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| Thesis title: | Investigating Visual Localization Based on Semi-Generalized Camera Pose Estimation |
| Author's name: | Alena Smutná |
| Type of thesis : | bachelor |
| Faculty/Institute: | Faculty of Electrical Engineering (FEE) |
| Department: | Department of Cybernetics |
| Thesis reviewer: | RNDr. Zuzana Kúkelová, Ph.D. |
| Reviewer's department: | Department of Cybernetics |

The goal of this thesis was to investigate in detail how the accuracy of camera poses estimated from 2D-2D correspondences between images depends on the geometric relation between the images. This is an interesting and not well-understood problem with direct applications to visual localization.

Visual localization is the problem of estimating the position and orientation, i.e., the camera pose, from which an image was taken. Visual localization algorithms are important parts of applications such as augmented reality and autonomous robots, e.g., self-driving cars. Most commonly, visual localization algorithms represent the scene via a 3D model and estimate the camera pose of a query image from 2D-3D correspondences between pixels in the query image and 3D scene points. While these approaches are highly accurate, building and maintaining a 3D model of a scene can be challenging. An alternative to using a 3D model for pose estimation is to represent the scene as a set of images with known intrinsic and extrinsic parameters and to estimate the query image pose from 2D-2D matches between the query and database images. This approach avoids having to construct and maintain a 3D scene model. However, in our experience, this structure-less visual localization approach is less accurate than the classical structure-based approach described above.

As a step towards understanding this behavior, the goal of the thesis was to investigate how the camera pose accuracy depends on the geometric relationship between the query and the database images and between the database images themselves. To this end, the thesis of Alena Smutná, after explaining the concepts underlying such a localization strategy, provides a detailed experimental analysis of this behavior. In detail, the thesis makes the following contributions:

- The thesis reviews structure-based and structure-less localization pipelines and motivates the advantages of the latter with respect to the former. It further explains the individual parts of the structure-less pipeline in detail. Given that this topic is not taught as part of the Bachelor studies, Alena had to learn new concepts and techniques. Thus, this part of the thesis constitutes a contribution in itself.
- The thesis presents detailed experiments that analyze the behavior of the chosen structure-less method on multiple scenes of a standard dataset, exploring how the distances between query and database images and between database images impact pose accuracy. To be able to draw valid conclusions, Alena not only used real images but also created virtual images in order to have more control over the distances between the query and database images. She proposed and investigated three different ways to create such virtual views. The results presented in the thesis are informative for rendering-based approaches to the localization problem that can create such virtual views (e.g., to improve pose accuracy). The level of detail of the experimental evaluation is clearly beyond what one would expect for a Bachelor thesis and would be very good for a Master thesis as well.
- The results of the experiments are interesting and partially unexpected. For example, the availability of database images taken close to the query image (but not too close) leads to better pose accuracy (our initial hypothesis was that database images taken from farther away would be more useful). The results presented in this thesis and the conclusions drawn from them will certainly inspire our further research into this topic.



THESIS SUPERVISOR'S REPORT

Alena is a very good student. She worked very independently and showed great attention to detail in the way she set up the experiments, executed them, and analyzed the resulting data. She was able to quickly grasp new concepts and learn about new problems and their solutions. She was able to nicely describe the motivation of the thesis and the technical parts and to derive good conclusions from the results of her experiments. Even in the review of the state-of-the-art and in the technical part of the thesis, she was able to describe the content in her own words, rather than closely adapting text from papers when describing prior work. She fulfilled the goals of the thesis completely.

The grade that I award for the thesis is **A - excellent**.

Date: **14.6.2023**

Signature: