# Developing Automated Trajectory Aggregation and Safety Indicator Analysis Techniques for multi-modal Traffic Data


## Bachelor‘s Thesis of Cheuk Wun Lo

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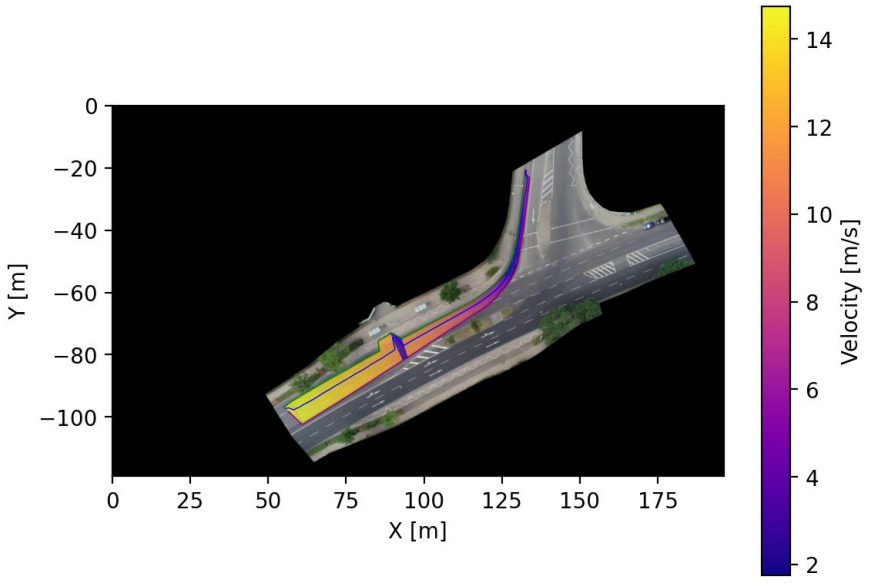


Fig. 1 Example of Trajectory Aggregation

A major challenge in this study is dealing with the complex behaviour of road users at 2D intersections. To simplify the analysis, all trajectories are transformed onto a curvilinear coordinate plane (Fig. 2). In this system, the reference path serves as the horizontal axis, while the perpendicular distance from the path forms the vertical axis. This transformation enables a more linear approach to analysing traffic behaviour.

All relevant data—such as lateral distance distributions, mean trajectories, and average velocities—are first calculated in this curvilinear plane. The results are then mapped back to the Cartesian plane for final visualization. Road segments are divided into small intervals along the S-axis, values are computed within each interval and allowing detailed, micro analysis of traffic patterns. This method effectively captures common driving behaviours like deceleration before entering a conflict zone and positional shifts when turning, while also identifying anomalies, such as sudden drops in velocity (Fig. 1) due to buses slowing down when approaching nearby bus stops.

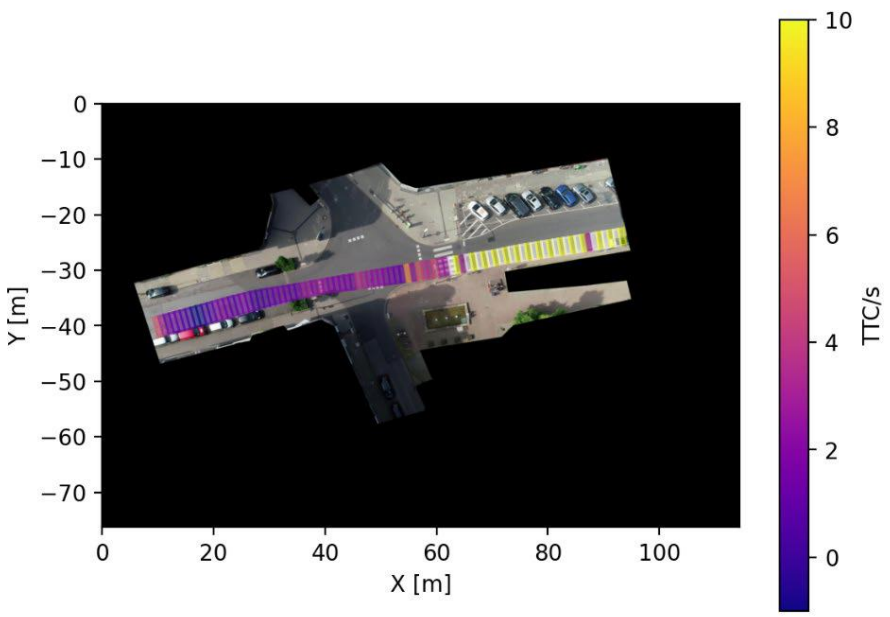


Fig. 3 Example of Safety Indicator

This thesis presents the development of an automated system for trajectory aggregation and safety indicator analysis using multi-modal traffic data. The primary goal is to facilitate road safety assessments, especially at intersections, by visualizing data collected from drones. The system combines trajectory aggregation techniques with Surrogate Safety Measures (SSMs), focusing on 2D Time-to-Collision (2D-TTC) as the core safety metric. Trajectories are aggregated to provide a summarized view of traffic behaviour, while the 2D-TTC metric predicts potential collision risks without relying on actual accident data.

The methodology was applied to datasets from the Intersections Drone Dataset (InD) and the University Drone Dataset (UniD). It involved pre-processing map data, transforming trajectory data into a curvilinear coordinate system, and visualizing aggregated results. The results showcase the ability to identify patterns, anomalies, and potential collision risks, thus providing an intuitive tool for traffic safety researchers.

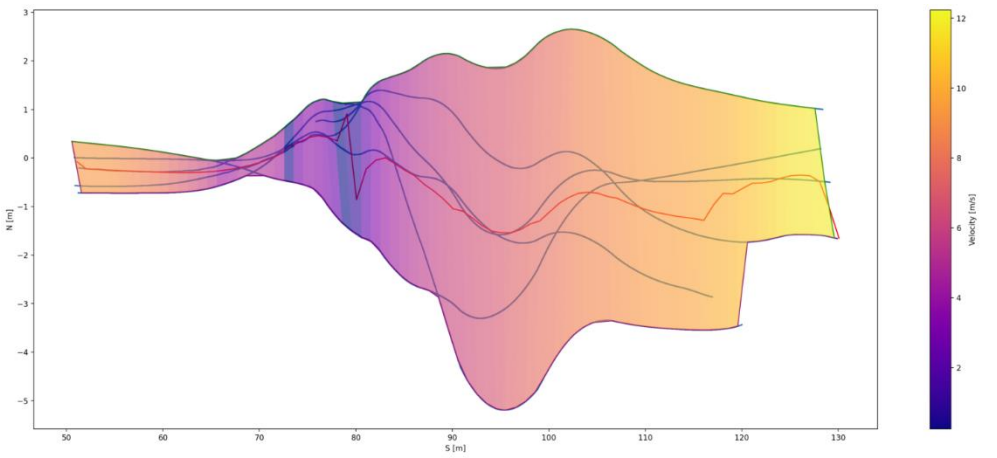


Fig. 2 Curvilinear Coordinate Plane

The safety indicator module uses similar visualization techniques to those applied in trajectory aggregation, with an intermediate step of plotting on the curvilinear coordinate plane. By combining the results from trajectory aggregation with safety indicators, we can derive valuable insights from the visualization of the 2D Time-to-Collision (2D-TTC) values. In this example (Fig. 3), a prolonged region of low-TTC appears before vehicles exit a major intersection. This pattern emerges due to the neighbouring minor streets being a Fahrradstraße (bicycle street) and the intersection's location within a residential area. The high volume of cyclists and pedestrians in this area forces vehicles to drive cautiously, which is reflected in the visualization.

We hope the visualization tool can give users a quick, intuitive insight into each road segment and encourage them to further investigate areas that exhibit abnormal patterns. Such a tool can have a wide range of applications, from improving urban traffic planning to enhancing safety in high-risk areas. It can also assist policymakers and engineers in identifying potential hazards before accidents occur, enabling proactive interventions.