scenario to real world experiments.

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

*Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.*

I found that tasks in the thesis were challenging and cope with some of the crucial problems in today's mobile robotics. All developed and adapted algorithms were successfully implemented and encountered problems were successfully solved. Also final experiments and solution evaluation were done in real world under challenging conditions.

I evaluate handed thesis with classification grade **A - excellent**.

#### **Questions:**

- 1. Would it be possible to implement probabilistic approach when choosing which area of the map is an obstacle and which is free?**
- 2. Could a 3D map be used for improving accuracy of 2D polygon map and how?**
- 3. Which features does RTAB-SLAM visual odometry use and would changing them improve the results?**

Date: **4.6.2016**

Signature:

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Kruno Lenac, mag. ing.