

## I. IDENTIFICATION DATA

<b>Thesis title:</b>	<b>Implementation of a Neural Network for Autonomous Trail Following</b>
<b>Author's name:</b>	<b>Kubov Yevhenii</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>	Ruslan Agishev
<b>Reviewer's department:</b>	Department of Cybernetics

## II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b>	<b>challenging</b>
<i>How demanding was the assigned project?</i>	
The project is based on the work [17] A. Giusti et al, "A machine learning approach to visual perception of forest trails for mobile robots" (reference number from the thesis). The thesis authors extend the previous work by introducing more robust quadrotor controller for forest trails following tasks. The proposed controller in the thesis is additionally equipped with obstacle avoidance algorithm, which was not utilized in the original work. Extensive tests in simulated as well as real world scenarios were described in the thesis.	

<b>Fulfilment of assignment</b>	<b>fulfilled</b>
<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 main goal (implementation of the trail-following algorithm for a quadrotor) of the thesis is fulfilled.	
1. The authors utilize a neural classifier which was trained on the dataset provided by the authors of [17] A. Giusti et al. In the thesis there is a dedicated part describing neural networks architectures. However, I consider that several paragraphs are not relevant to the thesis (GANs, RNNs). I would also recommend to describe in more details the use of classifiers. Minor issues: in Section 2.1.2 I would add that non-linearity in NNs is used to model more complex function other than linear (in the thesis it is written as "to solve more complex tasks" which is not detailed enough). It is also stated as a fact that the hyperbolic tangent non-linearity was utilized without a clear explanation of its benefits for the particular task. Section 2.3: I would probably also highlight that the loss function is used for a supervised learning task (in general, we do not need a ground truth data to compute it). Section 3.3: I missed a description of the accuracy metric (I assume, it is defined as ratio of correctly classified images to the overall number).	
2. I think, it would also be beneficial to add a description of the obstacle avoidance algorithm which was used in the thesis. It is described that a LiDAR sensor was used in order to detect obstacles. However, as it is one of the main differences from the original work [17], it would be better to provide for a reader a description of the collision avoidance algorithm. It would also be beneficial to have an intuition on how it is combined with the pathfinder method.	

<b>Methodology</b>	<b>correct</b>
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
The selected approach is suitable for trail-following tasks. Experimental results in simulation (Gazebo) and several different real-world scenarios are provided. Description of failure cases are also given, which is a benefit to understand the limitations and how to use the method in practice. I would also recommend to provide a link to a short video of the quadrotor following the trail. It would ease the experiments description part. Additionally, as the training data collection technique does not seem too challenging, I think, the thesis would benefit if the authors create their own dataset (not necessarily as large as the training one) in the real-world scenarios that were used for testing. The neural classifier could be then fine-tuned on more suitable domain-specific data, which could also be collected with cameras of the choice (Intel Realsense D435). However, a prove of concept is given that the method works in certain scenarios (described in the experiments section) with the NN trained on the dataset collected in a different environment and a different sensor.	

**Technical level**

**B - very good.**

*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?*

The work on the thesis involves several hardware (autopilot, sensors: cameras and LiDAR) and software components (path direction classifier, navigation controller, obstacle avoidance algorithm). The student demonstrated his ability to understand the whole quadrotor navigation system and to apply his knowledge in deep learning to train the neural network and use it for inference on a real hardware platform. The thesis is well-structured and comprehensive for a reader.

As for the evaluation part, it is also interesting to conduct an experiment with a splitting path (into 2 or more directions), or at least to discuss that the algorithm is designed for one-directional paths.

**Formal and language level, scope of thesis**

**A - excellent.**

*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 student demonstrated his ability to write in English and correctly utilize scientific terms. The description of overall system was given in a proper and understandable order. However, I lack descriptions of some components involved (applications of classification neural networks, obstacle avoidance method, and optionally a summary of other navigation components of the quadrotor: localization system, another sensors onboard).

**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 relevant works were cited for each sub-topic involved in the project. In general, the bibliographic citations meet the standards. I would recommend to add in introduction section a short statement of difference of the thesis from the original work [17], although it is described further in the text.

**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.*

**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.*



## THESIS REVIEWER'S REPORT

The grade that I award for the thesis is A - excellent.

Date: **29.5.2022**

Signature: