

# AI-BASED MONITORING SYSTEM FOR FATIGUE DETECTION IN PROFESSIONAL TRUCK DRIVERS: FROM SIMULATION TO REAL-WORLD VALIDATION

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## Abstract:

Driver fatigue is one of the leading causes of road traffic accidents and remains a persistent challenge in professional transport operations. Among occupational groups, truck drivers are particularly exposed due to extended working hours, monotonous routes, tight delivery schedules, and irregular rest patterns. The resulting decline in alertness compromises reaction time, decision-making, and situational awareness, leading to a substantial increase in crash risk. Although several fatigue detection technologies have emerged in recent years, most systems remain generic, insufficiently validated, and poorly adapted to the specific characteristics of professional drivers. Addressing these limitations is essential to improving both road safety and occupational health in the transport sector.

This doctoral research aims to develop and validate an artificial-intelligence-based monitoring system capable of detecting fatigue in professional truck drivers with greater precision and personalization. The system will integrate behavioral, physiological, and vehicle-based data to identify fatigue states and support preventive interventions before performance degradation occurs. The research follows a structured seven-stage methodology that connects theoretical foundations with empirical experimentation and model validation.

The empirical component relies on two complementary data sources. Controlled experiments will be conducted using the TRUST3000 high-fidelity driving simulator at the Faculty of Engineering of the University of Porto (FEUP). Thirty professional truck drivers will perform standardized driving tasks under fatigue-inducing conditions, while behavioral and physiological indicators—such as heart-rate variability, ocular activity, head position, and subjective sleepiness scores—are continuously recorded. In parallel, naturalistic driving data will be obtained through collaboration with WingDriver, a Portuguese company specializing in AI-based driver monitoring systems. The WingDriver platform provides real-world multimodal data, including facial videos and telemetric information, enabling comparison between simulated and operational environments.

The combined dataset will be processed to train and validate machine-learning models designed to classify fatigue states and predict onset patterns. Analytical emphasis will be placed on identifying inter-individual variability, evaluating model robustness, and assessing the feasibility of implementation within fleet-management contexts. Expected outcomes include an AI-driven system capable of adapting to different driver profiles, reducing false alarms, and enhancing the reliability of fatigue detection across diverse working conditions.

By bridging simulator-based experimentation with naturalistic data, this research advances scientific understanding of fatigue mechanisms while promoting practical applications in occupational safety. Ultimately, it aims to reduce fatigue-related incidents among professional drivers, contributing to safer roads and healthier working environments.

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