ETH zürich

EMBEDDED PHOTOMETRIC VISUAL ODOMETRY

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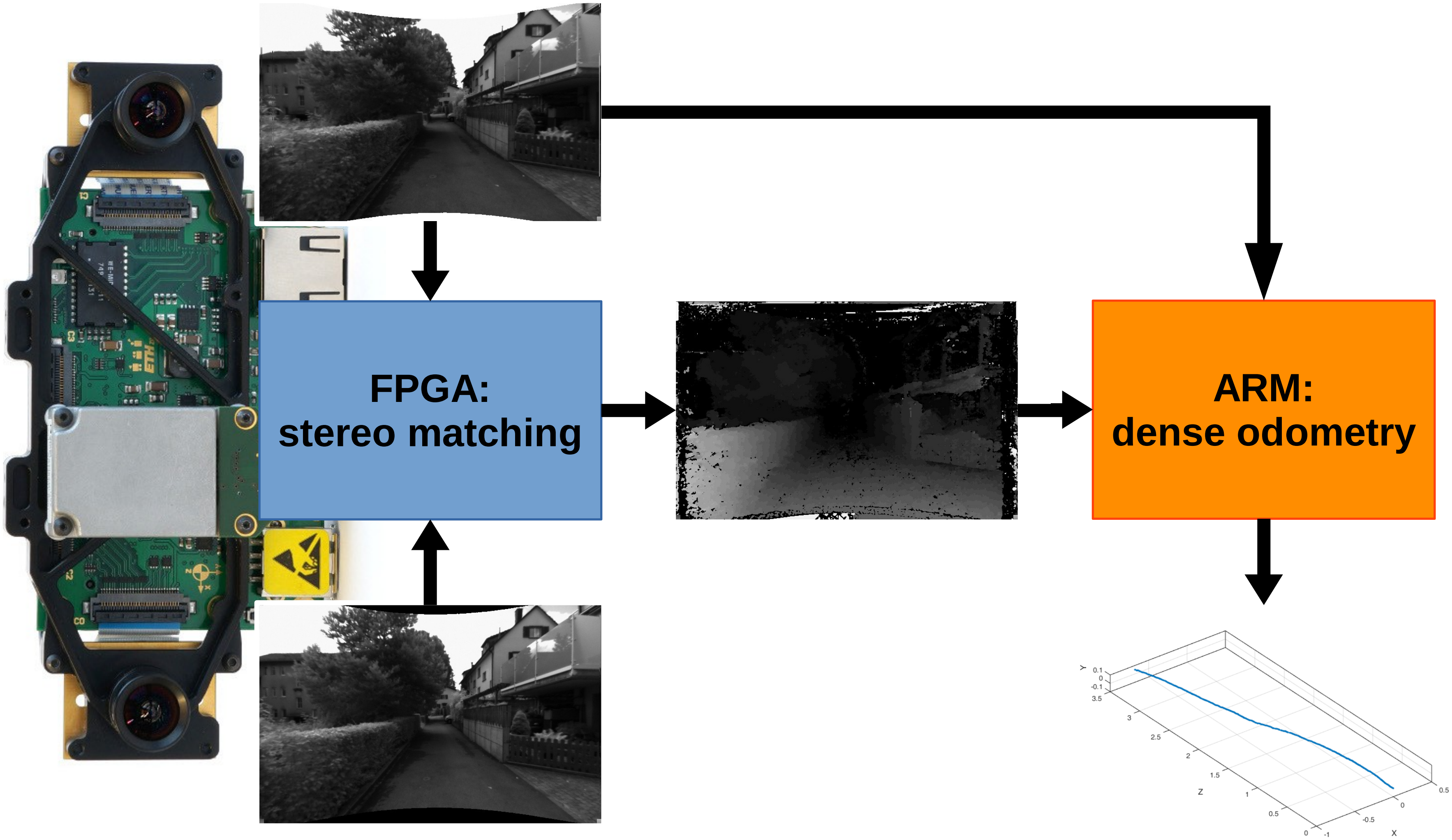
Bachelor Thesis
Supervised by Jörn Rehder and Pascal Gohl.

