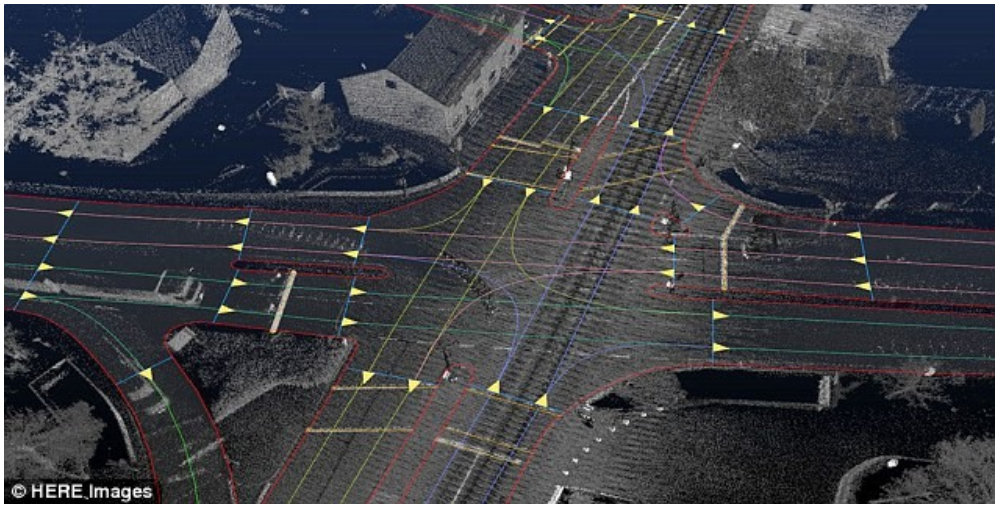
Introduction to 3D Reconstruction from a Moving Camera

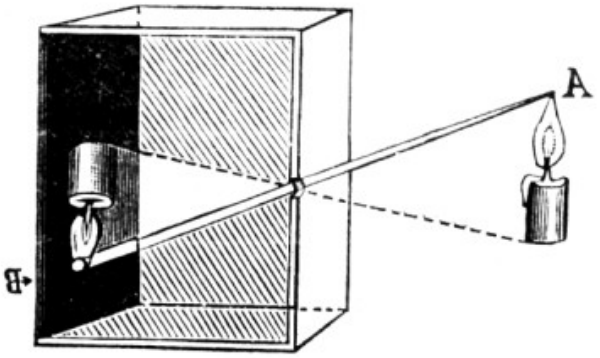
Background

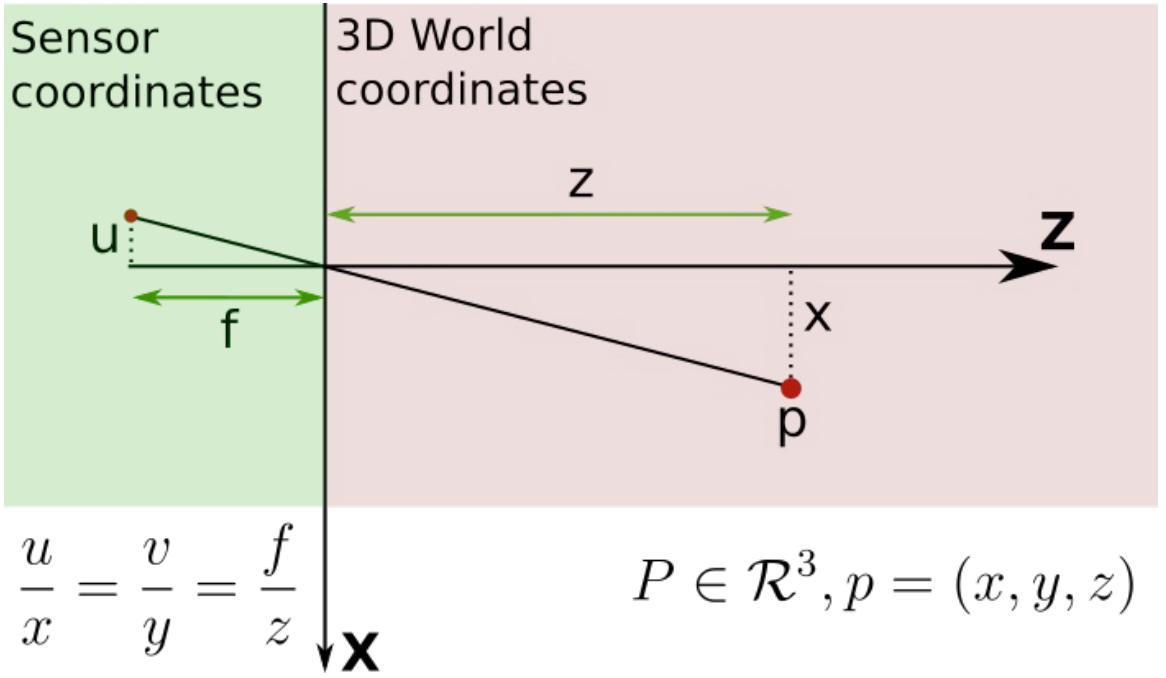
- UAV inspection
- 3D Map generation



Goal

Camera Geometry



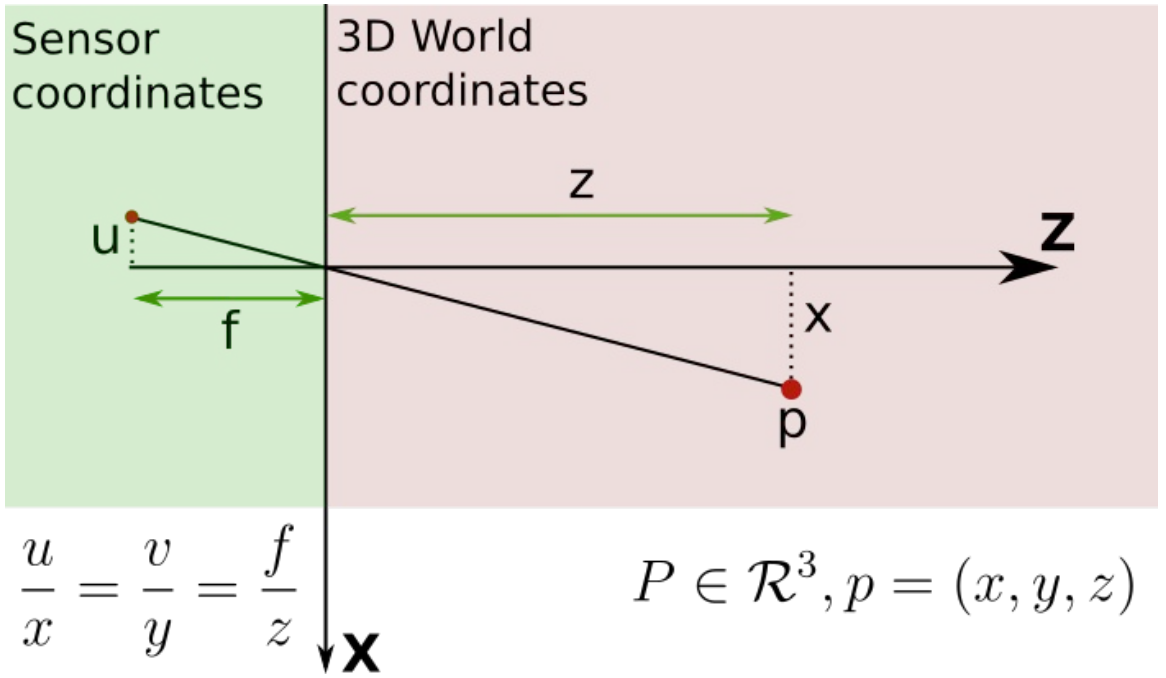


$$\frac{u}{x} = \frac{v}{y} = \frac{f}{z}$$

$$P \in \mathcal{R}^3, p = (x, y, z)$$

- Computational camera model: Pinhole Camera

Camera Geometry



$$\frac{u}{x} = \frac{v}{y} = \frac{f}{z}$$

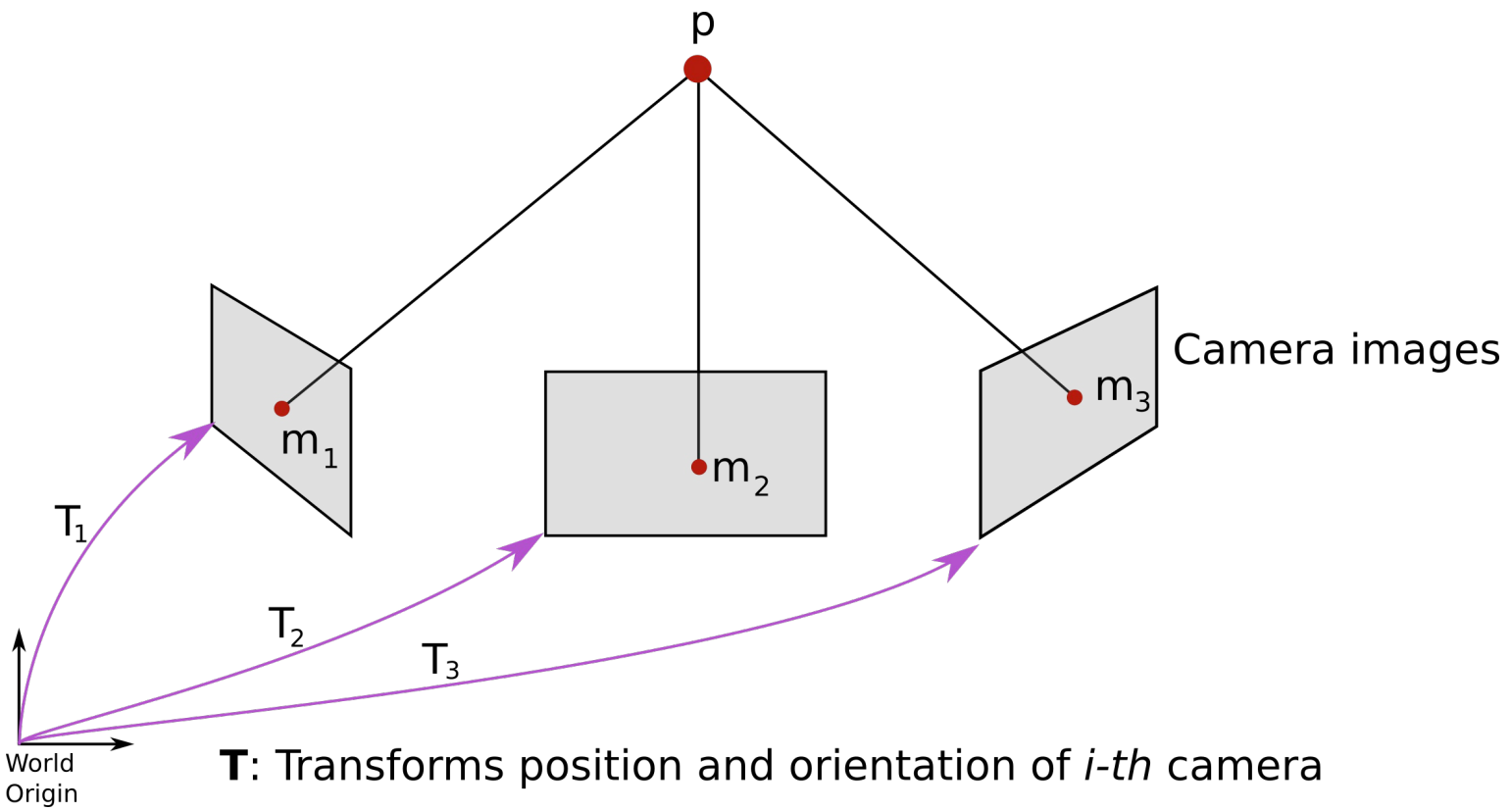
$$P \in \mathcal{R}^3, p = (x, y, z)$$

$$\underbrace{\begin{pmatrix} u \\ v \\ s \end{pmatrix}}_{m} = \begin{pmatrix} fx \\ fy \\ z \end{pmatrix} = \underbrace{\begin{pmatrix} f & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}}_{K} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

