ETH zürich — RSL Robotic Systems Lab — HAPTIC INTELLIGENCE MAX PLANCK INSTITUTE FOR INTELLIGENT SYSTEMS

Learning and Optimization for Reliable Robot Motion Estimation

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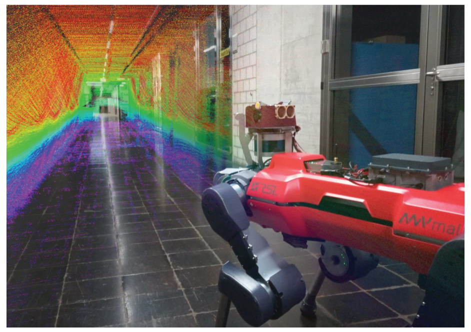
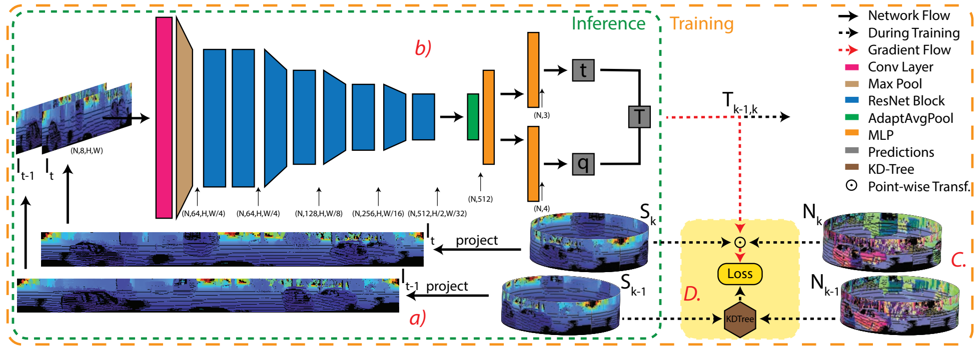
1 *Self-supervised Learning of LiDAR Odom (ICRA 2021)*

- Efficient utilization of data
- Geometric losses ONLY during training
- No labelled or GT data

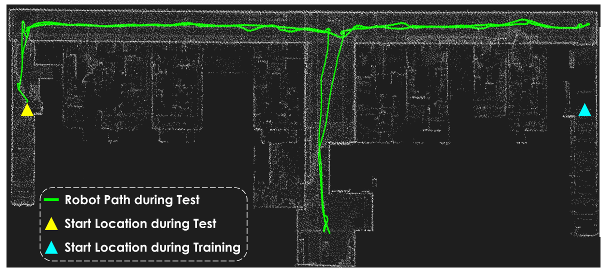
- Self-sup. network training
- Various experiments

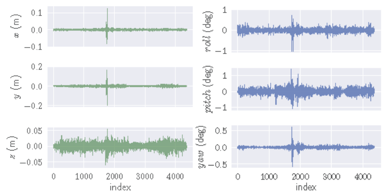


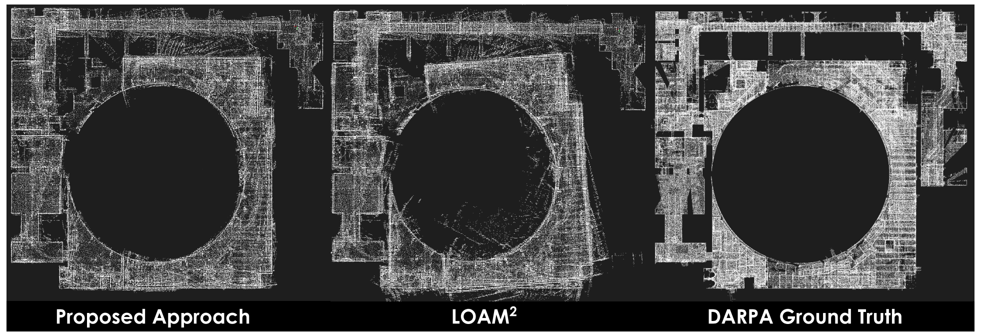
Approach



Results







KITTI Ablation Study

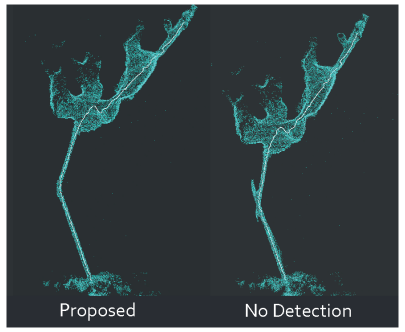
	Training 00−06		Test 07−10	
	t_{rel}	r_{rel}	t_{rel}	r_{rel}
p2pl + pl2pl	3.41	1.44	8.30	3.45
p2pl	6.47	2.72	8.90	4.00

https://github.com/leggedrobotics/delora https://youtu.be/rgeRseUTryA

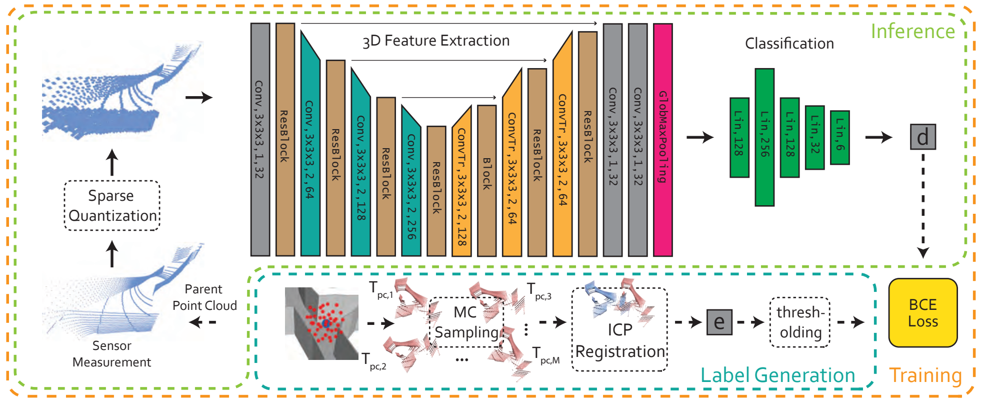
2 *Learning-based Localizability Estimation (IROS 2022)*

- Env.-Degeneracy → loc. failure
- Estimation on raw sensor meas.
- Underlying opt. not considered
- Generalization across envs/sensors

- NN-based estimation approach
- Only trained on simulated data



Approach



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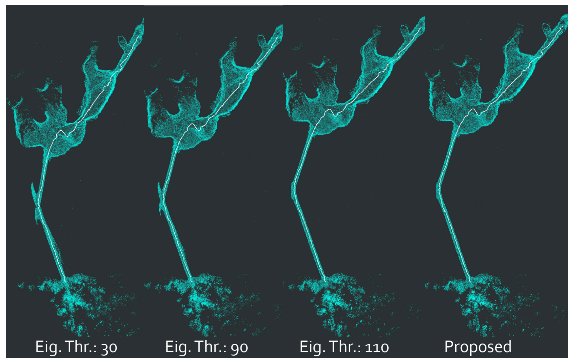
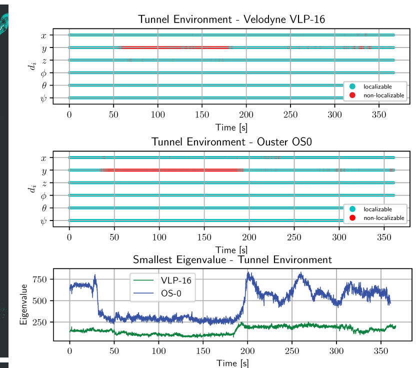
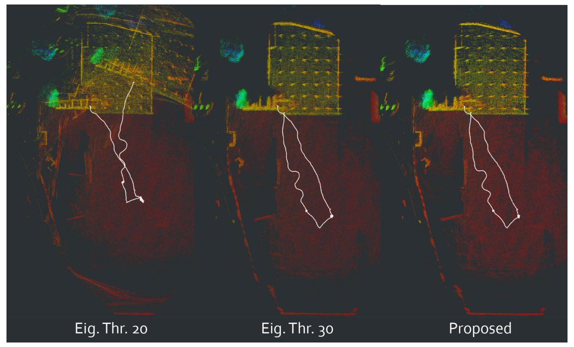
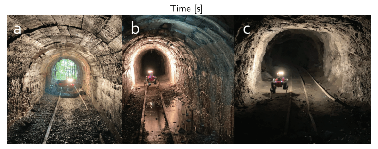
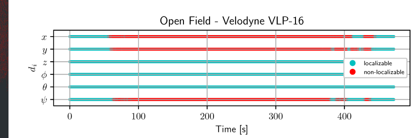








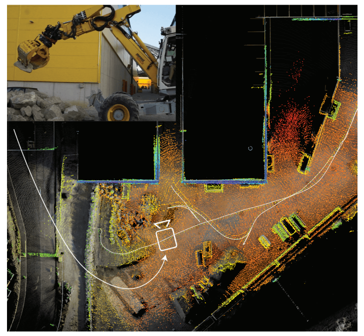


https://github.com/leggedrobotics/lidar_loc https://youtu.be/fm08PFwMO0c

3 *Graph-based Multi-sensor Fusion (ICRA 2022)*

- Fast-update rates for control
- Global accuracy for construction
- Smooth & consistent estimates
- Flexible (delay, meas. types)

- Opt.-based prediction-update loop
- Dual-graph design → switching



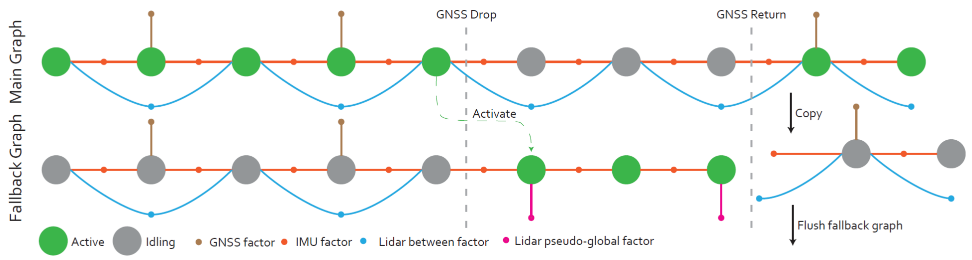
Method

State: $^{\mathtt{I}}\boldsymbol{x} \triangleq [\mathbf{R}_{\mathtt{WI}}, {}_{\mathtt{W}}\mathbf{p}_{\mathtt{WI}}, {}_{\mathtt{W}}\mathbf{v}_{\mathtt{WI}}, {}_{\mathtt{I}}\mathbf{b}^{g}, {}_{\mathtt{I}}\mathbf{b}^{a}] \in SO(3) \times \mathbb{R}^{12}$

$\mathbf{T}_{\mathtt{WO}} \in SE(3)$

$^{\mathtt{B}}\boldsymbol{x} \triangleq [\mathbf{R}_{\mathtt{OB}}, {}_{\mathtt{O}}\mathbf{p}_{\mathtt{OB}}, {}_{\mathtt{O}}\mathbf{v}_{\mathtt{OB}}] \in SO(3) \times \mathbb{R}^{6}$

MAP estimation $^{\mathtt{I}}\mathcal{X}_i^{\star} = \arg\max_{^{\mathtt{I}}\mathcal{X}_i} p(^{\mathtt{I}}\mathcal{X}_i | ^{\mathtt{I}}\mathcal{Z}_i) \propto p(^{\mathtt{I}}\mathcal{X}_0) p(^{\mathtt{I}}\mathcal{Z}_i | ^{\mathtt{I}}\mathcal{X}_i)$



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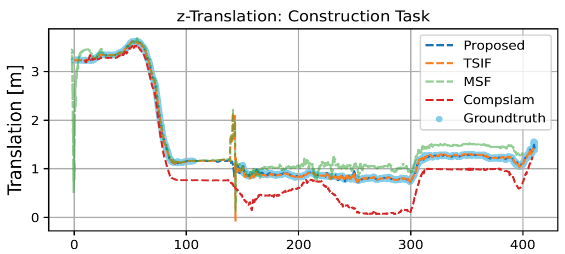
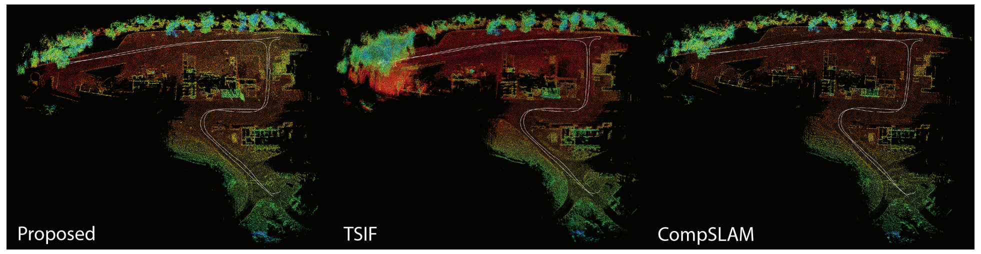


	μ	σ
Proposed	41μs	15μs
TSIF	102μs	40μs
MSF	33μs	19μs



https://github.com/leggedrobotics/GMFCL https://youtu.be/syTV7Ui36jg