

I. IDENTIFICATION DATA

Thesis title:	3D Point Clouds Reconstruction of Environment Subject to Thin Structures
Author's name:	Matěj Boxan
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Ing. Tomáš Petříček, Ph.D.
Reviewer's department:	Department of Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	ordinarily challenging
<i>How demanding was the assigned project?</i>	
The task was to investigate the impact of thin structures on 3D registration algorithms using input subsampling and propose and evaluate a solution to overcome observed limitations. A proper representation of thin structures is crucial for some applications of mobile robotics as these structures may present obstacles that must be avoided.	

Fulfilment of assignment	fulfilled with minor objection
<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 author investigated various subsampling filters, including search in their parameter space, and evaluated their impact on localization accuracy. As expected, identification and accurate reconstruction of thin structures in lidar data is challenging. More solutions may have been proposed to overcome the actual limitations of the current subsampling filters, as a step toward the goal of reconstructing thin structures, as this was one of the main goals. The title (reconstruction) and bibliography in the assignment [1, 2] seem to hint toward developing more complex solutions too. The goal of reporting on the findings in form of a conference paper was not evaluated.	

Methodology	correct
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
The author focused on the evaluation of open-source filters from the libpointmatcher library in the task of simultaneous localization and mapping. The decision of evaluating the whole localization pipeline instead of pairwise 3D registration separately complicated rather unnecessarily the whole methodology. The chosen evaluation metrics capture overall localization performance instead of reconstruction accuracy of thin structures and its impact on registration accuracy per se.	

Technical level	C - 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 overall technical level of the thesis is adequate, yet several points need clarification or improvement: The author states that point clouds lack any topological ordering which is not strictly true for the sensors used in the experiments. Their data can, for example, be treated as a 2D (spherical) depth map, and therefore some image processing techniques can easily be adapted to process it. Least-squares formulation of the absolute orientation problem [15, 88, 87] differs from (2.8) and (2.9). This is perhaps just a typo. As finetuning of individual subsampling filters and their parameters can easily depend on implementation details, the reader would benefit from including a formal description of the filters in form of an equation or algorithm. Namely, the comparison of the iterative and static variants of the Octree filter (p. 25) would benefit from an algorithmic description of both. The text is also lacking details about the parameters of each filter which makes it hard to interpret the results. The description of the Covariance filter (p. 26) seems to be missing completely. Properties of the filters are stated without proof or sufficient explanation and some claimed properties seem not to be general and depend on details that are not discussed. The final experiments seem to be very specific (single tunnel with introduced obstacles, poorly constrained in one dimension), yet there are multiple parameters optimized in the process (80% random sampling, time difference update	

trigger and the corresponding delay, following subsampling filters, etc.) which likely affected the results. This raises the question of whether the conclusions generalize to real-world scenarios and common SLAM applications.

Formal and language level, scope of thesis

C - good

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?

The structure of the "Point cloud sampling" section can be much improved. Namely, the method names used in the text and headings should match (clustering-based = spatial-based, geometric = local) and iteration-based and formulation-based techniques should be discussed at a corresponding place within the current structure.

A few minor things can be improved too: English text should use English interval notation (3.10). Match from (2.2) uses the same symbol as the map introduced later in Algorithm 2. The text contains occasional typos and spurious letters ("NNSearchFF!") which could have been corrected. Fig. 3.7, p. 26 "for the dashed lines": there are no dashed lines.

Selection of sources, citation correctness

A - excellent

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 author correctly cites relevant earlier works.

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 addresses an important problem relevant to the application of mobile robots. In my opinion, more emphasis should have been put on proposing solutions to the reconstruction of thin structures instead of only evaluating a few filters currently available in the libpointmatcher library. I kindly ask the author to address the following topics and questions at the defense:

- 1) Explain the equality of monotonicity and $CR \leq 100\%$ stated on p. 22.
- 2) Wouldn't the absence of the map filtering step in the "Random Informed" filter (p. 24) make it also age-biased but toward the earlier points, because, to maintain the map size, more and more points from new readings would need to be discarded?

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

Date: August 24, 2022

Signature: