

1 Thesis identification

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

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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 challenging. A system should be implemented to automatically detect the position of a honey bee queen in an observation hive and to analyze her movements. This is complicated by frequent concealment of the queen. For creating the system, basic knowledge about honey bees, in particular about interactions in the bee colony and knowledge about existing systems for automatic detection, tracking and behavior analysis in the hive should be acquired. A set of key performance indicators characterizing the performance of existing systems should be established, the most relevant methods should be selected, extended and the methods performance should be assessed. Based on the results of this assessment, the method should be integrated into an existing pipeline for honeybee queen detection and court behaviour analysis.

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 well, the primary goals were achieved. Although some aspects could have been covered in more detail, especially in the introduction, and the background information on biology is not always precisely formulated, the results show that the extension of the WhyCode system, which has been incorporated into the new WhyComb system, provides an impressive detection rate even under difficult conditions (e.g., under occlusions).

Methodology: A

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

The thesis introduces different state-of-the-art methods for bee detection and tracking, the student compares them and chooses one approach to be optimized for a specific real-world scenario. The practical aspect of the work presented here, aimed to implement a system for automatic detection and localization of a marked honey bee queen. The results show that this goal was very clearly achieved. Thus the approach and the methods were chosen correctly.

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 method as described in the thesis, which, suggests a proper application of the student's expertise in her field. There was also a comprehensible written account of what the student did.

Formal level and language level, scope of thesis: C

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 in sufficient length. The language is understandable for the most part, the English used is (mostly) satisfactory, although there are occasional linguistic errors.

In some places, carelessness errors can be found, sometimes space is inserted before a reference, sometimes not, sometimes the reference is before the end of a sentence, sometimes after the full stop. Sometimes a sub-chapter title at the beginning of the page overlaps with the title of the thesis (for example on page 4 to 7), or figures are not anchored correctly in the text.

Sometime the language used is not completely clear, for example in the sentence "In natural ecosystems, bees advance the reproduction of plants and the spread of vegetation and, in turn, provide food for animals" is probably meant to express the content "In natural ecosystems, bees promote the reproduction of plants and the spread of vegetation, which in turn provide food for animals".

Selection of sources, citation correctness: D

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 paper makes appropriate references to previous work on the subject, this is also an essential part of this paper and for the most part is done well.

However, there are some problematic citation issues, for example, it is not always entirely clear what certain sections of the text refer to. Figure 10 was taken from the paper "Bozek, Katarzyna and Hebert, Laetitia and Portugal, Yoann and Stephens, Greg. (2021). Markerless tracking of an entire honey bee colony. Nature Communications. 12. 10.1038/s41467-021-21769-1.", however this publication is not found in the reference list. The paper can be found in the list of recommended literature and was certainly used as background literature for the thesis (as for example the figure 10 is taken from it). This needs to be cited! The reference list is not quite uniformly formatted, for example sometimes publications with multiple authors are abbreviated et al. sometimes not.

Also, it is not clear which criteria the numbering of the citations follows. It does not correspond to the order of use in the text, nor does it correspond to an alphabetical order of authors names.

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.

There are a few inaccuracies in the introduction. The sentence "Despite the queen being the primary coordinator..." is factually not correct, the queen is not the primary coordinator of the colony. Another example can be found in the description of waggle dances, it is only in a few very special cases that the dances indicate the direction of the food source relative to gravity, usually a dance indicates the direction of the food source relative to the sun. It can also be questioned whether the planned integration of biomimetic robots into the queen's court can regulate the queen's pheromone production; what is targeted in the project "RoboRoyale" is influencing the transmission rate of pheromones from queen to workers.

Besides these and other smaller inaccuracies, the thesis is of high quality, the student shows the successful implementation of a method for marker detection on a system that provides visual data in less than optimal quality.

3 Final evaluation, questions and suggested grade

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

I have two questions:

1. How specific are the extensions of WhyComb to honeybee tracking? Does it make sense to apply the detection solutions for occluded markers to other fields?

2. What influence do the extensions to WhyCode have on the performance of the system in terms of computation speed?

The methodological work that was shown in this thesis is of high quality. The additions made to WhyCode leading to the WhyComb system show impressive results. The thesis shows, that the student has the necessary knowledge and skills to solve a complex problem and improve existing technical solutions. She shows the successful implementation of a method for marker detection on a system that provides visual data in less than optimal quality. Although the thesis shows certain formal problems, the methodological work prevails, as do the convincing results.

The grade that I award for the thesis is B.

Date: 30.05.2022, Graz, Austria Name and signature: Martin Stefanec

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