$$m = Kp$$

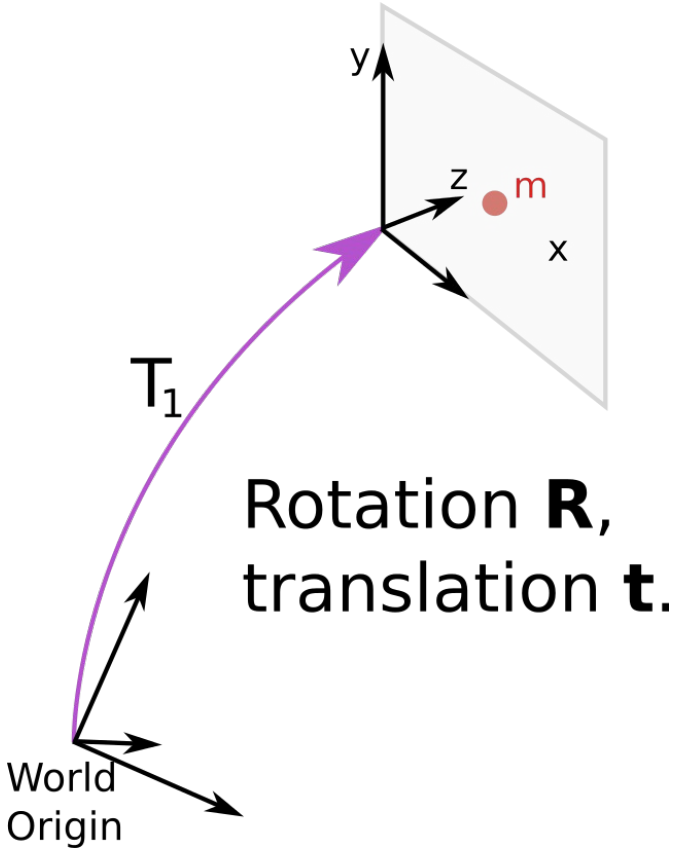
- Summary: linear computation of u and v.

Triangulation



- Move the camera around and photograph the point p.

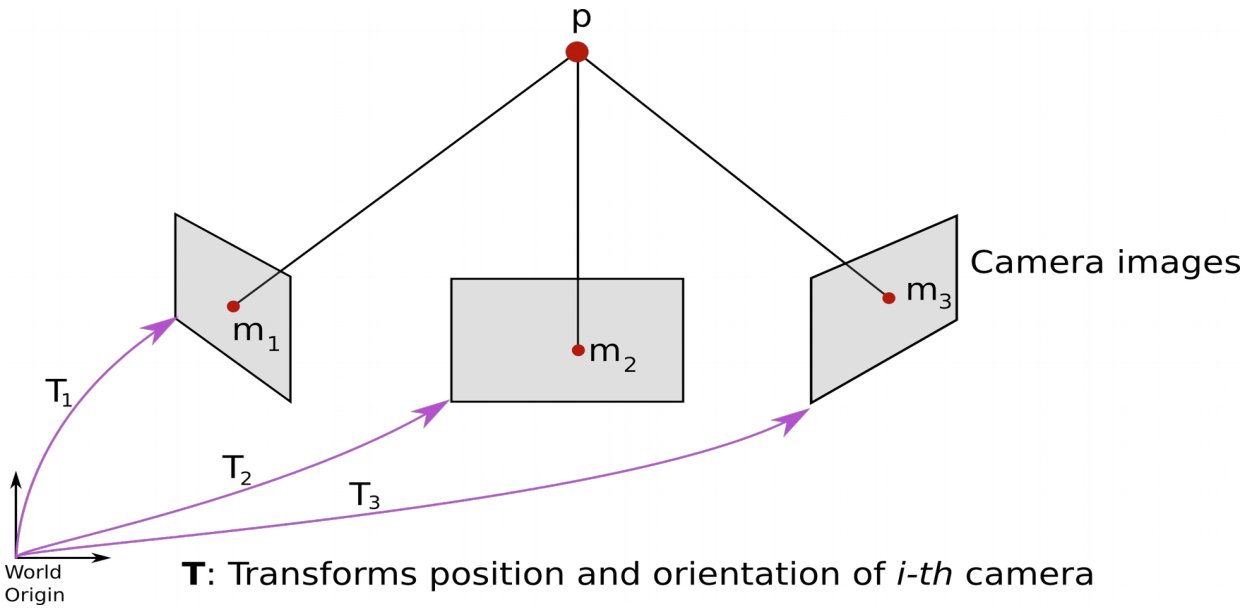
Transformation



$$m_1 = Kp^c = KT_1p$$

- Rotation **R**: 3 unknown rotation angles,
- Translation **t**: 3 unknowns

Triangulation



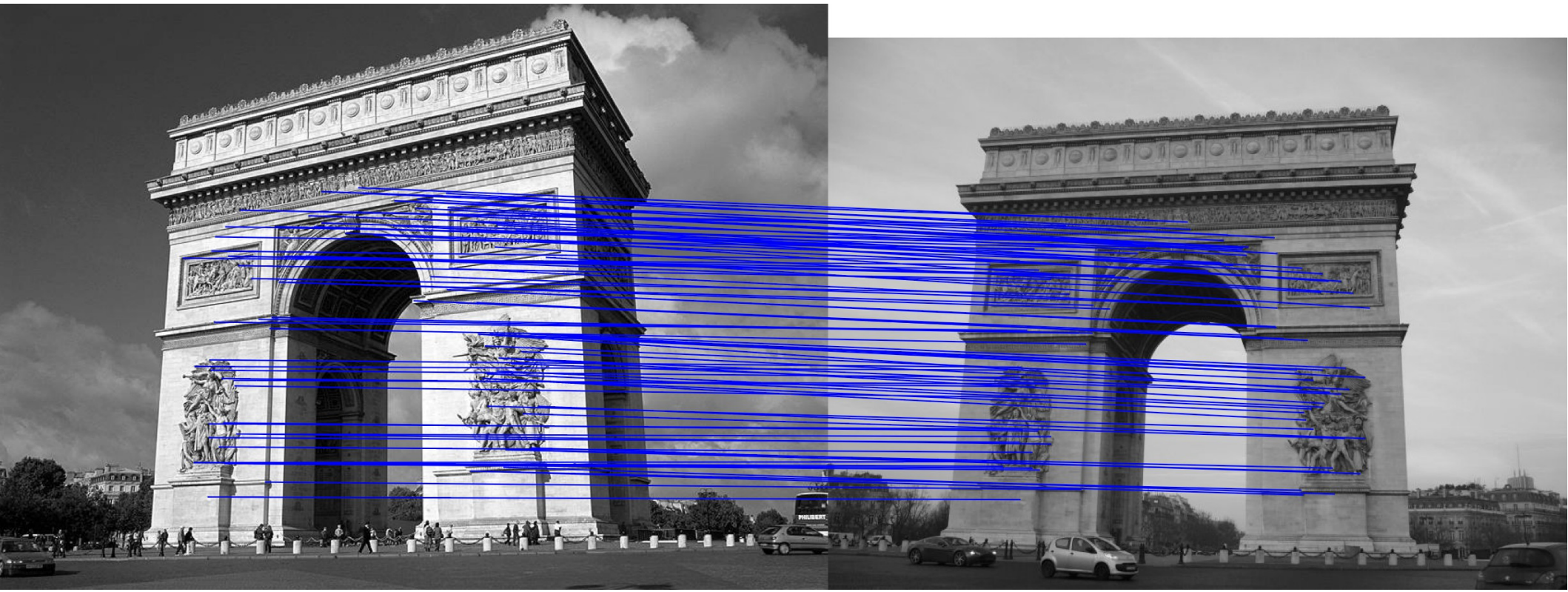
Goal:

- Estimate **p**: (x,y,z), 3 unknowns,
- Estimate **R** for each camera (3x3) 9 unknowns
- Estimate **t** for each camera (3x3) 9 unknowns
- **In total**: 21 unknown variables.

What to do?

What to do?

1. Find the same **m**~points in all images:



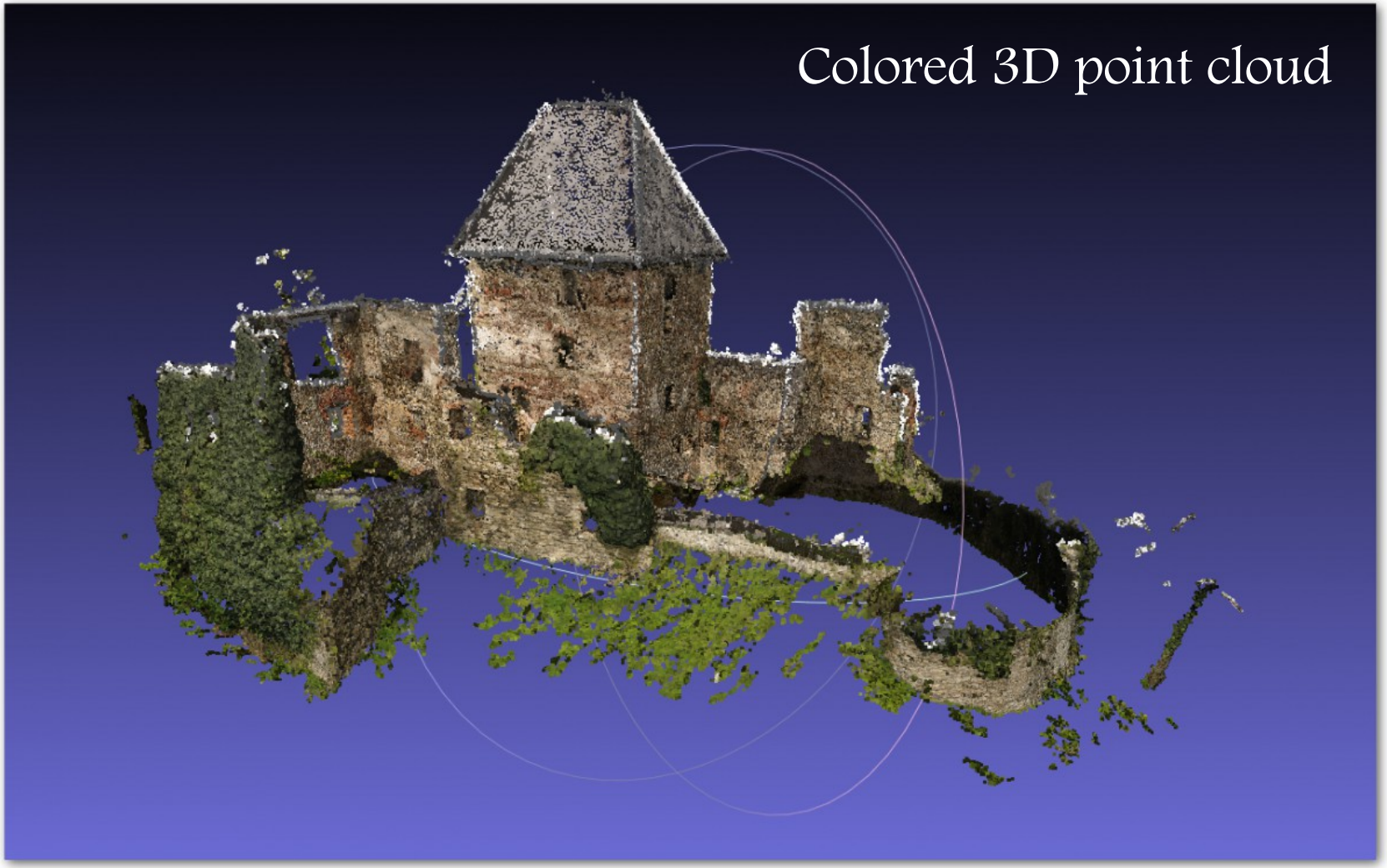
What to do?

2. Build a system of equations:

$$m_1 = KT_1p$$
$$m_2 = KT_2p$$
$$m_3 = KT_3p$$

$$\min_{p,T_i} \sum_{i}^{3} \| m_i - KT_ip \|_2^2$$

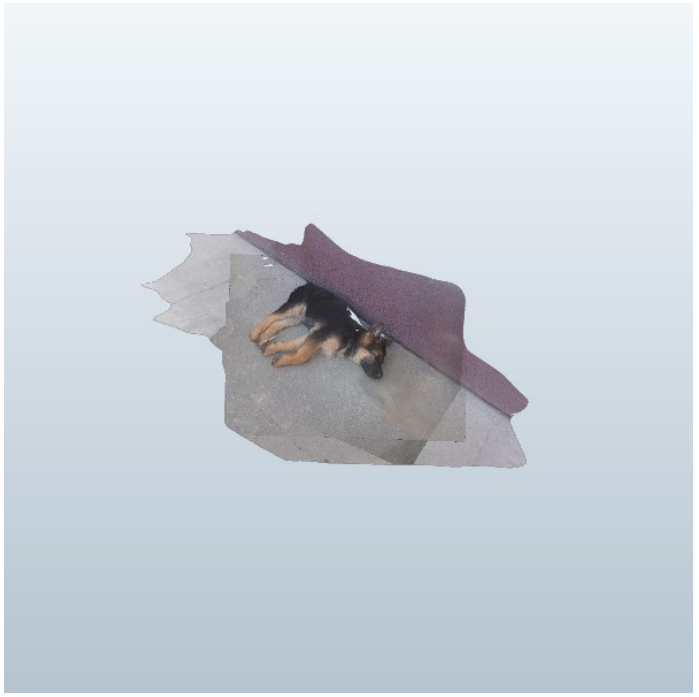
Visual SFM



- Open Source, for non-commercial use

123Catch





- Fully automated: 1. Upload images, 2. Download mesh.

PhotoScan ~ Acute3D

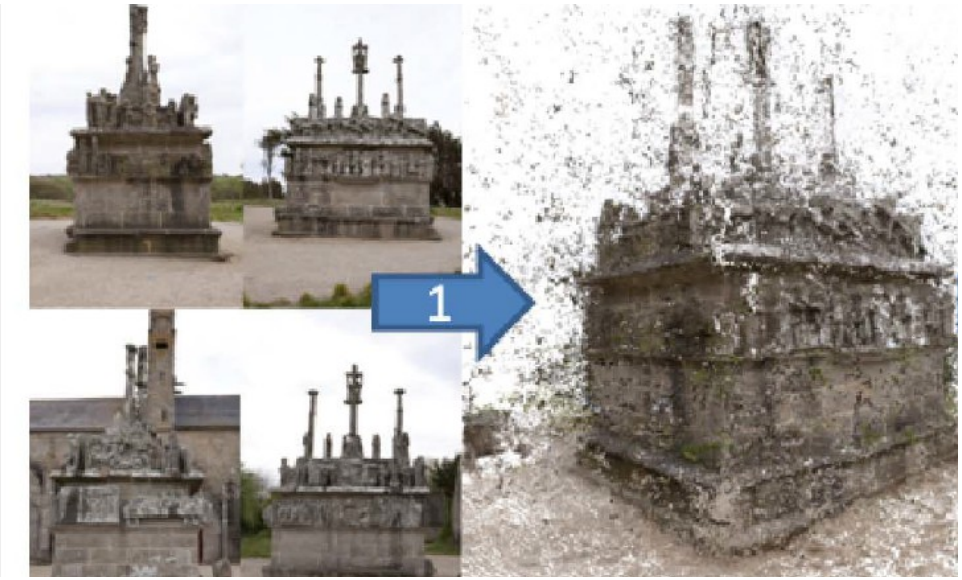
- Photoscan most advanced software out there (3.5K€)
- Smart3DCapture was acquired by Bentley 2/2015.

Large Scale 3D Mapping?

Video1

Large Scale 3D Mapping?

- No out-of-the box software available.
- Challenges:
  - Accuracy: very critical



Large Scale 3D Mapping?

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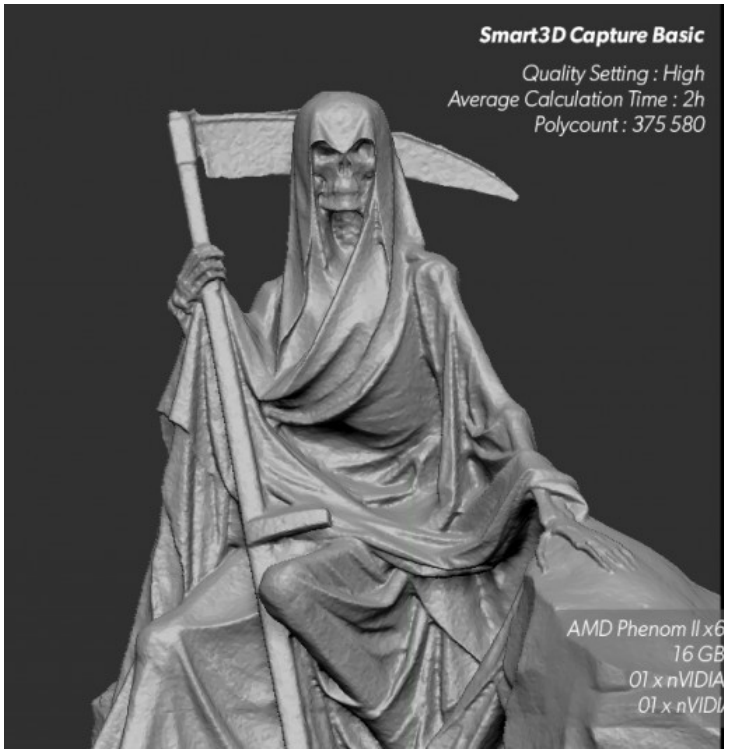
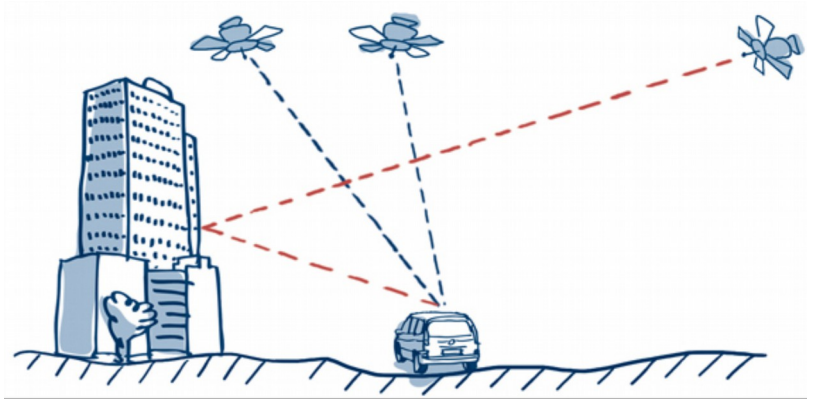
  - Huge datasets (processing, visualization)

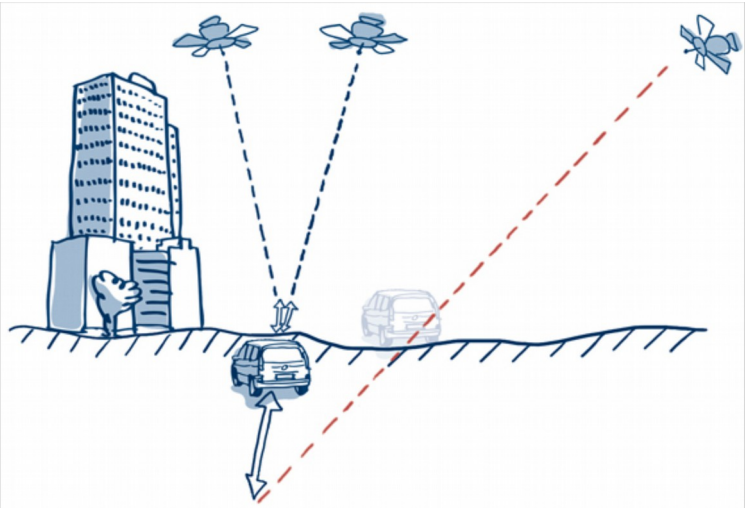


2h processing time

Large Scale 3D Mapping?

- No out-of-the box software available.
- Challenges:
  - Accuracy – very critical
  - Huge datasets (processing, visualization)
  - Localization





GPS very unreliable

More Questions

- Who works with accurate GIS data such as lanes, locations of thrash bins, etc.. ?
- What is this data worth?
- Can the technology be used for (semi-autonomous) bikes or wheel chairs?

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Thats it. Thank you!