Self-calibration of a Stereo Rig without Stereo Correspondence

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Abstract – *In this paper, we introduce a new self-calibration method for a stereo rig using general rigid motions. Unlike the existing methods, our method does not involve any stereo correspondence. Rather the method requires the computation of camera motion between pairs of monocular images. We show that the computation of the stereo geometry, i.e. the rotation and the translation between the two cameras can be carried out using standard linear algebra tools. We provide a stability study for the method in the presence of noise. Synthetic and real experiments demonstrate the feasibility and robustness of the proposed method. Moreover, the developed method can be used to solve the stereo correspondence problem as well as the 3D shape of the observed scenes using a cooperative stereo-motion framework.*

Keywords *Self-calibration, stereo rig extrinsic parameters, motion estimation, linear algebra*

1 Introduction and approach

In the last decade a number of researchers developed self-calibration methods for vision sensors that require no known reference object. Such methods can be used to determine the intrinsic camera parameters, the stereo geometry as well as the 3D shape of the observed scene (see [3], [4], [8], [9], [12], for a single moving camera and [5], [18], [19], for a moving stereo rig). The usefulness of the self-calibration techniques can be tangible in some cases where the sensor parameters are subject to variations and no known reference objects are available (active vision, space robots). In [18], authors use motion and stereo correspondences across two stereo pairs (one motion of the stereo rig). They propose a method that recovers simultaneously the two internal parameters and the motion of each camera as well as the stereo geometry. In [5], authors use stereo correspondences across a sequence of stereo pairs. Using different projective reconstructions that are associated with each stereo pair, they propose an algorithm for the recovery of the internal parameters and the 3D Euclidean shape.

All previous self-calibration techniques for stereo entails the solving of the correspondence problem between left and right images which has been proved to be a difficult problem. Several factors make the stereo correspondence problem difficult: occlusions, large disparities, photometric and figural distortions. One can notice that in many cases it is much easier to find motion correspondences than solving for stereo correspondences.

In this paper we attempt to solve the following problem. Given a sequence of stereo pairs of unknown and arbitrary scenes (see Figure 1), we like to recover the stereo geometry without solving the stereo correspondence problem. In the sequel, we restrict our work to the estimation of the stereo geometry (the rotation and the translation between the two cameras) and suppose that the camera intrinsic parameters are known. This assumption is not unrealistic since the intrinsic parameters are usually known weakly or partially. On the other hand, there is no information about the geometry of the stereo rig.

Unlike the existing methods for self-calibration which consider stereo correspondences as given, our approach uses motion correspondences to recover the stereo geometry. The monocular correspondences between pairs of images are easier to obtain, as an arbitrary number of intermediate frames can be available. Once the stereo geometry is recovered, the stereo rig fundamental matrix will be known. Then, the stereo correspondences can be easily recovered. One way to do so is to use geometrical constraints derived from the motion correspondences and the computed fundamental matrix (cooperative stereo-motion) [1]. The 3D shape of the observed scenes will be straightforward. Thus, our proposed method is very useful in recover-