INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	**SUVIN P. V.**
Roll Number	:	**166104028**
Programme of Study	:	**Ph.D.**

Thesis Title:
Trajectory-Based Proactive Safety Assessment of Road Traffic

Name of Thesis Supervisor(s)	:	**Mallikarjuna C.**
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SHORT ABSTRACT

The economic and social transformation has led to rapid growth in mobility demand leading to a growth in vehicle usage, which is further aggravated by ever-increasing urban sprawl and new commuting needs. Subsequently, several negative externalities of transportation systems, including congestion, road crashes, and pollution, arise, which are considered fundamental challenges of modern times. Researches have been conducted across the world to achieve zero fatalities or minimal severity on roads. Earlier studies have primarily depended on the historical crash reports for the road safety assessment. However, they were not successful in capturing the actual crash risk due to various limitations of the crash data. The proactive safety analyses, using an indicator that captures easily detectable and frequent unsafe events as a surrogate to the crash, is a better alternative for safety assessment.

Proactive safety assessment requires extensive but precise trajectory data. Researchers are collecting traffic videos to investigate realistic driving behavior. However, converting traffic videos into relevant traffic data is difficult. This study addresses the current issues of video-based microscopic traffic data extraction by developing a tool called Semi-Automated VEhicle Trajectory eXtractor (SAVETRAX). Nevertheless, deriving useful information from the observed trajectory data requires certain pre-processing to handle the noises added at several stages of the data collection. The present study proposes an adaptive and data-driven path smoothing technique that can universally be applied to the video-based path data obtained from any camera platform (drone or fixed camera setup). The proposed reconstruction framework works in three stages; in the first stage, the data is prepared by resampling any missing data. Also, any outlier in the observed path data is identified and removed at this stage. In the second stage, a Recursively Ensembled Low-Pass (RELP) filter is proposed to handle the `heavily tailed' noise found in the video-processing-based trajectory data, particularly for drone videos. A robust adaptive Gaussian kernel smoothing is applied in the third stage to have a localized reconstruction. For Kernel smoothing, the smoothing parameters such as the optimal bandwidth and polynomial order are estimated using the proposed grid-search algorithm. The parameter estimation process ensures that the bias and variance are perfectly traded-off to achieve a

smooth vehicle path. Notably, the proposed approach does not cause any over/under-smoothing. Therefore, the critical traffic incidents are not misinterpreted, which is crucial for proactive safety assessments.

Surrogate Safety Measures (SSMs) are widely used for the proactive assessment of potential crash risk. The majority of the existing SSMs are fundamentally designed to capture the rear-end collision risk. However, in reality, the traffic dynamics involve the simultaneous interaction of multiple vehicles on a 2-dimensional (2D) surface, which results in a broad spectrum of collision patterns, such as head-on, sideswipe, rear-end, angled, and run-off-road collisions. It is essential to reckon all crash occurrences, irrespective of their patterns, to capture the overall risk. This study proposes a novel 2D SSM called Anticipated Collision Time (ACT) to capture the overall risk. This study also introduces another safety indicator derived from the ACT profile called Time of Evasive Action (TEA). TEA primarily captures the time at which a vehicle commences to respond, in terms of deceleration, when it encounters an unsafe situation. Such a measure helps to understand the response pattern of different vehicles/drivers to a potential collision. We also derived Time Exposed ACT (TE-ACT) and Time Integrated ACT (TI-ACT) from the ACT profile to capture the crash exposure and severity, respectively.

Four case studies were used to evaluate the proposed tool and measures. First, the safety of lane changes was assessed. To this purpose, we devised a system for identifying and classifying lane changes into interrupted and uninterrupted. We discovered that these two-lane change operations are distinct. The safety of PTWs in an urban environment was also studied using trajectory data from a busy midblock section. The likelihood of a PTW being involved in a crash is double that of any other vehicle type. PTWs are found more vulnerable to sideswipe collisions. The analysis of vehicles' safety at horizontal curves superimposed with vertical alignments revealed that the vehicles are more vulnerable to run-off-road crashes at such geometries; thus, installing adequate crash barriers or warning systems is necessary to reduce fatalities. The correlation analysis of different crash types with various road geometric variables shows that the design parameters exhibit a contradicting correlation when modeling different crash types. Further, a network-level proactive safety assessment was performed. The results indicate that it is essential to properly integrate the crash frequency, exposure, and severity for identifying a hot spot on a transportation network.