The Art of Solving Minimal Problems

Success Story: Generalized Pose Computation

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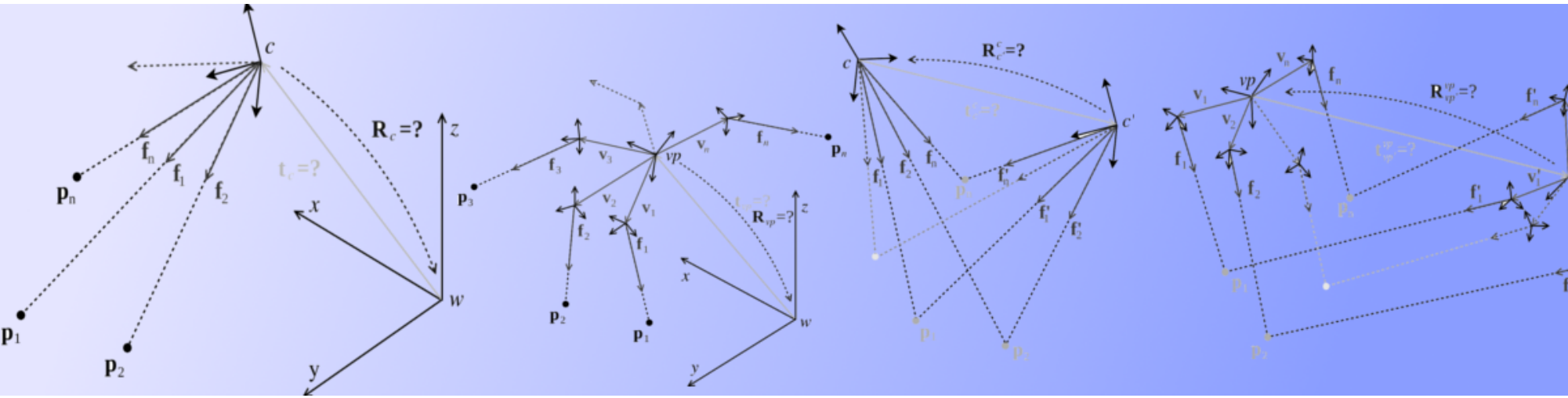
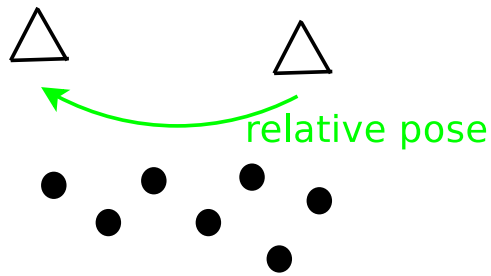


Structure from Motion (SfM)

- Derive **motion** and **structure** from image collection

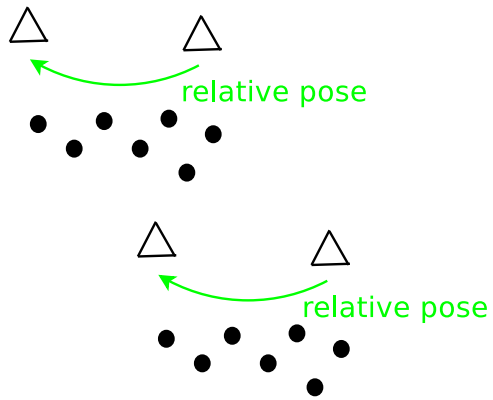
Figure: Courtesy of N. Snavely et al. Modeling the world from internet photo collections, IJCV, 80 (2):189—210, 2008.

Fundamental modules of SfM



- Fundamental modules:
  - Absolute pose computation
  - Relative pose computation

Fundamental modules of SfM



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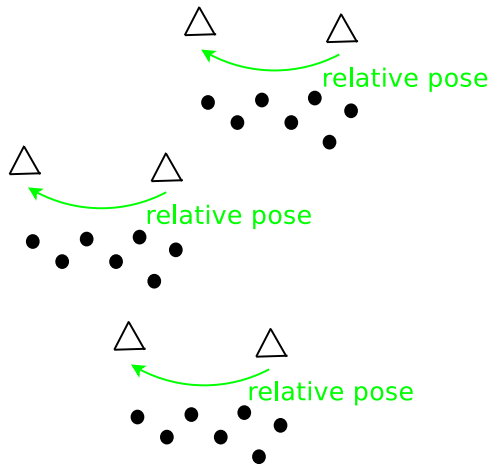

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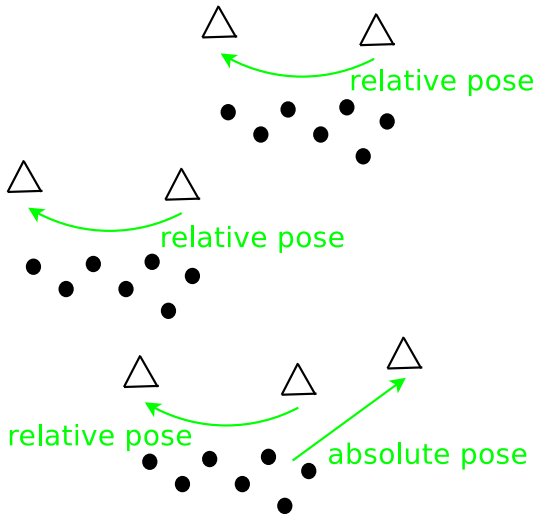

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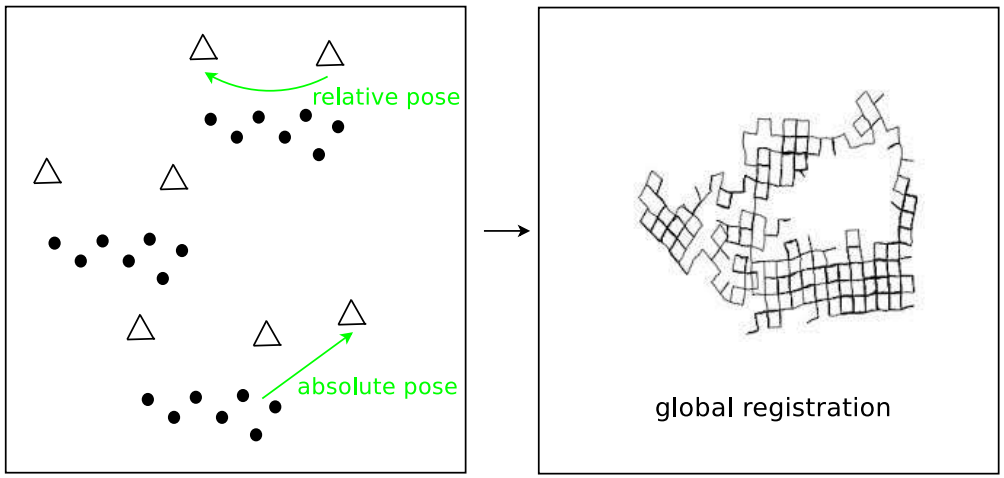

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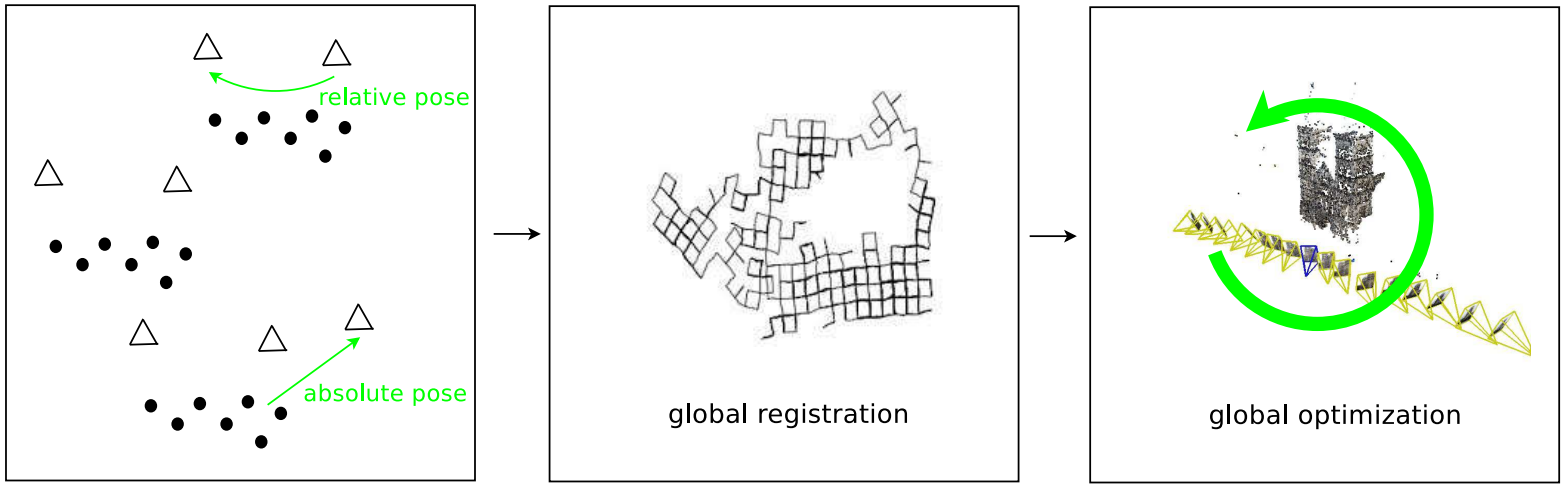

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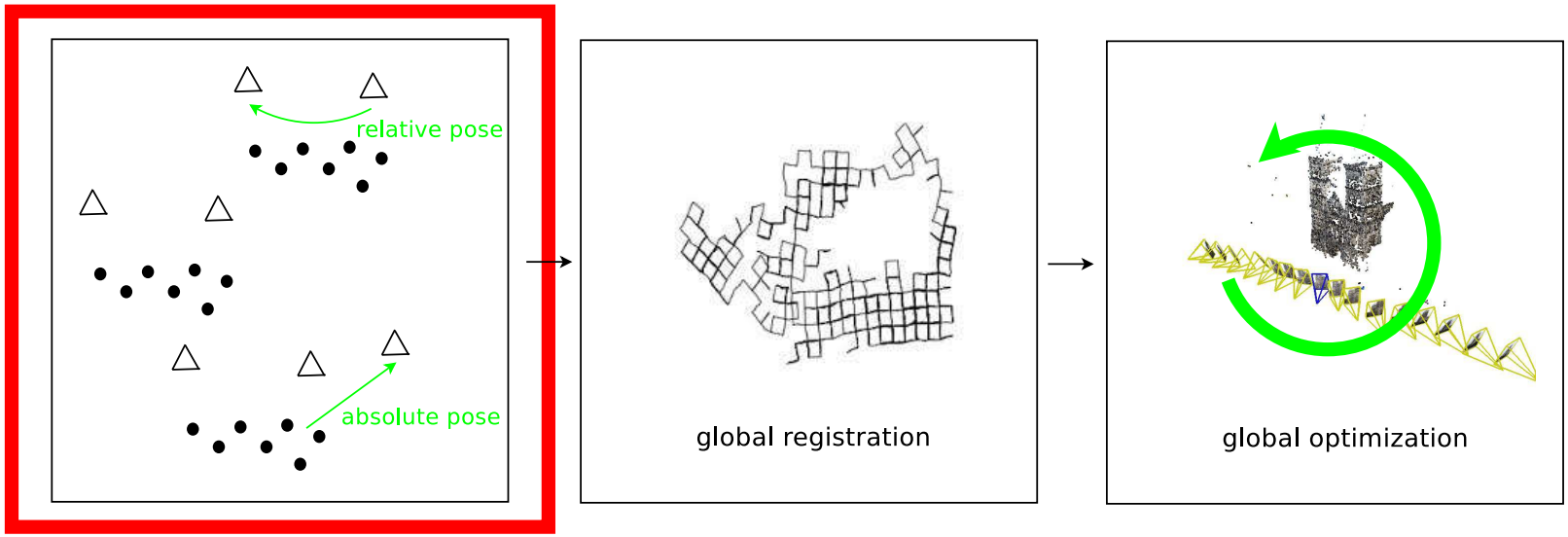

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Ubiquity of geometric problems

- Large-scale hierarchical SfM:
  - Basic blocks ⇒ **Absolute/Relative pose**
- Visual SLAM:
  - Initialization ⇒ **Relative pose**
  - Tracking ⇒ **Absolute pose**
  - Loop closure ⇒ **Absolute/Relative Pose**
  - Relocalization ⇒ **Absolute Pose**
- Robotics:
  - Geolocalization ⇒ **Absolute pose**
  - Object pose/Manipulation ⇒ **Absolute pose**

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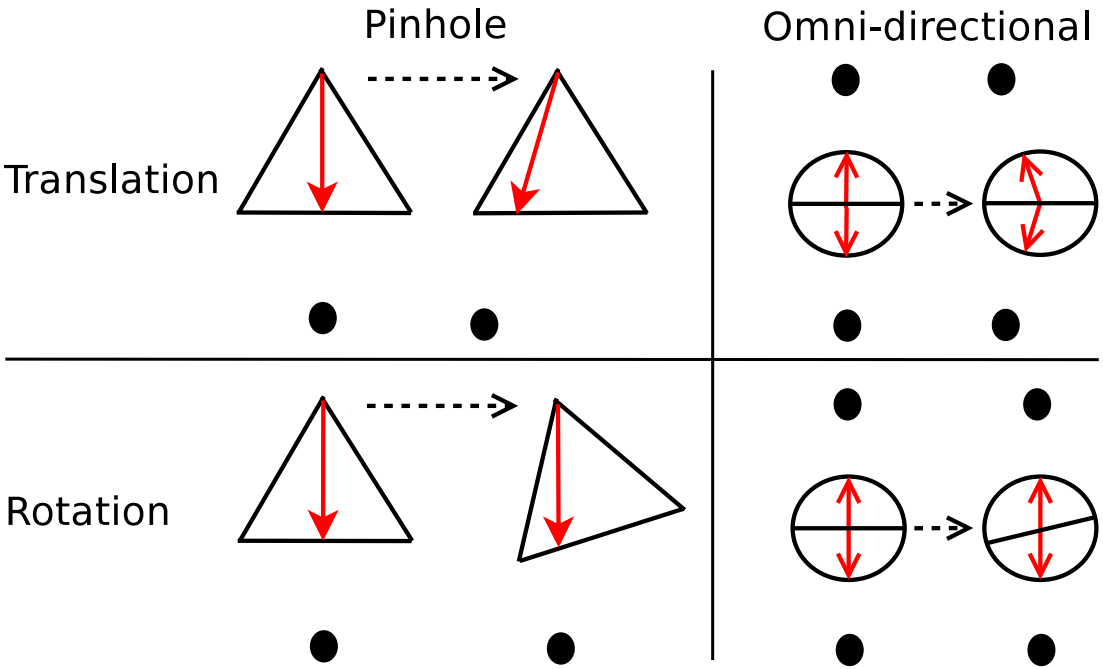
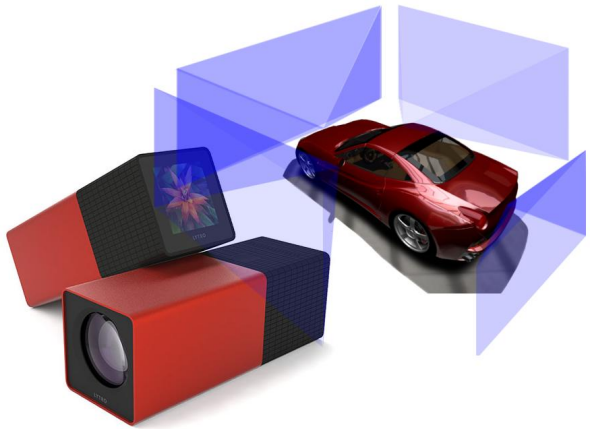
The normal case

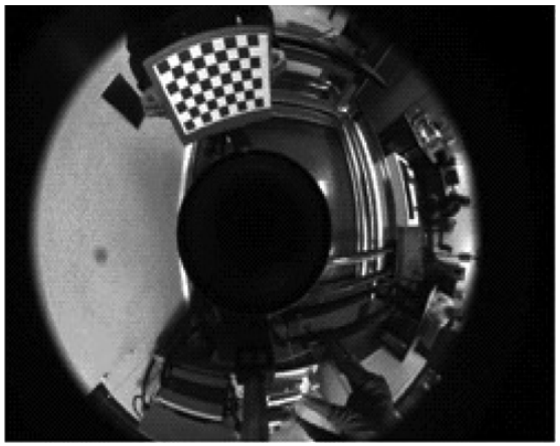
- Single perspective camera
  - Scale invariance
  - Limited field of view (ambiguities)



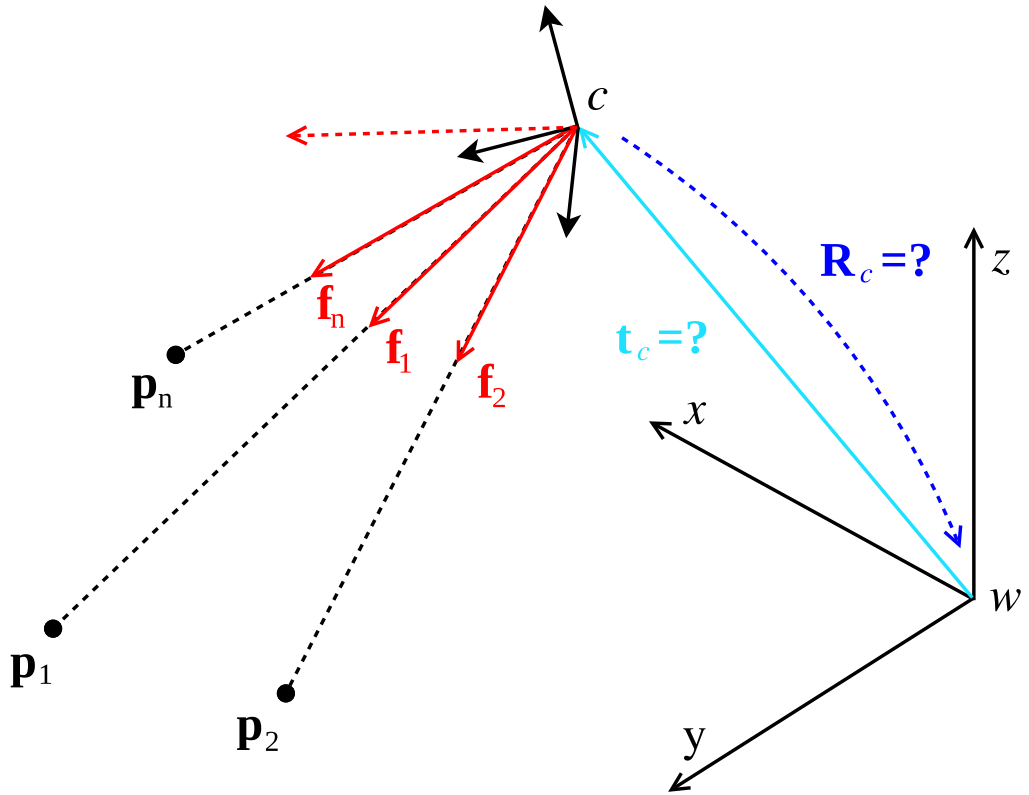
The general case

- Unconventional camera systems

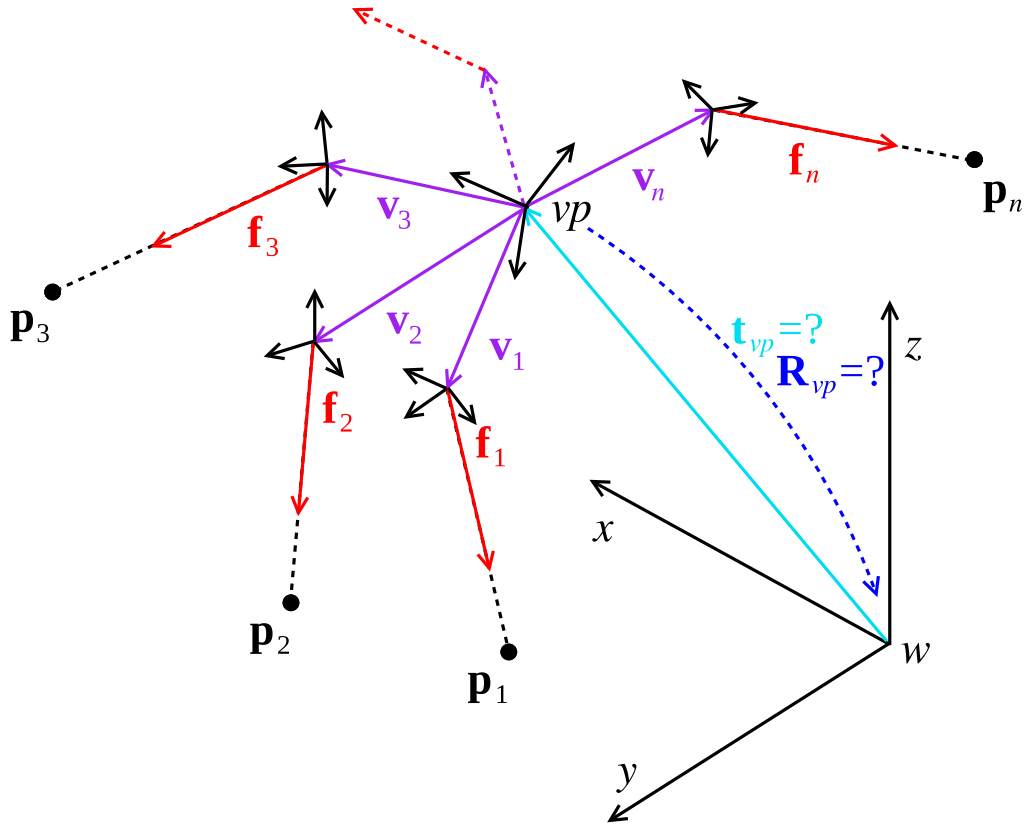


Central absolute pose computation



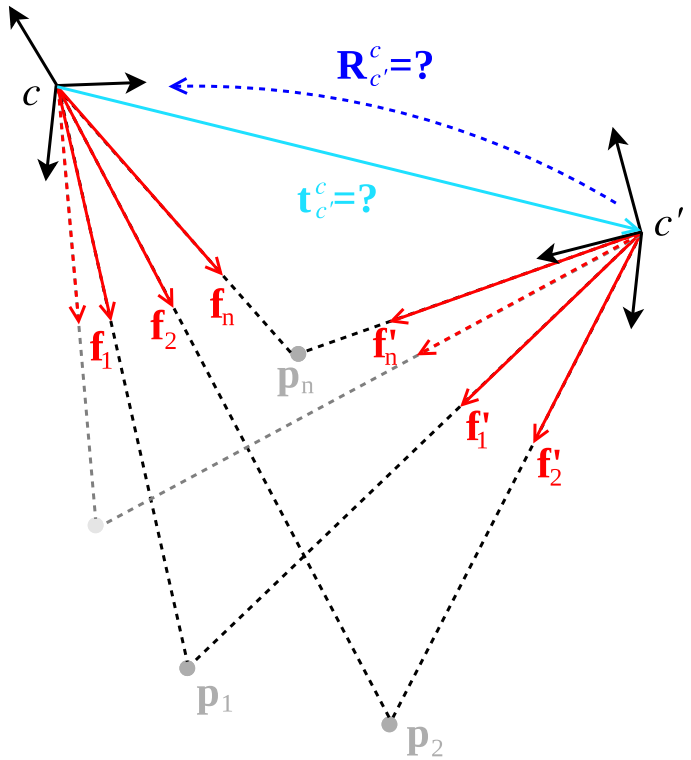
- Minimal Solutions:
  - P3P [Gao et al.'03], P3P [Kneip et al.'11], DLS [Hesch & Roumeliotis'11], UPnP [Kneip et al.'14], ...

Non-central absolute pose computation



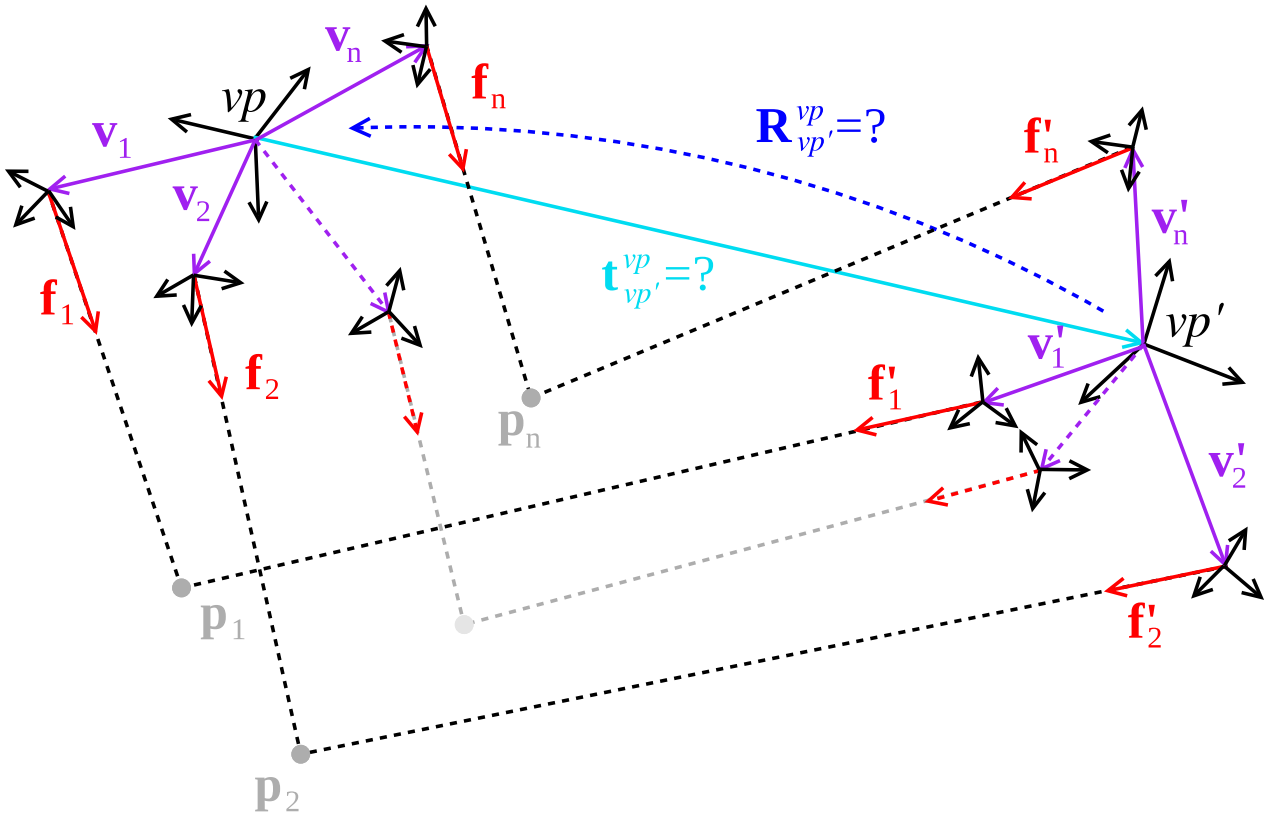
- Minimal Solutions:
  - GP3P [Nister & Stewenius'06], GP3P/GPnP [Kneip et al.'13], UPnP [Kneip et al.'14], ...

Central relative pose computation



- Minimal Solutions:
  - 5-point [Stewenius et al.'06], 5-point [Nister"04], 5-point [Kneip et al.'12], ...

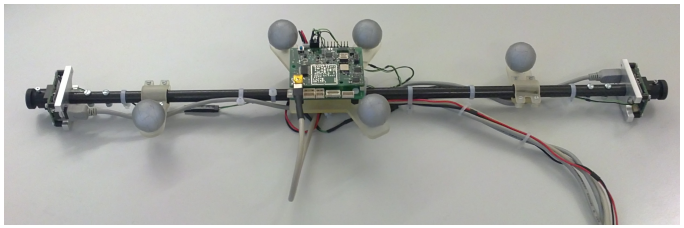
Non-central relative pose computation



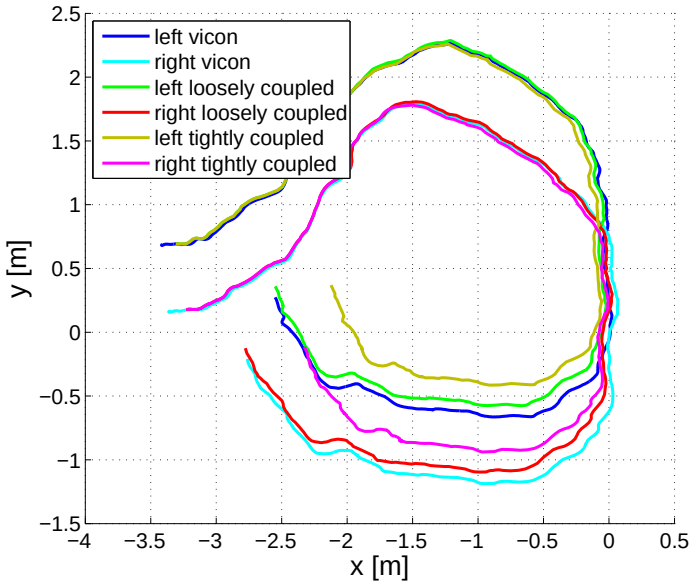
- Minimal Solutions:
  - 6-point [Stewenius & Nister'05], ...

Results with a two-camera system

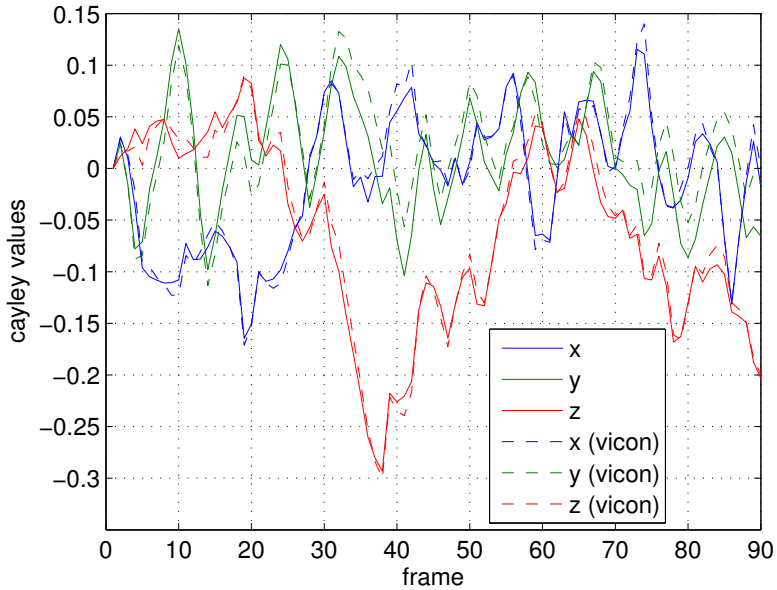
- Using all cameras as one!



- Generalized absolute pose
  - Tracking of a multi-camera system



- Generalized relative pose
  - Robust relative pose computation

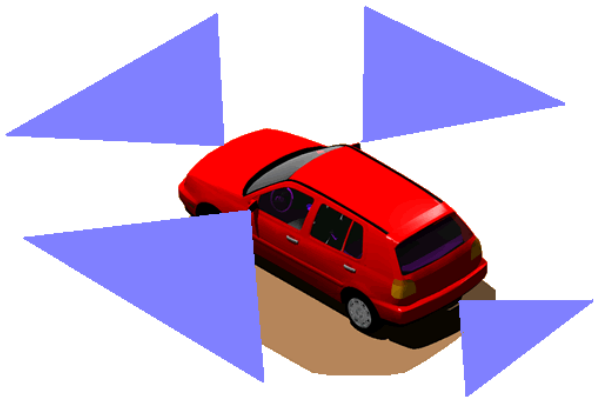


Results with a two-camera system

Multi-camera structure-from-motion

Results with a four-camera system

- Application within the V-charge project
- Four-camera system mounted on VW Golf
  - Front and rear-looking cameras
  - Two further cameras mounted in side mirrors



Results with a four-camera system

Multi-camera structure-from-motion

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