Global Bird's Eye View Semantic Mapping

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Abstract

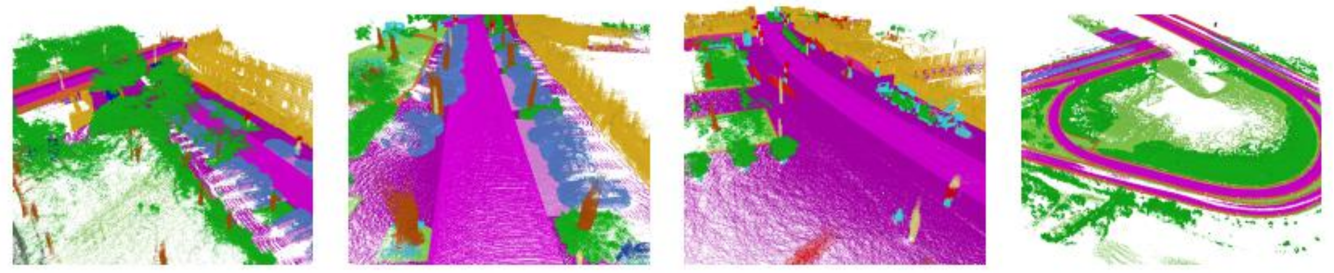
- We integrate AI-IMU[1] and MotionNet[2] to achieve robust localization and semantic scene understanding. AI-IMU dynamically adapts to varying sensor noise and motion patterns.MotionNet generates dense semantic BEV maps and effectively filters dynamic obstacles.
- Experimental validation on the SemanticKITTI dataset demonstrates strong robustness and accuracy in challenging scenarios, including dynamic objects and sensor dropout.

Motivation

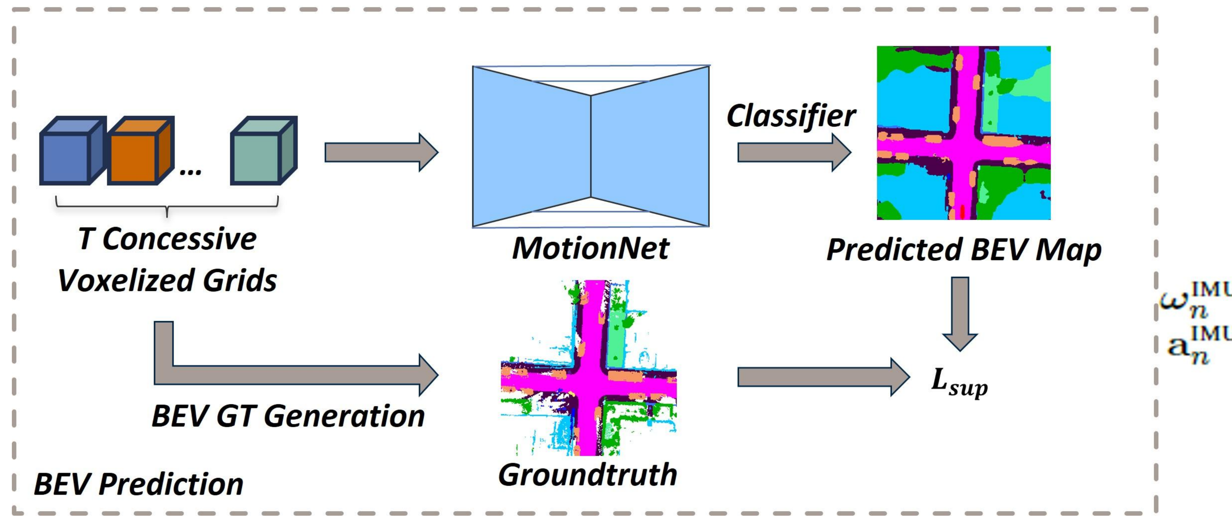
- LiDAR and vision-based SLAM systems tend to degrade significantly in the presence of occlusion, dynamic objects, and sensor dropout.
- IMUs suffer from drift and error accumulation when used in isolation.

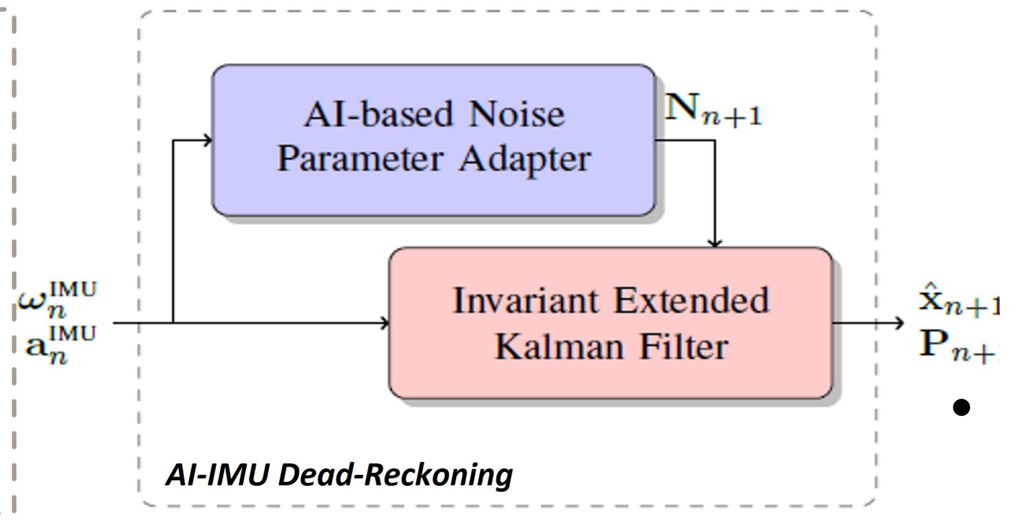
Data Sets

- We evaluate our method on the SemanticKITTI dataset

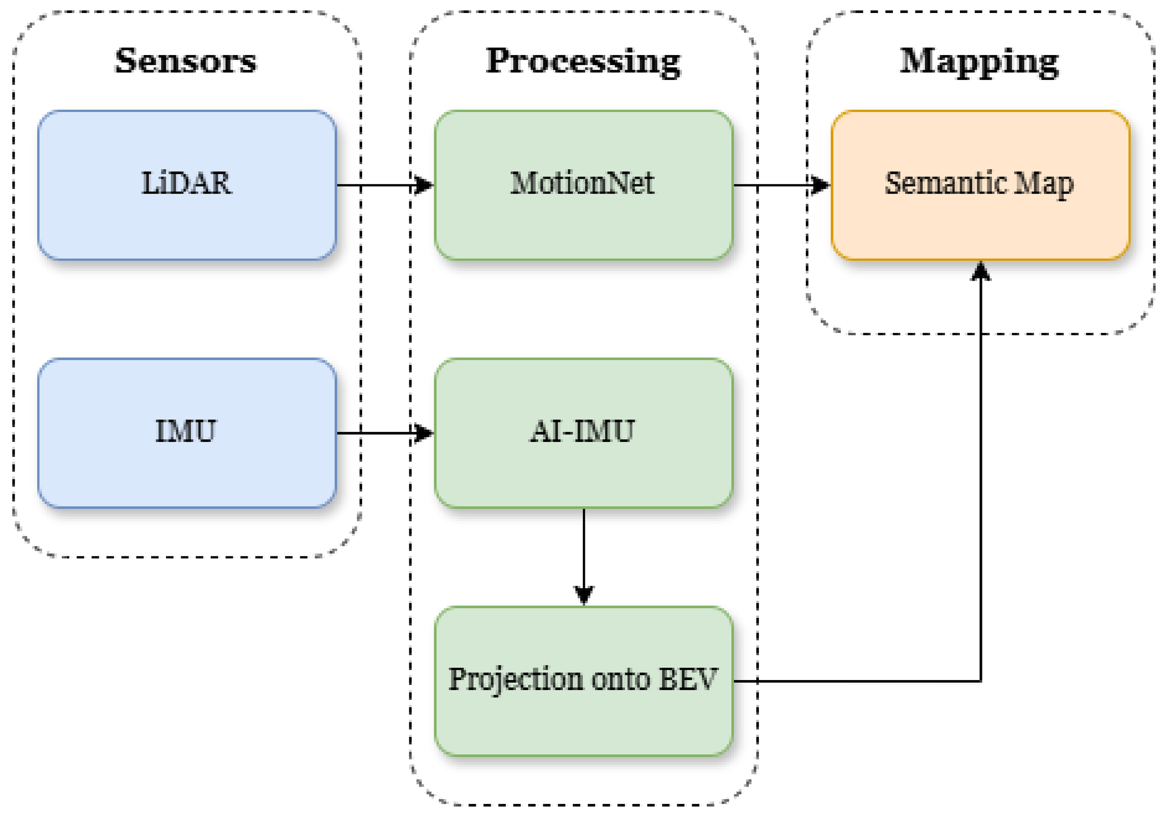


Methodology





- MotionNet processes LiDAR point clouds to produce accurate semantic BEV maps using a Spatio-Temporal Pyramid Network (STPN).
- AI-IMU employs an Invariant Extended Kalman Filter (IEKF) enhanced by CNN-adaptive pseudo-measurement covariance for precise IMU-based localization.



- Semantic maps from MotionNet are spatially aligned with accurate poses estimated by AI-IMU, enabling consistent semantic mapping.
- Our integrated framework effectively captures dynamic scenes and maintains robustness even when LiDAR or visual data are compromised.

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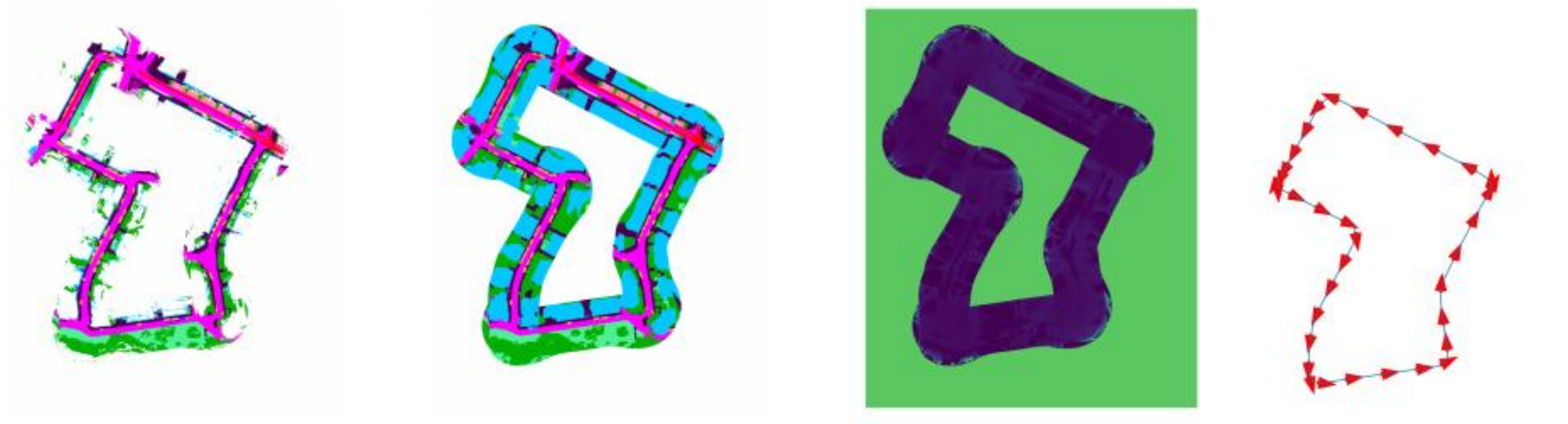
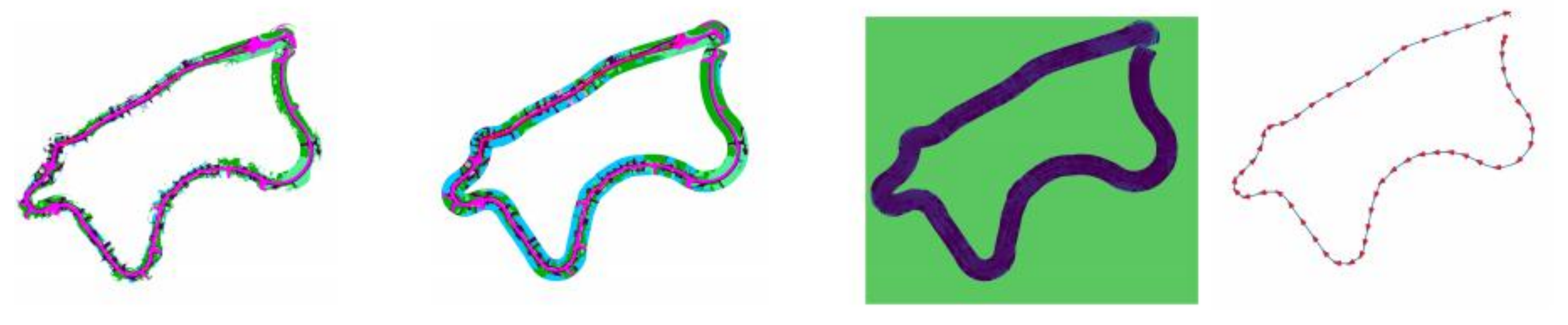
Results

Class ID	car	bicycle	road	parking	sidewalk	building	fence
Baseline IoU (%)	**74.8**	-	82.8	24.6	53.0	16.0	15.6
Ours IoU (%)	71.59	**15.62**	**87.09**	**61.32**	**67.07**	**19.63**	**29.63**
Class ID	vegetation	terrain	pole	traffic-sign	moving-car	moving-person	
Baseline IoU (%)	**49.3**	50.3	-	-	-	-	
Ours IoU (%)	45.91	**64.44**	**22.92**	**17.98**	**49.19**	**20.23**	
mIoU (%)			Ours (13 classes): 44.05		Baseline: 45.80		
mIoU on Baseline Classes Only (%)				Ours: 60.44			

- Our method improved IoU scores on crucial urban classes, such as roads, sidewalks, and terrains.
- Overall mIoU across all 13 classes was 44.05%, slightly below the baseline's 45.80%. When evaluating only classes present in the baseline, our approach notably outperformed, achieving an mIoU of 60.44%.
- These results highlight our model's strong capability in critical urban segmentation scenarios.



(a) Ground Truth Semantic Map (b) Predicted Semantic Map (c) Prediction Variance (Uncertainty) (d) Trajectory with Heading Angles



(a) Ground Truth Semantic Map (b) Predicted Semantic Map (c) Prediction Variance (Uncertainty) (d) Trajectory with Heading Angles

[1] M. Brossard, A. Barrau, and S. Bonnabel, "Ai-imu dead-reckoning,"IEEE Transactions on Intelligent Vehicles, vol. 5, no. 4, pp. 585–595,2020
[2] P. Wu, S. Chen, and D. N. Metaxas, "Motionnet: Joint perceptionand motion prediction for autonomous driving based on bird's eyeview maps," in Proceedings of the IEEE/CVF Conference on ComputerVision and Pattern Recognition (CVPR), June 2020