Synopsis

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Analysis of traffic flow under disordered traffic conditions is particularly important in developing countries such as India, where weak lane discipline and mixed traffic streams prevail. This study presents an empirical investigation of traffic flow dynamics in disordered traffic conditions using Unmanned aerial vehicle (UAV) vehicle trajectory data. To ensure the reliability of the extracted trajectories, a tracking accuracy evaluation was first conducted by comparing the automatically tracked trajectory data with manually generated ground truth data. The results demonstrated satisfactory accuracy, establishing the suitability of the trajectory data for detailed traffic flow analysis.

Traffic flow dynamics under disordered traffic conditions were examined using both microscopic and macroscopic analytical frameworks.At the macroscopic level, traffic flow behaviour was analysed using a two-dimensional framework that incorporates both longitudinal and lateral vehicle movements. Fundamental diagrams were developed in both directions using extended two-dimensional definitions based on Edie's formulation, enabling simultaneous characterization of longitudinal progression and lateral manoeuvring of vehicles. This approach provides a more realistic representation of disordered traffic behaviour compared with conventional one-dimensional traffic flow analysis.

At the microscopic level, vehicle interaction characteristics such as desired time gap and minimum lateral gap were estimated to understand driver behaviour and interaction mechanisms under mixed traffic conditions. The analysis showed significant variations in interaction characteristics across different vehicle categories, reflecting the complex and adaptive nature of vehicle movements in lane-free traffic environments.

The study shows that traffic flow under disordered, lane-free conditions is inherently two-dimensional, with both longitudinal and lateral movements influencing overall traffic behaviour. Macroscopic analysis indicated that lateral movements persist even under congested conditions, while congestion waves propagated upstream at speeds of 12.5 to 16.4 km/h despite weak lane discipline. Microscopic analysis revealed significant variation in interaction behaviour across vehicle categories, with smaller vehicles maintaining lower desired time gaps and performing more frequent lateral adjustments. Overall, the findings highlight that traffic behaviour in mixed traffic streams is governed by the combined effects of vehicle heterogeneity, lateral dynamics, and local vehicle interactions.

Overall, the study establishes a data-driven framework that links microscopic vehicle interactions with macroscopic traffic behaviour under mixed and lane-free traffic conditions. The findings emphasize the importance of incorporating lateral dynamics and realistic interaction mechanisms in traffic flow modelling and provide an empirical basis for the calibration and validation of advanced traffic flow models under disordered traffic conditions.