Visual Odometry: Literature Survey

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Abstract

0.1 A way to parameterize rotations

[2] proposes a method to use quaternions in an unconstrained nonlinear optimization. Quaternions representing rotation have four elements but only three degrees of freedom, since they have to be of norm one. This constraint has to be taken into account when applying e.g. Levenberg-Marquardt algorithm. One of the ways to address this issue is to use appropriate parameterization (others are a projection step and Lagrange multipliers). Well known parameterizations are Euler angles and axis-angle representation.

[1] call a parameterization fair if it does not introduce more numerical sensitivity than inherent to the problem itself. This is guaranteed, if any rigid transformation of the space to be parameterized results in an orthogonal transformation of the parameters. Both axis-angle and quaternion parameterizations are fair, while Euler angles is not.

Authors search for a parameteriation that:

1. is minimal, i.e. uses only three parameters
2. the three parameters may be changed arbitrarily by the optimization algorithm
3. the resulting quaternion has always norm 1.

This new approach is based on the observation that all quaternions of norm-1 lie on the unit sphere in $\mathbb{R}^4$. The authors use the shortest connection between two points on a sphere, i.e. a great circle. For describing a movement on the sphere starting at $\mathbf{h_0}$ they use a vector v_4 lying in the tangential hyperplane that touches the sphere at $\mathbf{h_0}$. This hyper-plane is a subspace of $\mathbb{R}^4$, thus vectors in this plane may be represented as 3-vectors with respect to a plane-local coordinate frame.

Experiments are made on a synthetic (small) data-set. The authors perform bundle adjustment and compare their approach with axis-angle representation. The conclusion is that this representation performs better for rotations, for transnational motion both method are approximately equal.

References

[1] Joachim Hornegger and Carlo Tomasi. Representation issues in the ml estimation of camera motion. In *Computer Vision, 1999. The Proceedings of the Seventh IEEE International Conference on*, volume 1, pages 640–647. IEEE, 1999.

[2] Jochen Schmidt and Heinrich Niemann. Using quaternions for parametrizing 3-d rotations in unconstrained nonlinear optimization. In *VMV*, volume 1, pages 399–406, 2001.