CBGL: Fast Monte Carlo Passive Global Localisation of 2D LIDAR Sensor

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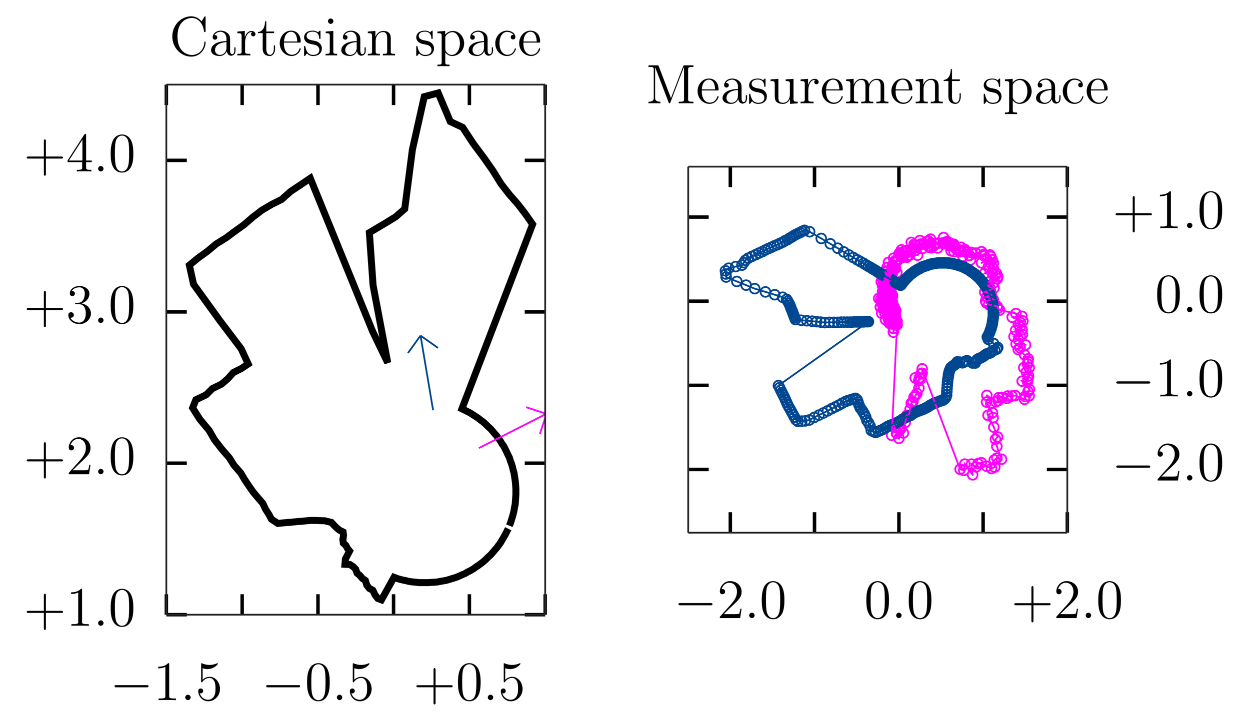
Setup & Motivation

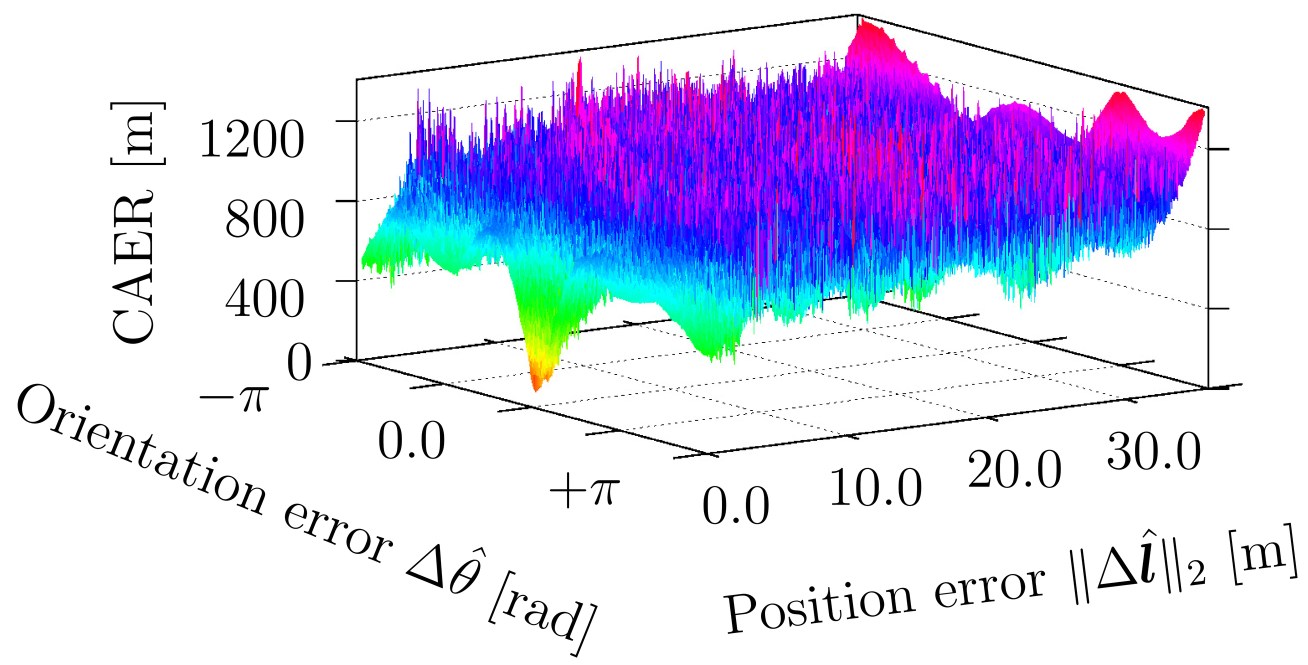


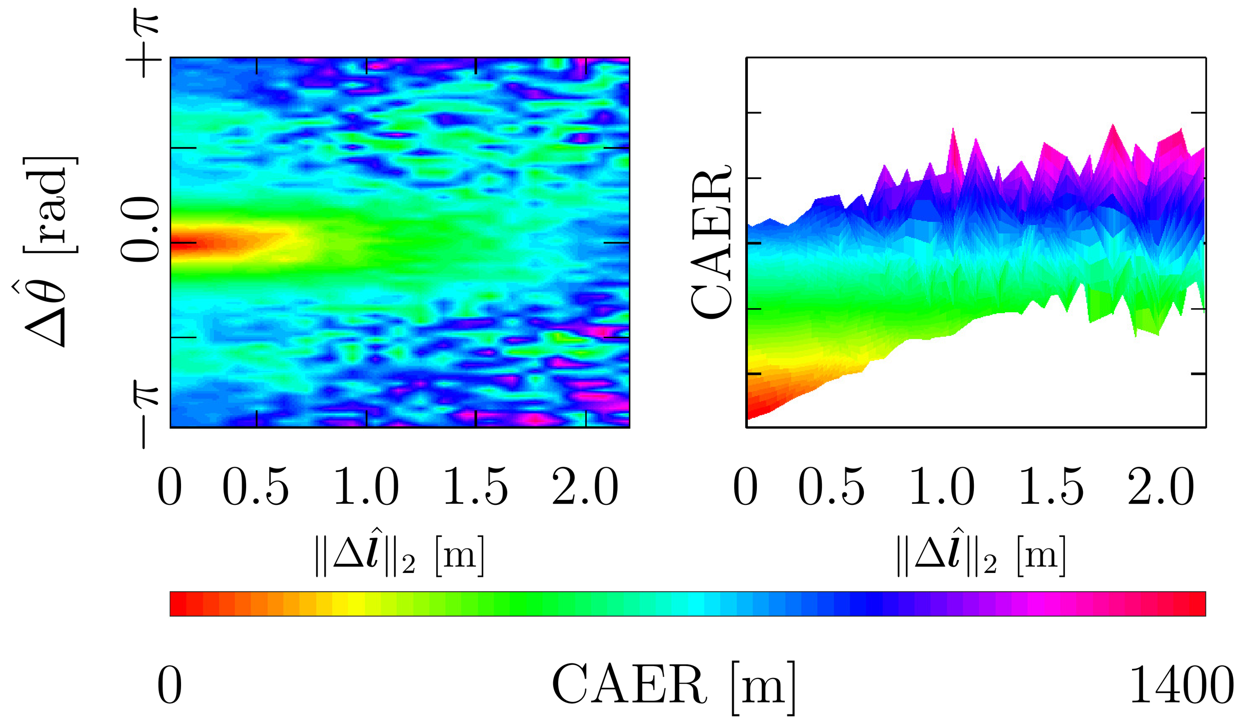
Unknown LIDAR pose $\boldsymbol{p}(x, y, \theta)$ and estimate $\hat{\boldsymbol{p}}(\hat{x}, \hat{y}, \hat{\theta})$. $\boldsymbol{p} - \hat{\boldsymbol{p}} = (\Delta\hat{\boldsymbol{l}}, \Delta\hat{\theta})$

Real $\mathcal{S}_R(\boldsymbol{p})$ and virtual $\mathcal{S}_V(\hat{\boldsymbol{p}})$ scans, in the local coordinate frame of each sensor

Definition 1. The Cumulative Absolute Error per Ray (CAER) metric

$$\text{CAER}(\mathcal{S}_R, \mathcal{S}_V) \triangleq \sum_{n=0}^{\text{scan rays}-1} \Big| \mathcal{S}_R[n] - \mathcal{S}_V[n] \Big| \qquad (1)$$





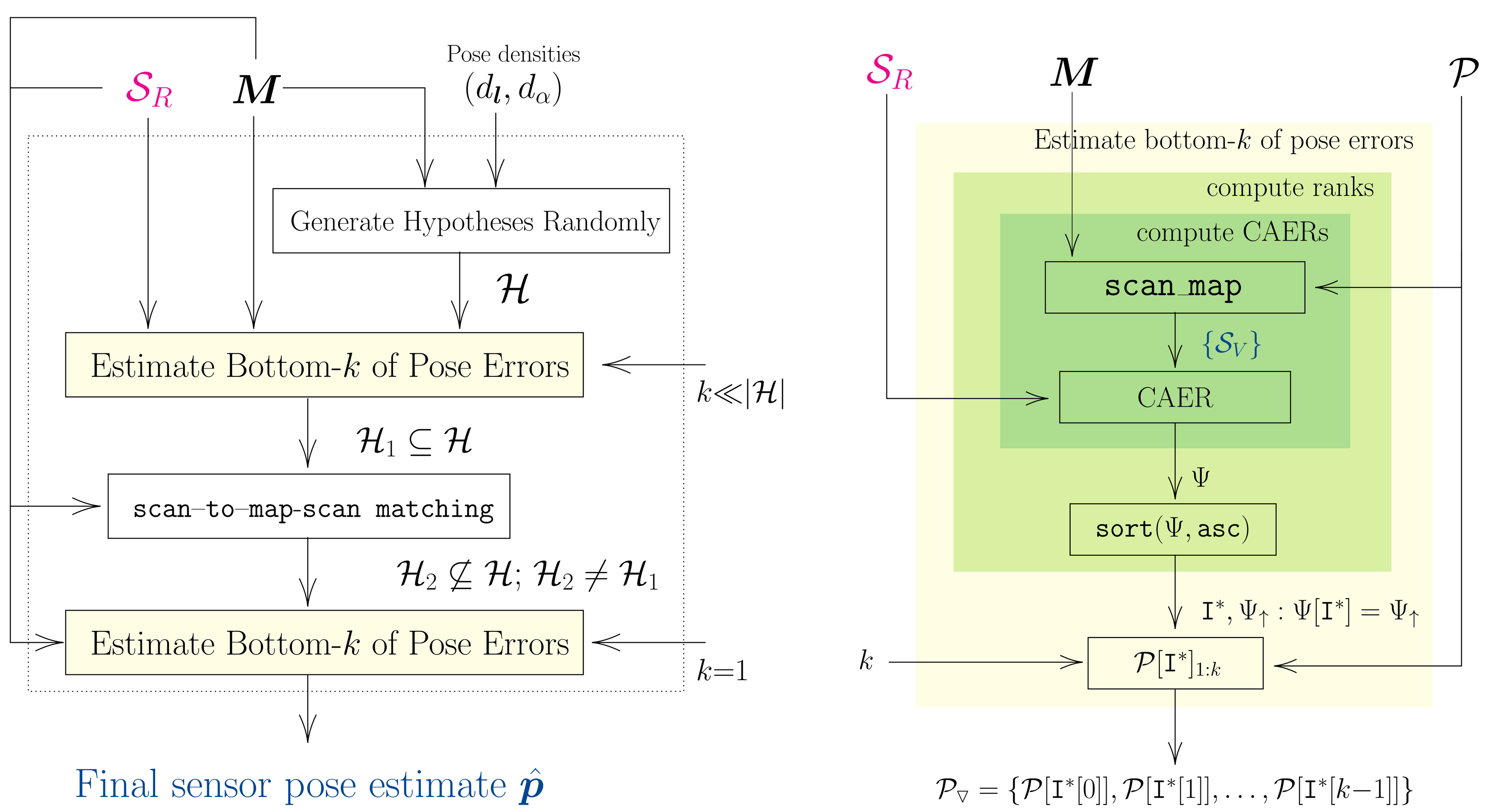
The gist

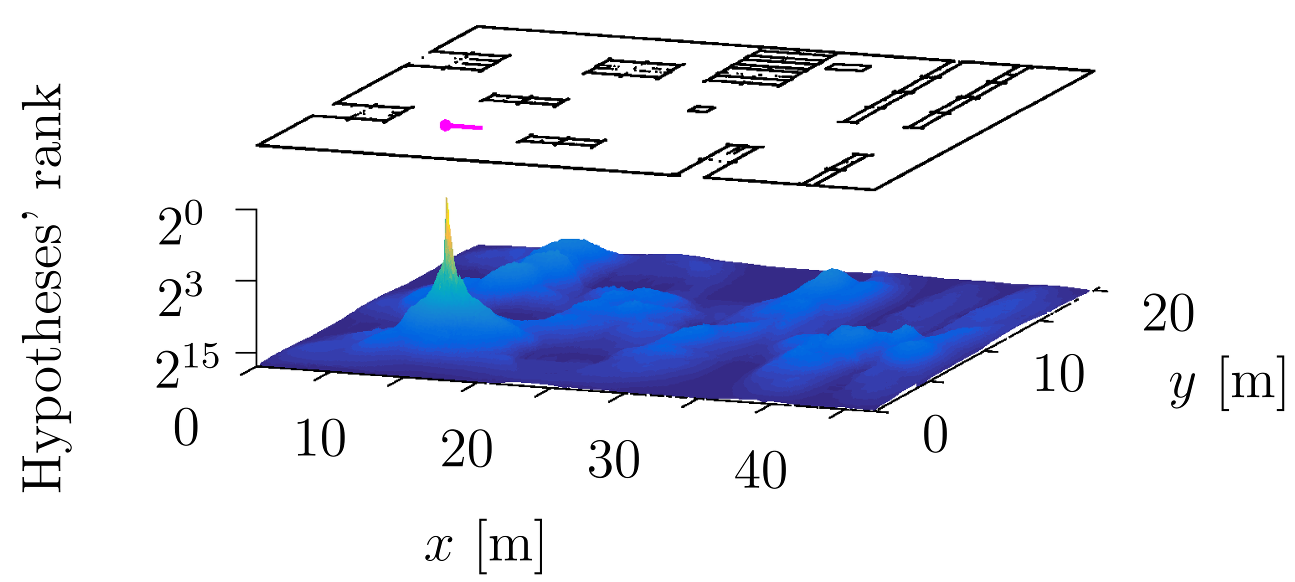
The method estimates the pose of a 2D LIDAR given only a single measurement and the map of the environment, while

- being robust against
  - environment repetitions
  - map distortions
  - sensor noise
  - sensor FOV (radial & angular)
- executing at ≈ 1 sec per 100 m^2 of environment area
- requiring no parameters to be tuned
- making no assumptions about the environment

because CAER (eq. (1) and left-hand bottom figures)

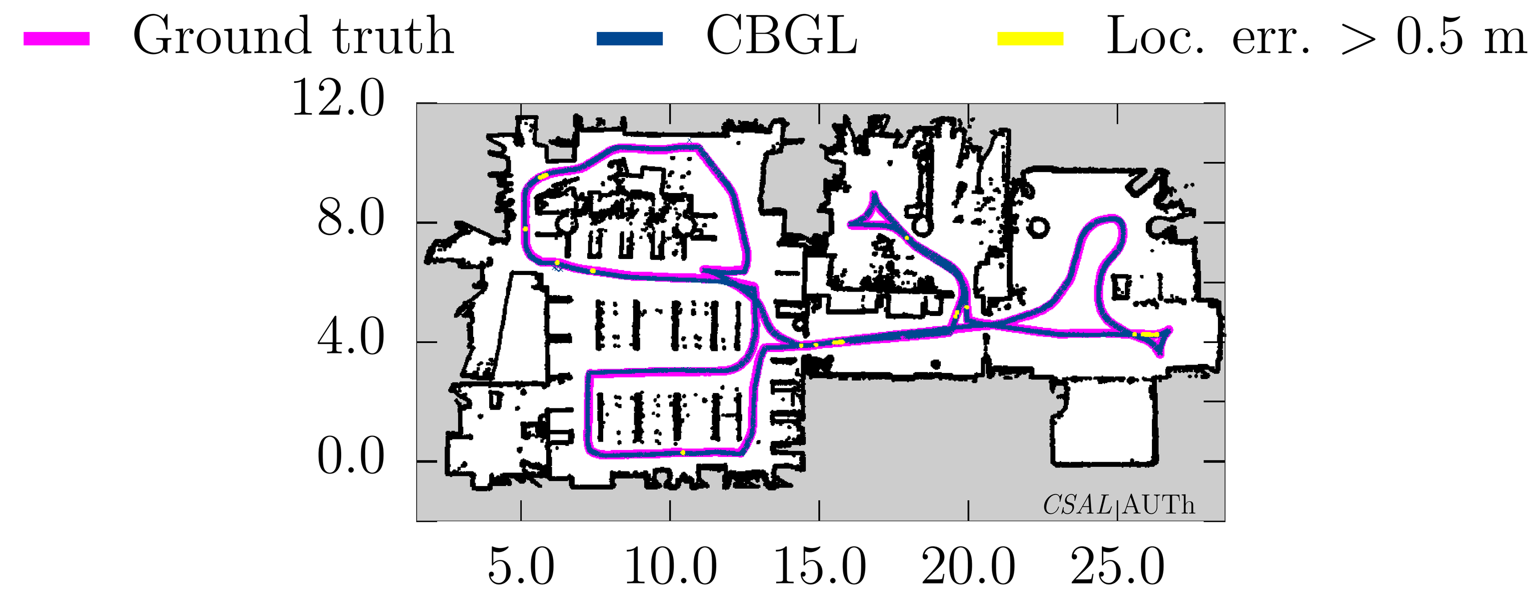
- scales with position and orientation error
- is computationally cheap at $\sim O$(sensor rays)

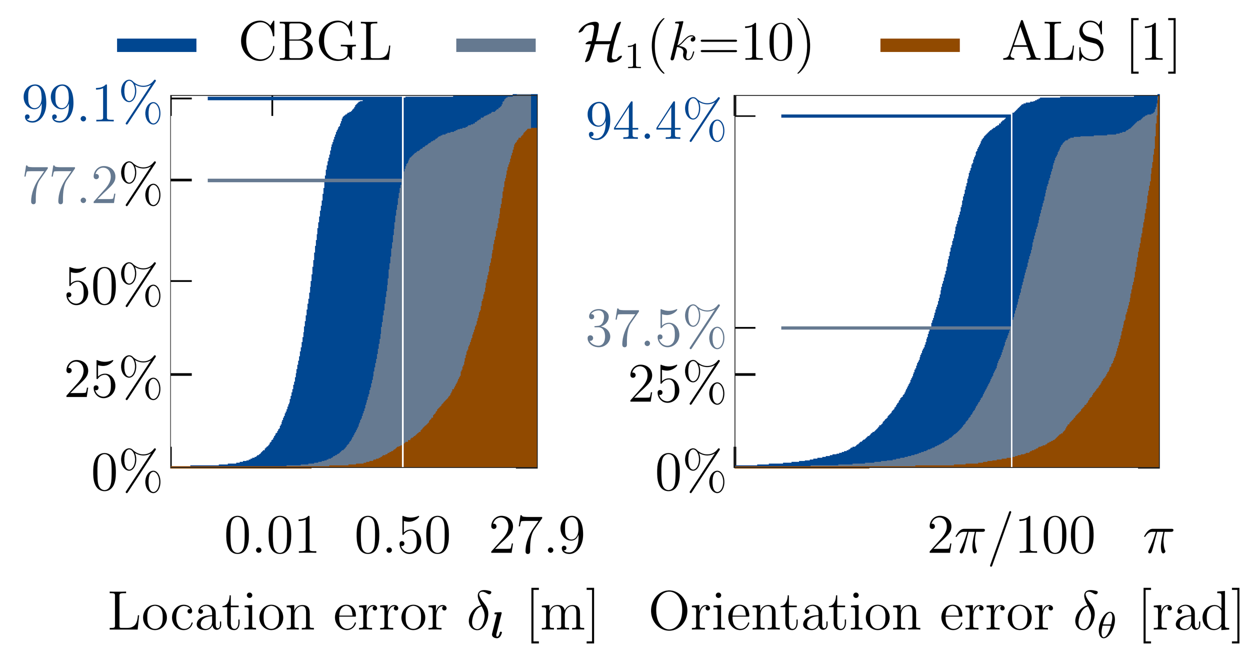


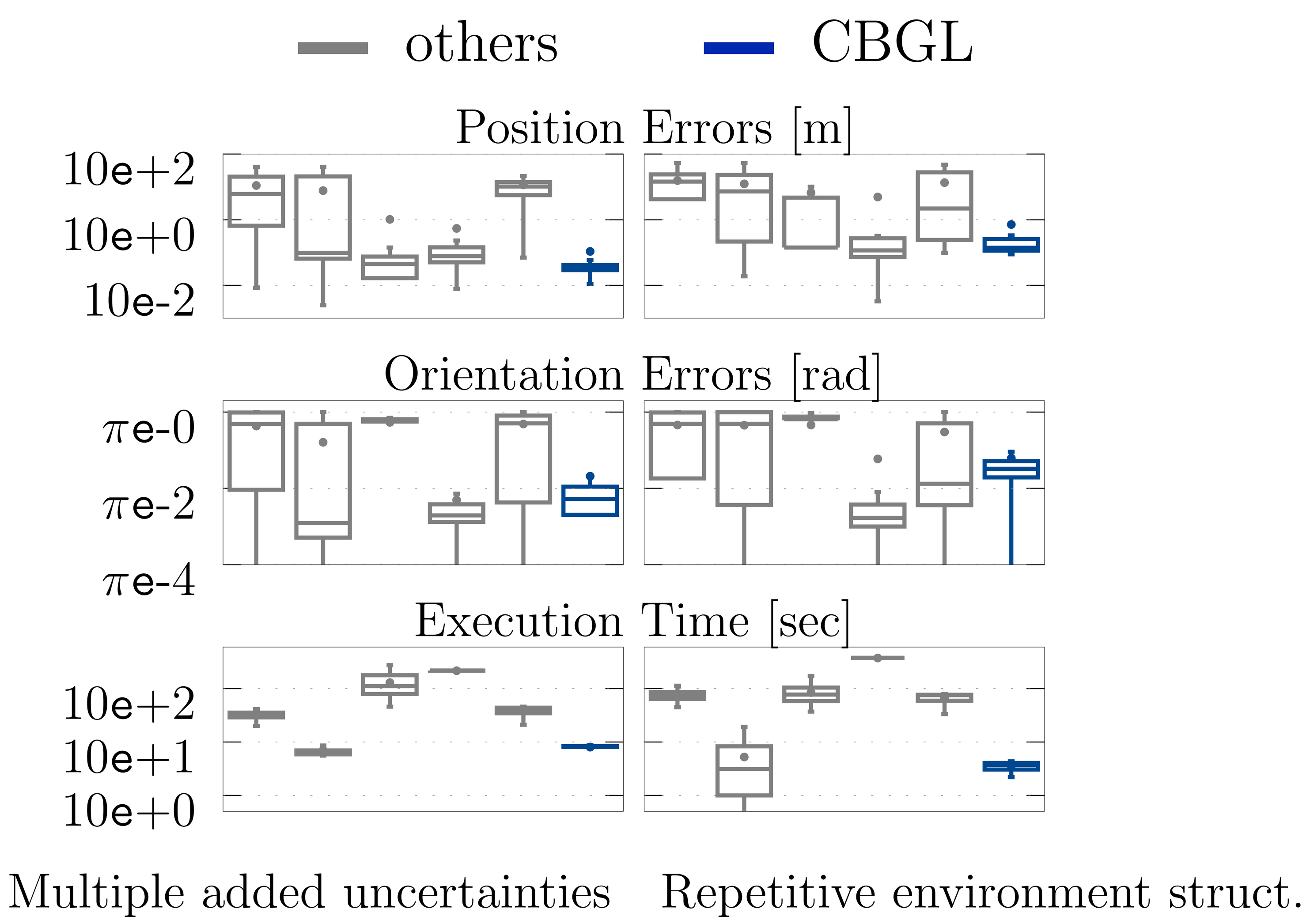


Experiments with real and synthetic data

	Position Error [m]		Orientation Error [rad]		Execution Time [sec]	
	Mean	std	Mean	std	Mean	std
ALS [1]	0.500	0.265	1.956	1.167	6.15	5.32
CBGL	**0.041**	**0.045**	**0.011**	**0.019**	**1.61**	**0.06**







[1] Naoki Akai, "Reliable Monte Carlo Localization for Mobile Robots", *Journal of Field Robotics*, 2023