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Jan-Michael Frahm

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Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9
Internet: www.shaker.de • eMail: info@shaker.de

Abstract

A fundamental problem of computer vision is the reconstruction of a three dimensional static scene from uncalibrated scene images. There are many fields of application for such reconstructions in robotics, architecture, biometrics, the computer game industry and the movie industry.

Most of the existing reconstruction approaches are using only the camera images as source of information. From scene images the camera motion is estimated simultaneously with the reconstruction. If the intrinsic camera calibration (focal length, aspect ratio and principal point) is not known in advance, then the resulting scene geometry is projectively skewed. The knowledge of the camera calibration is required to upgrade the projective reconstruction to a meaningful Euclidian reconstruction. The estimation of the camera calibration from image data, known as self-calibration, is a current research topic. Exploiting only the scene images as source of information leads to various problems because the estimation is very sensitive to measurement noise and degenerative camera motions.

The main contribution of this thesis is the development of self-calibration approaches for cameras with varying intrinsics which exploit the camera orientation as additional source of information. The first approach requires a purely rotating camera while the second calibrates freely moving cameras. The exploitation of the orientation for camera self-calibration leads to linear approaches in contrast to the known non-linear approaches for cameras with varying intrinsics. For purely rotating cameras the new approach overcomes the limitation on the number of varying intrinsic parameters. The new approaches reduce the number of images required for self-calibration for an arbitrary camera motion. Both approaches are able to compute the self-calibration from an image triplet by exploitation of the relative orientations between the images.

The additional requirement of known relative orientation between camera views is only a weak limitation in many applications. Often cameras are already equipped with rotation sensors, like in video conferencing and surveillance systems, in car safety systems or in TV studio cameras. All these systems can be enhanced by the methods developed in this thesis.

The thesis analyzes in detail the different sources of error and the critical camera rotations for the novel self-calibration approaches. The robustness against input data noise of the proposed approaches is measured using synthetic and real data with ground truth information. The analysis together with the experimental evaluation shows that the proposed methods provide accurate and reliable self-calibration techniques.