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LMI-based 2D-3D Registration: from Uncalibrated Images to Euclidean Scene

Danda Pani Paudel¹, Adlane Habed², Cédric Demonceaux¹, Pascal Vasseur³

¹Le2i laboratory, University of Bourgogne, CNRS, France

²ICube laboratory, University of Strasbourg, CNRS, France

³LITIS EA laboratory, University of Rouen, France,

{danda-pani.paudel, cedric.demonceaux}@u-bourgogne.fr, adlane.habed@icube.unistra.fr,
pascal.vasseur@univ-rouen.fr

Abstract

This paper investigates the problem of registering a scanned scene, represented by 3D Euclidean point coordinates, and two or more uncalibrated cameras. An unknown subset of the scanned points have their image projections detected and matched across images. The proposed approach assumes the cameras only known in some arbitrary projective frame and no calibration or autocalibration is required. The devised solution is based on a Linear Matrix Inequality (LMI) framework that allows simultaneously estimating the projective transformation relating the cameras to the scene and establishing 2D-3D correspondences without triangulating image points. The proposed LMI framework allows both deriving triangulation-free LMI chirality conditions and establishing putative correspondences between 3D volumes (boxes) and 2D pixel coordinates. Two registration algorithms, one exploiting the scene's structure and the other concerned with robustness, are presented. Both algorithms employ the Branch-and-Prune paradigm and guarantee convergence to a global solution under mild initial bound conditions. The results of our experiments are presented and compared against other approaches.

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References

- [1] D. Aiger, N. J. Mitra, and D. Cohen-Or. 4-points congruent sets for robust surface registration. *ACM Transactions on Graphics*, 27(3):85, 1–10, 2008.
- [2] S. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, New York, NY, USA, 2004.
- [3] M. Chandraker, S. Agarwal, F. Kahl, D. Nister, and D. Kriegman. Autocalibration via rank-constrained estimation of the absolute quadric. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2007.
- [4] M. Chandraker, S. Agarwal, D. Kriegman, and S. Belongie. Globally optimal algorithms for stratified autocalibration. *International Journal of Computer Vision (IJCV)*, pages 236–254, November 2009.
- [5] S. Christy and R. Horaud. Iterative pose computation from line correspondences. In *Comput. Vis. Image Underst (CVIU)*, pages 137–144, January 1999.
- [6] M. Corsini, M. Dellepiane, F. Ganovelli, R. Gherardi, A. Fusiello, and R. Scopigno. Fully automatic registration of image sets on approximate geometry. *International Journal of Computer Vision (IJCV)*, pages 91–111, March 2013.
- [7] P. Finsler. Uber das vorkommen definitiver und semidefinitiver formen in scharen quadratischer formen. *Comment. Math. Helv.*, 9, pages 188–192, 1936/37.
- [8] A. Fusiello, A. Benedetti, M. Farenzena, and A. Busti. Globally convergent autocalibration using interval analysis. *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, pages 1633–1638, December 2004.
- [9] A. Habed, D. Pani Paudel, C. Demonceaux, and D. Fofi. Efficient pruning lmi conditions for branch-and-prune rank and chirality-constrained estimation of the dual absolute quadric. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 493–500, 2014.
- [10] R. I. Hartley. Chirality. *International Journal of Computer Vision (IJCV)*, pages 41–61, January 1998.
- [11] R. I. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, second edition, 2004.
- [12] J. Knopp, J. Sivic, and T. Pajdla. Avoiding confusing features in place recognition. In *European Conference on Computer Vision (ECCV)*, pages 748–761, 2010.
- [13] L. Liu and I. Stamos. Automatic 3d to 2d registration for the photorealistic rendering of urban scenes. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 137–143, 2005.
- [14] M. A. Lourakis and A. Argyros. SBA: A software package for generic sparse bundle adjustment. In *ACM Trans. Math. Software*, pages 1–30, 2009.

- [15] P. Moulon, P. Monasse, and R. Marlet. Adaptive structure from motion with a contrario model estimation. In *Asian Conference on Computer Vision (ACCV)*, pages 257–270, 2013.
- [16] D. Nistér. Untwisting a projective reconstruction. *International Journal of Computer Vision (IJCV)*, pages 165–183, November 2004.
- [17] D. Nister, O. Naroditsky, and J. Bergen. Visual odometry. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 652–659, 2004.
- [18] J. Oliensis and R. Hartley. Iterative extensions of the sturm/triggs algorithm: Convergence and nonconvergence. *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, pages 2217–2233, December 2007.
- [19] D. P. Paudel, C. Demonceaux, A. Habed, and P. Vasseur. Localization of 2d cameras in a known environment using direct 2d-3d registration. In *IEEE International Conference on Pattern Recognition (ICPR)*, pages 1–6, 2014.
- [20] M.-T. Pham, O. J. Woodford, F. Perbet, A. Maki, B. Stenger, and R. Cipolla. A new distance for scale-invariant 3d shape recognition and registration. In *IEEE International Conference on Computer Vision (ICCV)*, pages 145–152, 2011.
- [21] V. Rabaud. Vincent’s Structure from Motion Toolbox. <http://vision.ucsd.edu/~vrabaud/toolbox/>.
- [22] S. Ramalingam, S. Bouaziz, P. Sturm, and M. Brand. Geolocalization using skylines from omni-images. In *IEEE International Conference on Computer Vision Workshops (ICCV Workshops)*, pages 23–30, 2009.
- [23] T. Sattler, B. Leibe, and L. Kobbelt. Fast image-based localization using direct 2d-to-3d matching. In *IEEE International Conference on Computer Vision (ICCV)*, pages 667–674, 2011.
- [24] D. Scaramuzza and F. Fraundorfer. Visual odometry, part i: The first 30 years and fundamentals. In *IEEE ROBOTICS and AUTOMATION MAGAZINE*, pages 80–92, December 2011.
- [25] C. Strecha, W. von Hansen, L. Van Gool, P. Fua, and U. Thoennessen. On benchmarking camera calibration and multi-view stereo for high resolution imagery. In *IEEE Conference on Computer Vision and Pattern Recognition, (CVPR)*, pages 1–8, 2008.
- [26] A. Taneja, L. Ballan, and M. Pollefeys. Registration of spherical panoramic images with cadastral 3d models. In *3DIM-PVT*, pages 479–486, 2012.
- [27] B. Triggs, P. Mclauchlan, R. Hartley, and A. Fitzgibbon. Bundle adjustment a modern synthesis. In *Vision Algorithms: Theory and Practice, LNCS*, pages 298–375. Springer Verlag, 2000.
- [28] P. Viola and W. M. Wells, III. Alignment by maximization of mutual information. *International Journal of Computer Vision (IJCV)*, pages 137–154, September 1997.
- [29] J. Yang, H. Li, and Y. Jia. Go-icp: Solving 3d registration efficiently and globally optimally. In *IEEE International Conference on Computer Vision (ICCV)*, pages 1457–1464, December 2013.