Robust Aged Feature Set

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ISL Lab Seminar

Image System Laboratory

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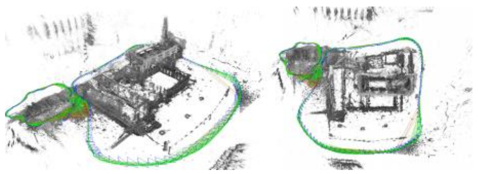
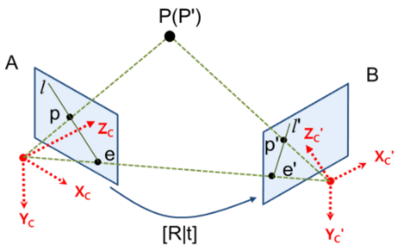
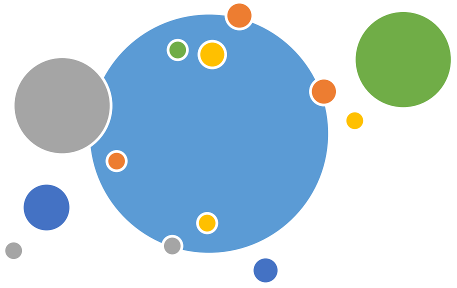


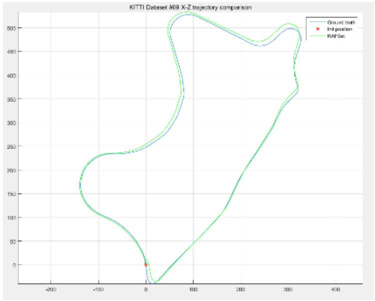
Motion estimation issue



Robust Aged Feature Set

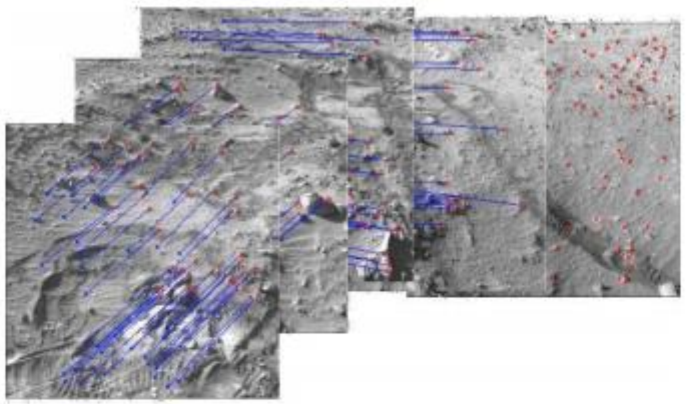


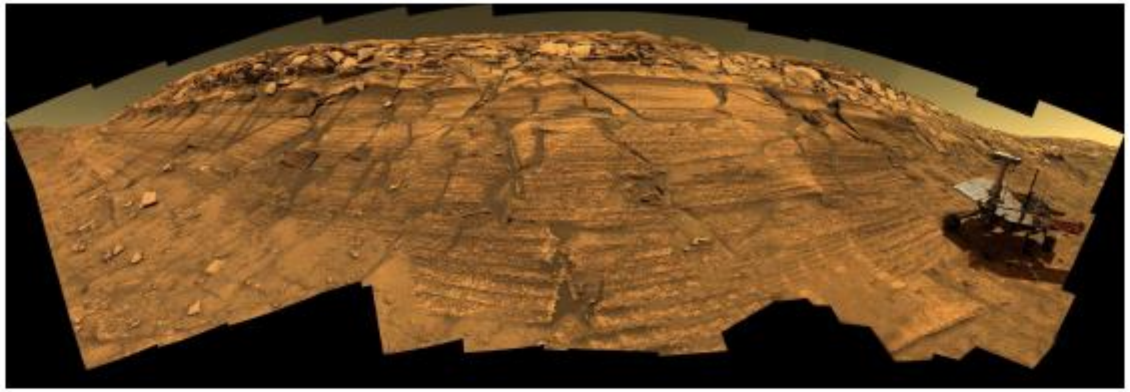
Result



Introduction – Visual Odometry

- **Visual odometry**
  - In robotics and computer vision, ***visual odometry*** is the process of determining the position and orientation of a robot by analyzing the associated camera images. It has been used in a wide variety of robotic applications, such as on the Mars Exploration Rovers.





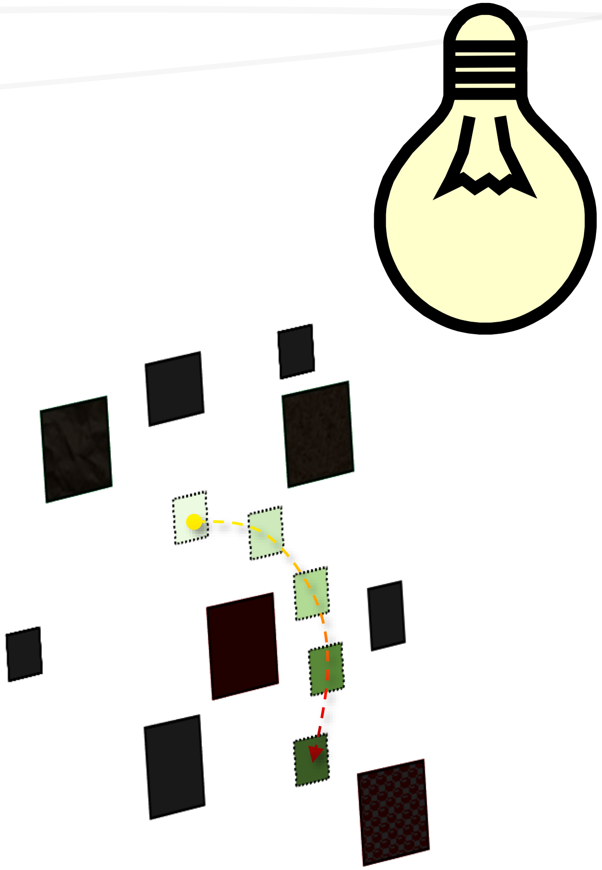
Maimone, M.; Cheng, Y.; Matthies, L. (2007). " Two Years of Visual Odometry on the Mars Exploration Rovers". *Journal of Field Robotics* **24**

Visual Odometry

- **Advantages of VO**

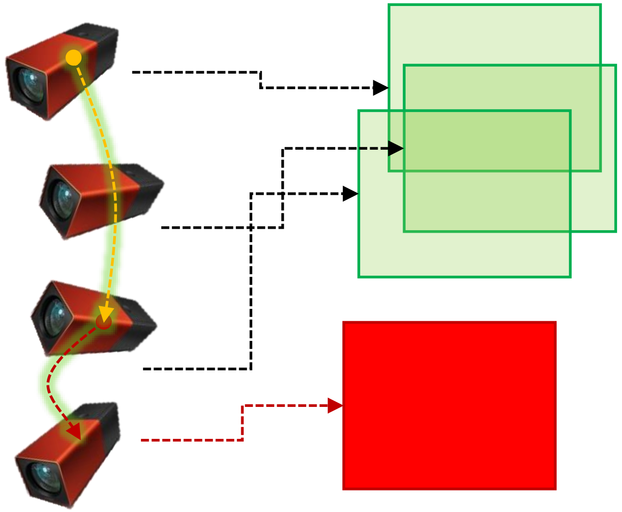
  - Is not affected by wheel slip in uneven terrain or other adverse conditions
  - Provide accurate trajectory estimates
  - Additional information acquisition
    - IMU, GPS, Wheel Odometry : egomotion only
  - Low cost comparing to IMU, Laser Odometry
  - Capable in GPS-denied environments
    - Underwater, Aerial, indoor, another planet

Positive condition for VO

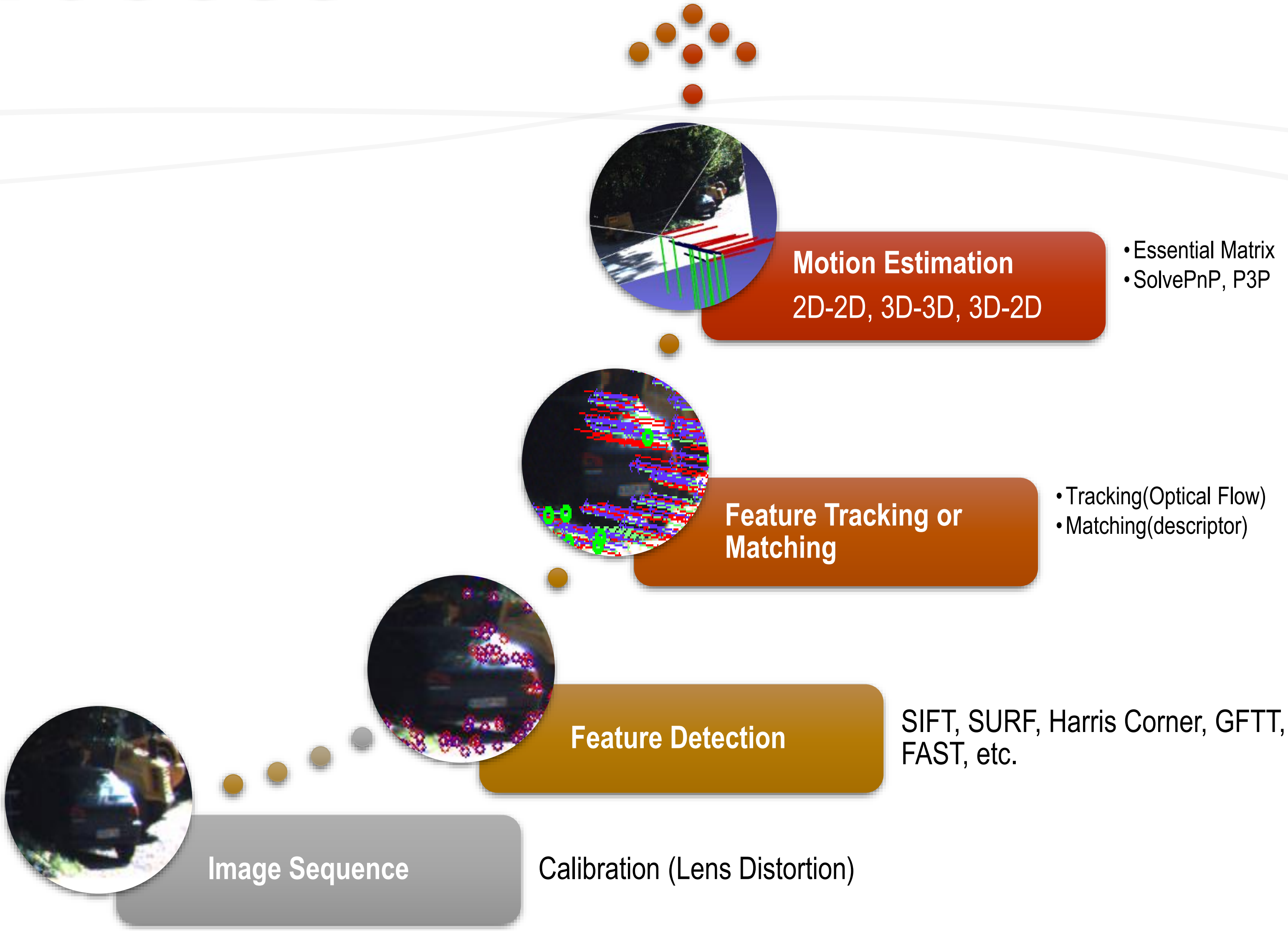


Static scene with enough textured features

Consecutive frames
that have sufficient scene overlap



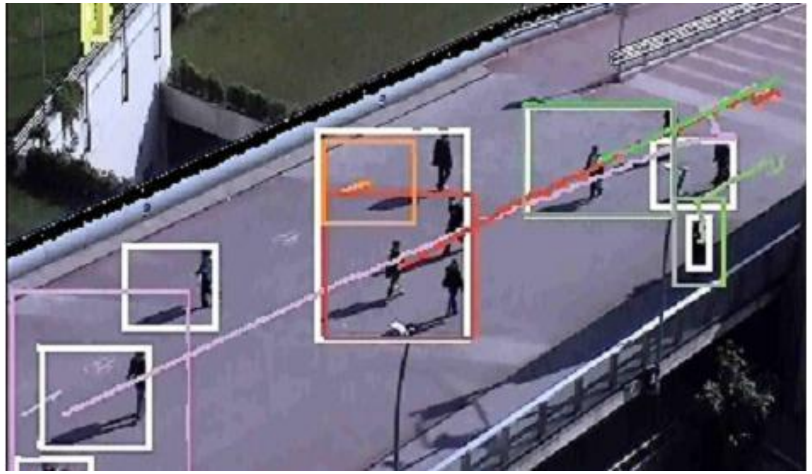
VO Process



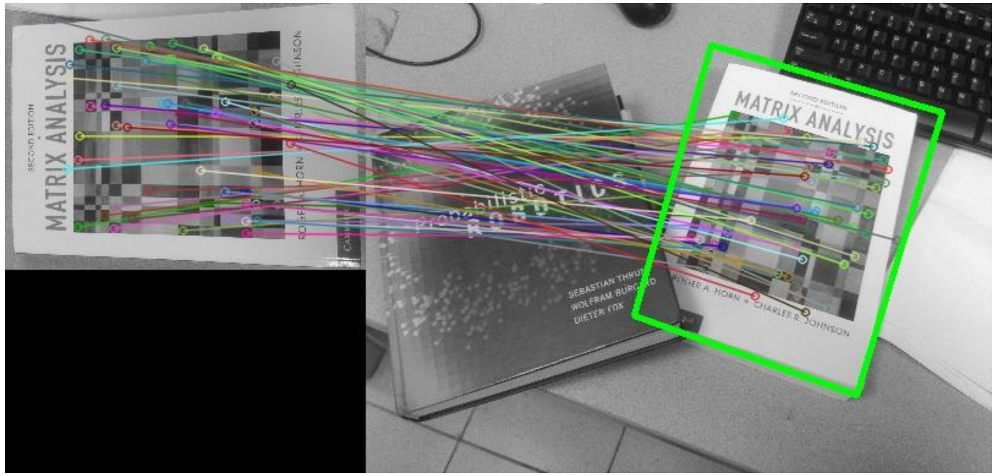
Motion Estimation
2D-2D, 3D-3D, 3D-2D
• Essential Matrix
• SolvePnP, P3P
Feature Tracking or Matching
• Tracking(Optical Flow)
• Matching(descriptor)
Feature Detection
SIFT, SURF, Harris Corner, GFTT, FAST, etc.
Image Sequence
Calibration (Lens Distortion)

Feature

- Features may be specific structures in the image such as points, edges or objects.

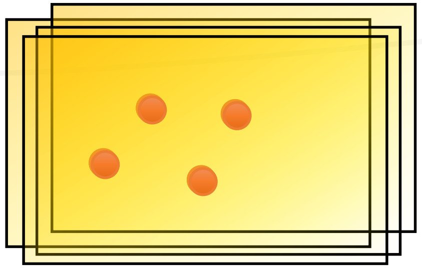


- Feature Tracking

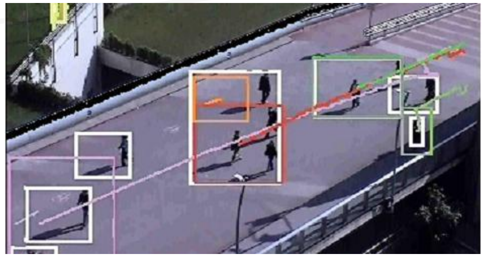


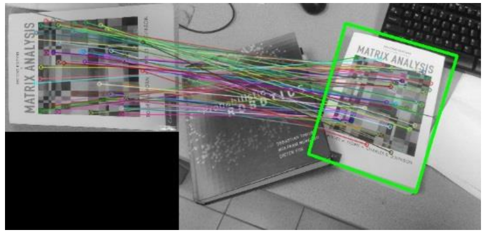
- Feature Matching

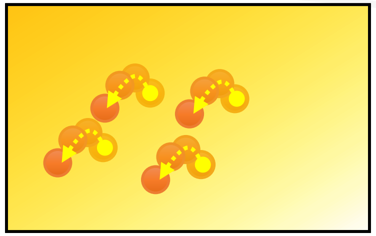
Tracking & Matching



Camera movement

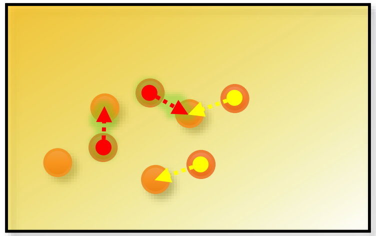






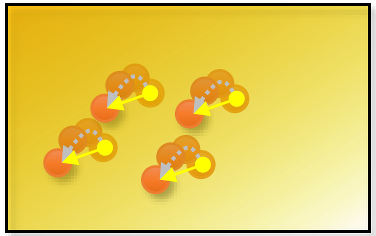
Feature Tracking

Short baseline : low ME accuracy
Guaranteed feature correspondence



Feature Matching

long baseline : High ME accuracy
Poor feature correspondence
(even heavy computation for descriptor)



Match after track

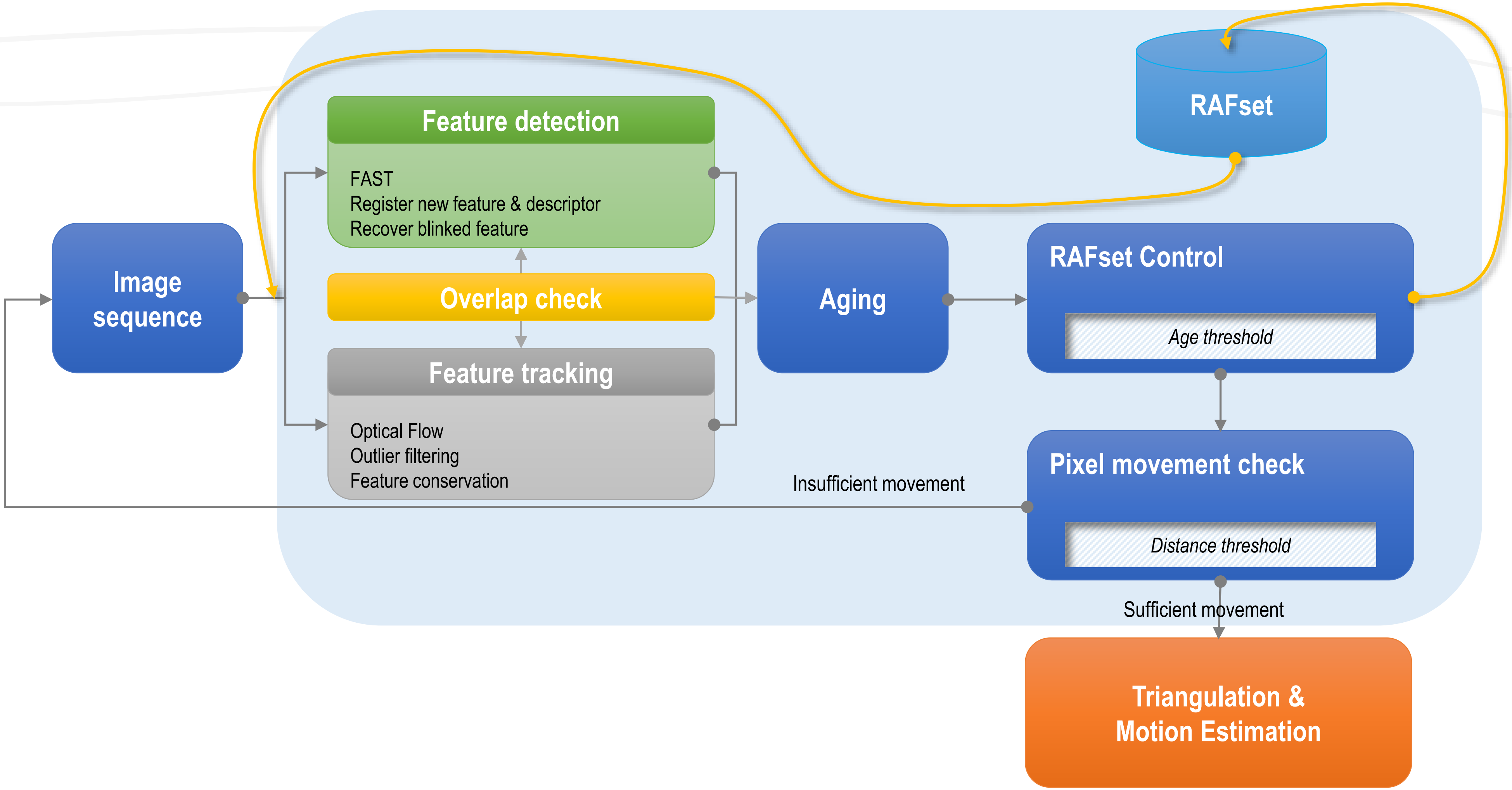
long baseline : High ME accuracy
Guaranteed feature correspondence

Robust Aged Feature Set

- **How to obtain accurate Motion Estimation**
  - Sufficient reliable correspondences
    - Repeatable & Traceable feature extraction(Aging & Tracking)
    - Adding feature of new part of scene(Feature detection & Matching)
    - Outlier rejection
  - Sufficient long baseline length

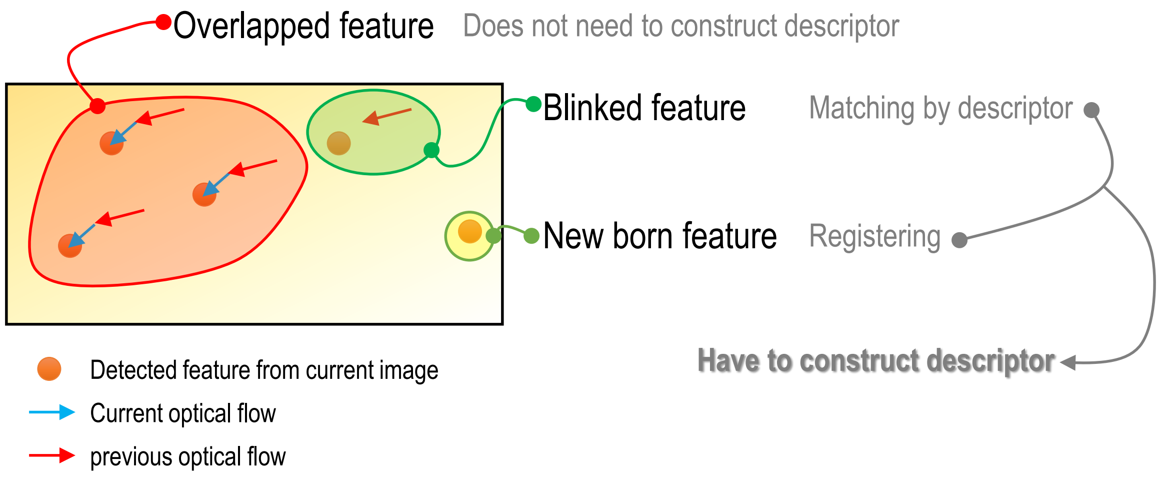
    - Sufficient pixel movement
- **VO : Real-time**
  - Low computational complexity feature detector
  - Low computational complexity descriptor
  - Simple tracking algorithm

Visual Odometry using RAFset



Overlap check

- Overlap check
  - Reduce computation, check overlapped features.



Filter

- **Outlier filtering**

$$e_i = \sqrt{\left(x_i - x_i^{'}\right)^2 + \left(y_i - y_i^{'}\right)^2} \qquad where,\ (x, y) \xleftrightarrow{correspondence} \left(x^{'}, y^{'}\right)$$

$$\mu = \frac{1}{n}\sum_{i=1}^{n} e_i, \qquad \sigma = \sqrt{\frac{\sum_{i=1}^{n}(e_i - \mu)^2}{n}}$$

$$T_{outlier} = \mu + \sigma_e$$

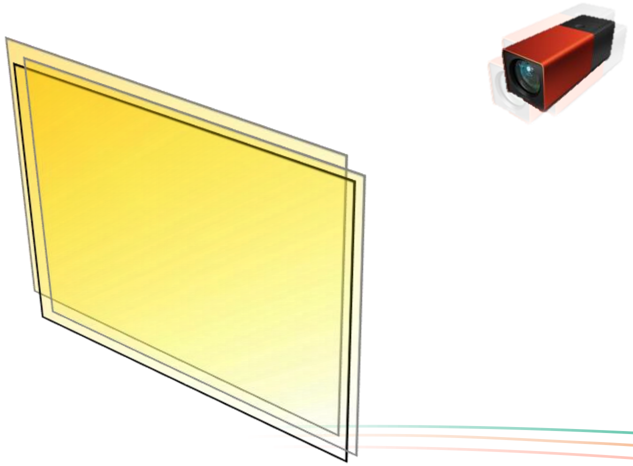
  - Inliers should be smaller than $T_{outlier}$

- **Stop state detection**

$$e_i = \sqrt{\left(x_i - x_i^{'}\right)^2 + \left(y_i - y_i^{'}\right)^2} \qquad where,\ (x, y) \xleftrightarrow{correspondence} \left(x^{'}, y^{'}\right)$$

$$\bar{e} = \sum_{i=1}^{n} e_i$$

$$if\ \ \bar{e} < T_m\ ,\ than\ the\ cam\ is\ stopped$$



Aging

Aging

- Tracked
- Overlapped
- Reappeared

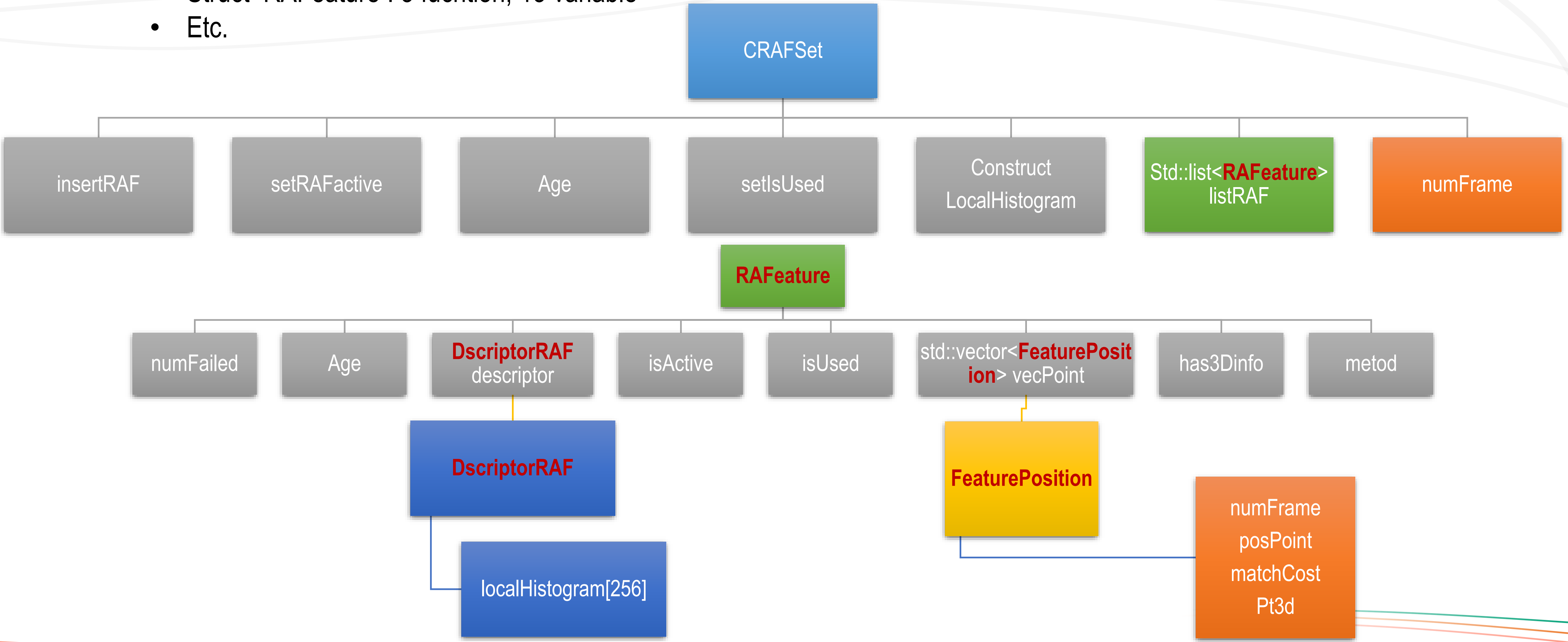
De-aging

- Disappeared

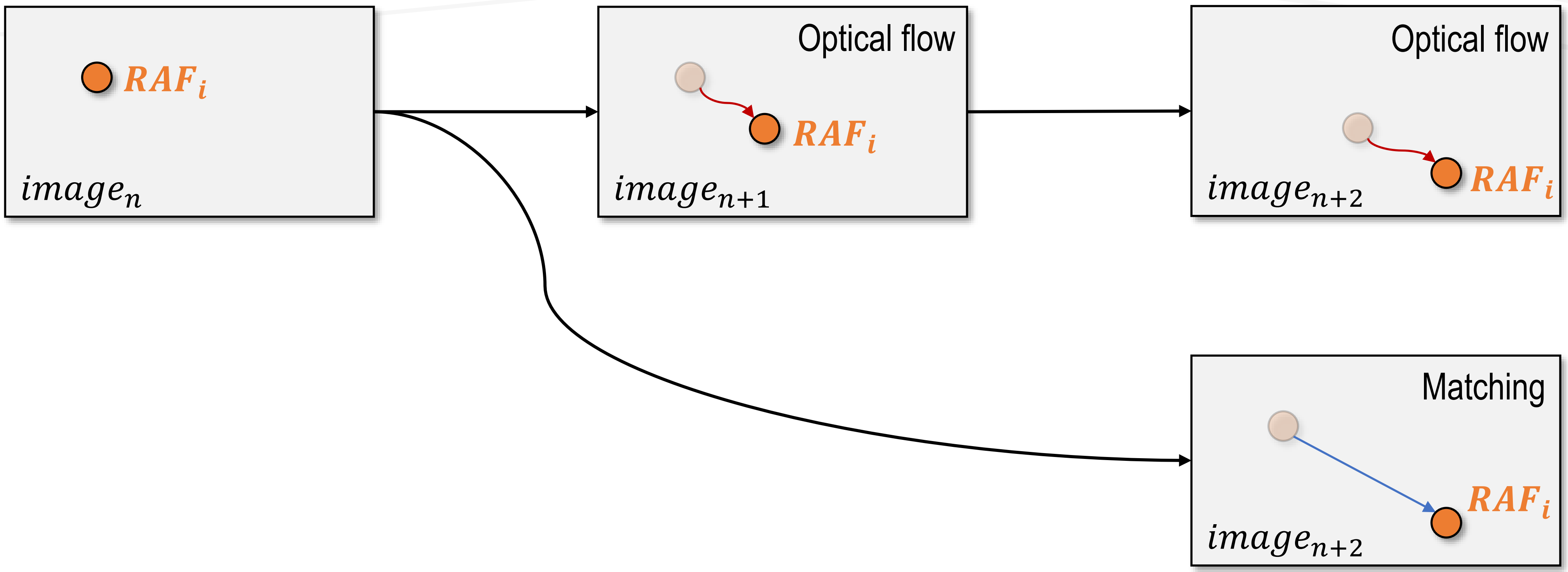
  age = age/numFailed

Structure of RAF

- Class CRAFSet : 19 function, 3 variable
- Struct RAFeature : 3 fucntion, 13 variable
- Etc.