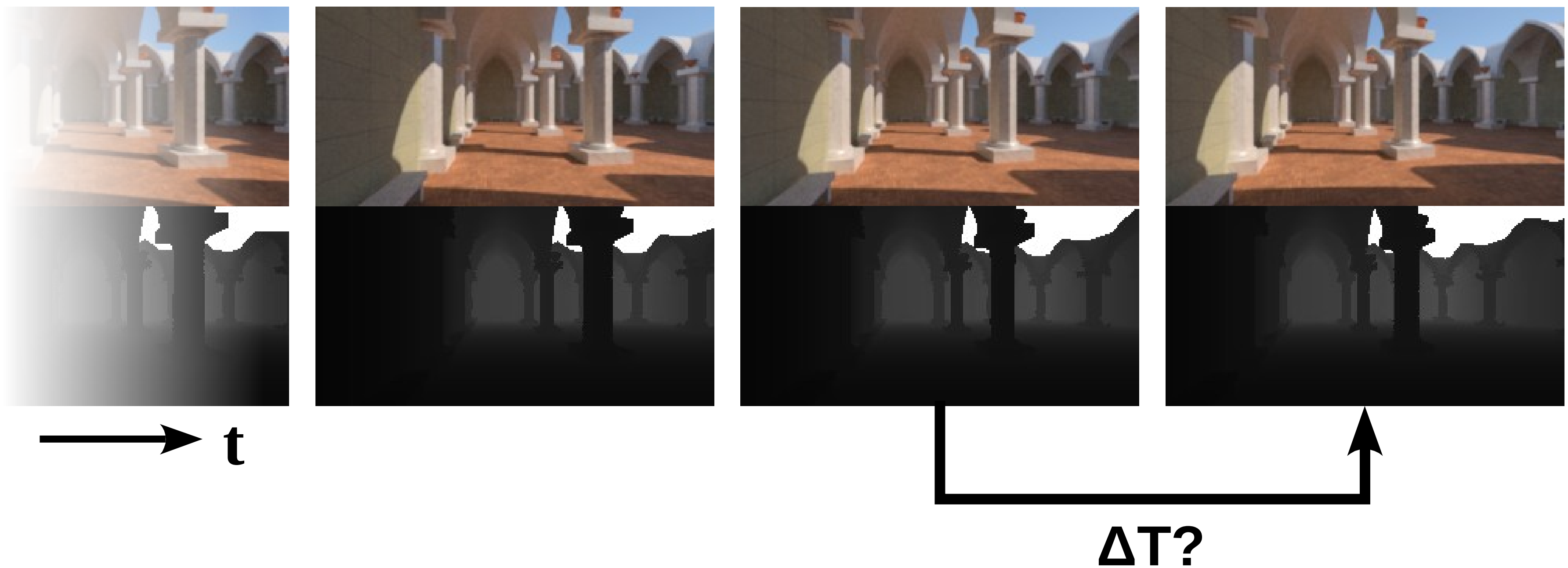
Autonomous Systems Lab


FPGA:
stereo matching
ARM:
dense odometry

MOTIVATION

- integrate FPGA and ARM
- stereo on FPGA ⇒ embedded odometry

