Practical Course: Vision-based Navigation
Winter Semester 2019

Projects

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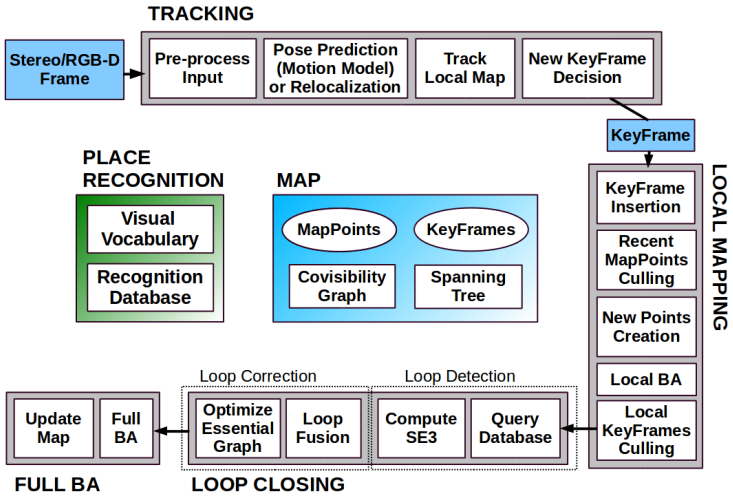
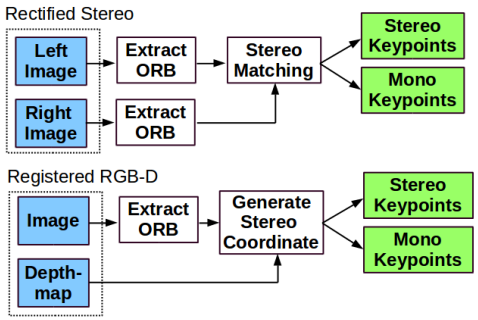
1. SLAM



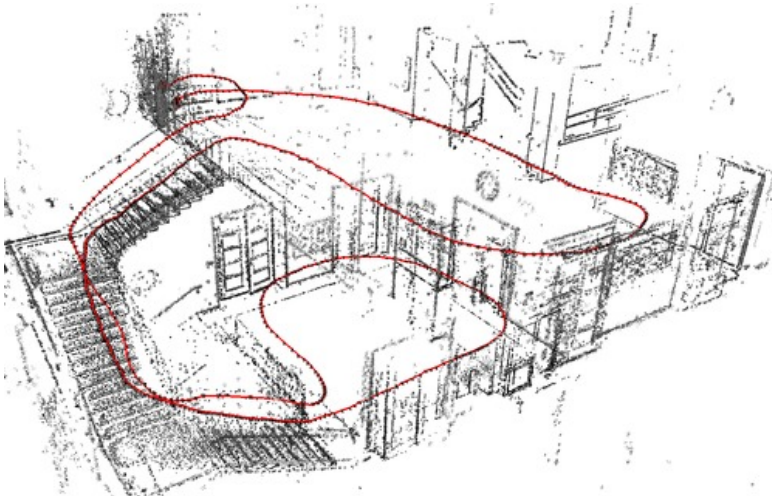
(a) System Threads and Modules.



(b) Input pre-processing

- ORB_SLAM: http://webdiis.unizar.es/~raulmur/MurMontielTardosTRO15.pdf
- ORB_SLAM2: https://arxiv.org/abs/1610.06475
- Map management
- Reusing Keyframes
- Spanning tree for optimization

2. Photometric Bundle Adjustment

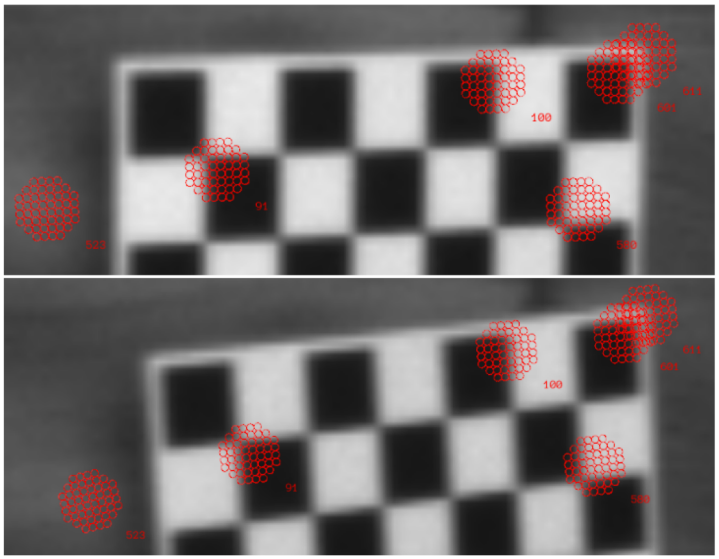


$$E_{\mathbf{p}j} := \sum_{\mathbf{p}\in\mathcal{N}_\mathbf{p}} w_\mathbf{p} \left\| (I_j[\mathbf{p}'] - b_j) - \frac{t_j e^{a_j}}{t_i e^{a_i}} (I_i[\mathbf{p}] - b_i) \right\|_\gamma$$

- Photometric Bundle adjustment in SFM
  - Error metric similar to DSO (https://arxiv.org/pdf/1607.02565.pdf)
  - Initialize and optimize additional (non-feature) points
  - Possibly use vignetting and response from online calibration

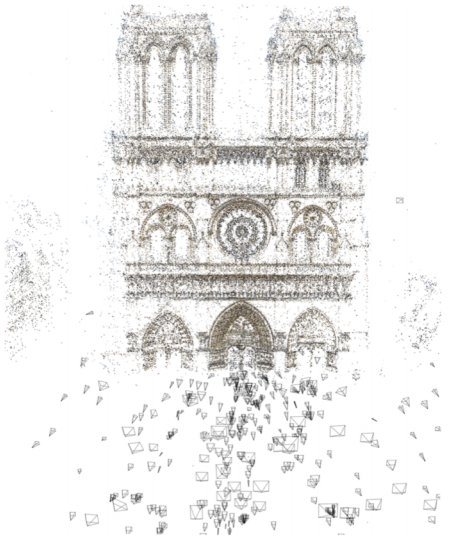
3. Indirect Visual Odometry with Optical Flow

- Sparse optical flow as alternative to feature matching
- Possible extensions:
  - patch similarity norms
  - Keyframing, local optimization
  - Different image warping strategies
  - Implement Gauss-Newton (or LM) manually

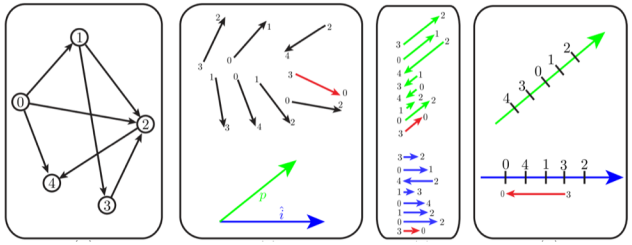


- **Visual-Inertial Mapping with Non-Linear Factor Recovery** (V. Usenko, N. Demmel, D. Schubert, J. Stueckler and D. Cremers), *In arXiv:1904.06504*, 2019. https://arxiv.org/pdf/1904.06504
- **Equivalence and efficiency of image alignment algorithms** (Baker, Simon, and Iain Matthews), *In IEEE Computer Society Conference on Computer Vision and Pattern Recognition*. Vol. 1. IEEE Computer Society; 1999, 2001. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.70.20&rep=rep1&type=pdf

4. Global SfM with Motion Averaging

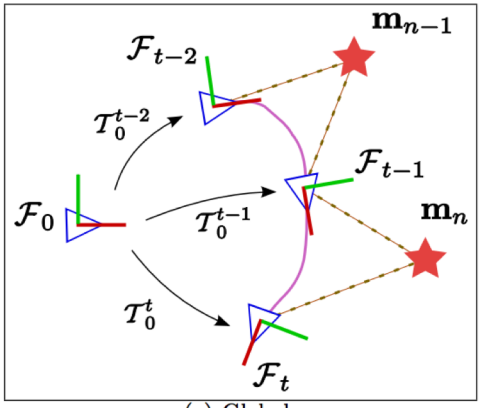


- Goal: Implement global SfM pipeline using Motion Averaging (as opposed to the incremental pipeline from sheet 4)
- Approach:
  - Estimate relative rotation between pairs of cameras
  - Solve for global camera orientations
  - Given the global orientations, estimate global translations
  - Triangulate structure

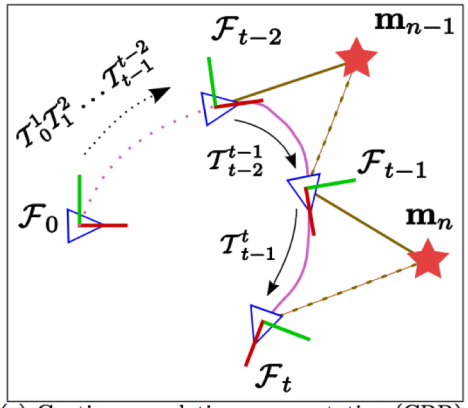


- Chatterjee, Avishek, and Venu Madhav Govindu. **"Efficient and robust large-scale rotation averaging."** Proceedings of the IEEE International Conference on Computer Vision. 2013. [pdf]
- Wilson, Kyle, and Noah Snavely. **"Robust global translations with 1dsfm."** European Conference on Computer Vision. Springer, Cham, 2014. [pdf]
- Zhu, Siyu, et al. **"Very large-scale global sfm by distributed motion averaging."** Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2018. [pdf]

5. Relative Map Formulation for SLAM

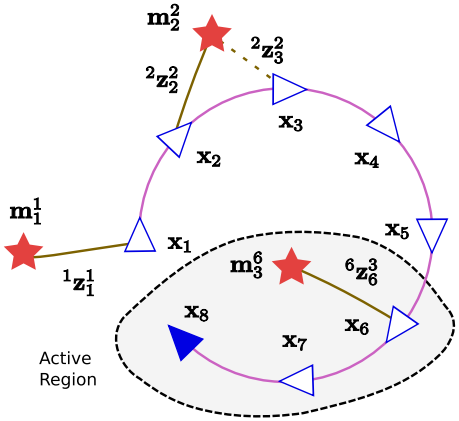


(a) Global

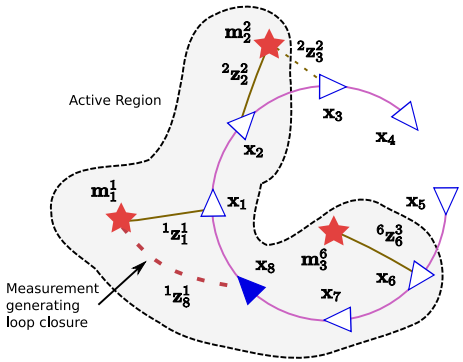


(e) Continuous relative representation (CRR)

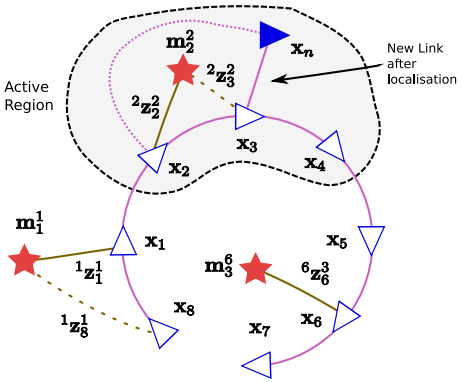
- Change the map formulation to the relative one
  - Parameters are relative poses between keyframes
  - All points are defined relative to some frame
- Extend either SfM or Odometry application
- Paper: http://www.robots.ox.ac.uk/~mobile/Papers/2010IJCV_mei.pdf



(a)



(b)



(c)