

I. IDENTIFICATION DATA

Thesis title:	Autonomous car driving with LIDAR
Author's name:	Sunkesula Mohammed Anas Hathif
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Mechanical Engineering (FME)
Department:	Department of Instrumentation and Control Engineering
Thesis reviewer:	Ing. Zdeněk Novák, Ph.D.
Reviewer's department:	Department of Instrumentation and Control Engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	ordinarily challenging
<i>How demanding was the assigned project?</i>	
Based on the thesis guideline I classify the thesis as ordinarily challenging. There are no points that would require any extra ordinarily skills or knowledge. I believe that the LIDAR technology itself is well documented online. Thus, it shouldn't be difficult to operate the device and write a program that operates as intended.	

Fulfilment of assignment	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>	
I consider first 3 objectives from the thesis guideline as fulfilled. However, I have major objections to the last objective of the guideline. There is a poorly chosen method of presenting experimental results and from the reviewer's point of view I cannot judge whether the method works correctly. The experimental results are described using an inappropriate type of graphs, insufficient to display the track clearance by an autonomous car. In these graphs, the student tries to display all the data about the surroundings of the vehicle during the test track. There is no reference where the test track can be found, nor is it included in the Table of contents. It would be more appropriate to show the distance of the obstacles in the main direction of the car, accompanied by photographs in successive order as the track was cleared. The car should only respond to the main direction (e.g., forward), because other objects do not move and therefore the surrounding data is irrelevant. Student could at least reconstruct (draw) the path, that the vehicle took during the experiment. It would describe exactly what happened during the test. Thus, I cannot follow his commentary, neither the presented graphs (Figures 23-34) to evaluate the last objective of the thesis, nor the technical level of the algorithm, as it is not clear, if it works or not.	

Methodology	partially applicable
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
I have objections to presented Figures 19 and 20. Such a type of graphs are not adequate for validation of surroundings. I would recommend using a type of polar chart, as the area is scanned in 360° manner. This could easily help to understand which obstacles are registered and which are not. Other software like Matlab can be easily used to reconstruct the surroundings and give overview of the 2D grid around the vehicle. As stated in previous paragraph, I have objections the presented results.	

Technical level	D - satisfactory.
<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>	
In the review part, the technical level of the thesis is good. However, that applies only for directly rewritten parts of the technical literature. At other parts of review, student makes his own interpretations of the written text, which not always ends positively. E.g., when describing the Inertial Measurement Unit (IMU), student has used a webpage as a source for information, and by wrong positioning of words, he completely changed the way how the device works. Thus, the description is completely wrong. For a sonar, student states "Some of the important parameters of the sonar sensors are range, which is about 3cm to 3m" which is a nonsense, because the given parameter is not a range, but these values are probably related to its wavelength and frequency. Student is also mixing non-SI units into the text (feet per milliseconds).	

Chapter 2.1.2 and 2.1.3 are unnecessary, while the main important wiring diagram (for Teensy, Arduino and Lidar) is completely missing. I cannot judge the technical level of the algorithm, as it is not clear, if it works or not.

Formal and language level, scope of thesis

D - satisfactory.

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 thesis is following guideline correctly. The text is readable, the level of English is good enough to understand basic of the proposed strategy, but with a lot of unclear parts. As marked before, description of the test results is poorly presented by using inappropriate type of graphs. Student might have idea, what he had done, but it is not clear for the reader. The only option left to reader is to check Summary or Conclusions to know if the method is at least working. The .pdf version of the thesis has no page numbers on lists, neither the printed version. Thus, to orient in page numbers it is necessary to use embedded page counter for pdf. Fig. 19 and 20 have multiple unused names in legend. In Fig. 17 and 18, direction of the car at the start is missing.

Selection of sources, citation correctness

E - sufficient.

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?

