Agents with Attitudes

Kurt Konolige, SRI International

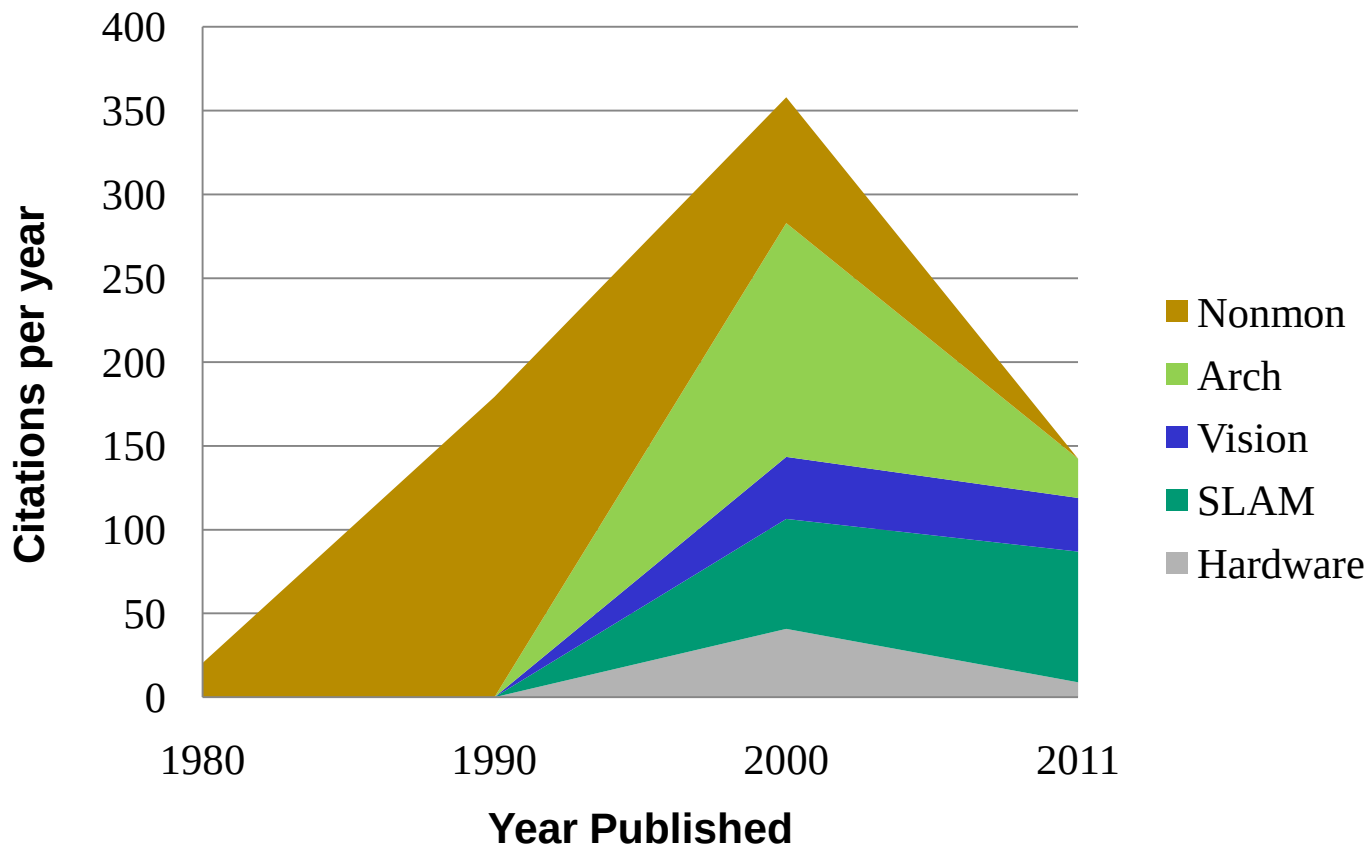
AAAI 9 (1991) Anaheim, CA

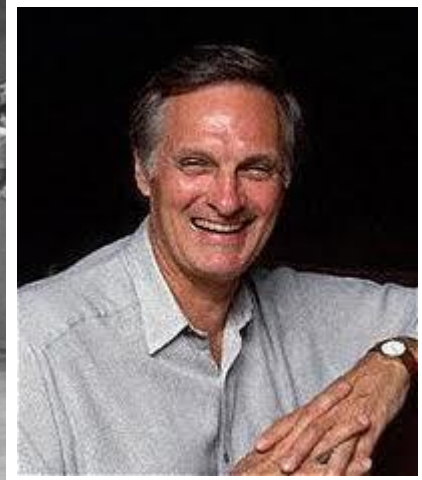
Speaker's beliefs as a consequence of the speech act:

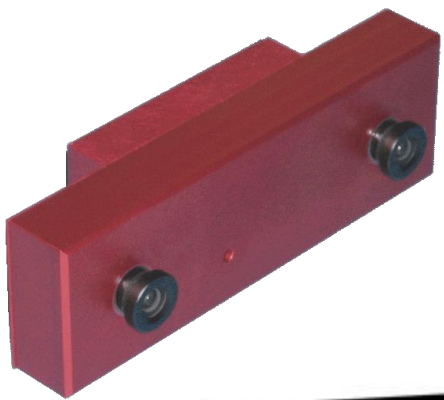
$$\text{in } A_1: \quad [u]\phi \wedge \neg L_0 \neg [s_f]\phi \supset [s_f]\phi \qquad (12)$$

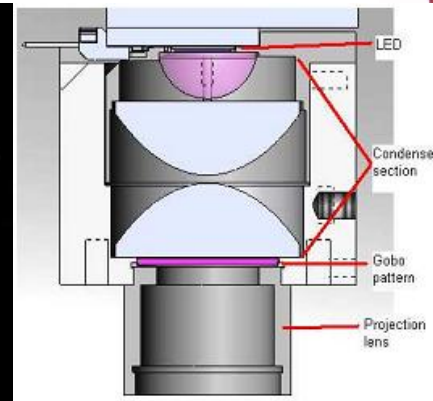
Hearer's beliefs as a consequence of the speech act:

$$\begin{aligned} &\text{in } A_1: \\ &\quad ([u]\phi \wedge \\ &\quad \neg L_0 \neg [h_f]\phi \wedge \neg L_0 [h_f] \neg [s_f]\phi \wedge \\ &\quad \neg L_0 [h_f] \neg \{s_i\}[h_f]\phi) \supset [h_f]\phi \end{aligned} \qquad (13)$$


400
350
300
250
200
150
100
50
0
Citations per year
1980
1990
2000
2011
Year Published
Nonmon
Arch
Vision
SLAM
Hardware



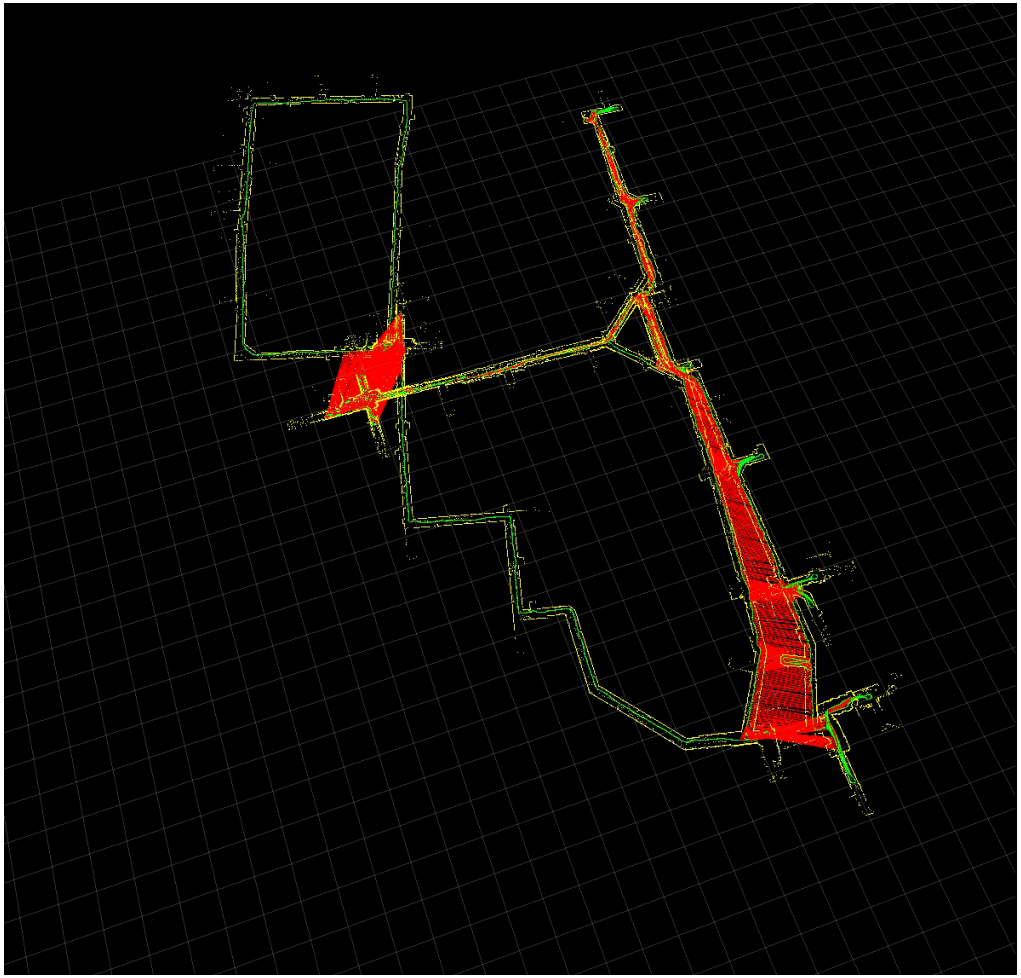


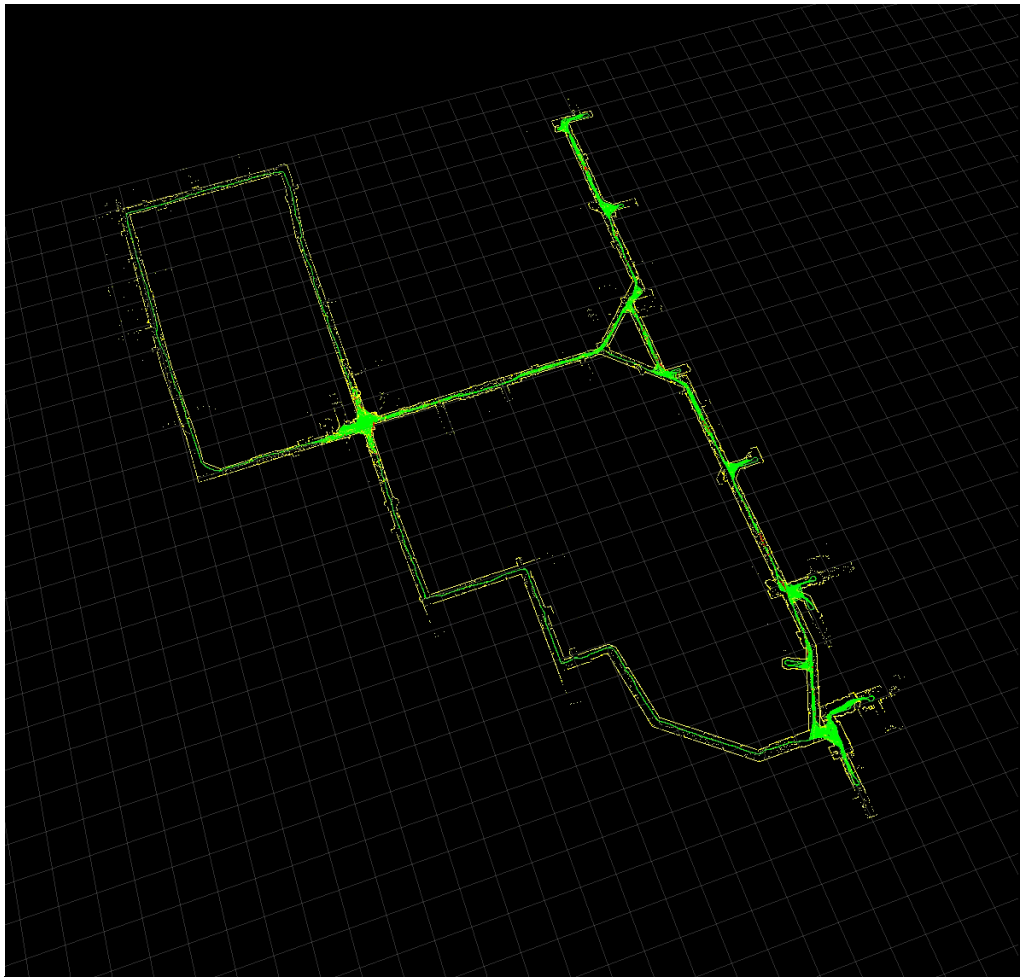

LED
Condenser section
Gobo pattern
Projection lens


SOFTWARE FOR ROBOTS ON THE MOVE
KARTO SDK 2.1
GPS Anchoring – Custom Items
TiledOccupancyGrid
KARTO

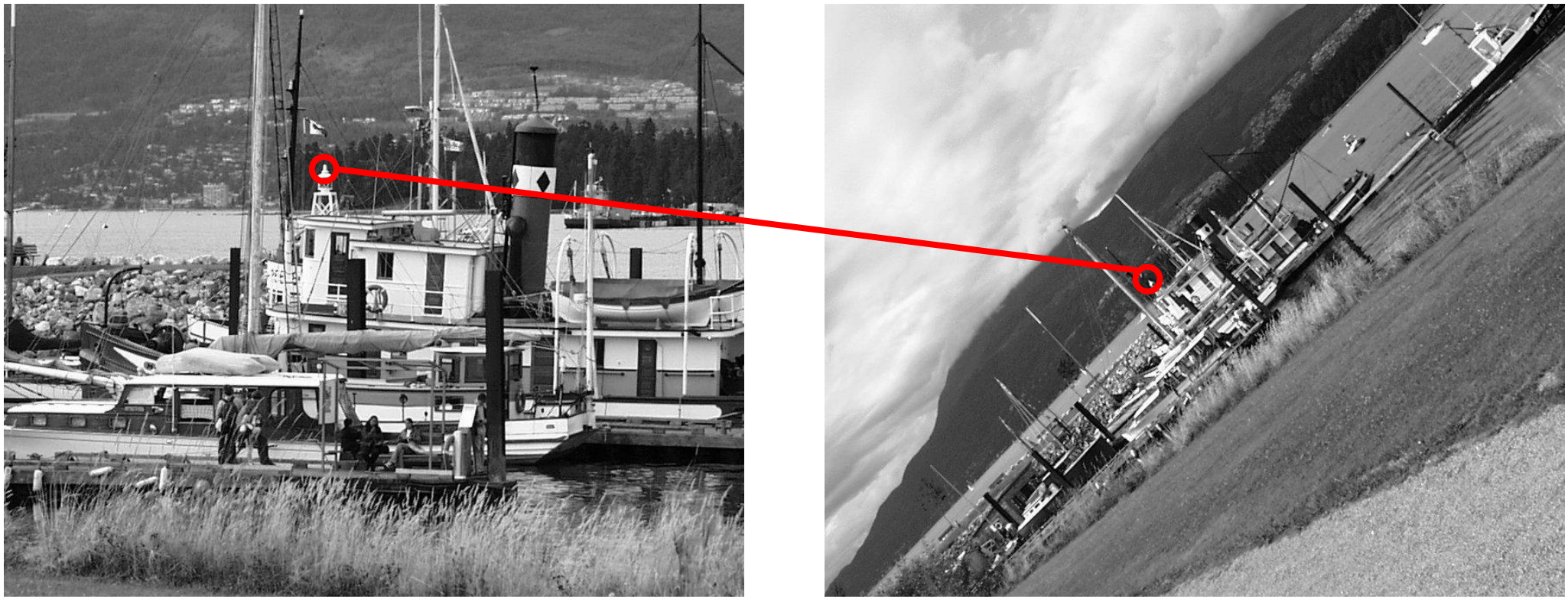
Registration for Robotics

Kurt Konolige
Willow Garage, Stanford CS

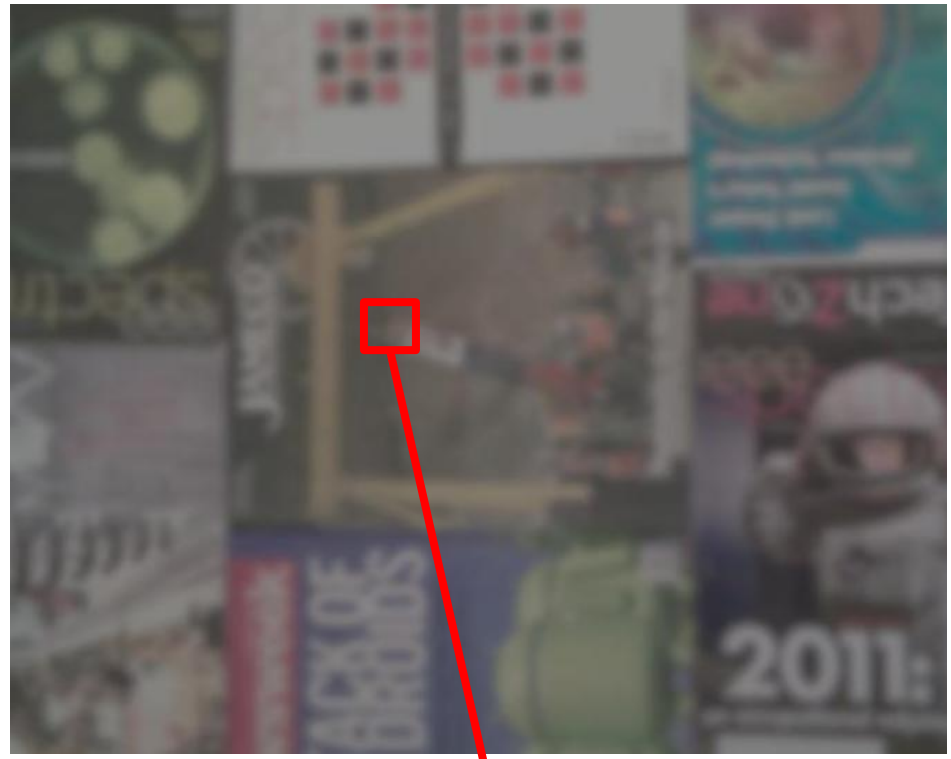


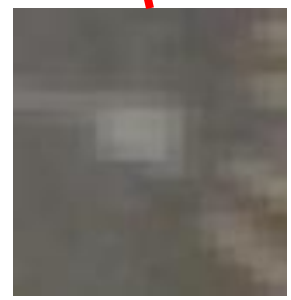


Visual Features



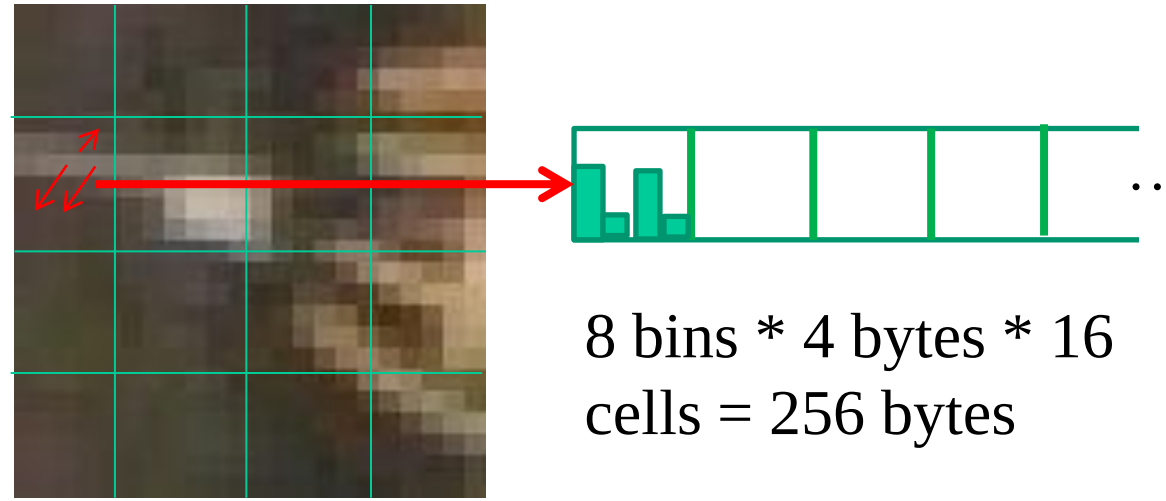

spectrum
Newsweek
ATTACK OF THE DROIDS
JAMECO
spectrum
TOP 11 TECHNOLOGIES OF THE DECADE
IEEE
2011:
TechZone
Look Deeper Into Today's Wireless Technology
Simplify the Design of an RF Remote Control
Considerations for Your Wireless Designs


2011:



2D Features - Descriptors

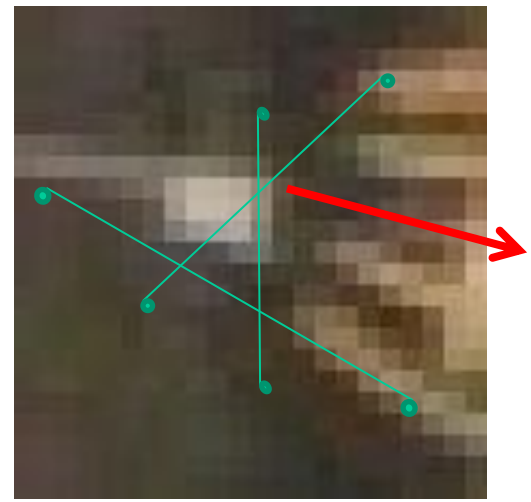
Histogram of Gradients
- SIFT [Lowe 1999]
- SURF [Bay et al. 2006]



8 bins * 4 bytes * 16 cells = 256 bytes

BRIEF Feature [Calonder et al. 2010]

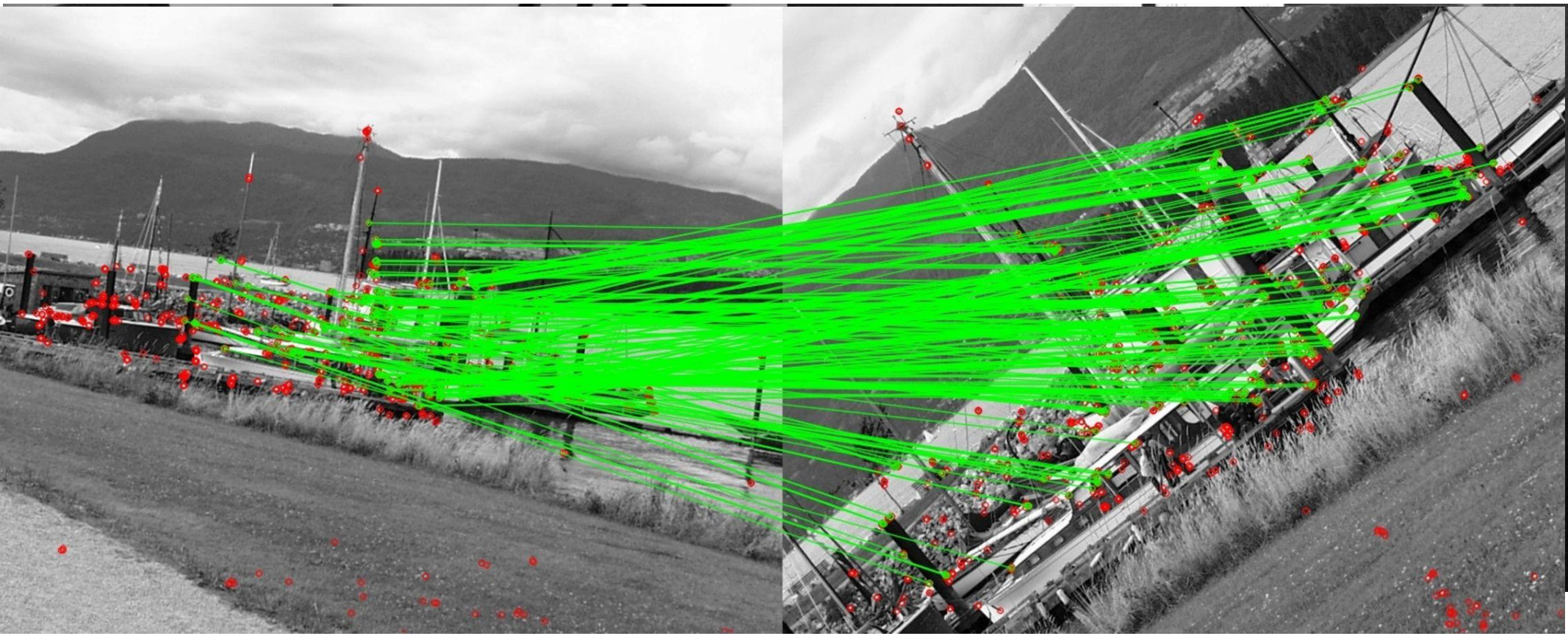
ORB Feature [Rublee et al. ICCV 2011]

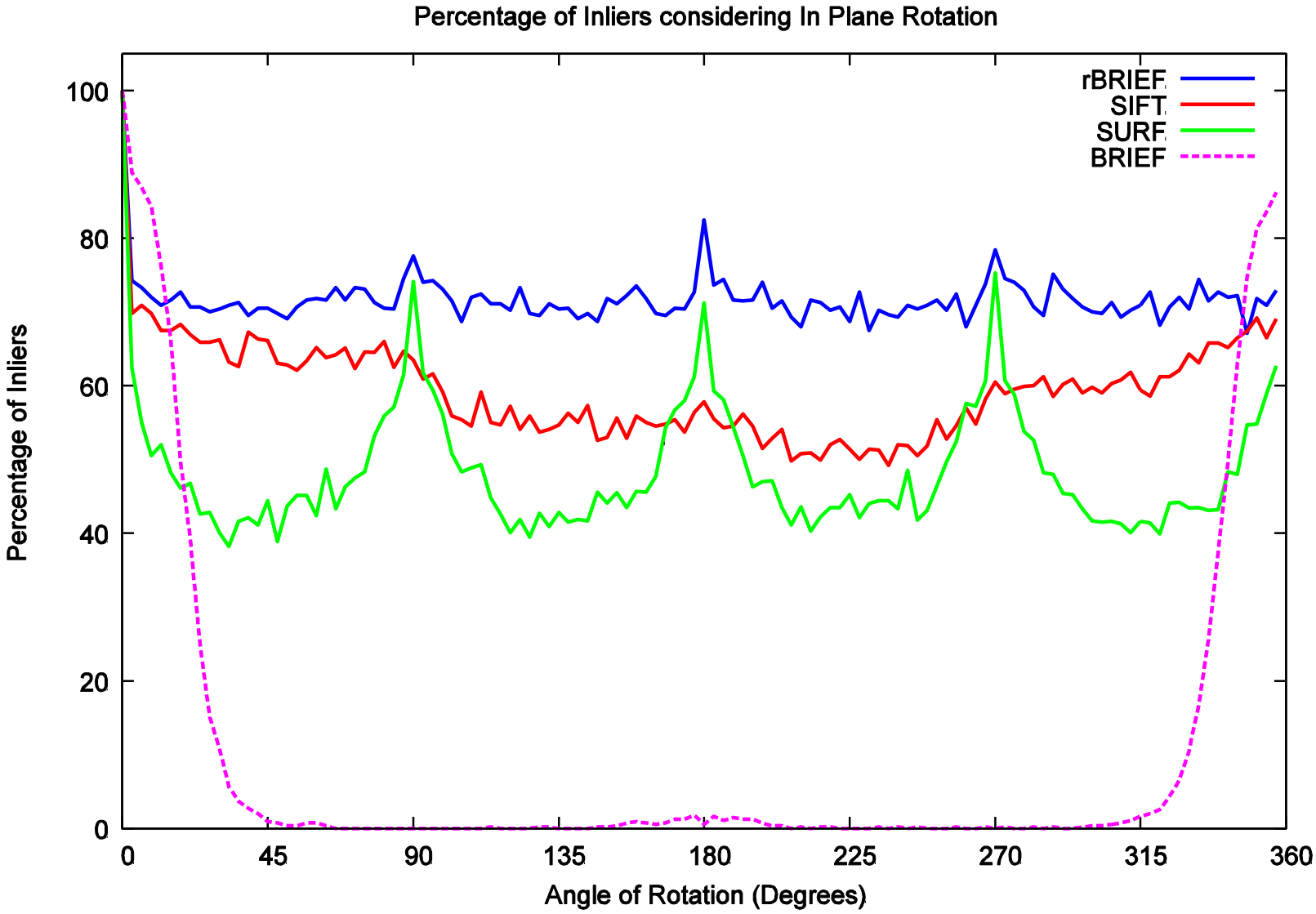


1 0 1 …

256 bits = 32 bytes

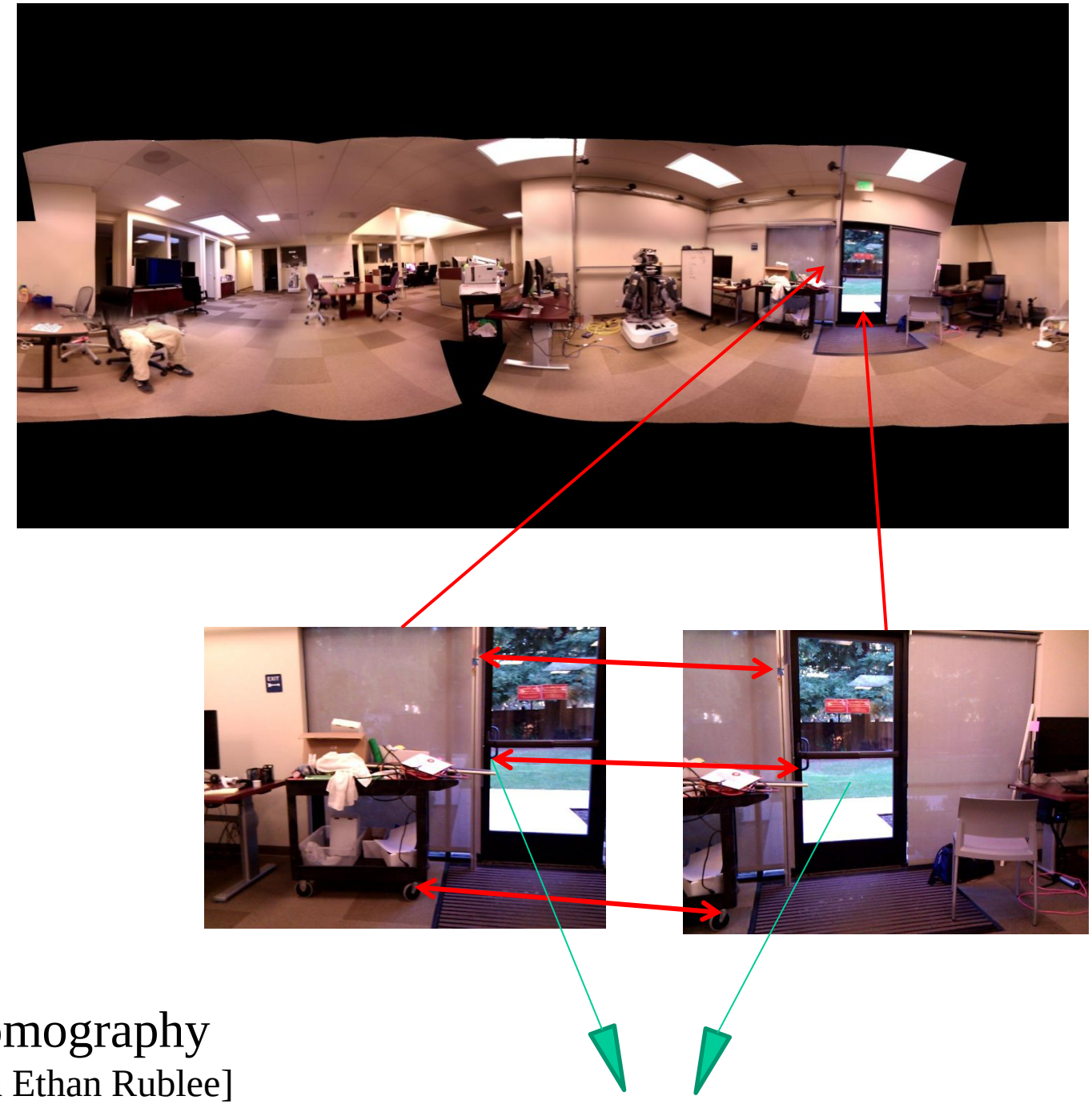
Works suprisingly well except for:
- scale
- image rotation




Percentage of Inliers considering In Plane Rotation
rBRIEF
SIFT
SURF
BRIEF
Percentage of Inliers
Angle of Rotation (Degrees)
0
20
40
60
80
100
0
45
90
135
180
225
270
315
360

ms per frame (2000 features, 640x480):

SIFT: 5228ms [1999]
SURF: 217ms [2006]
ORB **19ms** [2011]

