



# Practical Course: Vision-based Navigation WS 2018/2019

## Projects

Vladyslav Usenko, Nikolaus Demmel,  
Prof. Dr. Daniel Cremers

# 1. Bag of Words for Place Recognition

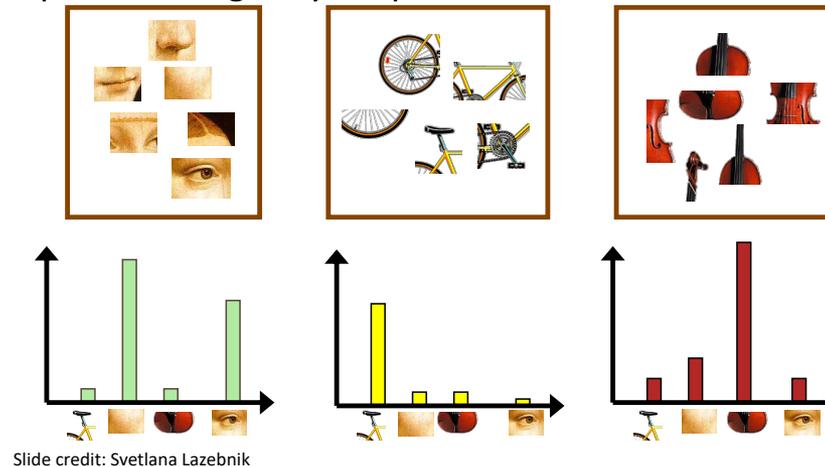


- Goals:
  - find additional image correspondences between non-sequential frames
  - detect when previous places are revisited
- Methods for detecting a revisit of previous places are often coined “**place recognition**” in the SLAM literature

Images: Cummins and Newman, Highly Scalable Appearance-Only SLAM – FAB-MAP 2.0, RSS 2009

# 1. Bag of Words for Place Recognition

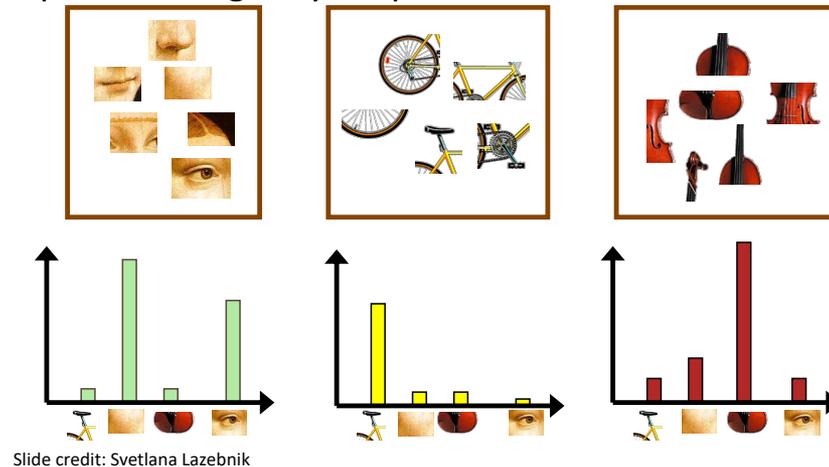
1. Extract local features
2. Learn “visual vocabulary”
3. Quantize local features using visual vocabulary
4. Represent images by frequencies of “visual words”



- Applications:
  - SfM: Speed up pairwise matching
  - SLAM: re-localization, loop-closure

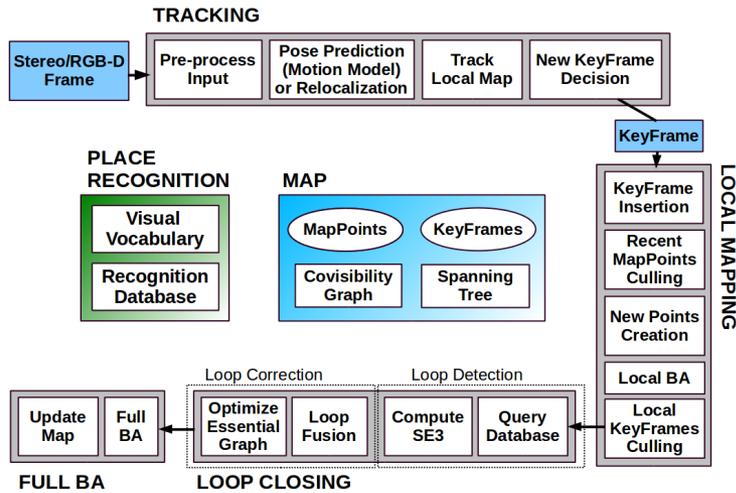
# 1. Bag of Words for Place Recognition

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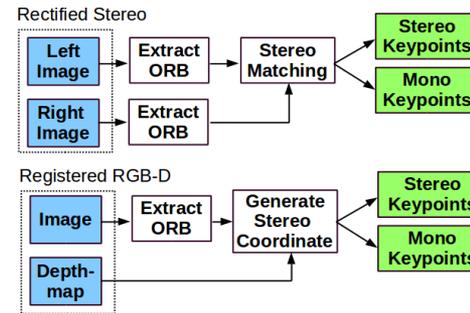


