Title: Behaviour Analysis Using A Multi-Level Motion Pattern Learning Framework

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Keywords: surrogate safety analysis, motion patterns, scene interpretation, video analysis, motion prediction, time series

The increasing availability of video data, through existing traffic cameras or dedicated field data collection, paves the way for the collection and analysis of massive datasets about the microscopic behaviour of road users using computer vision techniques. Our work aims to propose an effective and generic framework for surrogate safety analysis and the understanding of collision processes. New algorithms for multi-level motion pattern learning are proposed that enable automated scene interpretation, anomalous behaviour detection and surrogate safety analysis. Firstly, a novel method used to detect interest zones (Entry/Exit zones, occluded zones, and noisy zones due to failures of the video analysis) through a Gaussian mixture model and the Expectation Maximization (EM) algorithm. These interest zones are used to identify static occlusion zones, filter trajectories, connect divided trajectories and speed up motion learning and prediction models. Secondly, motion patterns are extracted in two levels using spatial and temporal information. Finally, the learnt motion patterns are used to detect anomalous behaviour and predict future behaviour. The multi-level framework successfully learns the motion patterns and speeds up the processing run time.

For surrogate safety analysis, motion prediction methods are needed to identify whether two road users are on a collision course and to compute several continuous surrogate safety indicators such as the time to collision (TTC). The default and unjustified method used in much of the literature is prediction at constant velocity. We propose a generic framework to predict the road users’ future positions depending on different extrapolation hypotheses, for example sampling distributions of acceleration and direction and applying motion patterns learnt from observations. While the current interpretation of continuous safety indicators overwhelmingly relies on only one indicator value at a given time to qualify the whole interaction, e.g. the minimum TTC, we analyze the whole time series or profiles of the indicators to find similarities between interactions with and without a collision. We propose a new similarity measure for time series that is applied to surrogate measures of safety and other indicators characterizing road user interactions. The new similarity measure based on the longest common sub-sequence is paired with a custom clustering algorithm that does not require to set the number of expected clusters and remains interpretable through the use of prototype indicator profiles as cluster representatives. This framework is demonstrated on two real world case studies with different sources of noises.