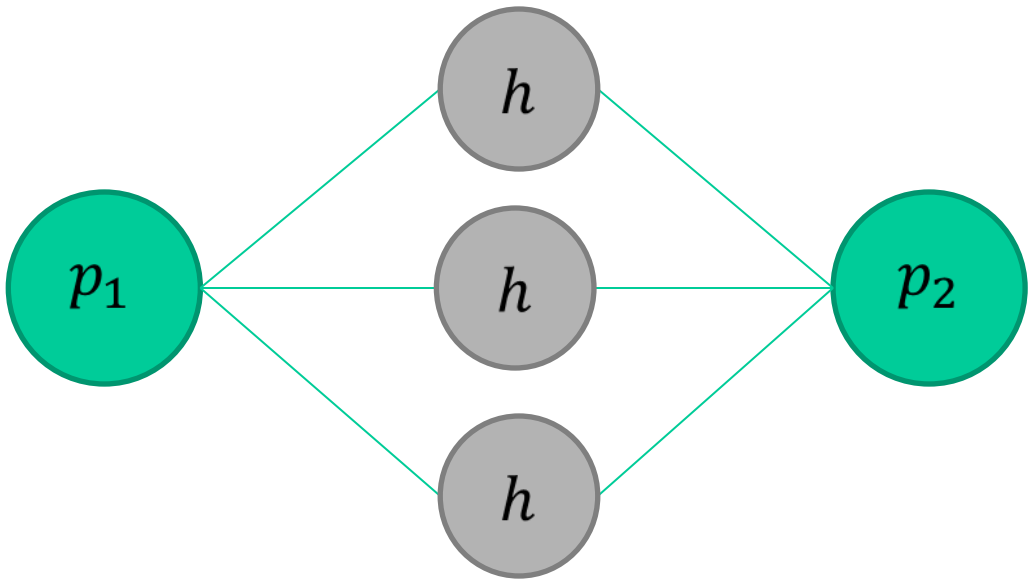


Planar Homography

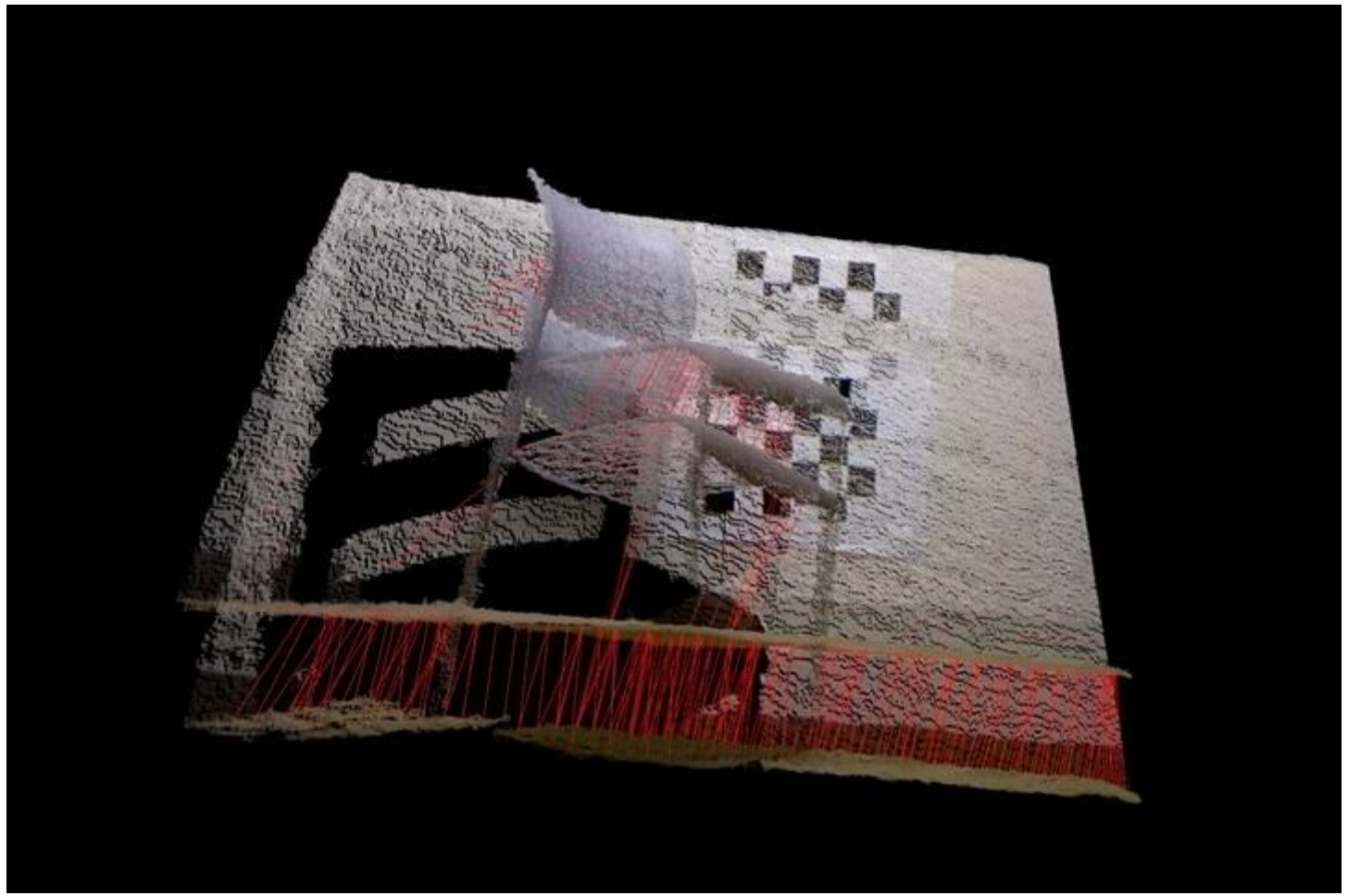
[images from Ethan Rublee]

$$f(p_1, p_2) = \prod_i h_i(p_1, p_2)$$

...

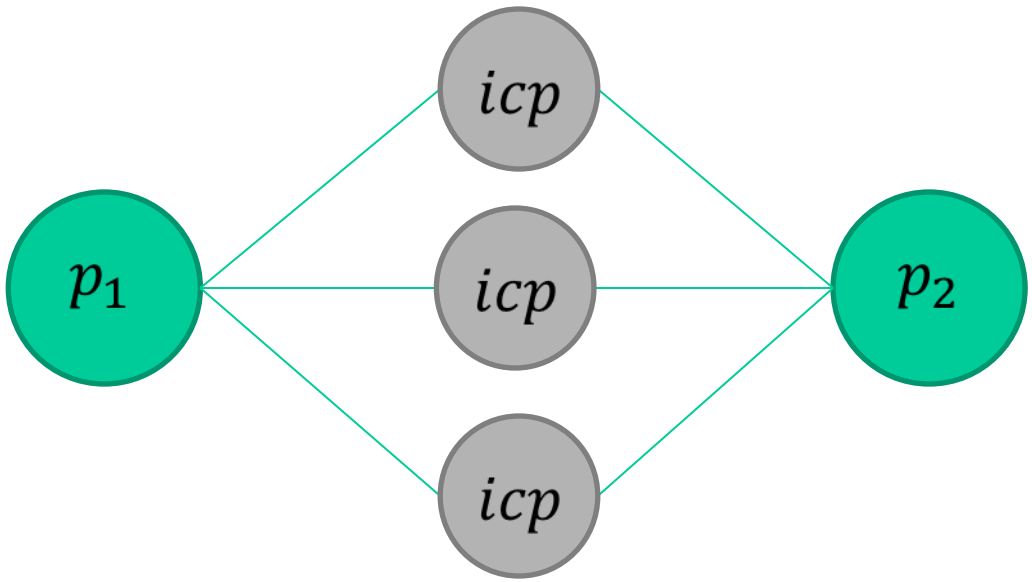


...

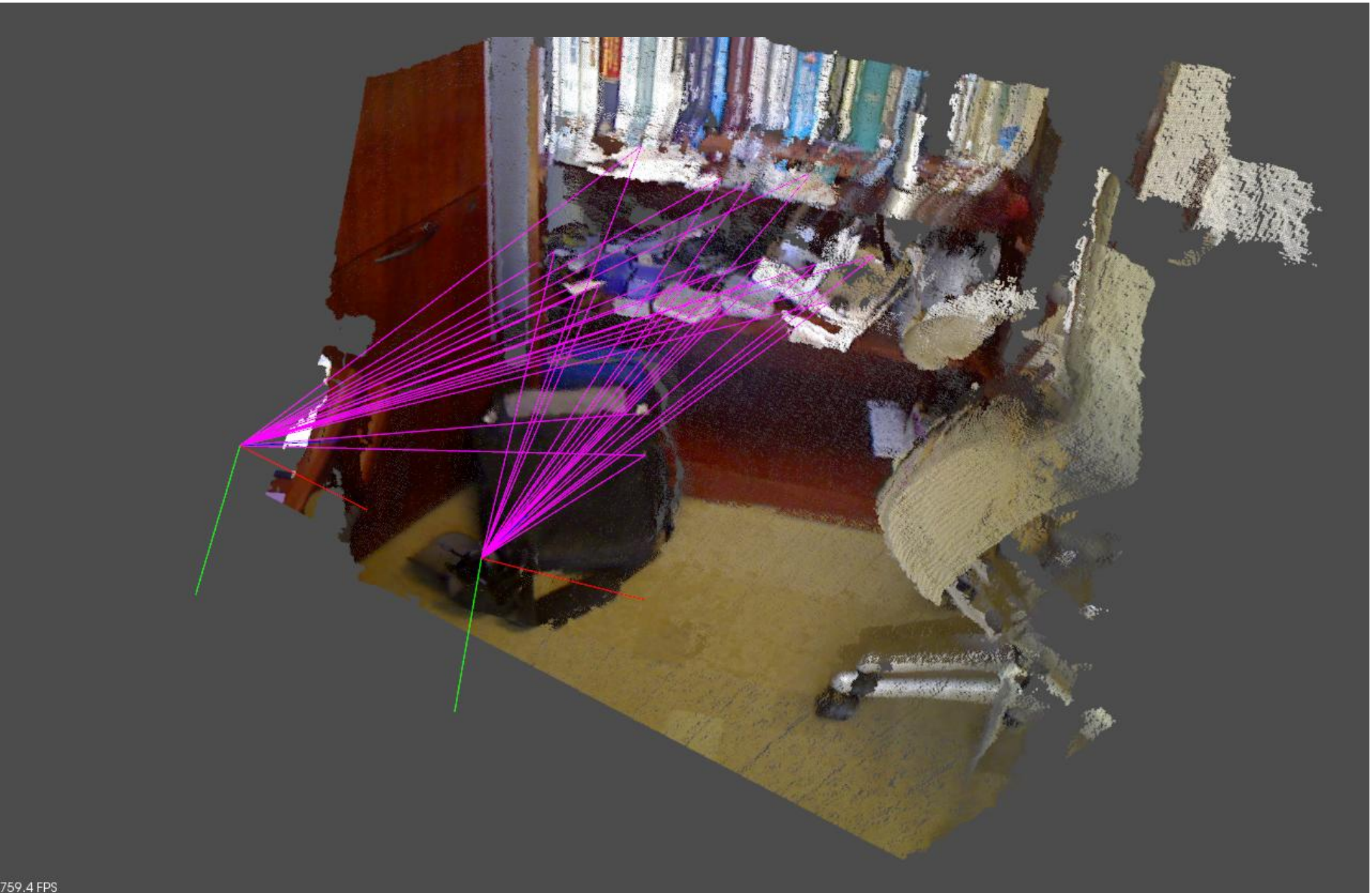


$$f(p_1, p_2) = \prod_i icp_i(p_1, p_2)$$

...

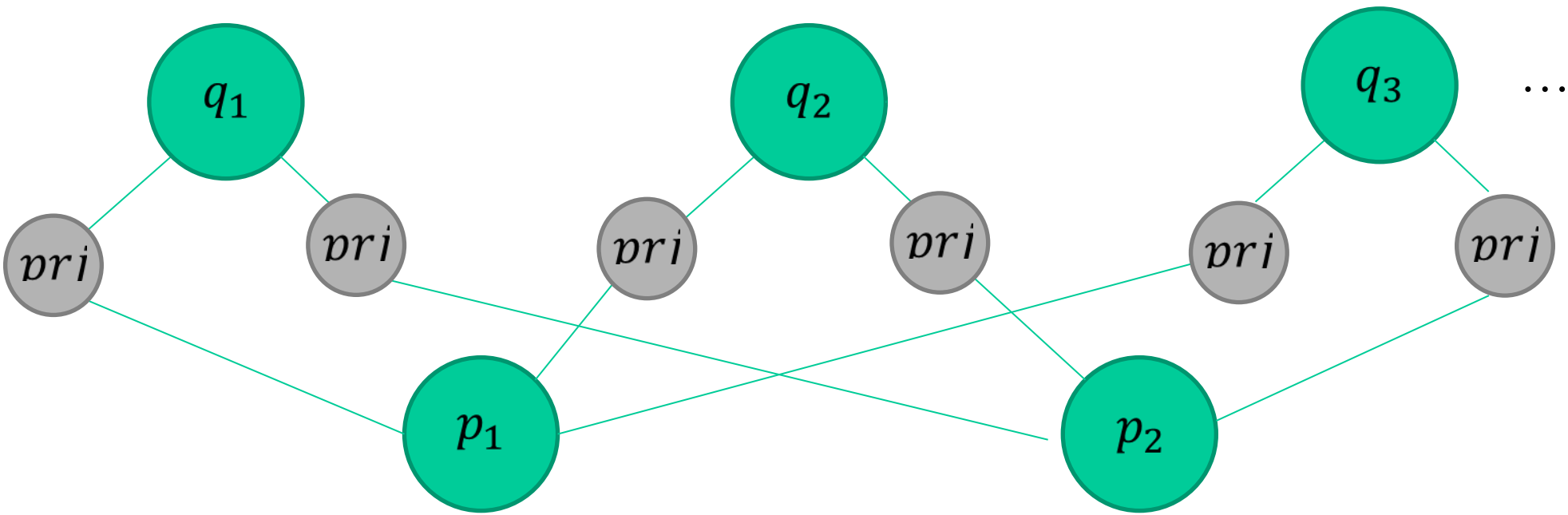


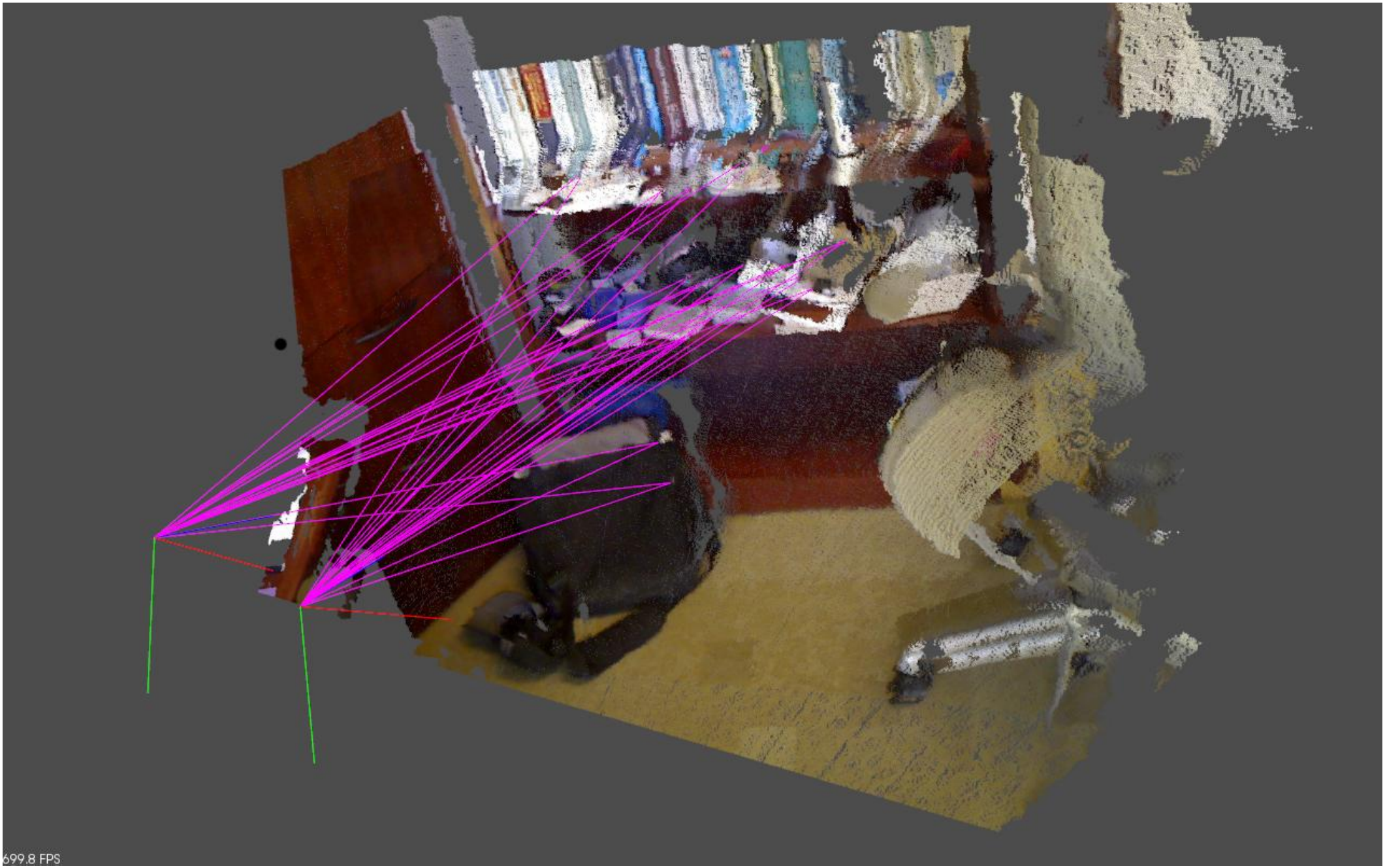
...



Bundle Adjustment [Nicola Fioraio, Boris Lau]

$$f(p_1, p_2, q_1, q_2, q_3, \dots) = \prod_i prj_i(p_1, q_i)\, prj_i(p_2, q_i)$$





Bundle Adjustment [Nicola Fioraio, Boris Lau]

$$f(p_1, p_2, q_1, q_2, q_3, \dots) = \prod_i prj_i(p_1, q_i)\, prj_i(p_2, q_i) \prod_i icp_i(p_1, p_2)$$

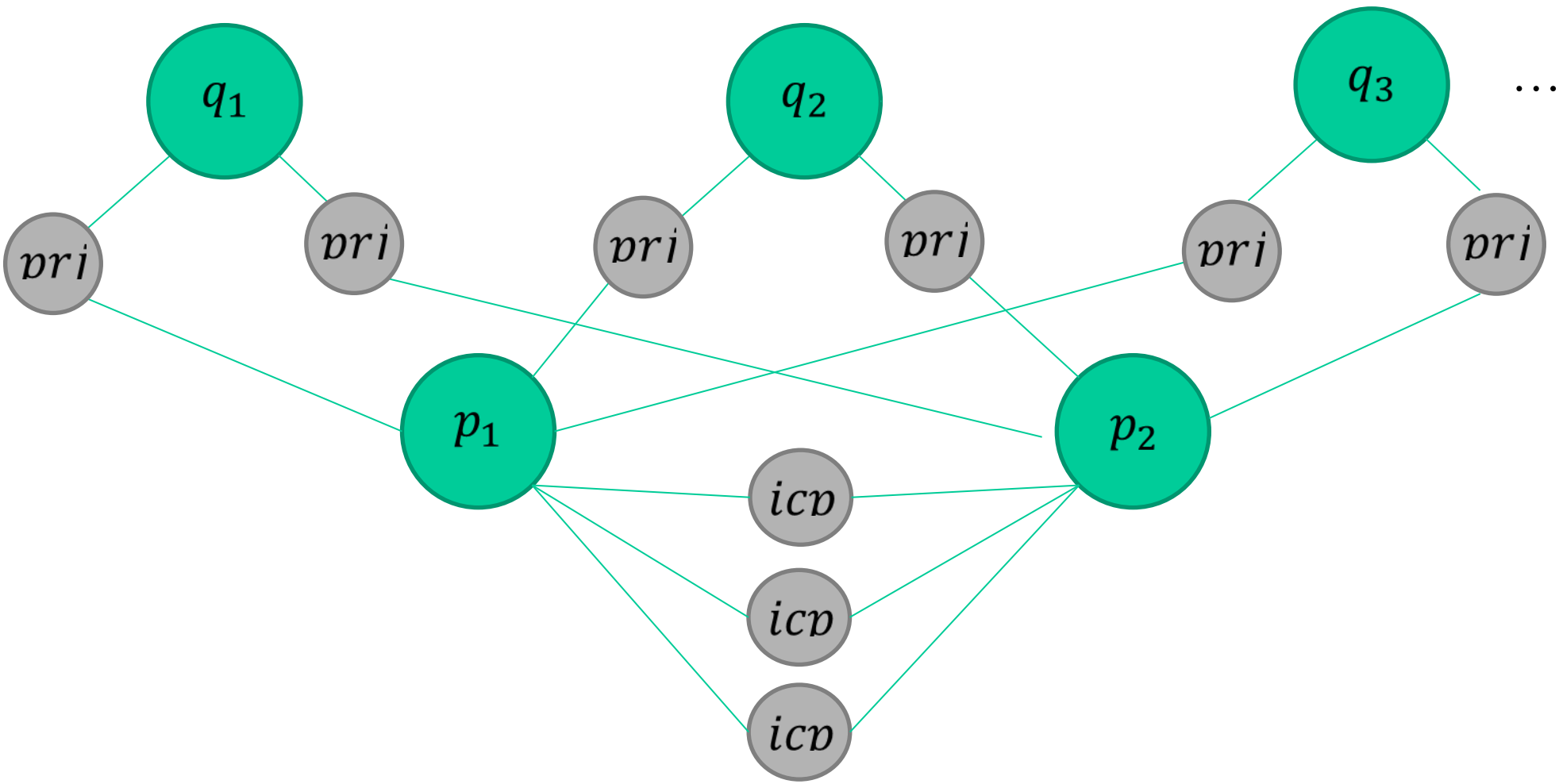


Photo tourism [Snavely, Seitz, Szeliski 2006]

Large nonlinear estimation problem: Bundle Adjustment

Thousands of camera poses, millions of points

Double Window Optimisation for Constant Time Visual SLAM

Hauke Strasdat et al., ICCV 2011

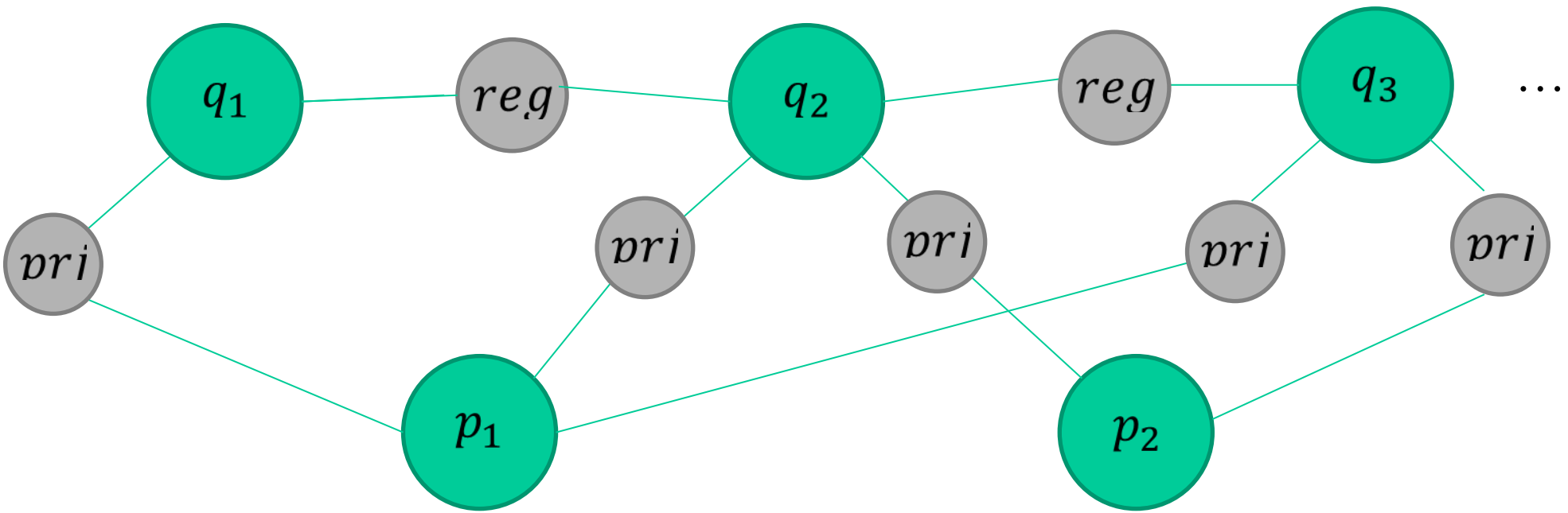
Sparse Surface Adjustment Demonstration on Kinect Data

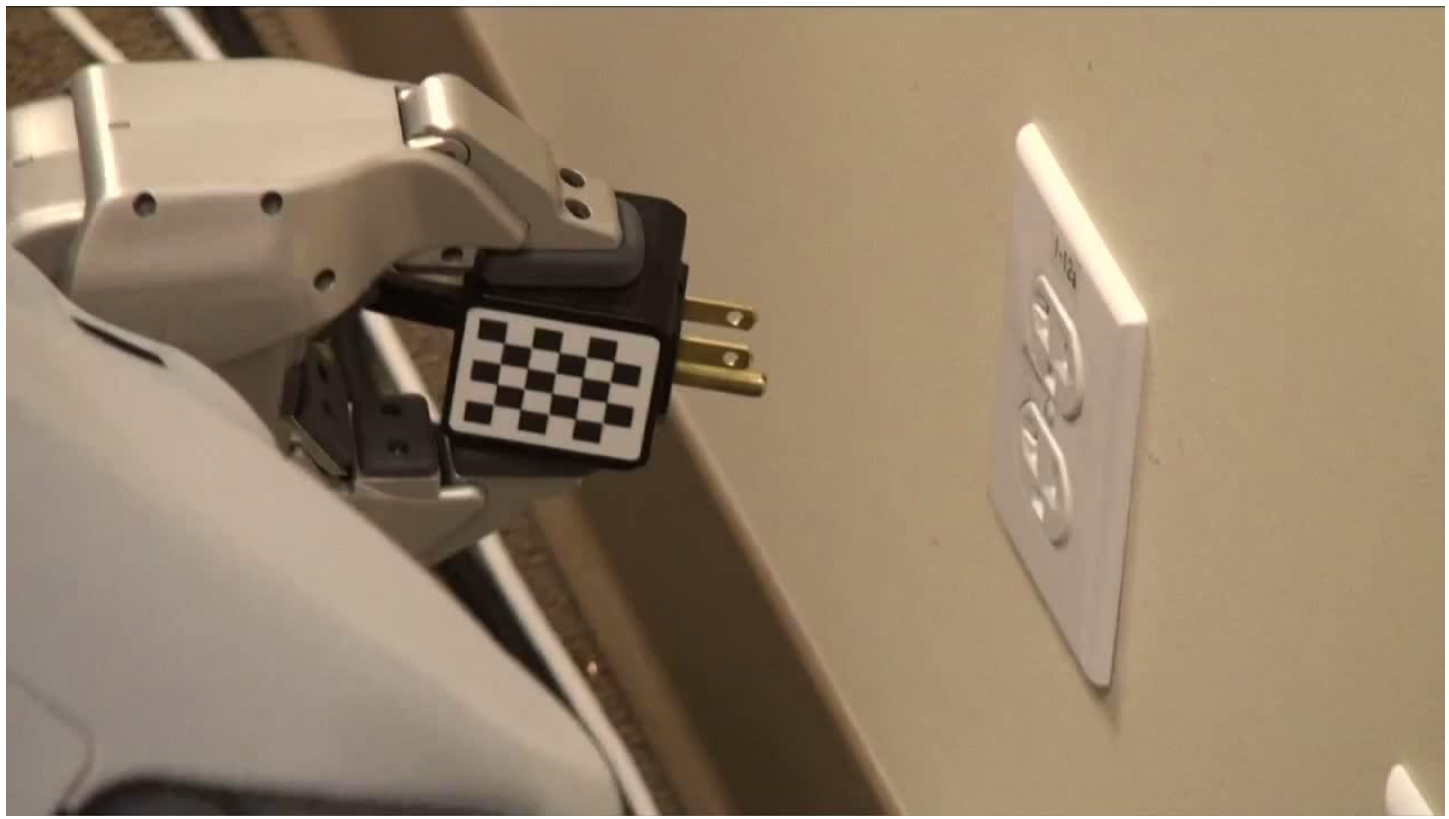
M. Ruhnke, R. Kümmerle, G. Grisetti, W.Burgard

University of Freiburg, Germany

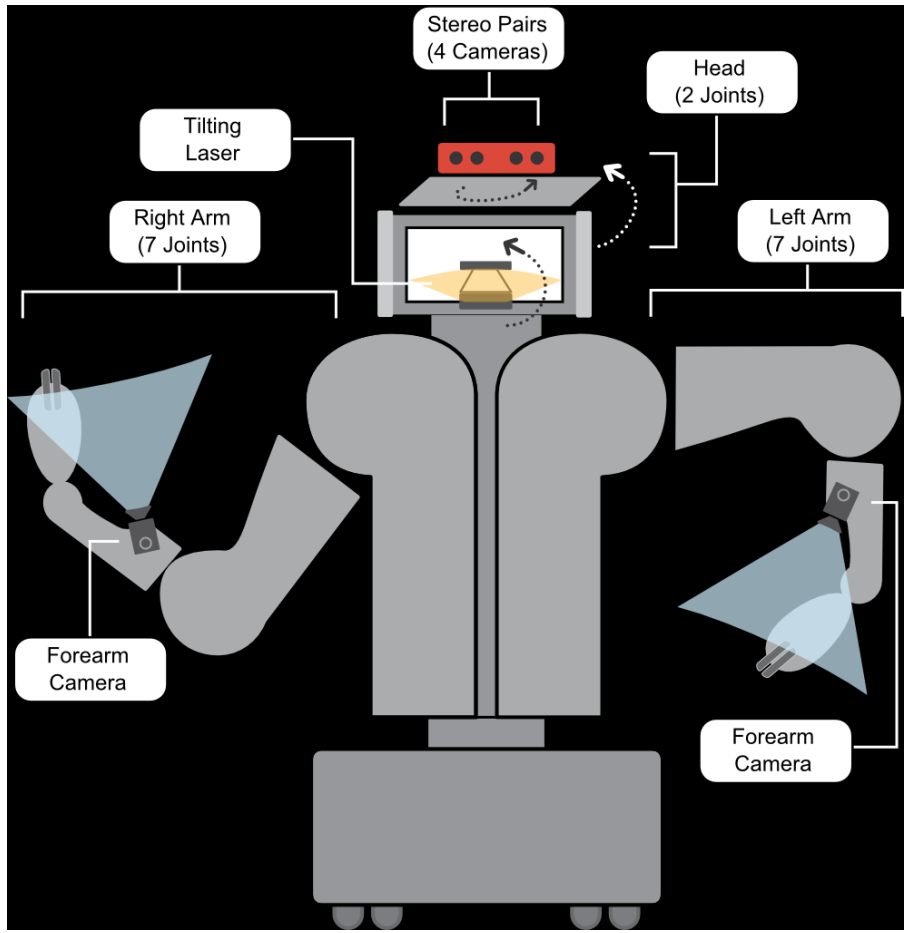
http://www.informatik.uni-freiburg.de/~ruhnke/

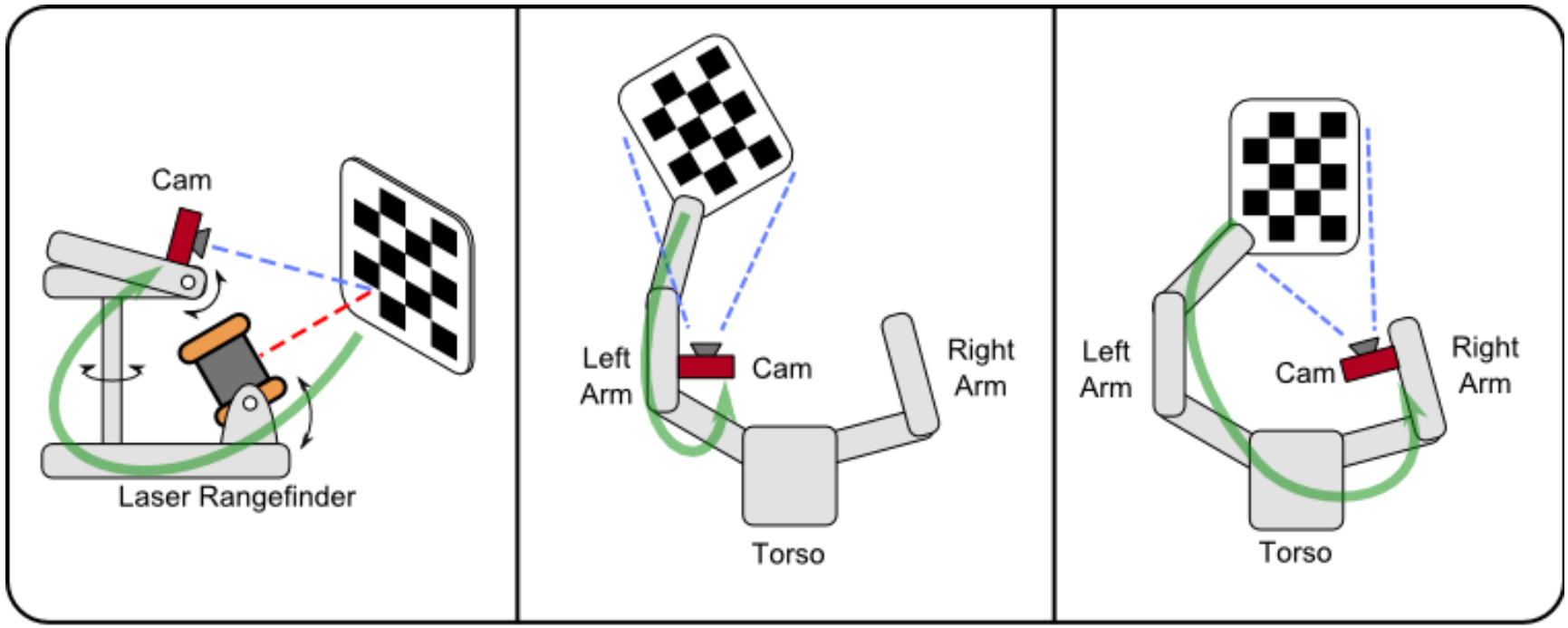
$$f(p_1, p_2, q_1, q_2, q_3, \dots) = \prod_i prj_i(p_1, q_i)\, prj_i(p_2, q_i) \prod_{jk} reg_{jk}(q_j, q_k)$$

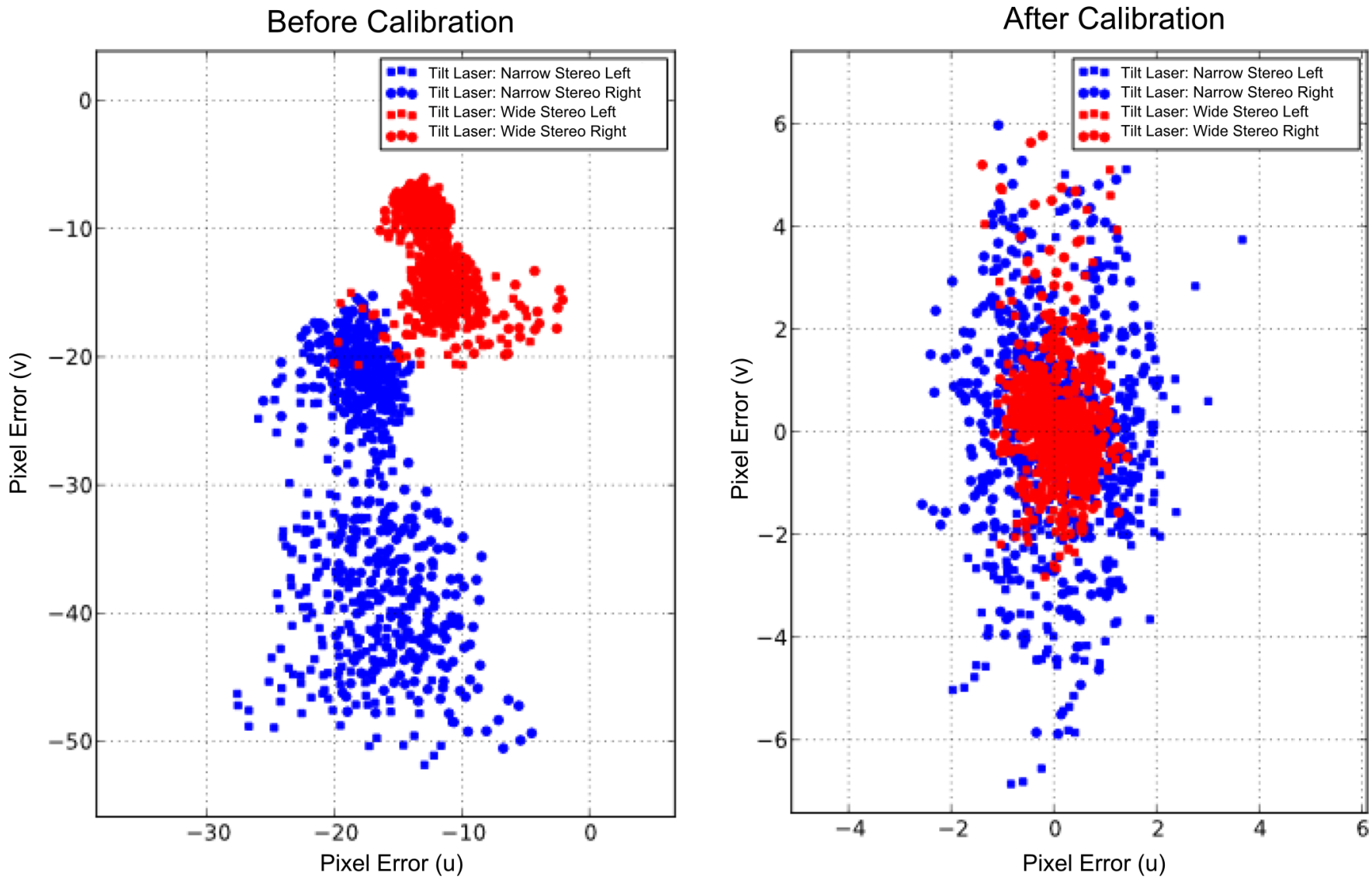




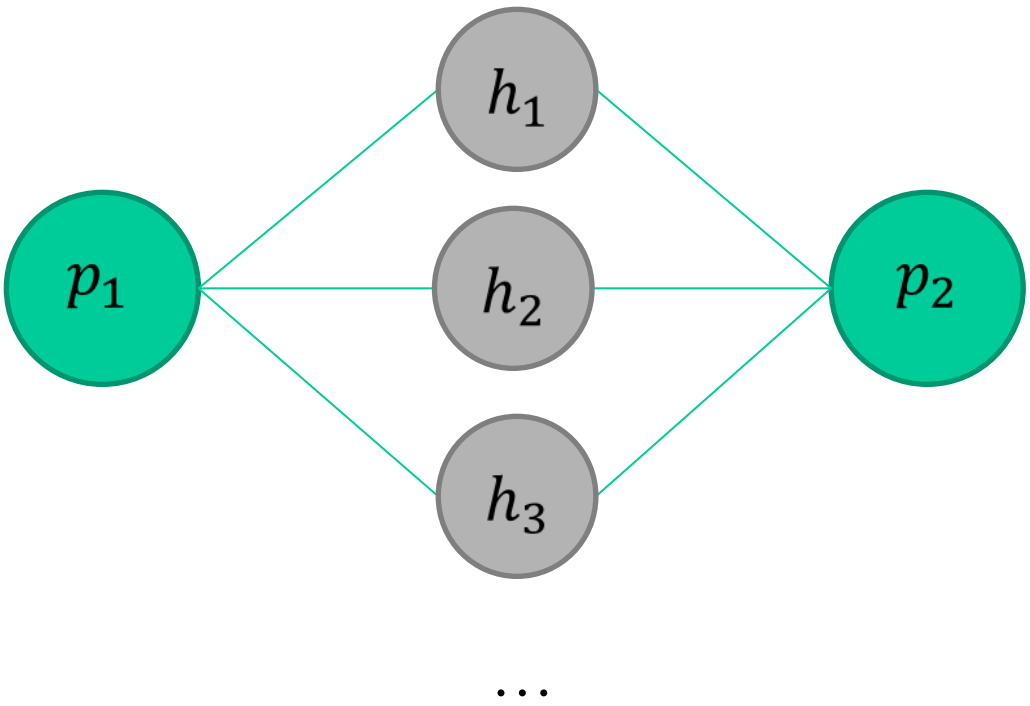
[Pradeep et al. ISER 2010]




Cam
Laser Rangefinder
Left
Arm
Cam
Right
Arm
Torso
Left
Arm
Cam
Right
Arm
Torso


Before Calibration
Tilt Laser: Narrow Stereo Left
Tilt Laser: Narrow Stereo Right
Tilt Laser: Wide Stereo Left
Tilt Laser: Wide Stereo Right
Pixel Error (v)
Pixel Error (u)
0
−10
−20
−30
−40
−50
−30
−20
−10
0
After Calibration
Tilt Laser: Narrow Stereo Left
Tilt Laser: Narrow Stereo Right
Tilt Laser: Wide Stereo Left
Tilt Laser: Wide Stereo Right
Pixel Error (v)
Pixel Error (u)
6
4
2
0
−2
−4
−6
−4
−2
0
2
4
6

Javier Romero, KTH



$$P(p_1, p_2) = \prod_i h_i(p_1, p_2)$$

Max Likelihood

$$\arg\min_{p_i} -\log P(p_1, p_2)$$

Product to log sum

$$\arg\min_{p_i} \sum_i -\log h_i(p_1, p_2)$$

Gaussian

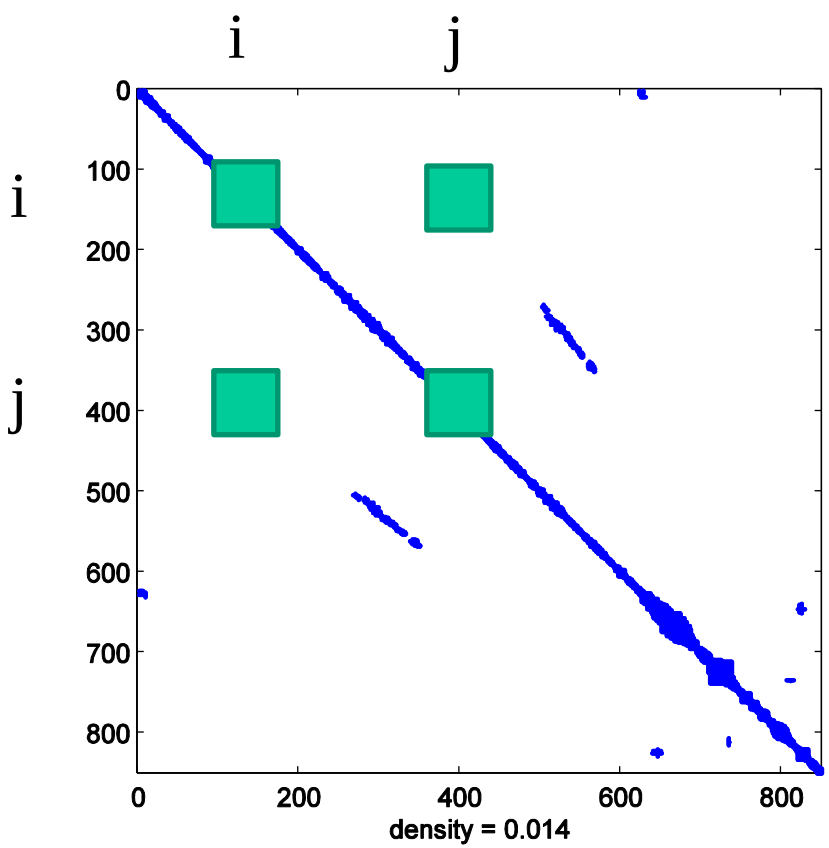
$$\arg\min_{p_i} \sum_i \|z_i(p_1, p_2) - \hat{z}_i\|^2$$

Sparse Bundle Adjustment

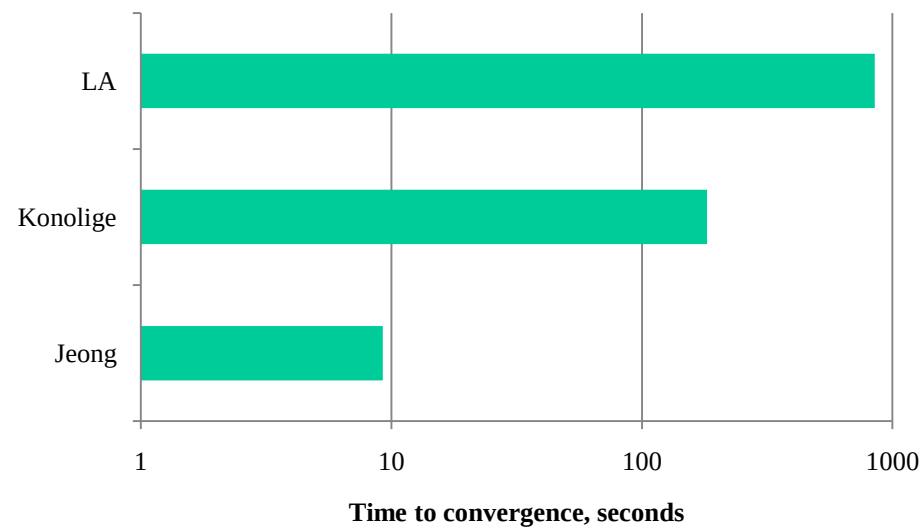
$$e_k = z_k(x_i, x_j) - \hat{z}_k$$ Error Equation

$$J_k = \frac{\partial e_k}{\partial x} | \bar{x}$$ Jacobians

$$\boldsymbol{J^T J x = J^T e}$$ Normal Equation

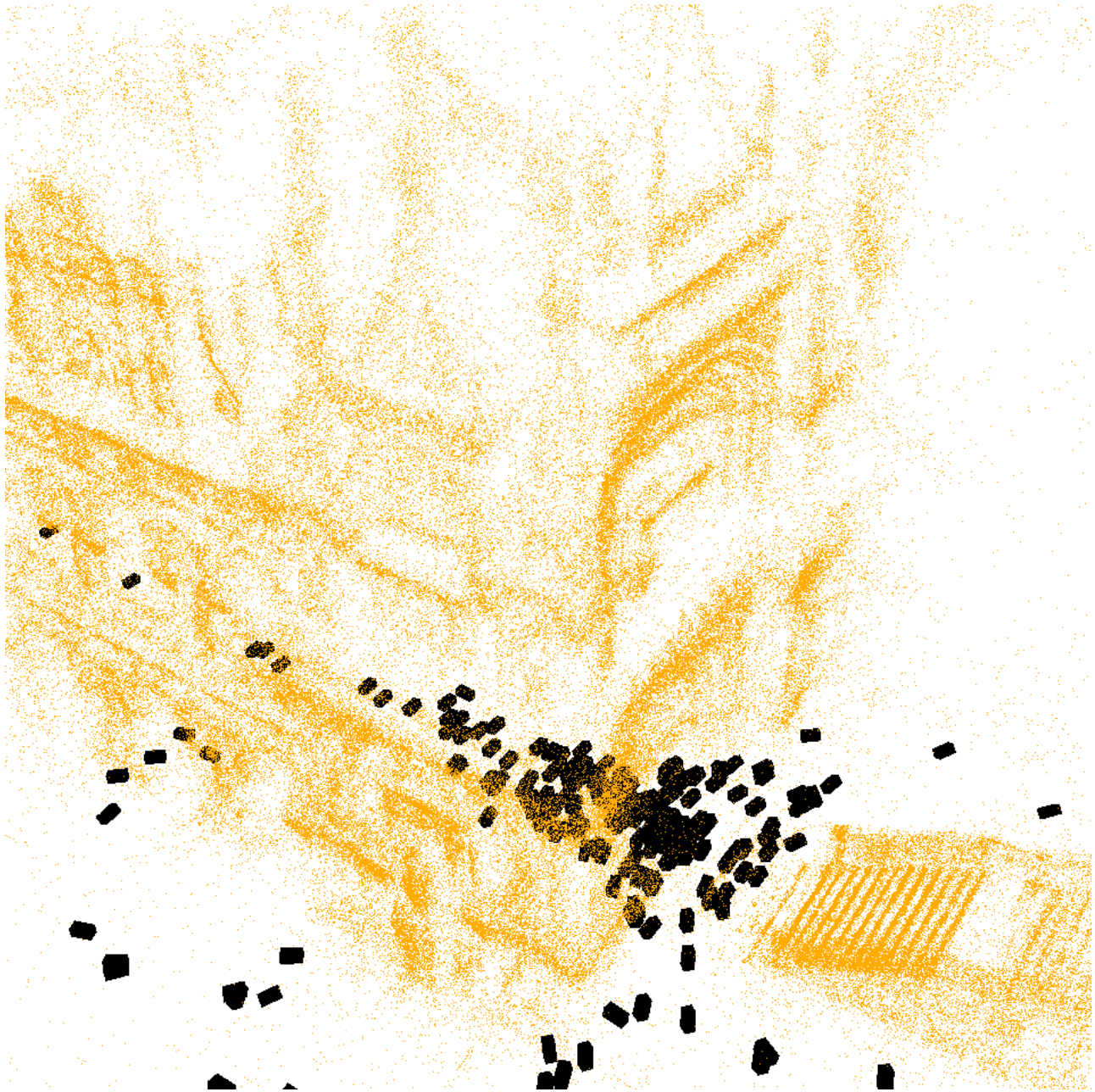


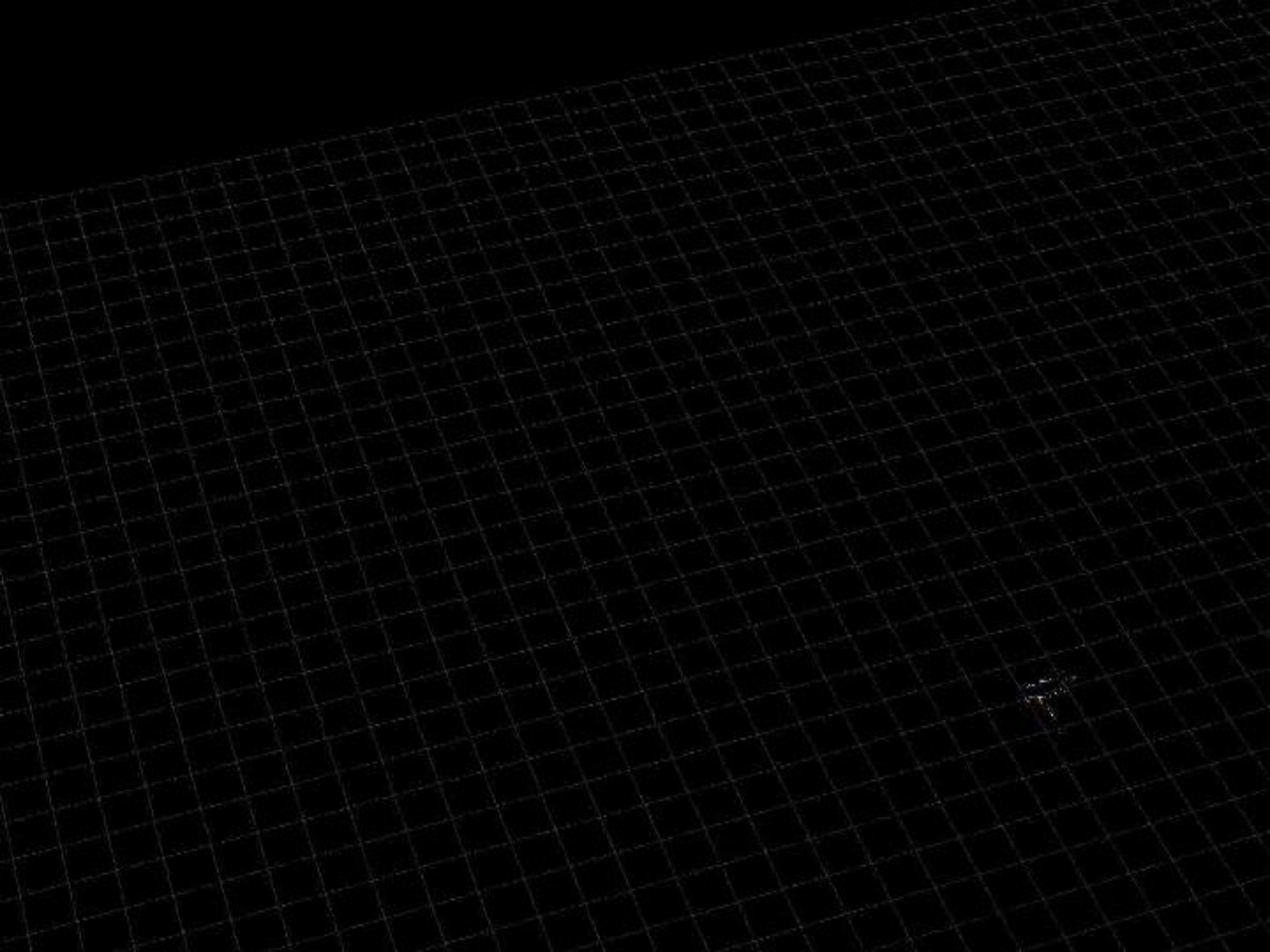
Lourakis and Argyros [TR 2004]
Konolige [BMVC 2010]
Jeong et al. [CVPR 2010]



2,010,363 vars, 2,857,277 constraints

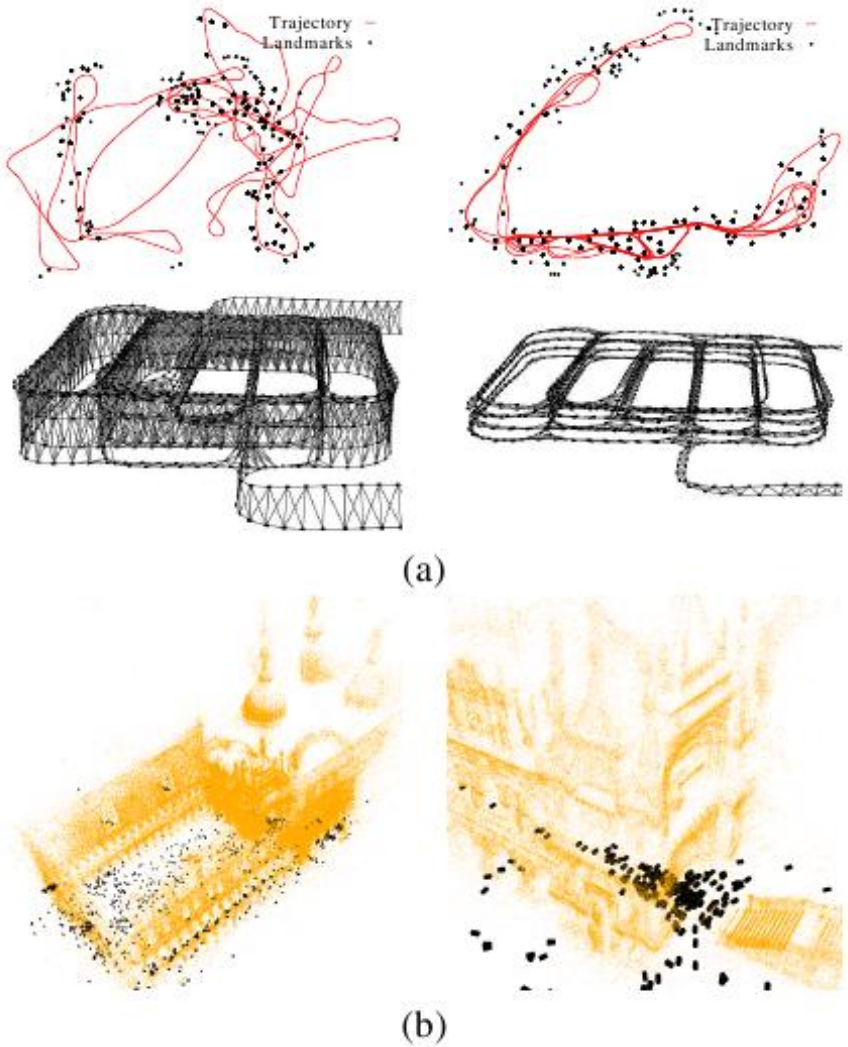
849 camera poses, 668,140 points

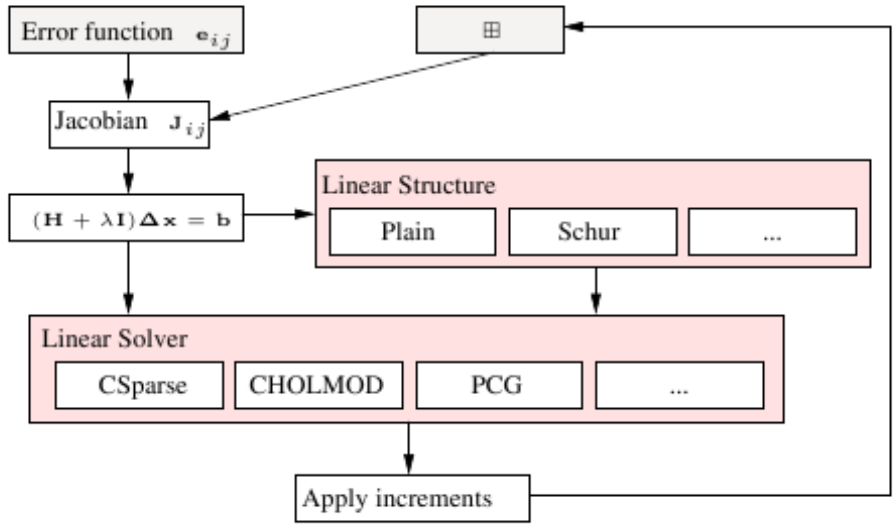




g2o: A General Framework for Graph Optimization

Kummerle, Grisetti, Strasdat, Konolige, Burgard [ICRA 2011]
Open Source!






ROS
PR2
Willow Garage