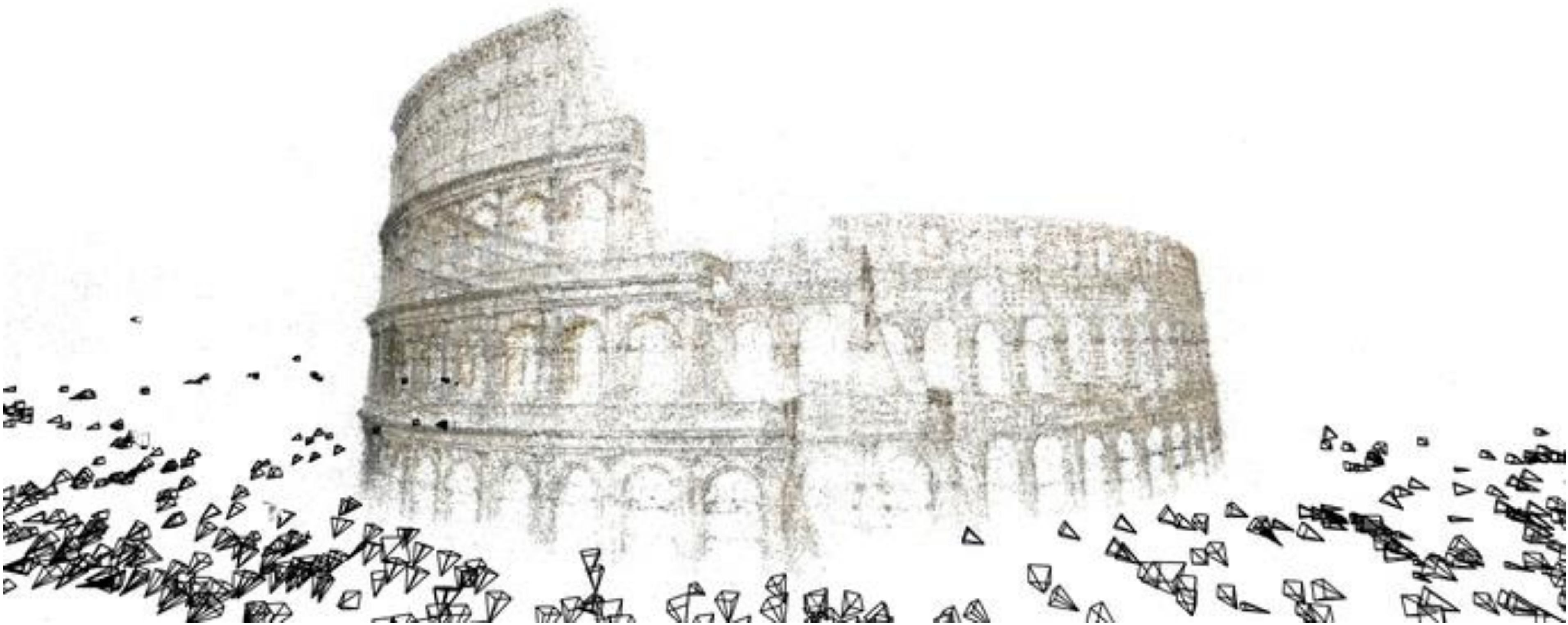
Structure from Motion



Frank Dellaert, Fall 2011

Building Rome in a Day
Agarwal et al

Outline

- Motivation/Visualization
- Feature Extraction
- Matching
- Optimization

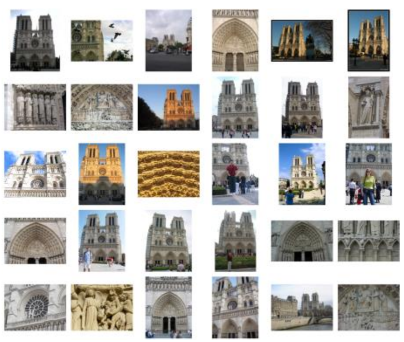
Motivation

- Photo Tourism
- Photosynth
- Multi-view stereo
- Building Rome in a Day
- Rome on a Cloudless Day

See also CVPR 2010 Short Course:
Scene Reconstruction from Community Photo Collections

Photo Tourism

Noah Snavely, Steven M. Seitz, Richard Szeliski, [Photo tourism: Exploring photo collections in 3D," ACM Transactions on Graphics (SIGGRAPH Proceedings), 25(3), 2006, 835-846.]



Input photographs

Scene reconstruction

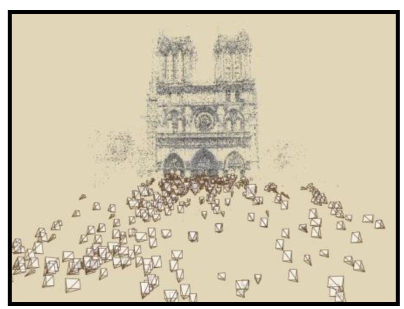
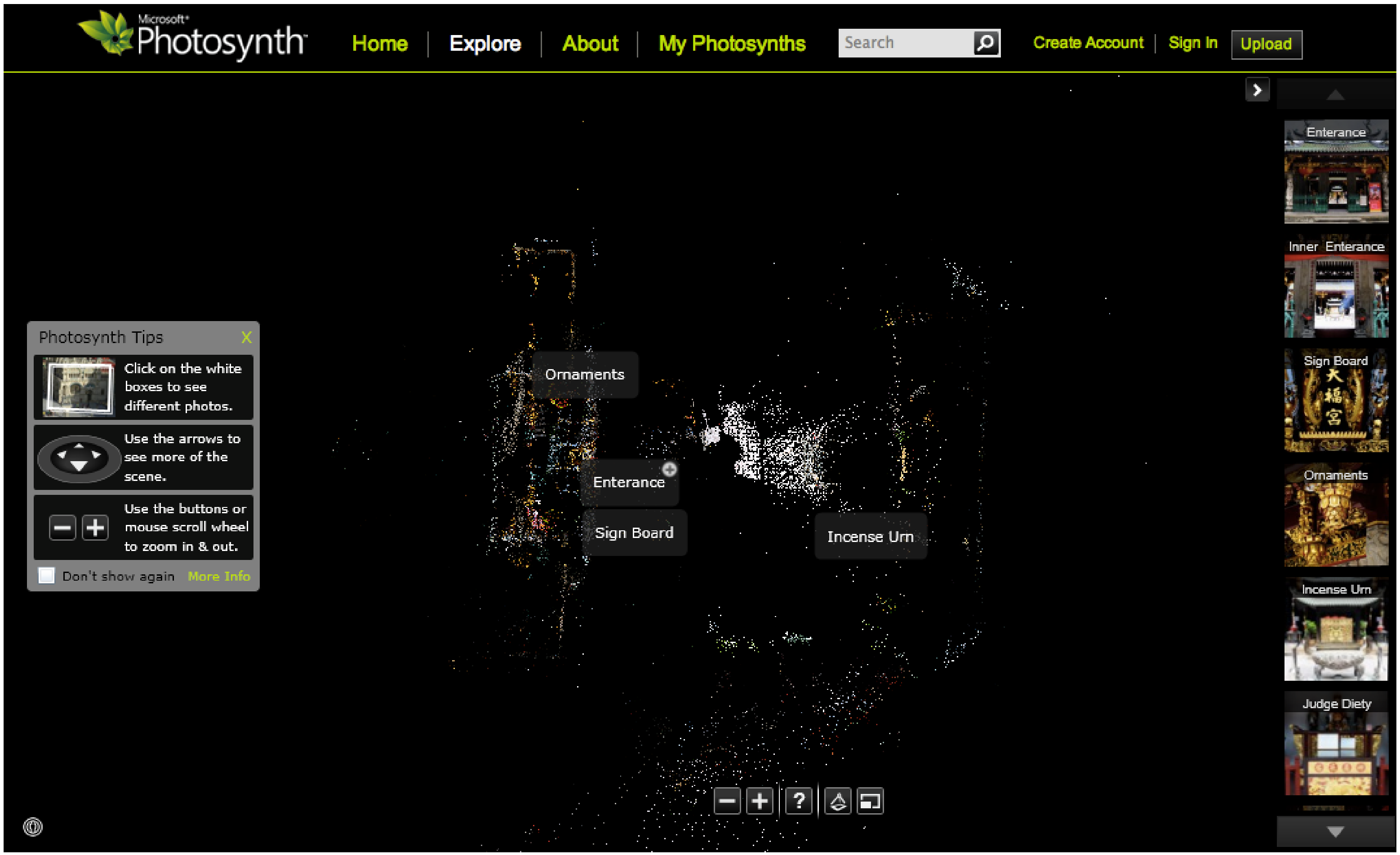


Photo Explorer

http://phototour.cs.washington.edu/

Photosynth

photosynth.net

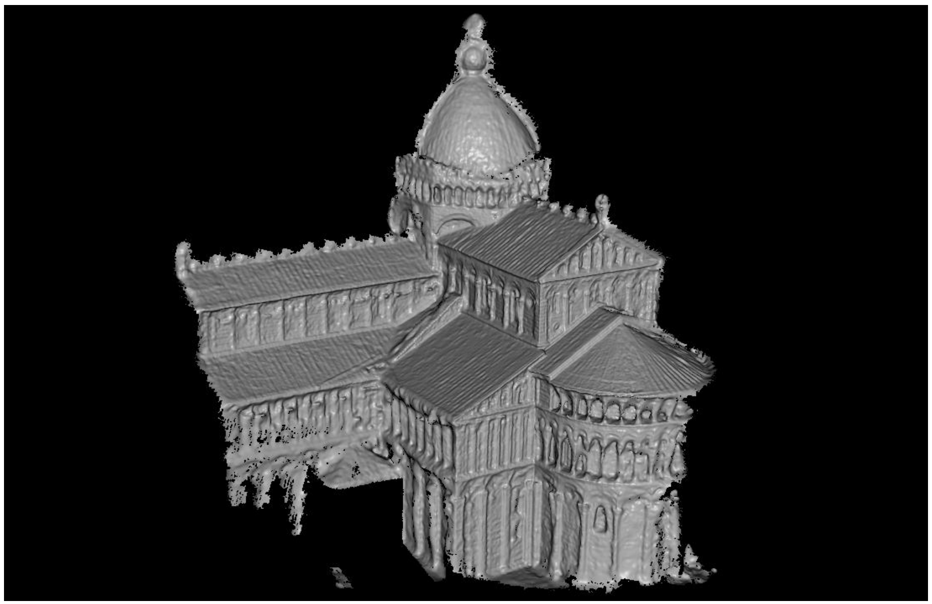


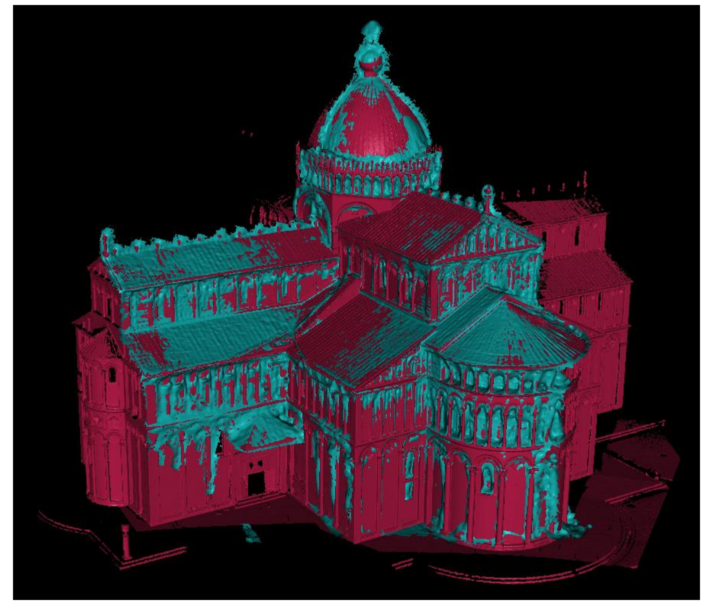
- http://photosynth.net/view.aspx?cid=29aa8616-a43a-43e4-9d6e-b8ad9b50483e

Multi-view Stereo

Multi-View Stereo for Community Photo Collections
Michael Goesele, Noah Snavely, Brian Curless, Hugues Hoppe, and Steven M. Seitz
ICCV 2007

Multi-view Stereo

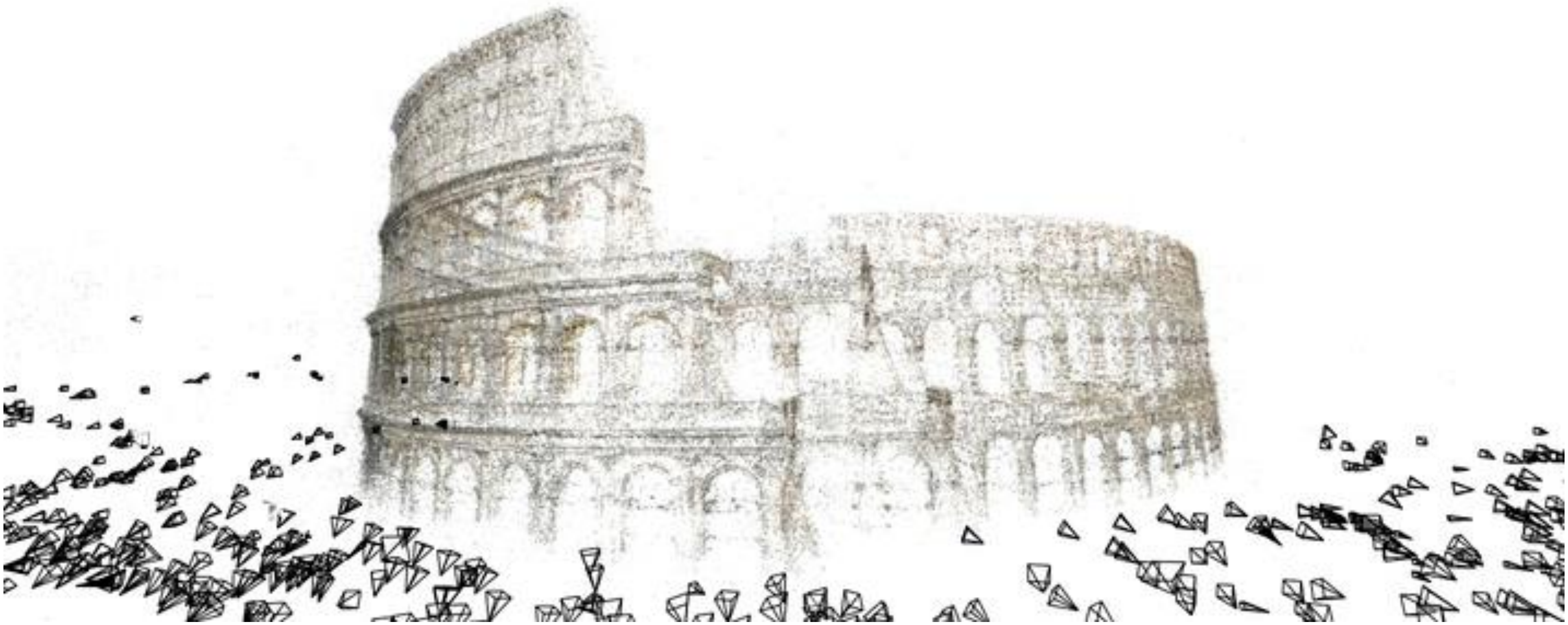




Compared with Laser-Scanner

Building Rome in a Day

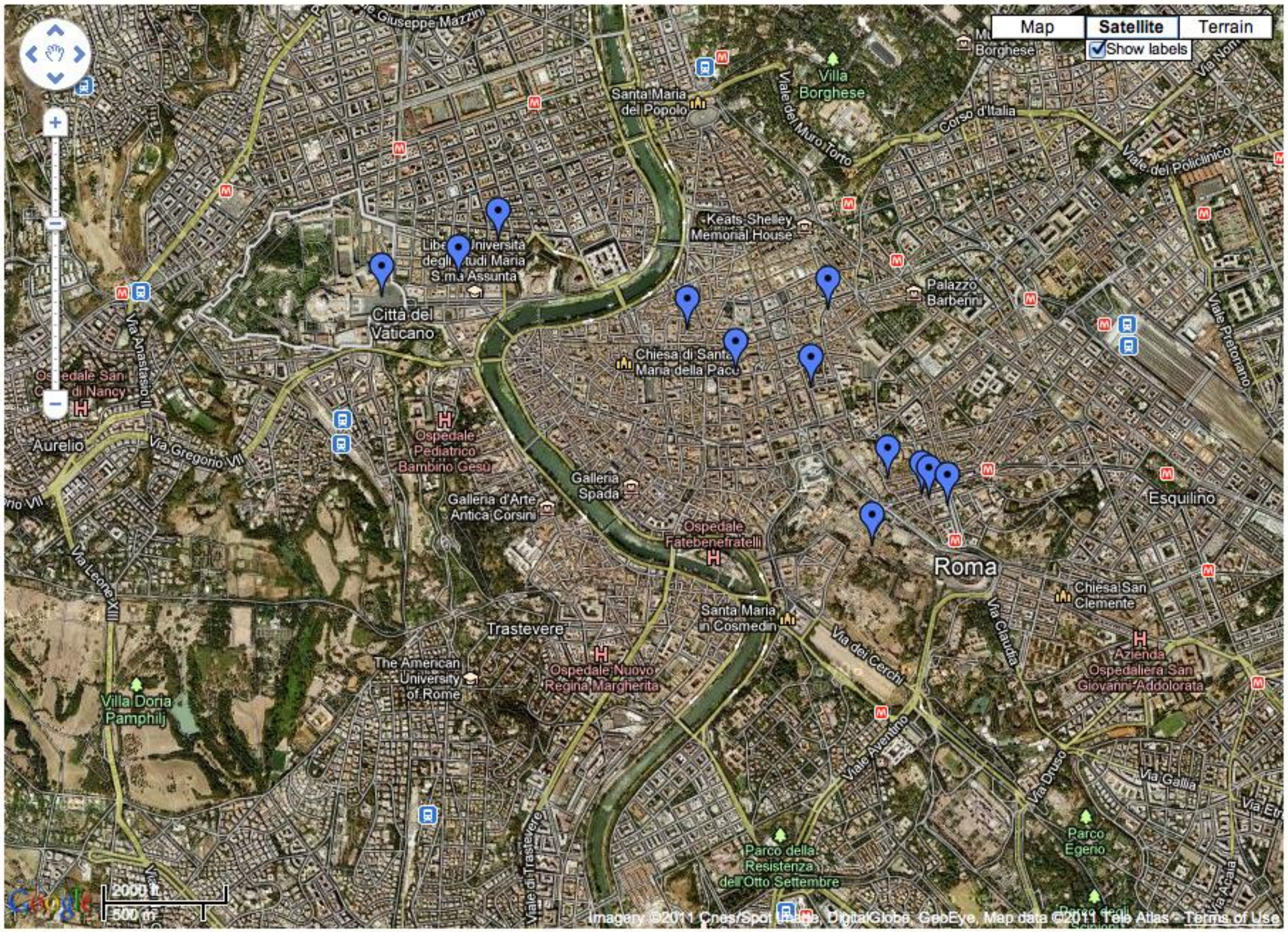
Building Rome in a Day Sameer Agarwal, Noah Snavely, Ian Simon, Steven M. Seitz and Richard Szeliski International Conference on Computer Vision, 2009, Kyoto, Japan.



http://grail.cs.washington.edu/rome/

Rome on a Cloudless Day

Jan-Michael Frahm, Pierre Georgel, David Gallup, Tim Johnson, Rahul Raguram, Changchang Wu, Yi-Hung Jen, Enrique Dunn, Brian Clipp, Svetlana Lazebnik, Marc Pollefeys, *ECCV 2010*



http://www.cs.unc.edu/~jmf/rome_on_a_cloudless_day/

Outline

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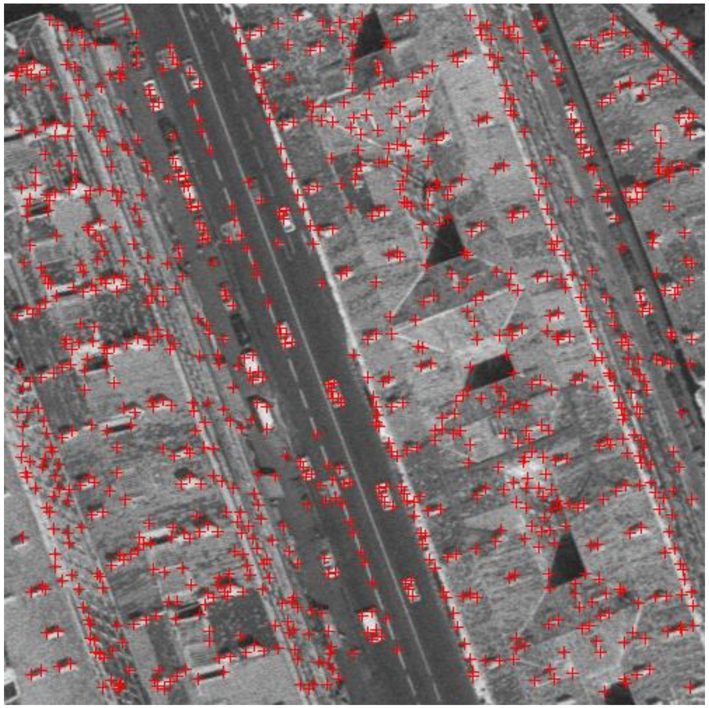
Interest points



Geometric features

➡ repeatable under transformations

➡ 2D characteristics of the signal

high informational content

Comparison of different detectors [Schmid98] ➡ Harris detector

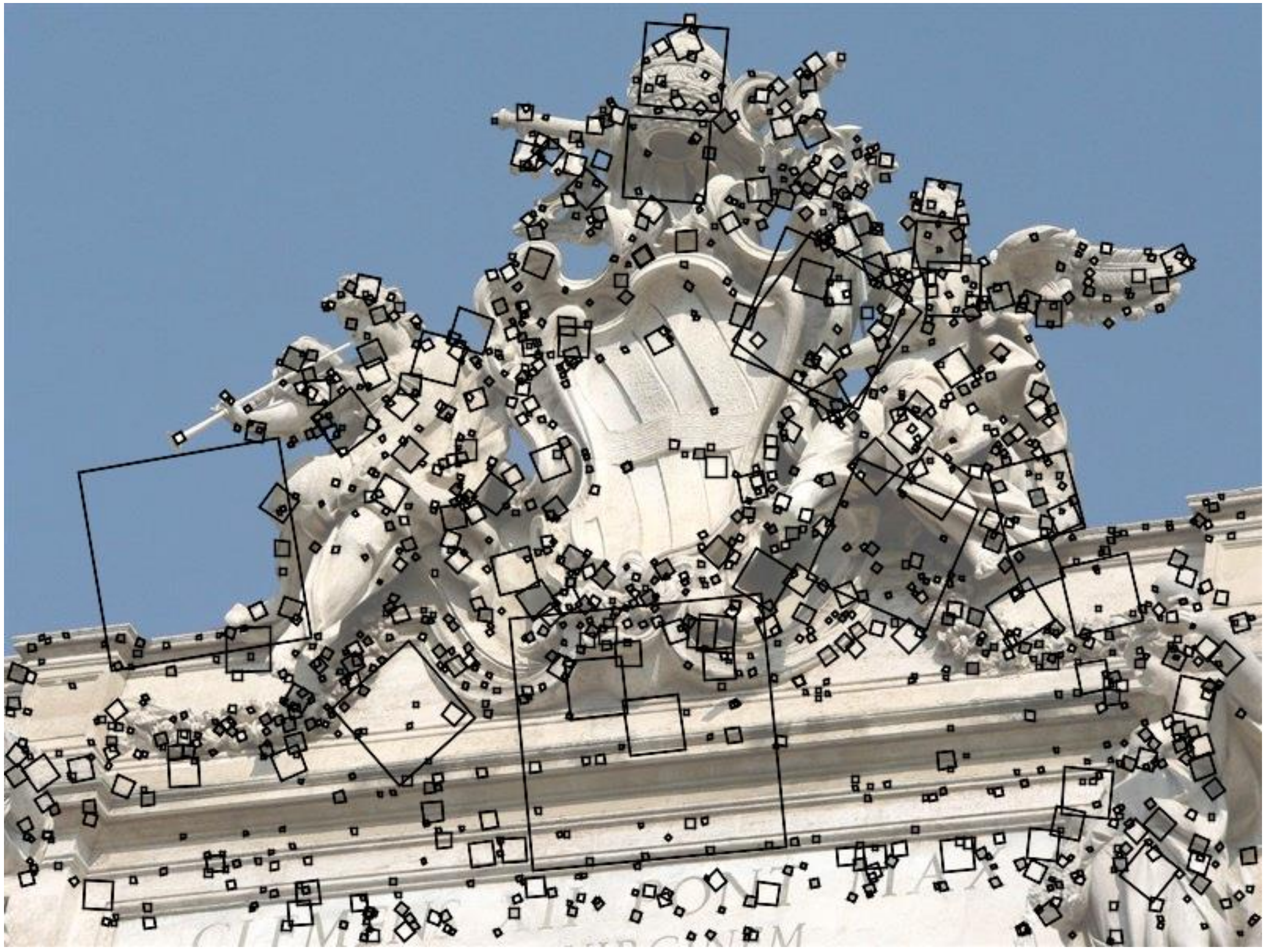
Harris detector

Based on the idea of auto-correlation

Important difference in all directions => interest point

Feature detection

Detect features using SIFT [Lowe, IJCV 2004]



Outline

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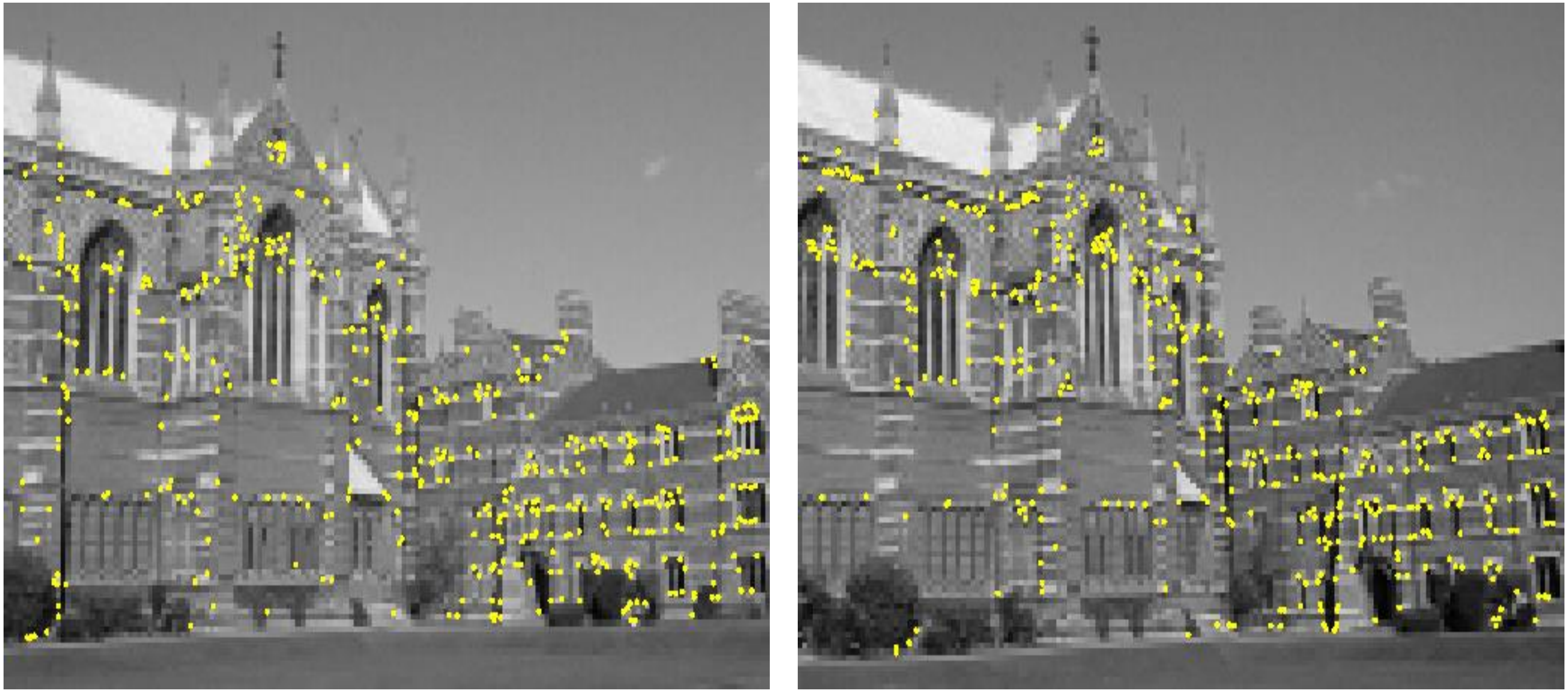
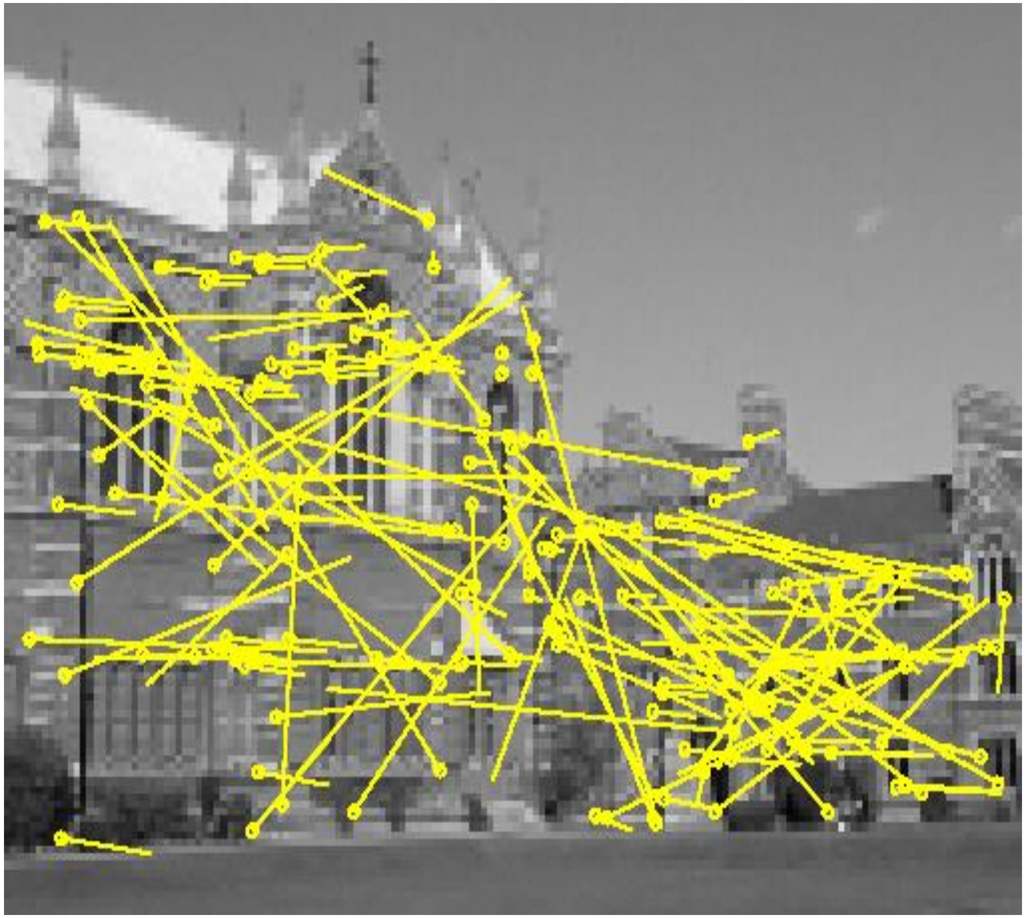
Feature Matching !



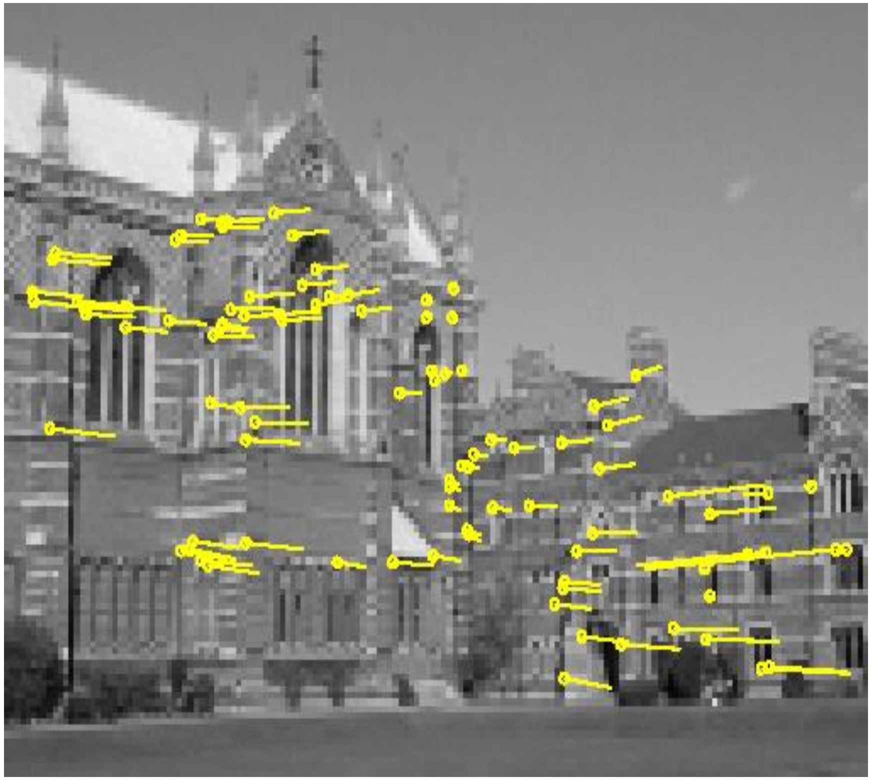
Cross-correlation matching



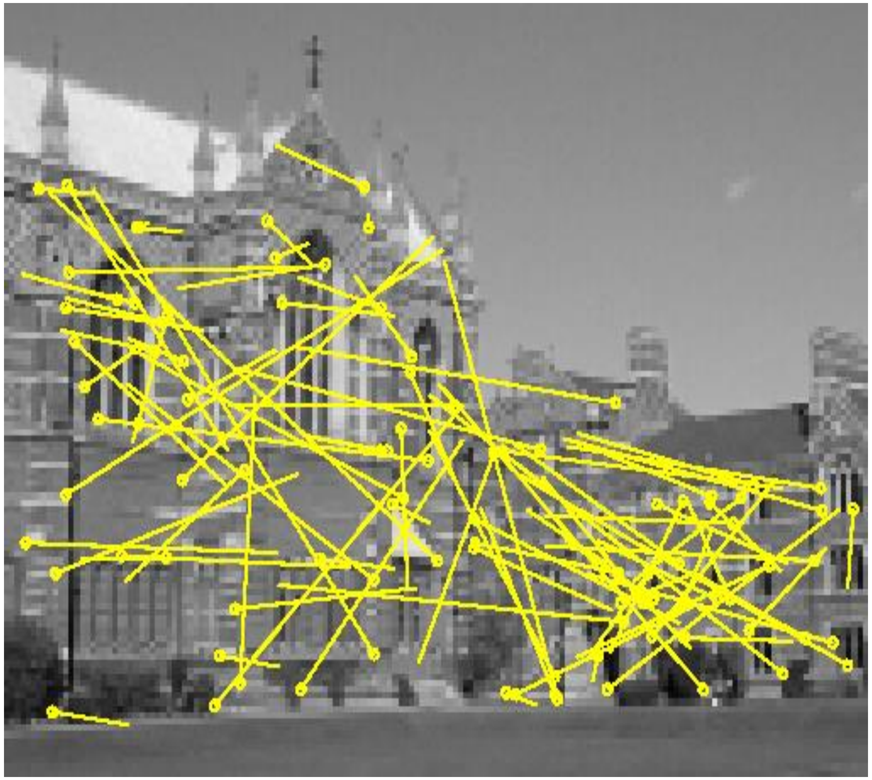
Initial matches (188 pairs)

Global constraints

Robust estimation of the fundamental matrix



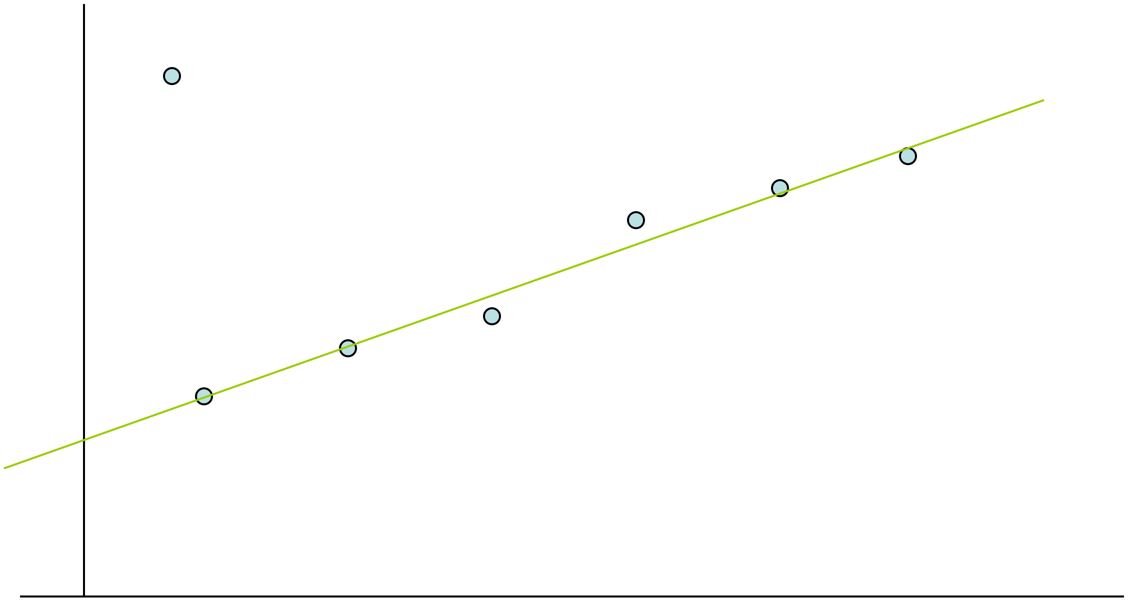
99 inliers



89
outliers

Simpler Example

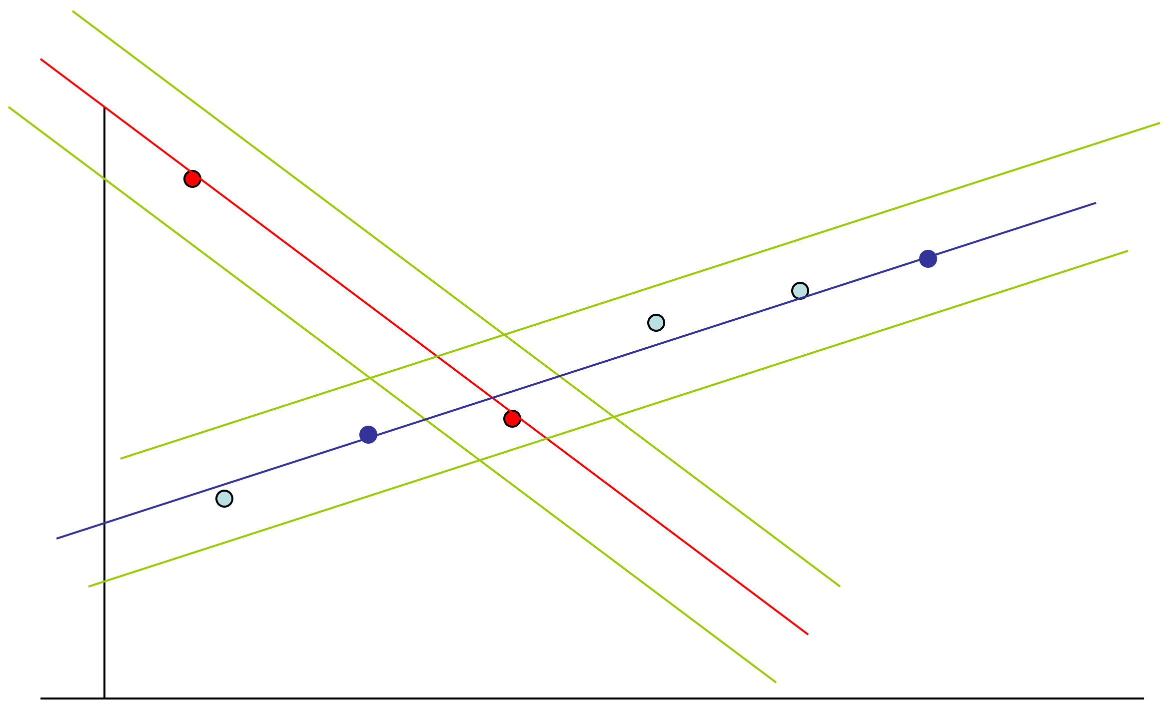
- Fitting a straight line



RANSAC

- Select 2 points at random
- Fit a line
- “Support” = number of inliers
- Line with most inliers wins

Why will this work ?



Outline

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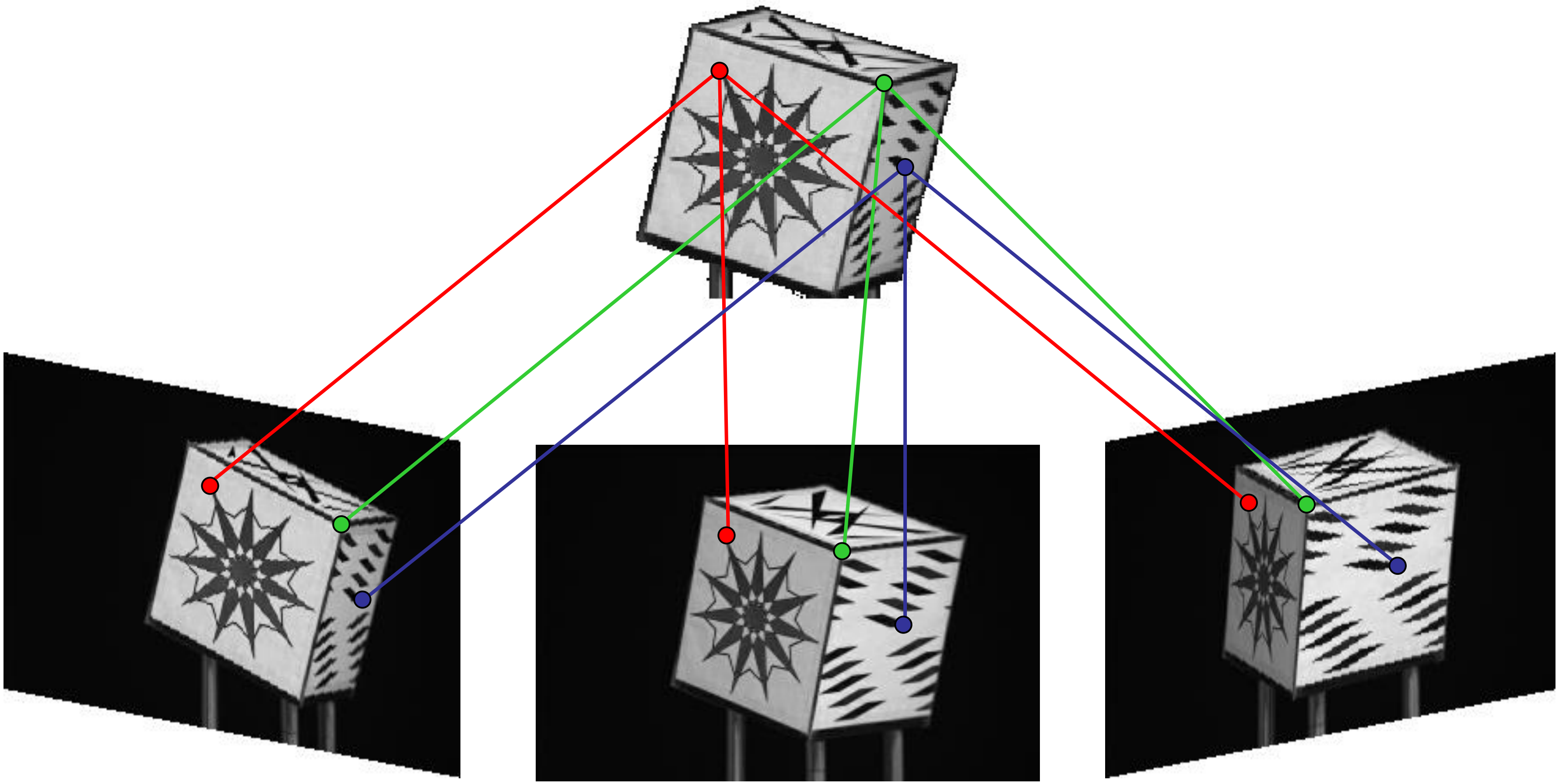
2 Problems !

Correspondence

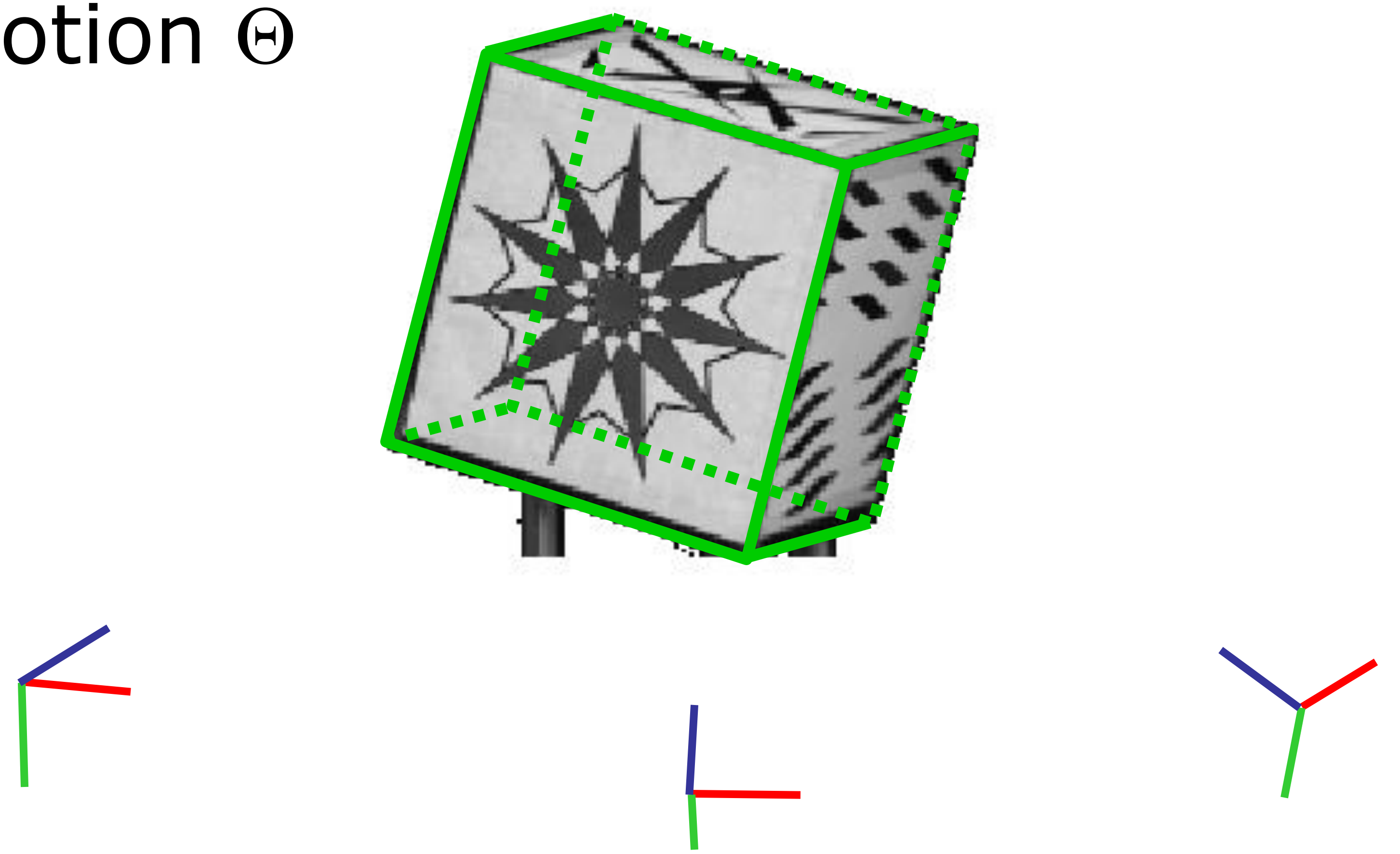
Optimization

A Correspondence Problem



An Optimization Problem

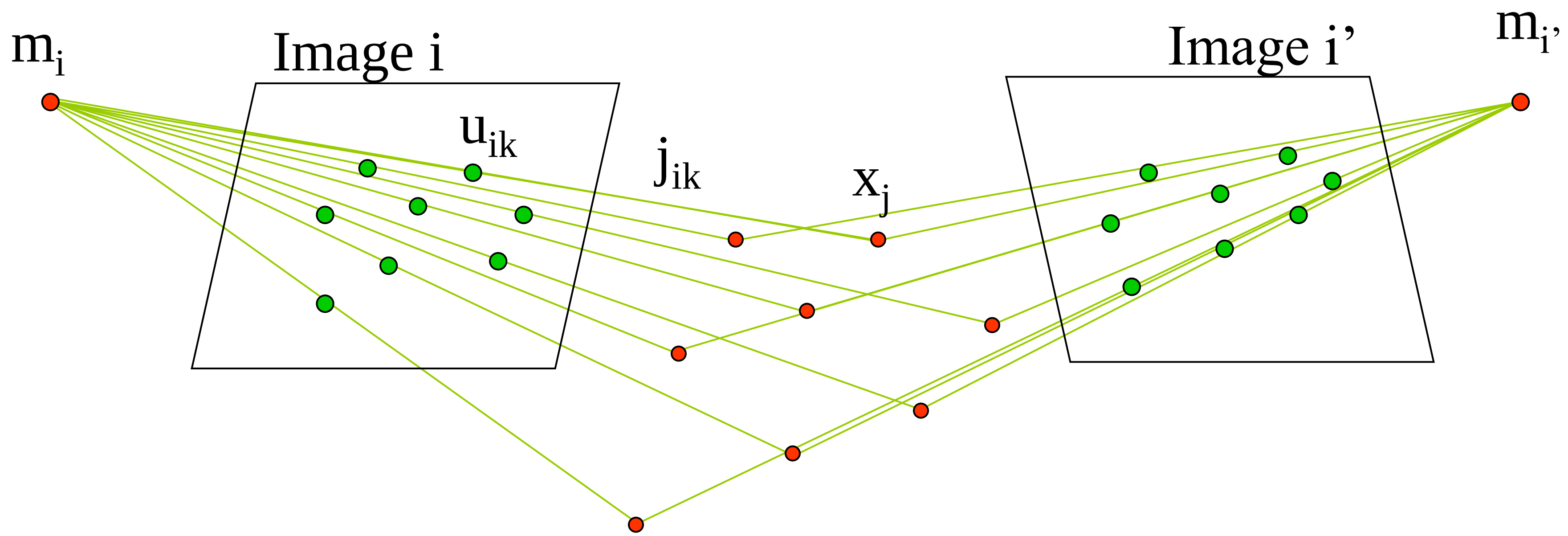
- Find the most likely structure and motion Θ



Optimization

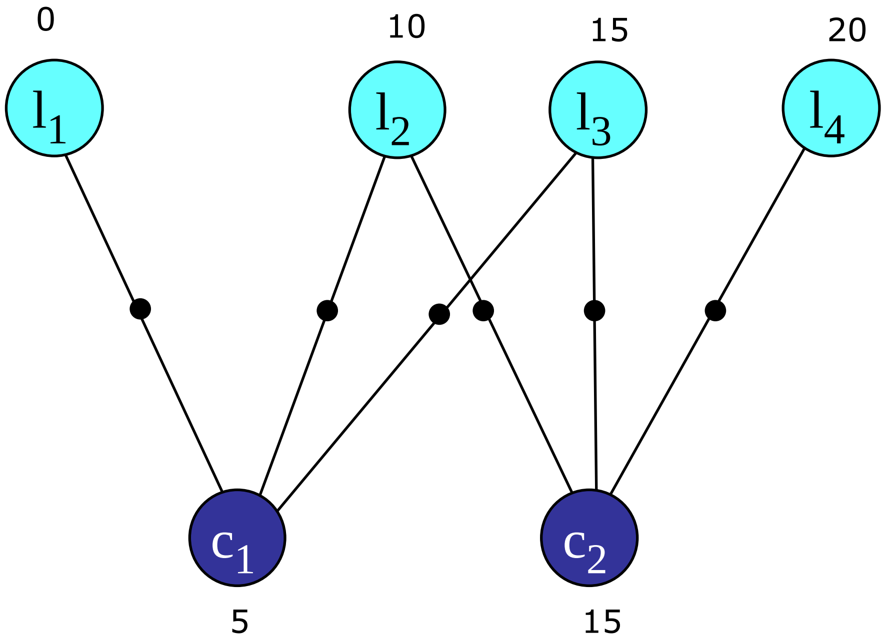
=Non-linear Least-Squares !

$$\sum_{i=1}^{m} \sum_{k=1}^{K_i} \|\mathbf{u}_{ik} - \mathbf{h}(\mathbf{m}_i, \mathbf{x}_{\mathbf{j}_{ik}})\|^2$$



Very simple example

- 1-dimensional



u=l-c

X=[c1 c2 l1 l2 l3 l4]’

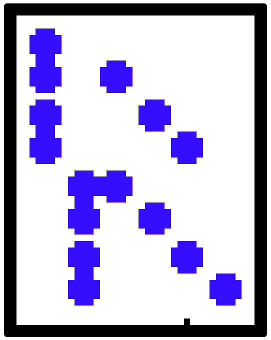
Sparse Jacobian

A =

1	0	0	0	0	0
-1	0	1	0	0	0
-1	0	0	1	0	0
-1	0	0	0	1	0
0	-1	1	0	0	0
0	-1	0	1	0	0
0	-1	0	0	1	0
0	-1	0	0	0	1

b =

5
-5
5
10
-15
-5
0
5



A'*A = inv(Sigma)

4	0	-1	-1	-1	0
0	4	-1	-1	-1	-1
-1	-1	2	0	0	0
-1	-1	0	2	0	0
-1	-1	0	0	2	0
0	-1	0	0	0	1

(A'*A)\A'*b =

5.0000
15.0000
0.0000
10.0000
15.0000
20.0000