ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Semidefinite Programming for Geometric Problems in Computer Vision**
Author's name:	**Pavel Trutman**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Radim Šára
Reviewer's department:	Department of Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment — **extraordinarily challenging**

Evaluation of thesis difficulty of assignment.

The goal of the thesis was to explore and evaluate the use of semidefinite programming methods in solving minimal geometric problems in computer vision. Minimal problem solvers are a long-standing research topic in computer vision. They are important for constructing data-driven random proposals for robust non-linear optimization problems that arise from geometric tasks in 3D computer vision. Even basic understanding of these methods requires a good proficiency in a quite advanced mathematics of polynomial algebra. The assignment also required the student to understand results from semidefinite programming and polynomial optimization.

Satisfaction of assignment — **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

In my opinion the goals of the thesis, as stated in the formal assignment, were fulfilled in all points.

Method of conception — **outstanding**

Assess that student has chosen correct approach or solution methods.

To the best of my knowledge, state of the art approaches and methods were used.

Technical level — **A - excellent.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The technical level of the thesis is just outstanding. As mentioned above the work is based on a qualified use of advanced theoretical results well beyond the standard education in computer science.

Formal and language level, scope of thesis — **A - excellent.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis is well-written, its structure is logical and it is written in very good English. I only found a few very minor mistakes, some missing articles, and a few typos. I liked that the student provided examples that help understand the theoretical material. I also value that the student is aware of technical problems that arise in the individual steps of the discussed algorithms, e.g. the danger of infeasibility in (3.127), but also elsewhere.

Selection of sources, citation correctness — **A - excellent.**

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The thesis contains an excellent state-of-the-art review. Original work is clearly separable from published results. The student showed an excellent ability to work with bibliographic sources. He followed citation standards usual in computer science.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

I have a few questions that could be addressed during the defense:

1. Why all of the P3P solvers in Sec. 4.2 worked with a single quartic equation as opposed to a system of quadratic equations that comes naturally from the geometry of the problem?
2. In the experimental section 4.2 you show that the non-algebraic methods could not find all of the real solutions. You also show that it did not hurt the reprojection errors. Could this mean that the missed real solutions are typically worthless or accompanied by solutions that are inaccurate but good enough?
3. On p.67 you mention numerical problems in Polyopt. What kind were they? Have you solved them in the mean time?
4. Suppose we want to distinguish two classes of minimal problems: Ones that lead to polynomial equation systems with data-dependent coefficients (like in the classical P3P problem formulation) and ones in which the polynomial equations just define a feasible solution set that is independent on the problem instance (eg. a rotation matrix **R** must always be an element of SO(3), which can be expressed by a set of polynomial constraints on the elements of **R**). In your opinion, would it make sense to approach these two classes of problems differently?

Minor comments :

1. P.16: What exactly is meant by $A \succcurlyeq B$ in (2.32)?
2. P.15: I found the definition of $\|u\|_x$ in (2.24) incomplete. It makes it difficult to understand (2.48), where it is not clear what would the function f be.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

I have no doubt that this is an excellent thesis. The student had to understand advanced concepts from polynomial algebra, semidefinite programming and polynomial optimization. The thesis contains an excellent state-of-the-art review. The thesis includes a valuable experimental analysis of the implemented methods and two other state-of-the art methods. The summary of the work, given in the Conclusions chapter, is accurate.

I evaluate the thesis with classification grade **A - excellent.**

Date: **22.1.2018**

Signature: