Human Error in Traffic: Understanding Failures Beyond Accidents with AI

The classical approach to traffic safety has long been centred on accident data, relying on correlations rather than causation to identify risk factors. Causality is often inferred through Crash Modification Factors (CMFs), providing a data-driven method to estimate the impact of various road safety interventions. However, waiting for accidents to occur to analyse safety issues is inherently reactive and inefficient.

The emergence of surrogate measures of safety (SMoS) has allowed researchers to analyse near-miss events and behavioural interactions, moving towards a more predictive approach. Instead of reacting to accidents, SMoS and Extreme Value Theory (EVT) enable a shift in paradigm—actively predicting possible accident scenarios to prevent them before they occur. While SMoS effectively enable relative safety comparisons between different sites, early attempts to directly correlate these measures with accident frequency were unsuccessful due to oversimplified linear assumptions.

To enhance predictive accuracy, EVT has been employed as a possible approach to a more reliable accident frequency estimation. However, it has never found a concrete application since the introduction of AI algorithms for video data analysis. The combination of the computational power of AI for data extraction and the EVT enables the estimation of accident frequencies and severities but also operates independently of historical accident records, ensuring proactivity. Furthermore, it remains applicable across different vehicle types and varying levels of connectivity and automation.

However, two critical challenges persist. First, on a technical level, there remains a fundamental question: what constitutes a genuinely safety-relevant event? The effectiveness of SMoS hinges on accurately identifying and measuring these events. Second, from a practical perspective, determining causality remains a complex task.

Simulation-based approaches provide a valuable tool for addressing these challenges by analysing when and why human failures occur. The key premise is that accidents result from mistakes—errors in judgment induced by external conditions or cognitive misjudgments. By comparing a driver's decision-making process to external observations, we can better understand the nature of these errors and their role in severe traffic outcomes.

This keynote will explore how combining SMoS, advanced data analytics, and simulation-based modelling can even more contribute to transforming traffic safety from a reactive discipline into a proactive strategy—shifting the focus from analysing past accidents to predicting and preventing future ones.