Student used enough resources for the given thesis. However, citations are not according to ČSN ISO. Most of the references are missing publisher information and other important items. Student is mixing citing styles, where he uses [ref] style, and in other parts of the thesis he uses (author, year) + [ref] style all together. I also have found directly copied text from Wikipedia and other sources, without any citation:

.pdf Page 14 "The distance between the lenses in a typical stereo camera (the intra-axial distance) is about the distance between one's eyes (known as the intra-ocular distance) and is about 6.35 centimeter. A longer base line (greater inter-camera distance) produces more extreme 3-dimensionality." [https://en.wikipedia.org/wiki/Stereo_camera]

.pdf Page 14 "TOF cameras are equipped with an image chip with several thousand receiving elements" [<https://future-markets-magazine.com/en/markets-technology-en/3d-cameras-in-autonomous-vehicles/>].

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.

It is hard to find any positive comments for the presented thesis. The only positives I can pinpoint is that the presented thesis has some overview of sensors applicable for obstacle detection. I can imagine that student had difficulties during the current time of the global pandemic, however, from my point of view, the topic wasn't that difficult to solve independently. Moreover, there are wide sources of programming examples from robot competitions, held around the world, where he could find any help, that he needed to finish the thesis successfully. The choice of results presentation should have been considered more practically, rather than leaving a lot of data in charts, but with a little telling value.

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.

Based on the thesis guideline I classify the thesis as ordinarily challenging. There are no points that would require any extra ordinarily skills or knowledge.

I consider first 3 objectives from the thesis guideline as fulfilled. However, I have major objections to the last objective of the guideline. There is a poorly chosen method of presenting experimental results and from the reviewer's point of view I cannot judge whether the method works correctly. The experimental results are described using an inappropriate type of graphs, insufficient to display the track clearance by an autonomous car.

In these graphs, the student tries to display all the data about the surroundings of the vehicle during the test track. There is no reference where the test track can be found, nor is it included in the Table of contents. It would be more appropriate to show the distance of the obstacles in the main direction of the car, accompanied by photographs in successive order as the track was cleared. The car should only respond to the main direction (e.g., forward), because other objects do not move and therefore the surrounding data is irrelevant. Student could at least reconstruct (draw) the path, that the vehicle took during the experiment. It would describe exactly what happened during the test. Thus, I cannot follow his commentary, neither the presented graphs (Figures 23-34) to evaluate the last objective of the thesis, nor the technical level of the algorithm, as it is not clear, if it works or not.

In the review of literature, the technical level of the thesis is good. However, that applies only for directly rewritten parts of the technical literature. In other parts of the review, student makes his own interpretations of the written text, which does not always end meaningfully. For example, when describing the Inertial Measurement Unit (IMU), student has used a webpage as a source for information, and by wrong positioning of words, he completely changed the way how the device works. Thus, the description is completely wrong. Student is also mixing non-SI units into the text, such as feet per milliseconds. Chapter 2.1.2 and 2.1.3 are unnecessary, as they describe a common equipment (cables and breadboard), while the main important wiring diagram (for Teensy, Arduino and Lidar) is completely missing. The .pdf version of the thesis has no page numbers on lists, neither the printed version.

Student used enough resources for the given thesis. However, citations are not according to ČSN ISO. Most of the references are missing publisher information and other important items. Student is mixing citing styles, where he uses [ref] style, and in other parts of the thesis he uses (author, year) + [ref] style all together. I also have found directly copied text from Wikipedia and other sources, without any proper citation.

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The grade that I award for the thesis is **E - sufficient**.

Questions:

- 1) Using data from Fig. 19 and 20, try to reconstruct the image of surroundings for LIDAR. You can use Matlab or other software to do so. Compare it to the obstacle detection test 1 and 2 from Fig. 17 and Fig. 18, respectively. Does it show the same obstacles at the same locations?
- 2) Using results of your choice, try to reconstruct the pathway that the car has traveled in one of the test tracks.
- 3) Does the car drive continuously throughout the track, or does it stop at some locations or slow down?

Date: **2.2.2021**

Signature: