FACULTY OF INFORMATION TECHNOLOGY CTU IN PRAGUE

Review report of a final thesis

Reviewer:	Ing. Miroslav Skrbek, Ph.D.
Student:	Artem Redchych
Thesis title:	Visual Object Detection and Tracking by the Crazyflie Quadcopter
Branch / specialization:	Knowledge Engineering
Created on:	10 June 2023

Evaluation criteria

1. Fulfillment of the assignment

▸ [1] **assignment fulfilled**
[2] assignment fulfilled with minor objections
[3] assignment fulfilled with major objections
[4] assignment not fulfilled

All points of the assignment were fulfilled. The student identified suitable algorithms for the Crazyflie ecosystem and implemented object detection using existing DNN models and object tracking using the Kalman filter. Everything composes a working system, as shown in the video enclosed.

2. Main written part

75 /100 (C)

The text is written well, with minimal typing errors, and is understandable. The size (40 pages without the appendixes) is above the minimum limit for this type of thesis. But I have several notes to the text. First, the top-level architecture of the whole system in a separate chapter is missing. The expected information is partially spread out in subsections of the Implementation (chapter 3) but is insufficient. For example, it is not obvious where the script containing the main control loop is running (PC or drone). Section 1.2.2 use ϕ for denoting the transition matrix but Section 3.4 use the letter A (according to OpenCV). This is confusing. In Eq.3.3 and Eq.3.4, it is not clear how coefficients were obtained. Another essential piece of information missing in the text is the timing of the main control loop. It means latency of object detection, tracking, drone control action, and sum of them. The matrix A (Eq. 3.1) does not consider the period of the main control loop. It is valid only for a constant period equal to 1s (delta t = 1s), but it must be corrected by real sampling period, otherwise, distance and velocity will not be well related. A description of preparing data for the object detector is also missing. Notebook (ipynb) uses object detection API, but images in the data directory (zip file) have a structure relating to YOLO. It is not clear to me.

3. Non-written part, attachments 85 /100 (B)

The technologies used are adequate for the solved problem. Crazyflie ecosystem must be used due to the Crazyflie drone. Using Tensorflow for custom model learning is also ok, and using Python for integrating all together into a single application is also recommendable. I want to comment testing of the system. The student mentioned problems with recognizing balls or other simple objects as a reason for using a big teddy bear. As evident from dark collected images, the problem is backlight from windows in the laboratory, even if they are darkened. The experiments were to be carried out in the evening under electric lights. Strong backlight from a window cause the automatic gain control sets very low gain, and the camera produces dark images. Another approach is switching off the automatic gain control and manually tuning the camera parameters.

4. Evaluation of results, publication outputs and awards 90 /100 (A)

The results of this work will find practical usage in the Robotic Agents Laboratory for demonstrations of drones. But some improvements regarding the backlight and timing of the main loop and Kalman filter will be necessary.

The overall evaluation 88 /100 (B)

The student solved the complex problem of navigation of the drone. This problem includes deep neural networks, custom object detector learning, image processing, Kalman filters, distance estimation, drone control, and drone hardware. This makes work challenging for students because they must study many advanced topics. I consider this work also challenging, even though the target system was primarily composed of existing (referenced) software and libraries. I appreciate that the student mastered the solved problem and created a functional solution. On the other hand, I have to consider my notes above, so I evaluate the thesis as (B).

Questions for the defense

1. What is the latency for image capture from the drone, object detection latency, Kalman filter, distance estimation latency, and control drone latency?
2. Is it possible to perform inference directly on AI-Deck?

Instructions

Fulfillment of the assignment

Assess whether the submitted FT defines the objectives sufficiently and in line with the assignment; whether the objectives are formulated correctly and fulfilled sufficiently. In the comment, specify the points of the assignment that have not been met, assess the severity, impact, and, if appropriate, also the cause of the deficiencies. If the assignment differs substantially from the standards for the FT or if the student has developed the FT beyond the assignment, describe the way it got reflected on the quality of the assignment's fulfilment and the way it affected your final evaluation.

Main written part

Evaluate whether the extent of the FT is adequate to its content and scope: are all the parts of the FT contentful and necessary? Next, consider whether the submitted FT is actually correct – are there factual errors or inaccuracies?

Evaluate the logical structure of the FT, the thematic flow between chapters and whether the text is comprehensible to the reader. Assess whether the formal notations in the FT are used correctly. Assess the typographic and language aspects of the FT, follow the Dean's Directive No. 52/2021, Art. 3.

Evaluate whether the relevant sources are properly used, quoted and cited. Verify that all quotes are properly distinguished from the results achieved in the FT, thus, that the citation ethics has not been violated and that the citations are complete and in accordance with citation practices and standards. Finally, evaluate whether the software and other copyrighted works have been used in accordance with their license terms.

Non-written part, attachments

Depending on the nature of the FT, comment on the non-written part of the thesis. For example: SW work – the overall quality of the program. Is the technology used (from the development to deployment) suitable and adequate? HW – functional sample. Evaluate the technology and tools used. Research and experimental work – repeatability of the experiment.

Evaluation of results, publication outputs and awards

Depending on the nature of the thesis, estimate whether the thesis results could be deployed in practice; alternatively, evaluate whether the results of the FT extend the already published/known results or whether they bring in completely new findings.

The overall evaluation

Summarize which of the aspects of the FT affected your grading process the most. The overall grade does not need to be an arithmetic mean (or other value) calculated from the evaluation in the previous criteria. Generally, a well-fulfilled assignment is assessed by grade A.