Assessment of the master thesis by Stanislav Steidl

**Camera Rig Calibration**

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The goal of the thesis was to extend camera rig calibration to be able to work with multiple different cameras in the rig. Camera calibration is an old and studied problem in computer vision but achieving high quality results when working with different cameras is still a non-trivial engineering problem. The difficulty is in the choice of the right camera model as well as in imposing the right constraints on the relative poses of cameras and on their internal parameters. Every situation requires a tailored solution to reach stable and accurate results. The assignment of the thesis was motivated by the need to calibrate a system of cameras on a car consisting from two very different camera rigs.

The thesis presents three contributions. The first contribution proposes to deal with multiple rig calibration by creating a hierarchy of primary and secondary rigs that are connected by a shared camera(s). This allows to use the primary rig as a constraint on the secondary rig to stabilize its calibration. This is a good engineering approach that proved to provide a stable working solution. The second contribution extended the existing local optimization by bundle adjustment towards more complex relationships between camera parameters and more complex calibration models. In particular, the extension developed in the thesis allows a more flexible initialization as well as control over which parameters may change during the optimization. The third contribution is in putting together a complete practical system that was experimentally verified on a number of data sets from a real engineering project developing new technology.

The text of the thesis consists of five chapters. The second chapter aims at reviewing the state of the art in camera calibration. It correctly reviews the basic notions but is rather brief in reviewing previous camera calibration systems. It would be very useful to have more detailed treatment of the previous work and more detailed comparison between existing solutions and the solution presented in the thesis. The third chapter presents the main contributions. The hierarchy of rigs is described relatively well but I would still like to have a more complete and compact mathematical formalization of the calibration problem leading to a more detailed mathematical formulation of the complete optimization problem. I miss the mathematical description of the extension of the bundle adjustment. The description in the thesis, paragraph 4.3.2. is too brief and does not really explain what and how was really done. The fifth chapter describes the experimental verification of the system on real calibration data. Experiments consist of many different steps. This is reasonably captured on the qualitative level. The quantitative evaluation is sufficient to convince us that the approach really works but I would like to see more detailed analysis of the errors. For instance, we see that the trifocal camera system has considerably larger residual errors but we do not really understand why. This needs to be analyzed and explained.

The quality of the text of the thesis is lower than we would like to see. I believe that the main problem was lack of time. Unfortunately, Stanislav started writing too late to be able to capture all his work he

had done in full detail in the text. It is also clear that he will have to work hard on improving his writing skill to be able to deliver well structured, clear and detailed research text.

Stanislav Steidl is a motivated, capable, and very autonomous student. He was able to grasp existing software tools for camera calibration and extend them in a non-trivial way into a complete working system for camera calibration. He was supporting a complex development project and his results were instrumental for the project.

Stanislav Steidl presented a very solid engineering work and fulfilled the goals set in the thesis assignment. I value positively that he was able to master a complicated topic, improve existing solutions and develop a new working approach to rig calibration. On the other hand, the text of the thesis does not really reveal the quality of his work. The text lacks sufficient detail a clarity. Therefore, I recommend grade the thesis by grade *C - good*.

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