- DBoW2/3
  - Paper: <http://doriangalvez.com/papers/GalvezTRO12.pdf>
  - Code: <https://github.com/rmsalinas/DBow3>
- HBST: A Hamming Distance embedding Binary Search Tree
  - Paper: <https://arxiv.org/abs/1802.09261>
  - Code: [https://gitlab.com/srrg-software/srrg\\_hbst](https://gitlab.com/srrg-software/srrg_hbst)

# 2. SLAM



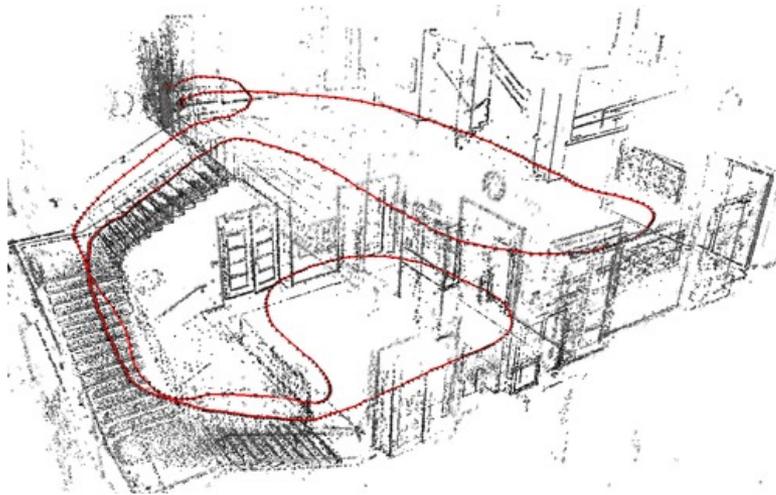
(a) System Threads and Modules.



(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

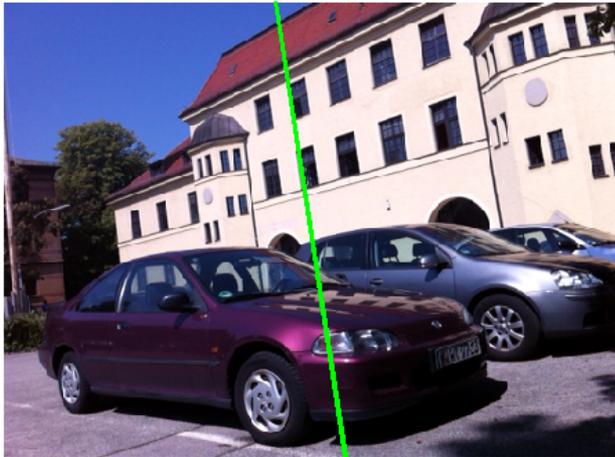
# 3. Photometric BA



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

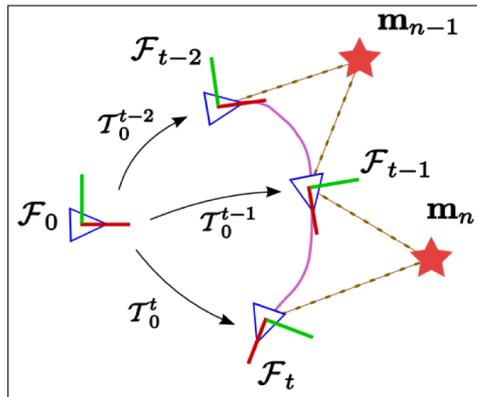
- Photometric Bundle adjustment in SFM
  - Error metric similar to DSO
  - <https://arxiv.org/pdf/1607.02565.pdf>
  - Possibly use vignetting and response from online calibration