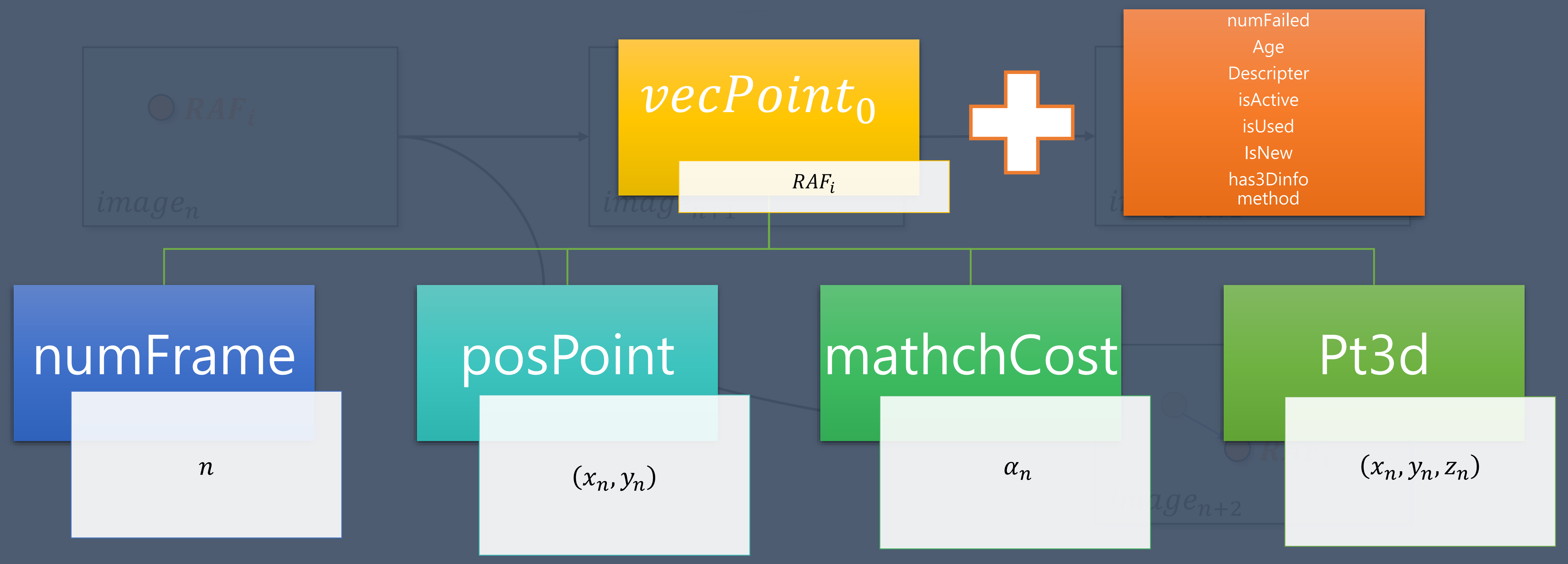


vecPoint



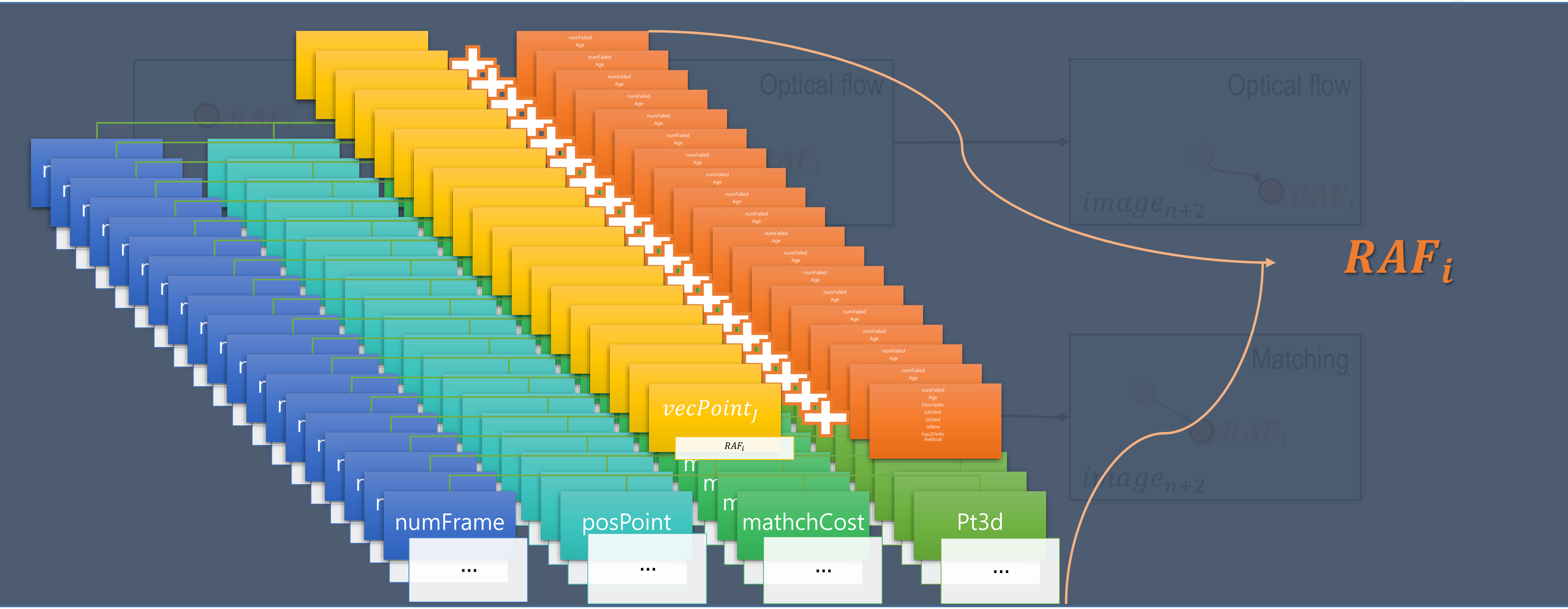
RAF_i
$image_n$
Optical flow
RAF_i
$image_{n+1}$
Optical flow
$image_{n+2}$
RAF_i
Matching
RAF_i
$image_{n+2}$

vecPoint

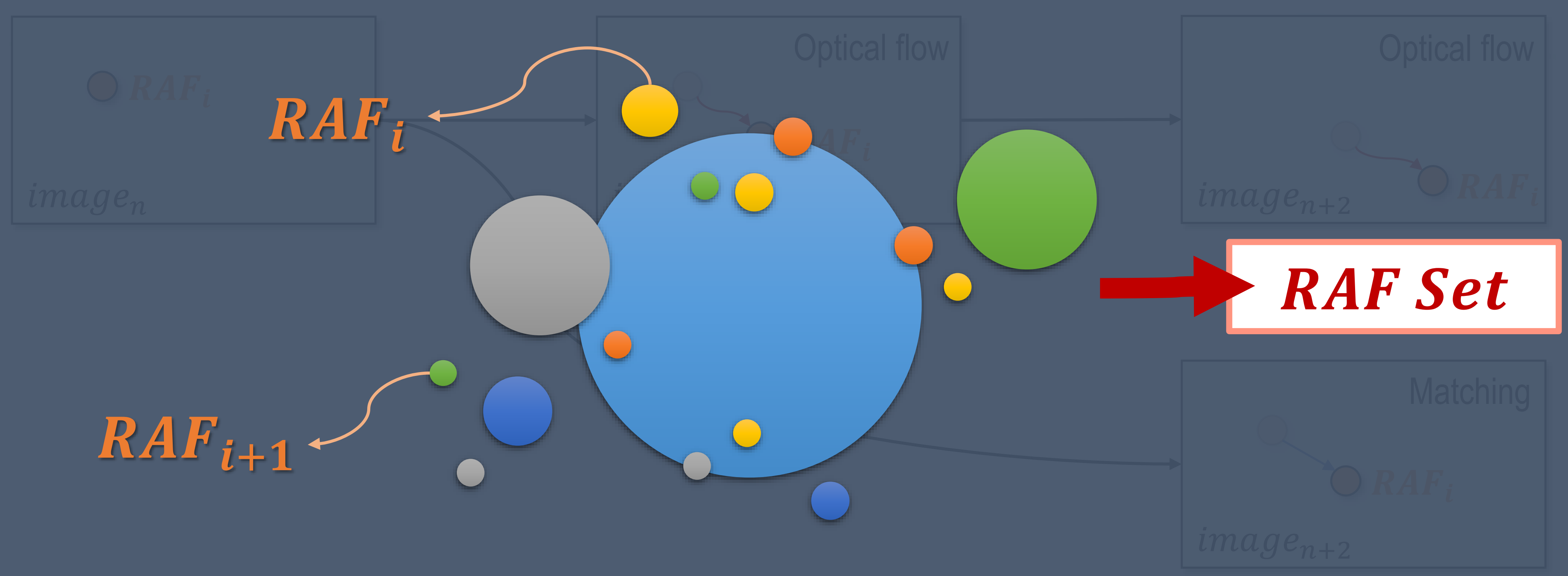


$vecPoint_0$
RAF_i
numFailed
Age
Descripter
isActive
isUsed
IsNew
has3Dinfo
method
numFrame
n
posPoint
(x_n, y_n)
mathchCost
α_n
Pt3d
(x_n, y_n, z_n)

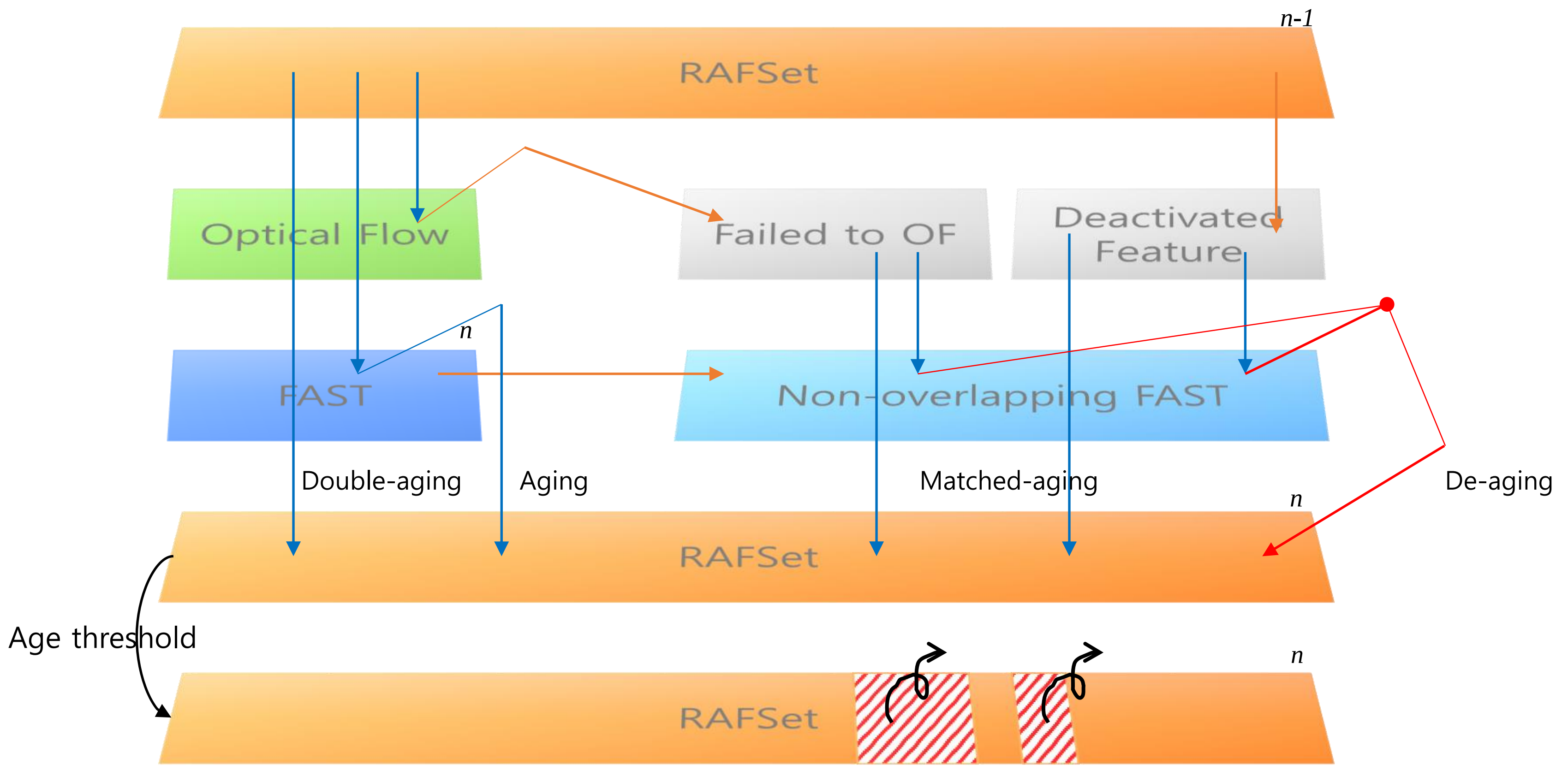
RAF Set = (vecPoint + other data) × nRAF



RAF Set = (vecPoint + other data) × nRAF

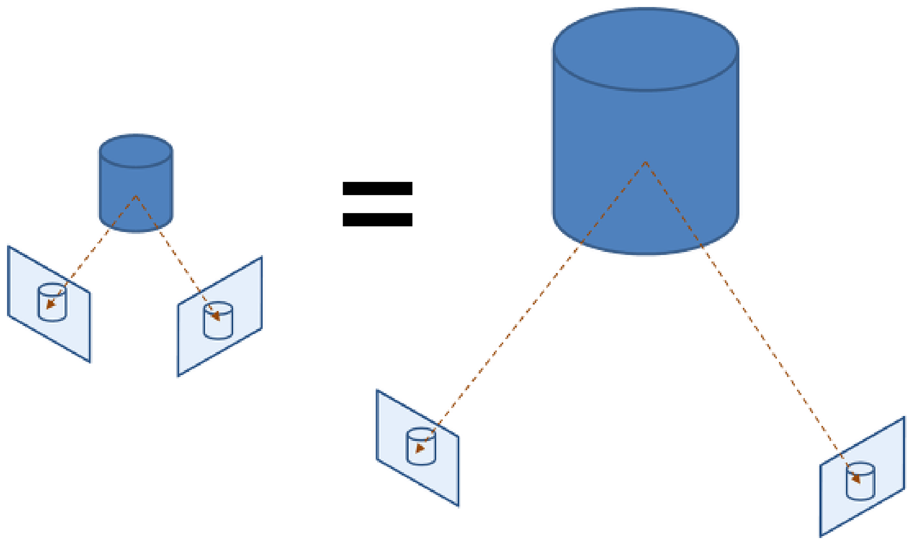


Robust Aged Feature Set



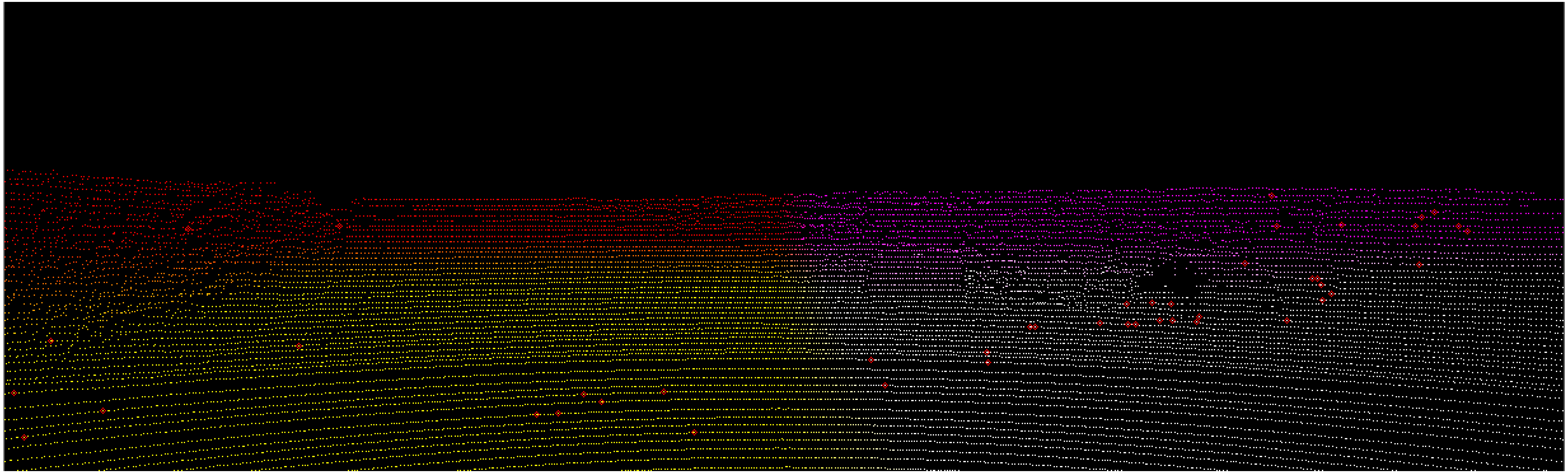
Scale Problem (2D-2D)

- [R|T] from E, $|\mathbf{T}| = 1$

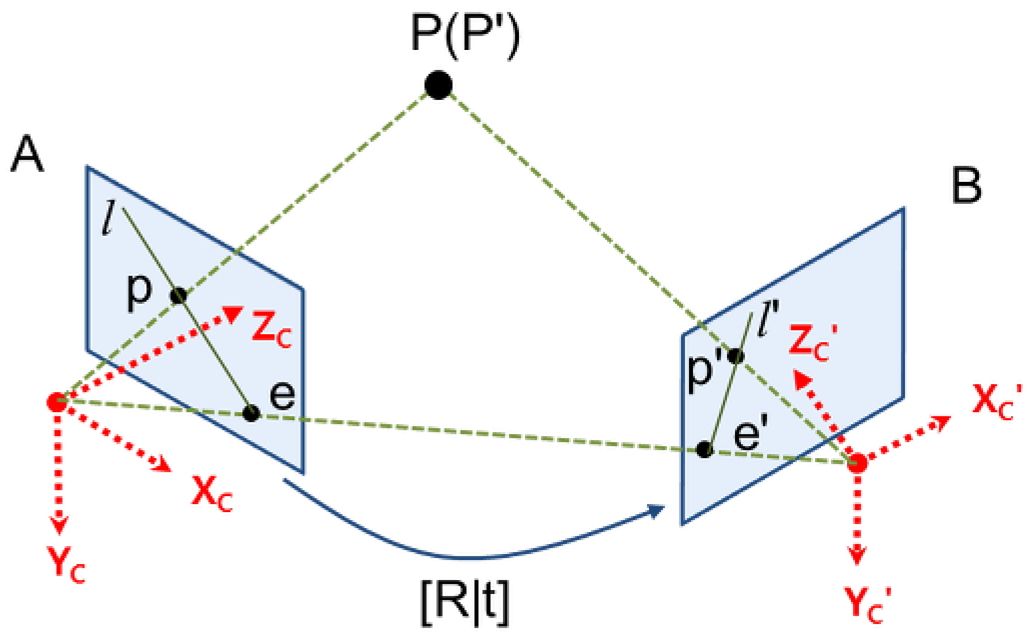


Scale Problem(3D-2D)

- Use LIDAR information



Motion Estimation



- 2D-2D RT from Essential matrix => Triangulation(add 3D points)
- 3D-2D RT from solvePnP => Motion Estimation

KITTI Dataset

The KITTI Vision Benchmark Suite

A project of Karlsruhe Institute of Technology and Toyota Technological Institute at Chicago

Karlsruhe Institute of Technology

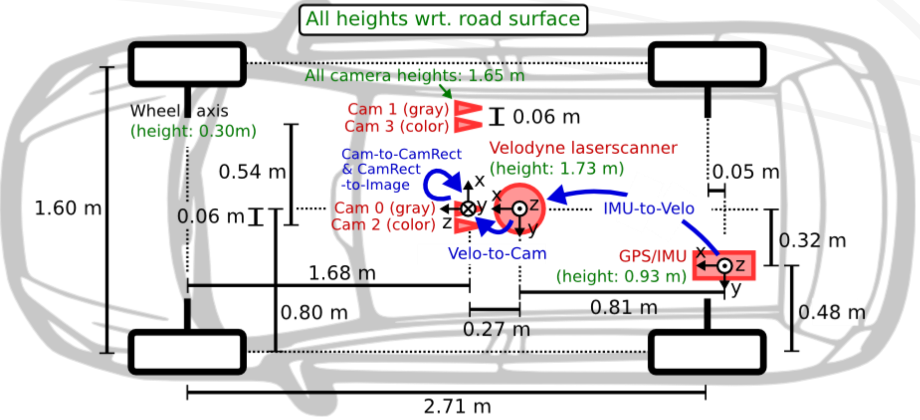
home | setup | stereo | flow | scene flow | odometry | object | tracking | road | semantics | raw data | submit results | jobs

Andreas Geiger (MPI Tübingen) | Philip Lenz (KIT) | Christoph Stiller (KIT) | Raquel Urtasun (University of Toronto)

Visual Odometry / SLAM Evaluation 2012

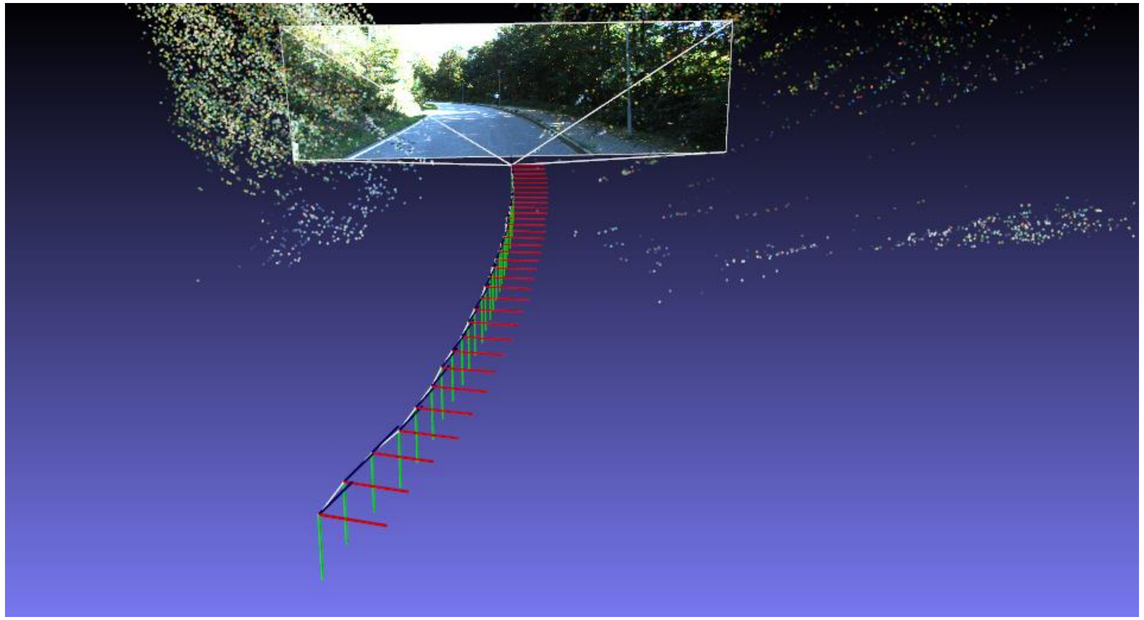
The odometry benchmark consists of 22 stereo sequences, saved in loss less png format: We provide 11 sequences (00-10) with ground truth trajectories for training and 11 sequences (11-21) without ground truth for evaluation. For this benchmark you may provide results using monocular or stereo visual odometry, laser-based SLAM or algorithms that combine visual and LIDAR information. The only restriction we impose is that your method is fully automatic (e.g., no manual loop-closure tagging is allowed) and that the same parameter set is used for all sequences. A development kit provides details about the data format.

