

## 1 Thesis identification

**Thesis title:** Automatic analysis of worker bee behavior in the vicinity of the honeybee queen

**Author's name:** Dominik

**Author's name:** Dvořáček

**Thesis type:** Bachelor

**Faculty/Department:** Faculty of Electrical Engineering /  
Department of Computer Science

**Supervisor's name:** doc. Ing. Tomáš Krajník Ph.D.

**Supervisor's institute:** Artificial Intelligence Center

## 2 Evaluation of individual criteria

### **Assignment difficulty: challenging**

How demanding was the assigned project?

The assigned project was quite challenging and ambitious. The thesis deals with different methods of implementing automated computer vision detection of honey bees in an observation beehive, with special emphasis on the so called court bees. The system should be able to detect and potentially track the bees surrounding the queen, as well as assessing their behaviour to some extent. The student should acquire basic knowledge of honey bee biology and known systems for automatic detection, tracking and behavioral analysis of bees in the hive via literature study. He should find key performance indicators to assess these systems, select the best-possible method, implement it on an existing (and not optimized for this task) real life system, and measure the performance there. A pipeline for honeybee queen and court bees detection should then be implemented.

### **Fulfilment of assignment: fulfilled**

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.

The thesis fulfills the assigned tasks very well, the primary goals were achieved. The thesis gives a good overview of the basics of bee biology on the aspect of court bees, describes very well existing, state of the art systems for automated bee detection and tracking. It describes the key performance indicators for detection of objects in images, tracking, the court state detection and the system performance and speed. Background information on the various methods is described in great detail, but not overly so. None of the assigned tasks were completed insufficiently and all objectives were achieved.

## **Methodology: A**

Comment on the correctness of the approach and/or the solution methods.

The thesis uses different state-of-the-art methods for bee detection, tracking and (to some extent) behavior classification and compared those methods. The results show that the different methods were successfully applied. Various performance statistics show that ultimately the detection of bees, tracking and classification of queen bees into court and non-court bees were not only possible, but also successful to a satisfactorily high quality. At the end of the work, the best approach was discussed and advantages were highlighted. The approach was thus correctly chosen.

## **Technical level: A**

Is the thesis technically sound? How well did the student employ expertise in his/her field of study? Does the student explain clearly what he/she has done?

The thesis is technically sound. The results presented in the thesis, suggest a successful implementation of the methods as described above, which, together with a relative extensive code base, suggests a proper application of the student's expertise in his field. There was also a clear and comprehensible written account of what the student did.

## **Formal level and language level, scope of thesis: B**

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?

Formalisms and notations were applied properly, the thesis is logically organized and worked in sufficient scope and length. The language is clear and understandable for the most part, the English used is (mostly) satisfactory, although there are occasional linguistic errors. The presentation of some results could be improved, for example, the x- and y-axis should be labeled more clearly and more consistently.

## **Selection of sources, citation correctness: A**

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 thesis makes adequate reference to previous work on the topic and the selection of sources is appropriate. For the most part, the student's original work can be distinguished from previous work in the field. The reference list is not

quite uniformly formatted, for example sometimes publications with multiple authors are abbreviated et al. sometimes not.

### **Additional comments and evaluation**

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.

The thesis is of high quality, the student shows the successful implementation of different methods on a system that provides visual data in less than optimal quality. This implementation has a lot of potential and will certainly reveal interesting biological insights into the internal organization of honey bee colonies. Since most of the methods used have already been used in honey bee research before, the novelty lies mainly in the fact that the image recognition methods successfully run on relatively low-cost hardware. This will allow a comparatively high degree of parallelization on multiple bee hives, generating valuable data from different bee colonies.

The strengths of the work lie in the detailed description of background information on the biology of the animals and in the successful implementation of the methods for detecting, tracking and evaluating animal behavior.

## **3 Final evaluation, questions and suggested grade**

Summarize your opinion on the thesis and explain your final grading.

I have two open questions:

1. The honeybee queen is considered in the thesis as a central element in the hive, the court around her as an interface between the colony and this central element. Would it be possible to gain more information on the interactions between court and queen from the available data? For example, whether there is direct contact between the court bees at certain times, how long this contact lasts, how long individual bees stay within the court, whether there are possible feeding events, etc.?
2. How would a changed setup (e.g., the better lighting suggested in the thesis) affect detection and tracking? Would new training data need to be created?

The thesis shows that the student has the necessary knowledge and skills to solve a complex problem using existing algorithms. He can implement and evaluate these algorithms in a meaningful way. Furthermore, the solution has been integrated into existing frameworks, which will lead to the work done here being used in future scientific projects. Thus, this work builds a bridge to potentially



# THESIS REVIEWER'S REPORT

new biological insights. The thesis itself is structured in an understandable way and the reader can follow the content well.

The grade that I award for the thesis is A.

Date: 29.05.2022, Graz, Austria      Name and signature: Martin Stefanec

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