## 4. Gravity-Aware Relative Pose

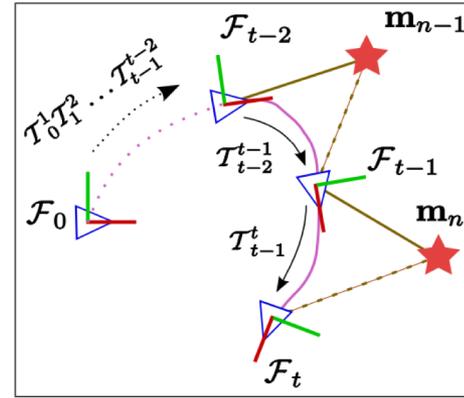


- Implement 3-point algorithm for RANSAC given known gravity direction
- Reuse the framework of OpenGV
  - Paper: Solving for Relative Pose with a Partially Known Rotation is a Quadratic Eigenvalue Problem ([link](#))

# 5. Relative Map Formulation for SLAM



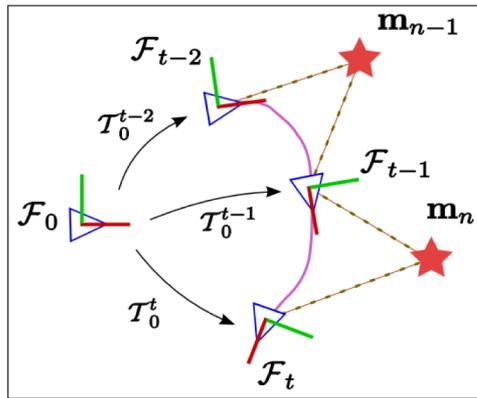
(a) Global



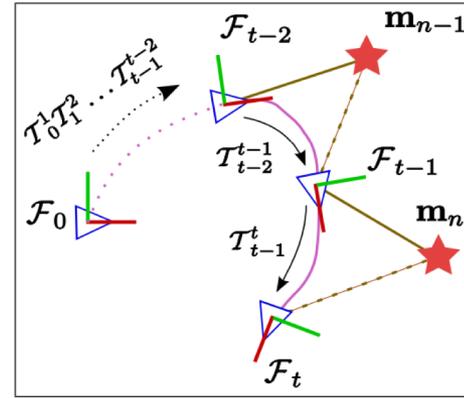
(e) Continuous relative representation (CRR)

- Change the map formulation to the continuous relative representation
- All points are defined relative to some frame
- Paper: [http://www.robots.ox.ac.uk/~mobile/Papers/2010IJCV\\_mei.pdf](http://www.robots.ox.ac.uk/~mobile/Papers/2010IJCV_mei.pdf)

# 4. Relative Map Formulation for SLAM

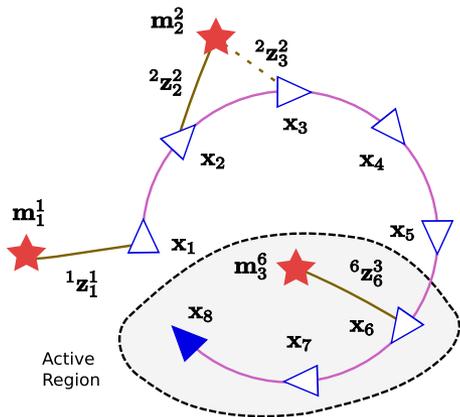


(a) Global

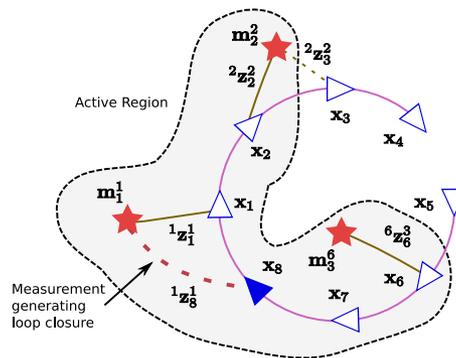


(e) Continuous relative representation (CRR)

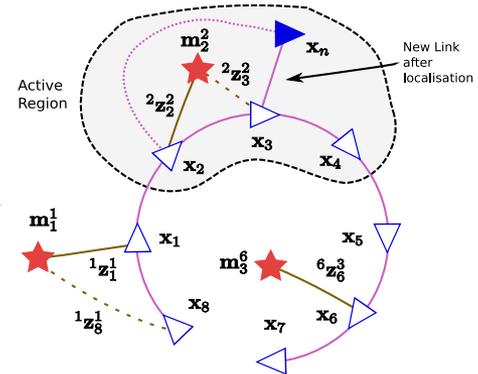
- Change the map formulation to the relative one
- All points are defined relative to some frame
- Paper: [http://www.robots.ox.ac.uk/~mobile/Papers/2010IJCV\\_mei.pdf](http://www.robots.ox.ac.uk/~mobile/Papers/2010IJCV_mei.pdf)



(a)



(b)



(c)