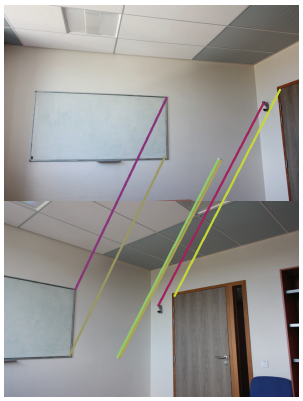
Robust and Accurate Line- and/or Point-Based Pose Estimation without Manhattan Assumptions

Yohann Salaün[1,2], **Renaud Marlet**[1], **Pascal Monasse**[1]

[1]LIGM, UMR 8049, École des Ponts, UPE, Champs-sur-Marne, France

[2]CentraleSupélec, Châtenay-Malabry, France

Motivation



Point matches

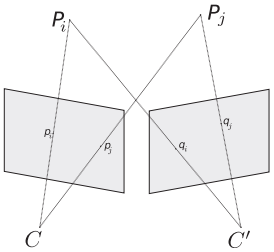
Line matches

Common failure cases of point-based SfM:

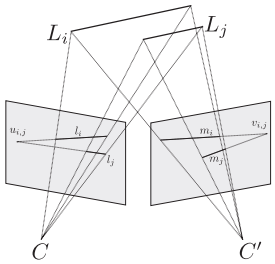
- lack of texture ⇒ few point detections
- wide baseline or little overlap ⇒ few point matches
- planar surfaces ⇒ degenerate cases for computing E, F

However, **line-based SfM not affected**.

Two-View Line-Based Pose Estimation



Point matches



Line matches, vanishing points

Main existing approach [1] (3-line):

- R estimated from 3 lines assumed s.t. $(L_1 \parallel L_2) \perp L_3$ ⇒Hyp. $\exists \perp$ vanishing directions / Hyp. $\exists$ enough triplets
- t estimated from line intersections ⇒ poor cues
- (R, t) refined from line intersections ⇒ information loss

Our approach (2x2-line):

- R estimated from 2 pairs of lines $(L_1 \parallel L_2), (L_3 \parallel L_4)$ ⇒ **no Manhattan-world assumption & $\exists$ many pairs**
- t estimated from line intersections **and/or points**
- (R, t) refined **from lines and points** using angular error

Robust Pose Estimation

- RANSAC-based framework
- **sampling of both lines and points** (mixed method)
- **unifying angular distance** for both lines and points

Robust and Parameterless Pose-Estimation

***A contrario* variant (AC-mixed):**

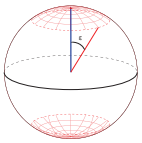
- **automatic RANSAC threshold**
- **single probabilistic framework** for both lines & points

$$\mathrm{NFA}(n,k,\epsilon) = 10(n-6)\binom{n}{k}\binom{k}{6}\mathrm{p}(\epsilon)^{k-6}$$

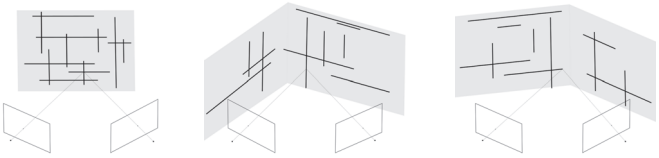
$$d_{\text{points}}(p_i, q_i) = \angle(Rp_i \times t, q_i \times t)$$

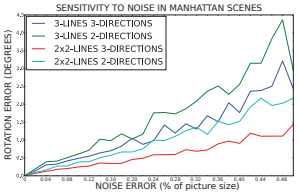
$$d_{\text{line}}(l_i, m_i, R) = \min_{L_j \parallel L_i} d_{\text{lines}}(l_i, l_j, m_i, m_j)$$

$$\mathrm{p}_{\text{line}}(\epsilon) = \mathbb{P}(d_{\text{line}}(l_i, m_i, R) \le \epsilon) = 1 - \cos\epsilon.$$

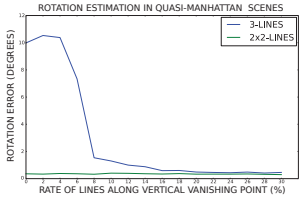


Experiments





Lesser sensitivity to noise



Robustness to non-Manhattan configurations

Dataset \ Method		5-point [2]	3-line [1]	2×2-line	mixed	AC-mixed
Strecha	R	**0.02**	0.46	0.25	0.19	**0.02**
	t	**0.18**	3.37	1.03	0.80	0.21
Office	R	6.88	6.45	1.03	1.01	**0.57**
	t	27.19	20.38	3.26	3.13	**1.44**
Building	R	0.23	6.68	0.49	0.24	**0.21**
	t	**0.31**	37.63	1.57	0.83	0.45
Car	R	**0.19**	24.25	2.37	0.75	0.24
	t	**0.20**	69.47	18.03	0.89	0.28

Residual errors: mixed (line-&-point) methods provide extra robustness while preserving accuracy

References

[1] A. Elqursh and A. Elgammal. Line-based relative pose estimation. In *CVPR*, 2011.

[2] David Nistér. An efficient solution to the five-point relative pose problem. *TPAMI*, 2004.