METHOD



project into space

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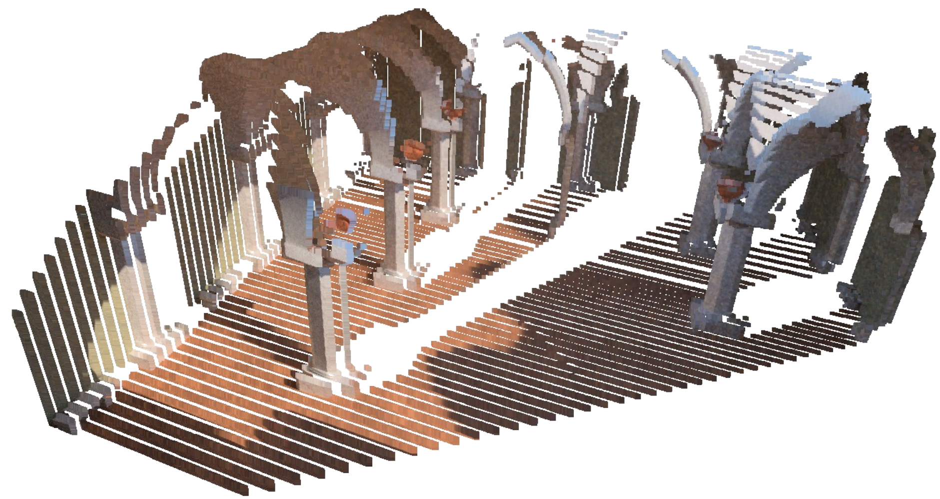
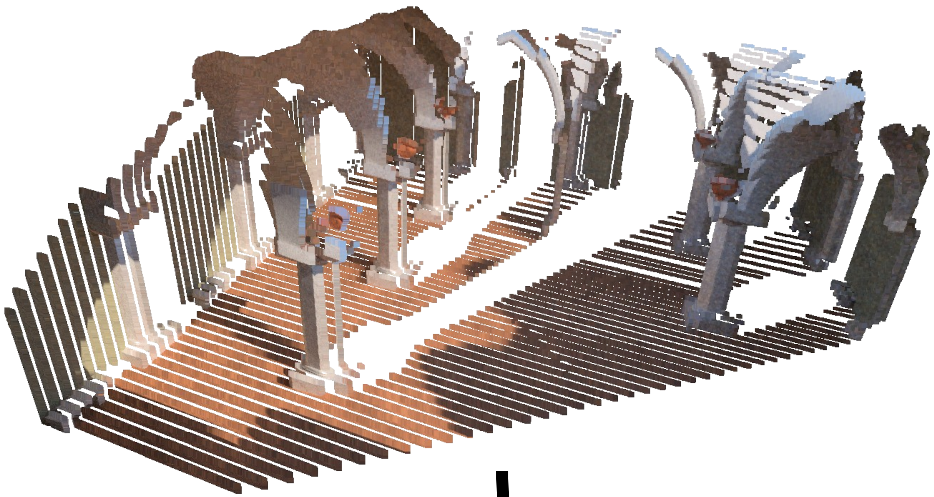


point cloud

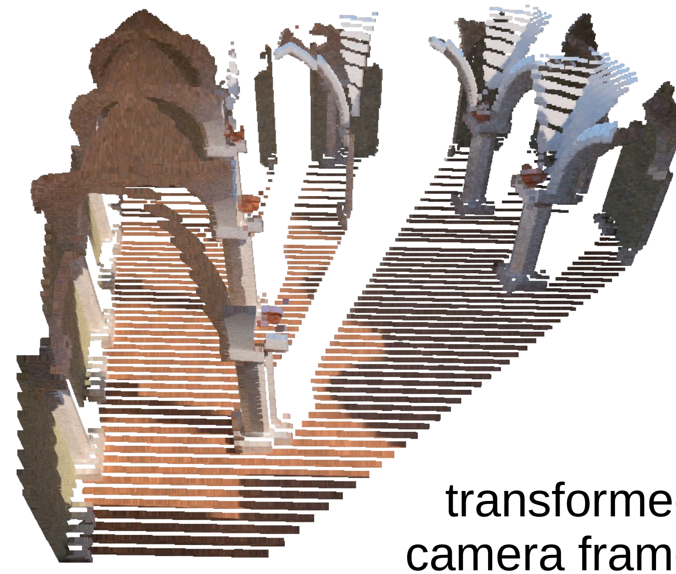
move camera trough space



original camera frame

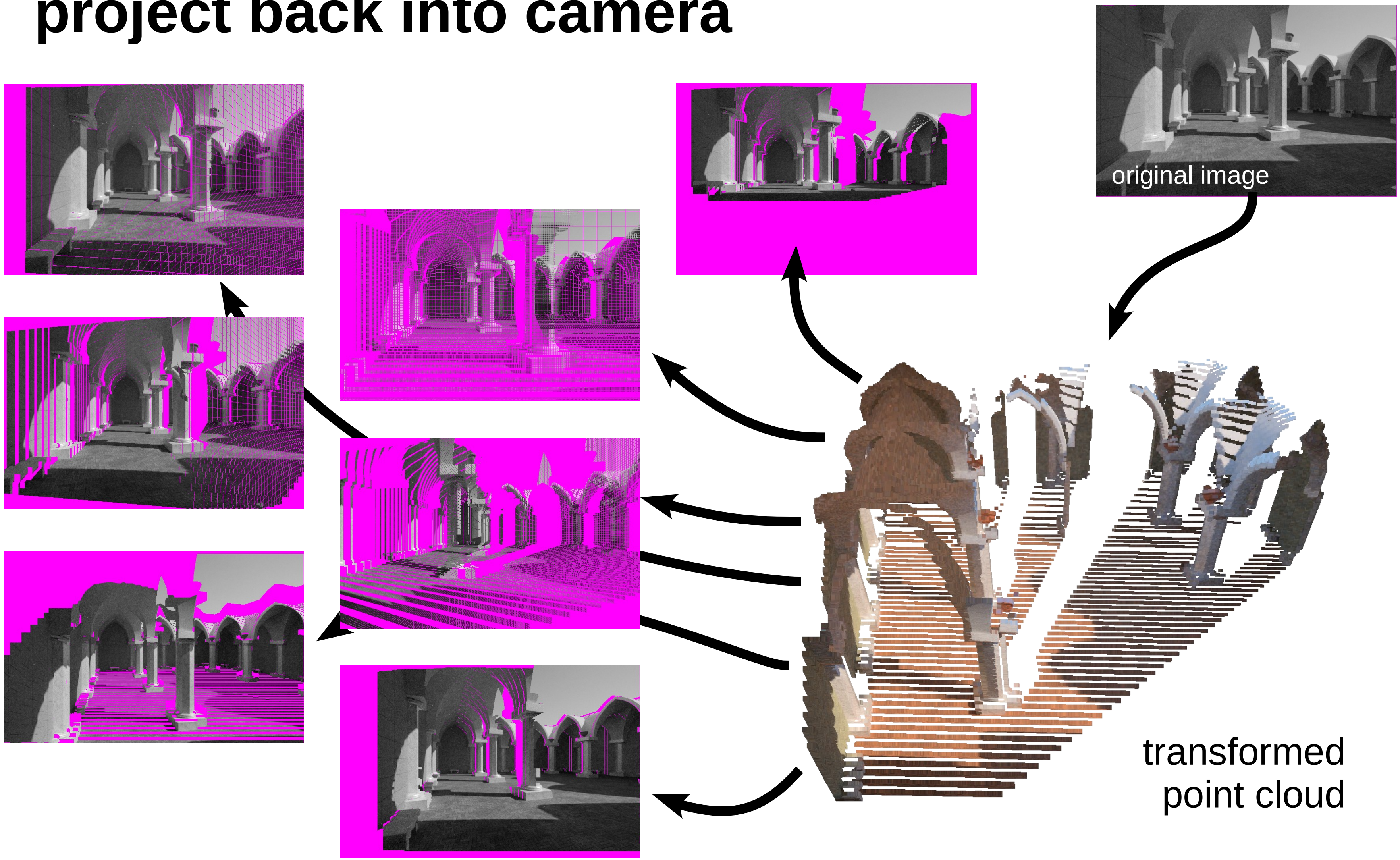
T translation rotation

that's what we're actually looking for

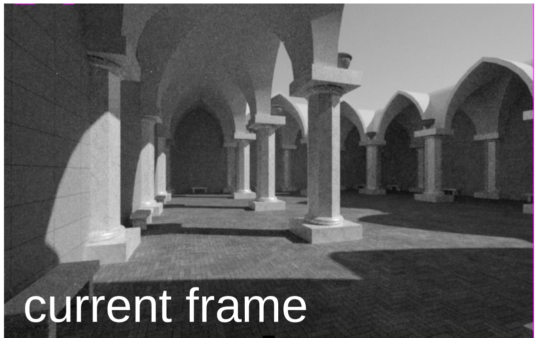


transformed camera frame

project back into camera

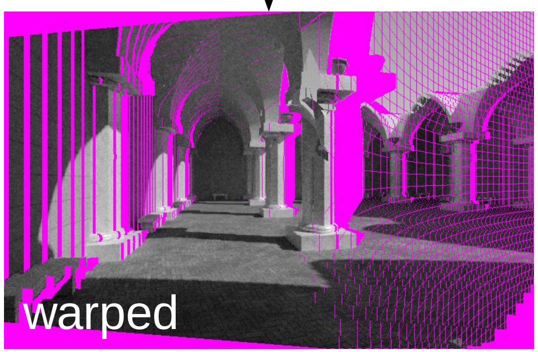


but which transformation is the best?



transformation **T**

just minimize that!



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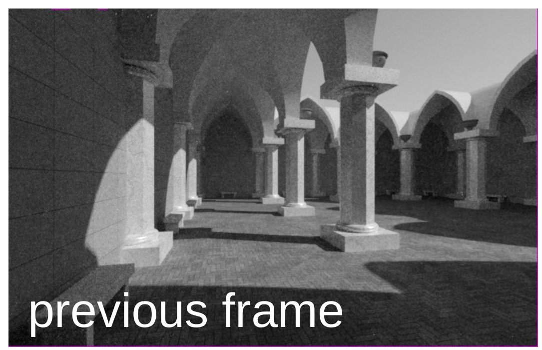

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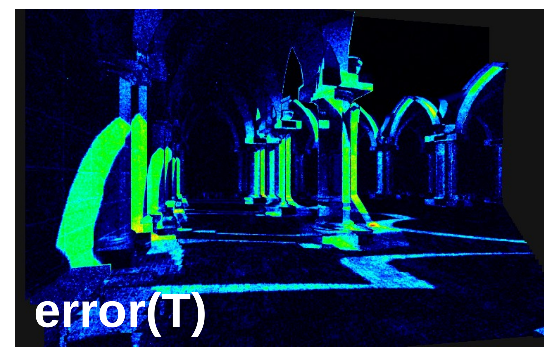
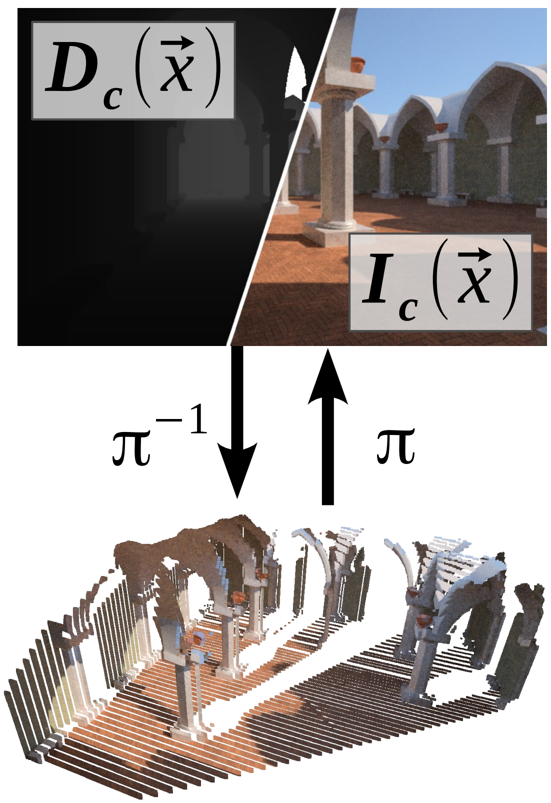


formularizing the problem



point in image: $\vec{x} := (u, v) \in \mathbb{R}^2$

intensity: $I(\vec{x}) \in \mathbb{R}$

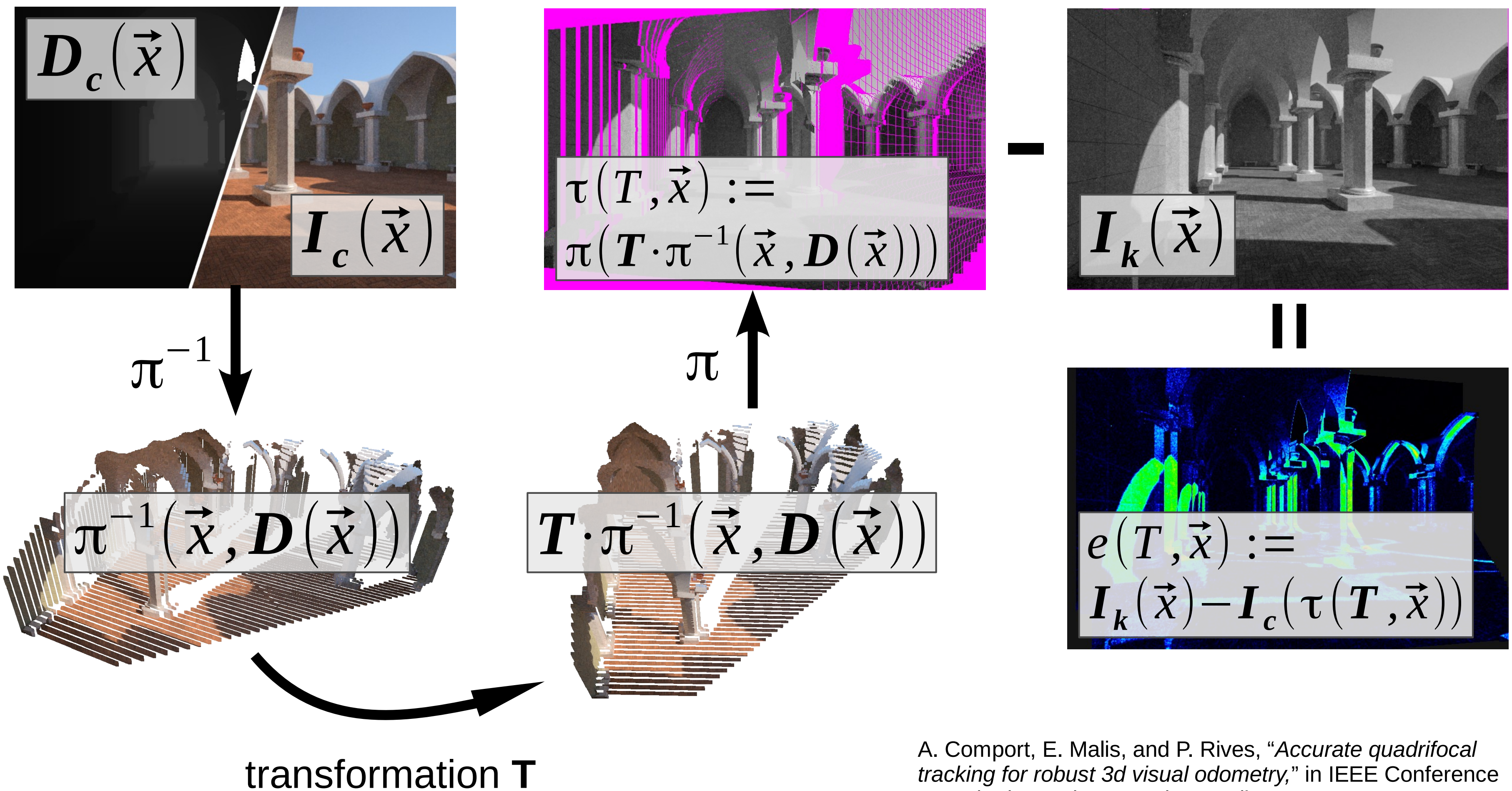
disparity: $D(\vec{x}) \in \mathbb{R}$

transformation: $T \in \mathbb{R}^6$

$$\pi^{-1}(\vec{x}, D(\vec{x})) := \frac{b}{D(\vec{x})} \begin{bmatrix} u - c_u \\ v - c_v \\ f \end{bmatrix}$$

$$\pi(x, y, z) := \frac{f}{z} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} c_u \\ c_v \end{bmatrix}$$

FULL WARPING



A. Comport, E. Malis, and P. Rives, “*Accurate quadrifocal tracking for robust 3d visual odometry,*” in IEEE Conference on Robotics and Automation, April 2007, pp. 40–45.

therefore:

minimize

$$e(T,\vec{x}) := \boldsymbol{I}_{\boldsymbol{k}}(\vec{x}) - \boldsymbol{I}_{\boldsymbol{c}}(\tau(\boldsymbol{T},\vec{x}))$$

for every pixel:

$$\hat{\boldsymbol{T}} = \underset{\boldsymbol{T}}{argmin} \sum_{\vec{x} \in \boldsymbol{I}_{\boldsymbol{k}}} e(T,\vec{x})^2$$

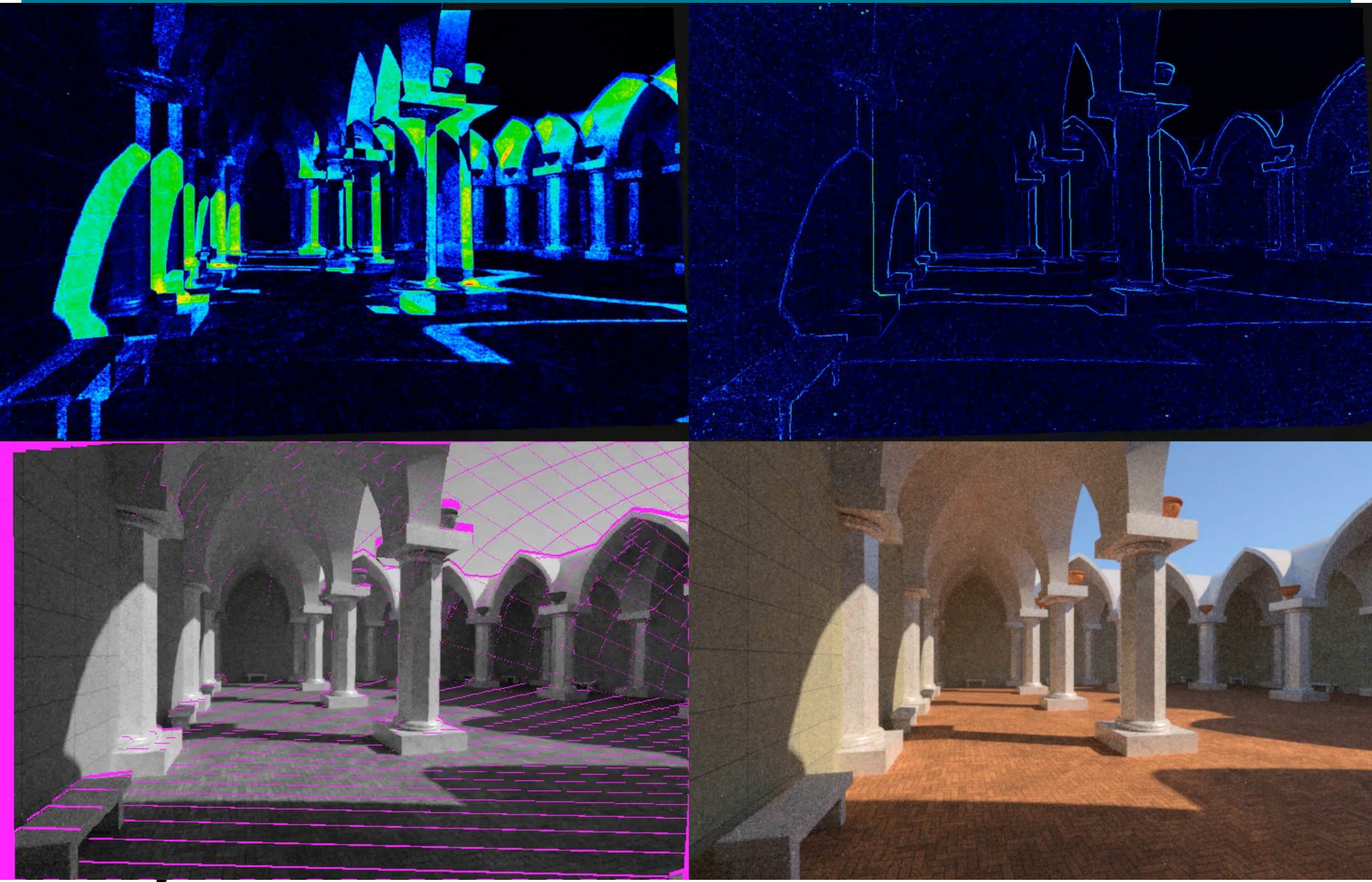
using Gauss Newton:

$$\boldsymbol{J}^{\boldsymbol{T}} \boldsymbol{J} \Delta T = -\boldsymbol{J}^{\boldsymbol{T}} e(\boldsymbol{T})$$

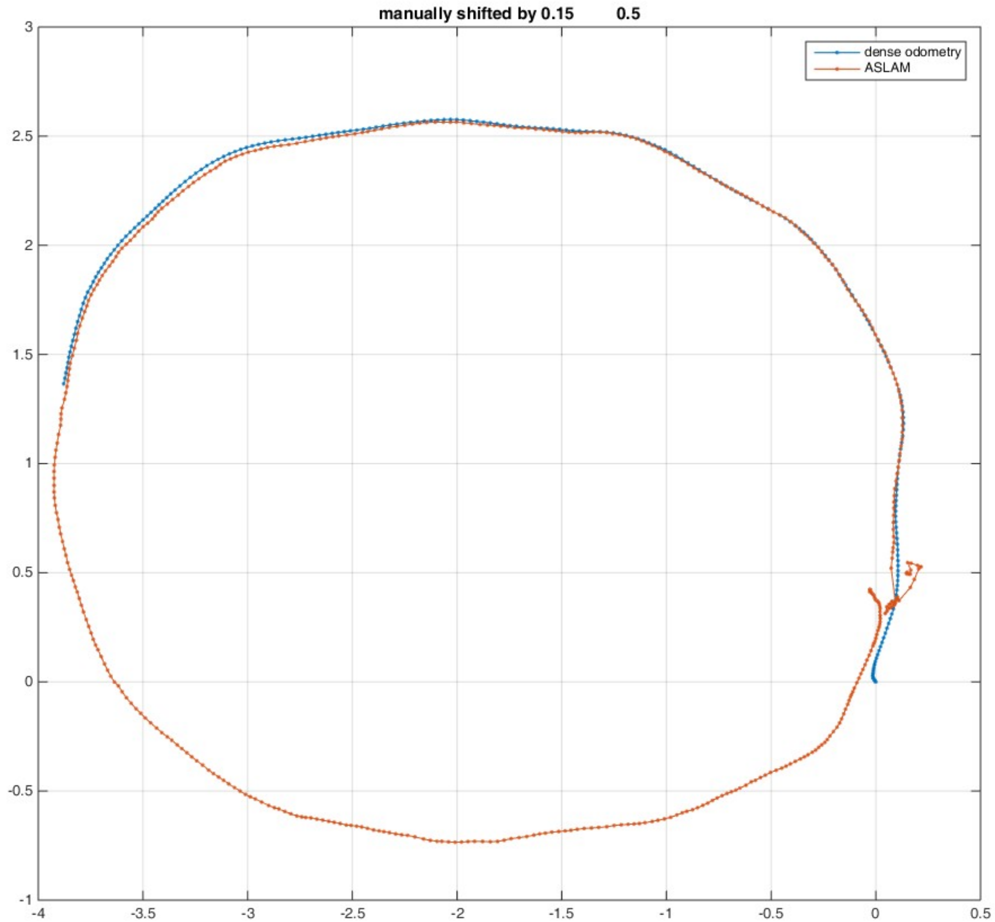
OPTIMIZATIONS

- use image pyramid
  - full resolution isn't really necessary
- only use pixels with strong gradient
- Huber weights?
- Levenberg-Marquardt?

TODO: provide data on how much a difference these things make



TODO: RESULTS



TODO: use full trajectory here and bigger plot

TODO: MORE RESULTS

- circular trajectory
- timing data on visensor

TODO: CONCLUSION