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An Optimization Framework for Information Management in Adaptive Automotive Human–Machine Interfaces

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Abstract: In recent years, advancements in Intelligent and Connected Vehicles (ICVs) have led to a significant increase in the amount of information to the driver through Human–Machine Interfaces (HMIs). To prevent driver cognitive overload, the development of Adaptive HMIs (A-HMIs) has emerged. Indeed, A-HMIs regulate information flows by dynamically adapting the presentation to suit the contextual driving conditions. This paper presents a novel methodology, based on multi-objective optimization, that offers a more generalized design approach for adaptive strategies in A-HMIs. The proposed methodology is specifically tailored for designing an A-HMI that, by continuously monitoring the Driver–Vehicle–Environment (DVE) system, schedules actions requested by applications and selects appropriate presentation modalities to suit the current state of the DVE. The problem to derive these adaptive strategies is formulated as an optimization task where the objective is to find a set of rules to manage information flow between vehicle and driver that minimizes both the driver's workload and the queuing of actions. To achieve these goals, the methodology evaluates through two indexes how applications' requests impact the driver's cognitive load and the waiting queue for actions. The optimization procedure has been solved offline to define adaptive strategies for scheduling five application requests, i.e., forward collision warning, system interaction, turn indicators, infotainment volume increase, and phone calls. A theoretical analysis has demonstrated the effectiveness of the proposed framework in optimizing the prioritization strategy for actions requested by applications. By adopting this approach, the design of rules for the scheduling process of the A-HMI architecture is significantly streamlined while gaining adaptive capabilities to prevent driver cognitive overload.

Keywords: adaptive human–machine interface; intelligent and connected vehicle; multi-objective optimization

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