

## I. IDENTIFICATION DATA

<b>Thesis title:</b>	<b>Autonomous Robotic Exploration of Underground Environments</b>
<b>Author's name:</b>	<b>Lars Kahlert</b>
<b>Type of thesis :</b>	bachelor
<b>Faculty/Institute:</b>	Faculty of Electrical Engineering (FEE)
<b>Department:</b>	Department of Cybernetics
<b>Thesis reviewer:</b>	Ing. Matěj Petrлік
<b>Reviewer's department:</b>	Multi-robot Systems Group

## II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b>	ordinarily challenging
<i>How demanding was the assigned project?</i>	
The task of autonomous robotic exploration should be solved in the assigned project. Such a task is demanding in its complexity as there are many sub-problems that need to be solved. Moreover, the developed method must be general enough to work in environments with different scale and geometry. Nevertheless, this work solves only the first step of autonomous exploration – the detection of frontiers in the current environment map.	

<b>Fulfilment of assignment</b>	fulfilled with major objections
<i>How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.</i>	
The thesis aims to design, implement and verify a method for solving the task of autonomous robotic exploration with a focus on identifying suitable exploration goals. The result of this work is a method for finding edges of point clouds that would probably lead to the expansion of the known space if the robot could reach these edge points. The work does not discuss obtaining valid exploration (navigation) goals from whose positions the known space could be expanded.	

<b>Methodology</b>	partially applicable
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
The frontier is defined as the boundary between the open and unknown space at the beginning of chapter 2. On the other hand, the proposed method identifies the boundary between occupied and unknown space. This is a significant difference, which affects other parts of autonomous exploration, most notably the exploration goals selection and planning paths to them. This deviation from the standard definition of a frontier should have been highlighted much sooner than in the chapter with experiments, ideally in the introduction. A discussion of the consequences of this unconventional frontier definition for autonomous exploration should follow for the methodology to be correct.	

<b>Technical level</b>	B - very good
<i>Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?</i>	
The technical level is very good. The proposed methods are first evaluated quantitatively on an artificially prepared dataset using standard techniques for classifier evaluation. Optimal parameter values of the classifier and three methods for the filtration of false positives are found using the same methodology. The proposed method is then compared to a voxel-based method. This comparison is only qualitative but is supported by a discussion of pros and cons.	

<b>Formal and language level, scope of thesis</b>	B - very good
<i>Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?</i>	
Both formal and language levels are decent, with only a few minor issues. The captions in the List of figures should be shorter with omitted details and parameters. The tables are missing units of values. The $r$ symbol in section 3.2 does not represent units but a variable. Figure 3.7 (a) looks like it was generated for $T^f=0.001$ instead of 0.01 as stated in the caption. The thesis is shorter, and especially the introductory chapter could have been more extensive with longer motivation and related works sections.	

**Selection of sources, citation correctness**

C - good

*Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?*

The sources are cited correctly. The work contains only nine references, which I do not consider sufficient for a bachelor thesis. The reference [7] misses spaces between words. Section 1.2 – Related works contains only one paragraph with four citations. More detailed research of state of the art would definitely benefit this work.

**Additional commentary and evaluation (optional)**

*Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.*

No additional comments.

**III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE**

*Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.*

The thesis is less extensive with good technical and formal levels. The unconventional definition of frontiers as the border between occupied and unknown space raises questions of suitability for autonomous exploration. The student should answer the following questions as part of his defense:

- 1) How can suitable exploration goals be obtained from the frontiers? Can the sensor model (LiDAR, 3D camera) be used in the process?
- 2) In section 3.3.1, you claim that with increasing  $r$ , the positive classification zone expands. Does this mean that the false positive rate rises? From the ROC curves in figure 3.3, it appears that increasing  $r$  leads to a lower false positive rate for the same true positive rate. Please explain this inconsistency.

The grade that I award for the thesis is C – good.

Date: 27.8.2021

Signature: