# IMPROVE PERFORMANCE ON JUNCTION SCENARIOS VIA IMM FILTERING

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## ABSTRACT

This work presents an Interacting Multiple Model (IMM) filter for multi-object tracking (MOT) in autonomous driving, combining Constant Velocity (CV) and Constant Turn Rate Acceleration (CTRA) motion models. The filter adaptively switches between models based on mode probabilities and likelihoods, improving performance in turning scenarios. Evaluated on junction-focused sequences from the KITTI benchmark, the proposed IMM consistently outperforms standalone CV and CTRA filters across key metrics, including detection accuracy, association accuracy, and HOTA. These results highlight the benefit of model fusion in handling complex motion dynamics.

**Keywords:** *Multi-Object Tracking,IMM filter, Junction Scenarios*

## Introduction

Multi-object tracking in autonomous driving must handle a wide range of motion behaviors. Filters based solely on CV are effective on straight paths but often fail in junctions. While CTRA improves curvilinear motion handling, it lacks generalization. To address this, we apply an IMM filtering framework [1] that combines CV and CTRA models to adaptively switch based on object behavior, improving performance in dynamic turning scenes.

## Materials and Methods

Building on the MCTrack baseline [2], we integrate CV and CTRA motion models within an EKF-based IMM structure. Model transition probabilities and likelihood-based updates are performed at each time step to estimate the most suitable motion model for the current object state. As illustrated in Figure 2, the IMM filter uses both models in parallel, with their outputs fused using mode probabilities. The data interaction block handles mixing, prediction, and state update, enabling the filter to adapt dynamically changing object motions.

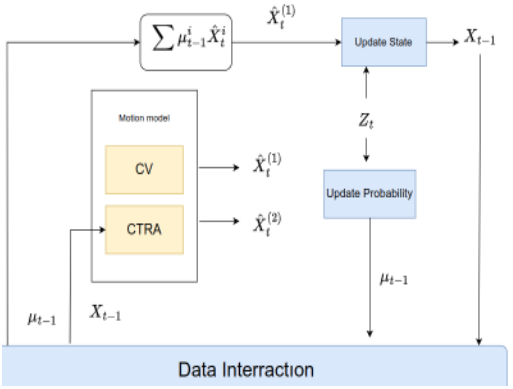



*Figure 1 : Architecture of IMM*

## Results and Discussion

As illustrated in Table 1, the IMM filter performs better than CV-only and CTRA-only filters in turning scenarios such as Scenes 12 and 15. It achieves higher values in metrics: HOTA (a unified score balancing detection, association, and localization), DetA (detection accuracy), AssA (ID consistency), and LocA (spatial alignment). For instance, in Scene 12, IMM achieves a HOTA of 82.51, outperforming CV (82.28) and CTRA (81.48). Gains in detection and association precision (DetPr, AssPr) further confirm that the adaptive nature of IMM contributes to overall tracking consistency.

*Table 1: Table comparison (IMM and single model filters)*

| | Scene | HOTA | DetA | AssA | DetRe | DetPr | AssRe | AssPr | LocA |
|---|---|---|---|---|---|---|---|---|---|
| IMM(CV-CTRA) | 12 | 82.51 | 81.44 | 83.71 | 83.70 | 92.78 | 85.03 | 94.70 | 91.85 |
| | 15 | 83.22 | 82.33 | 84.29 | 85.00 | 89.11 | 86.82 | 90.95 | 88.49 |
| CV | 12 | 82.28 | 81.30 | 83.34 | 83.66 | 92.74 | 84.73 | 94.37 | 91.63 |
| | 15 | 83.08 | 82.14 | 84.21 | 84.86 | 88.96 | 86.74 | 90.83 | 88.36 |
| CTRA | 12 | 81.48 | 80.07 | 83.10 | 82.78 | 91.76 | 84.62 | 94.18 | 91.05 |
| | 15 | 83.18 | 82.24 | 84.26 | 85.11 | 89.23 | 86.85 | 90.86 | 88.58 |

## Conclusion

The proposed IMM filtering approach improves tracking performance in junction scenarios by combining the strengths of CV and CTRA models. Evaluated on the KITTI dataset, the method improves accuracy in detection, association, and HOTA, making it suitable for real-world autonomous systems.

## References

[1] H. A. P. Blom, "An efficient filter for abruptly changing systems," *IEEE*, 1984.

[2] X. Wang *et al.*, "MCTrack: A unified 3D multi-object tracking framework,"*arXiv preprint arXiv:2401.12345*, 2024.