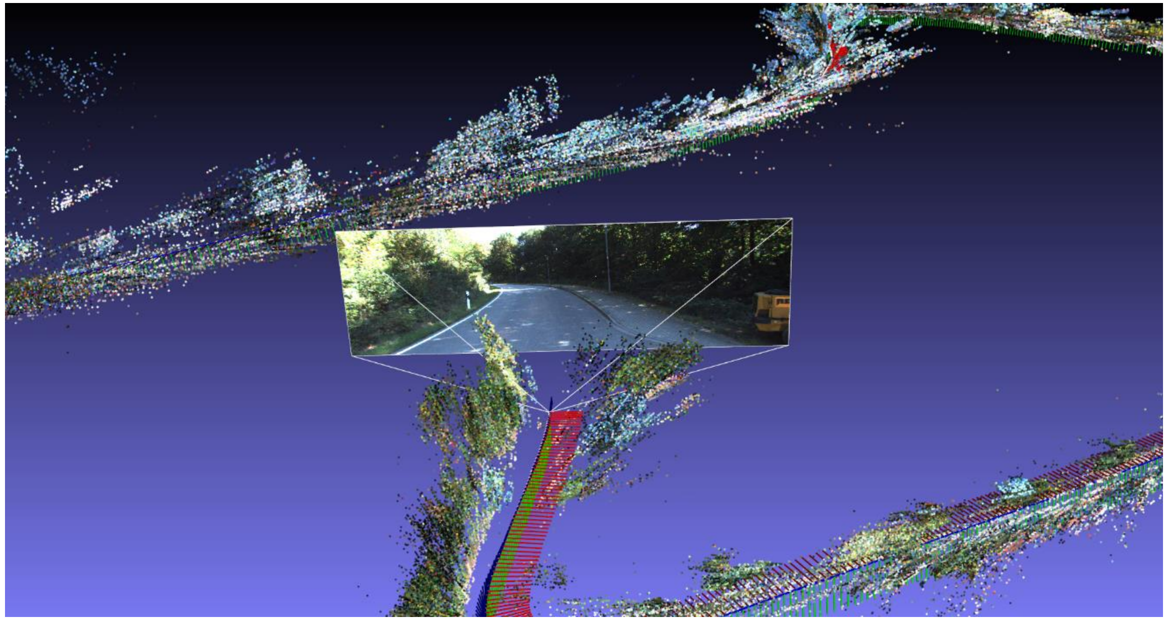
- Download odometry data set (grayscale, 22 GB)
- Download odometry data set (color, 65 GB)
- Download odometry data set (velodyne laser data, 80 GB)
- Download odometry data set (calibration files, 1 MB)
- Download odometry ground truth poses (4 MB)
- Download odometry development kit (1 MB)



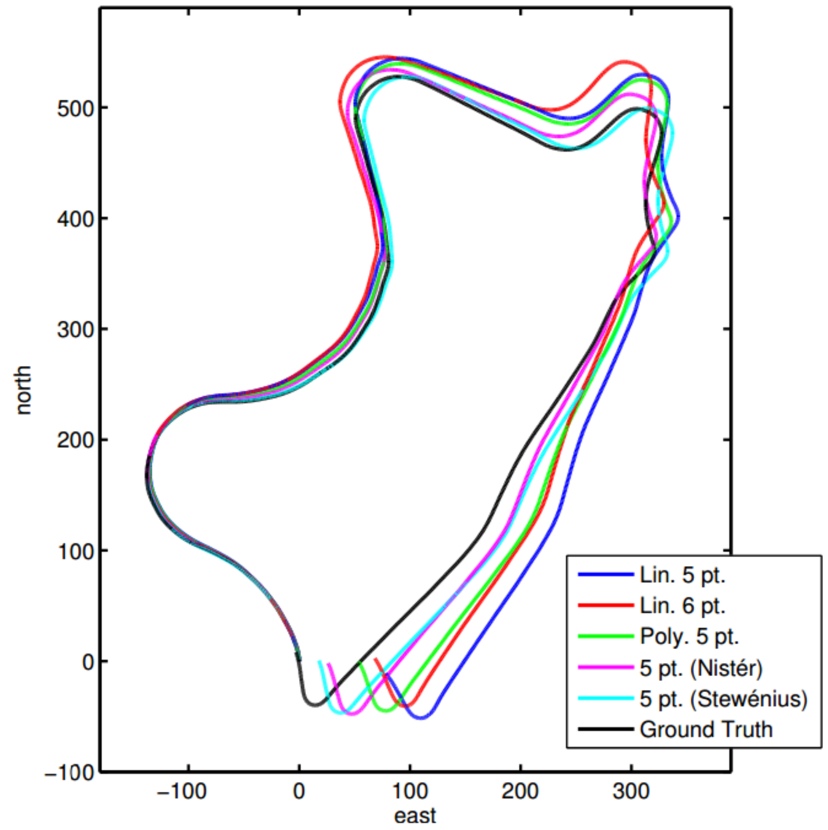
Experimental result

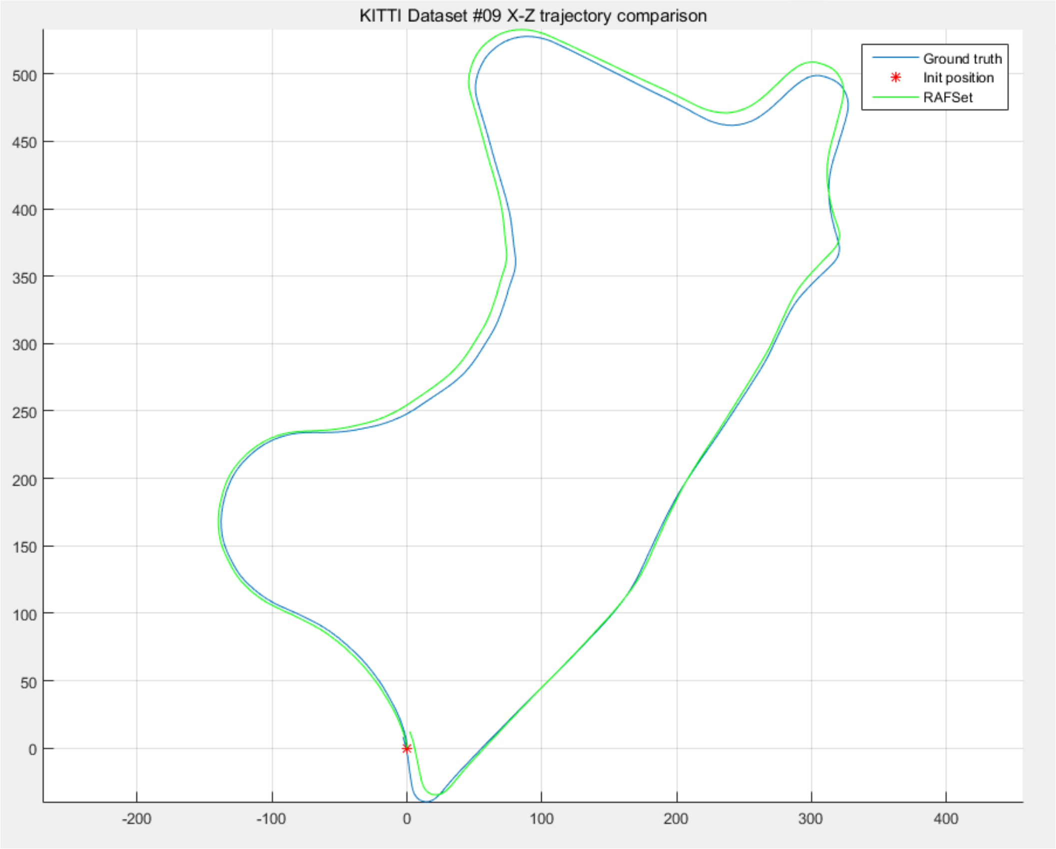
Experimental result





Experimental result : #09





Ventura, Jonathan, Clemens Arth, and Vincent Lepetit. "Approximated Relative Pose Solvers for Efficient Camera Motion Estimation." *Computer Vision-ECCV 2014 Workshops*. Springer International Publishing, 2014.

Q&A

Optical flow