Construction of an Automatic Driver Modeling System Based on Fuzzy Inference from Vehicle Trajectory Data

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Abstract: This study develops an automatic driver behaviour modelling system based on fuzzy inference, utilizing real-world vehicle trajectory data. Vehicle speed and headway distance were estimated from roadside video footage through YOLO-based detection combined with camera height and angle calibration. These quantitative measures were converted into linguistic variables (e.g., slow/medium/fast for speed, near/medium/far for headway), with corresponding membership functions and inference rules designed. A pilot experiment demonstrated the system's ability to preliminarily classify driver types, such as commuters and tourists. The proposed approach provides a flexible and interpretable framework for traffic analysis and driving behaviour prediction.

Keywords: *fuzzy inference, driver modelling, Vehicle trajectory data, traffic analysis*

1. INTRODUCTION

Understanding driver behaviour is fundamental to traffic flow analysis and road safety improvement (Maekawa et al., 2022). Traffic performance is shaped by diverse driving styles—for example, commuters who emphasize efficiency, tourists who adopt more cautious behaviour, and taxis that frequently accelerate or change lanes.

Traditional approaches, such as statistical models and micro-simulations, have contributed valuable insights but often fall short in representing the uncertainty and variability inherent in human driving. Fuzzy inference has emerged as a promising method for addressing such uncertainty, with applications in congestion evaluation and traffic simulations. However, existing research has primarily focused on aggregate traffic flow rather than individual driver characteristics derived from real-world trajectory data.

This study addresses this limitation by proposing a fuzzy inference-based framework for modelling driver behavior using vehicle trajectory data extracted from roadside camera videos. By incorporating variables such as vehicle speed and headway distance, the framework enables the characterization of distinct driving styles, forming the foundation for adaptive traffic analysis and predictive modelling.

2. METHODOLOGY AND RESULTS

Vehicle trajectory data were extracted from roadside videos using YOLO-based detection. By applying camera height and angle calibration, pixel displacements of vehicles were converted into real-world speed and headway values. Road surface condition was also considered as an auxiliary variable, though preliminary analysis in this study mainly focused on speed and headway.

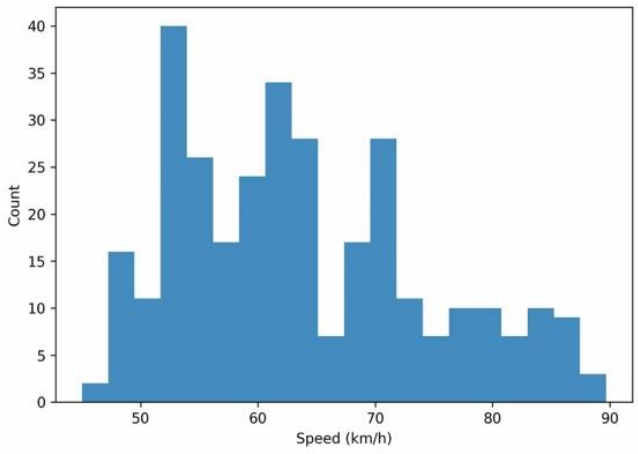

Figure 1. Distribution of observed speeds

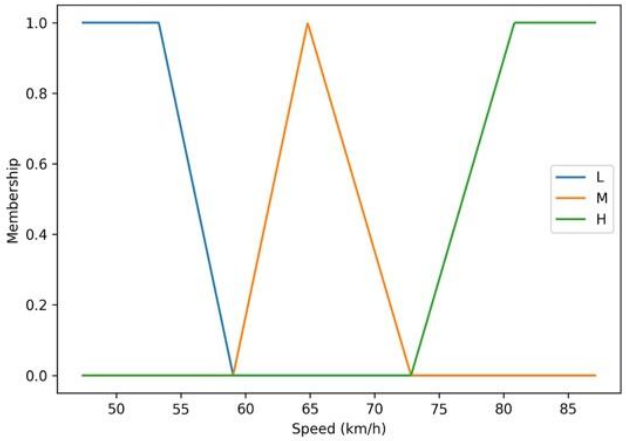

Figure 2. Speed membership functions

The quantitative values were transformed into linguistic categories such as "slow/medium/fast" for speed and "near/medium/far" for headway. Corresponding membership functions were designed using triangular and trapezoidal forms (Feng et al. 2021). Figure 1 shows the distribution of observed speeds, while Figure 2 presents an example of the speed membership functions. Headway membership functions were constructed in the same manner but are not displayed here for brevity.

Based on these fuzzy variables, inference rules were created to represent different driving styles. The initial application of these rules suggested that drivers can be distinguished into patterns such as commuter type (higher speed with shorter headway) and tourist type (lower speed with longer headway).

3. CONCLUSIONS

This study introduced a fuzzy inference framework for driver behaviour modelling based on real-world vehicle trajectory data. By integrating speed and headway measures derived from video analysis, the framework enables flexible classification of driver types, addressing limitations in conventional traffic modelling approaches.

The preliminary trials suggest that the system can generate interpretable rules and reveal distinct driving patterns (Almadi et al., 2022). Future work will refine the membership functions using larger datasets and extend validation across multiple road environments. The proposed approach contributes to the advancement of intelligent driver behaviour modelling, with implications for both academic research and practical traffic management applications.

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