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Inclusive HMI Design to Mitigate Mode Confusion in Multilevel Driving Automation

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Automated driving systems are transforming the driver–vehicle relationship by redistributing control between human and machine. While automation has strong potential to reduce accidents—largely attributed to human error—it introduces new cognitive challenges, particularly *mode confusion*. This occurs when drivers misinterpret the current automation state or fail to anticipate transitions. Such issues are especially critical for diverse user groups (e.g., older adults, novice drivers, and people with disabilities), whose needs are often insufficiently addressed in existing Human–Machine Interface (HMI) guidelines. This paper, developed within the CERTAIN project, aims to bridge this gap by proposing an inclusive, user-centred methodology to improve mode awareness and reduce confusion.

Methodology: The CERTAIN project adopts a **top-down, user-centred design approach** structured in three phases:

1. **Requirements Collection and Analysis**
   Existing regulatory frameworks (e.g., EuroNCAP, UN Regulation No. 171, DCAS) and scientific literature are systematically reviewed to extract guidelines related to mode awareness. These requirements are categorized by automation level, modality (visual, auditory, haptic), and user relevance. However, two key limitations are identified:
   - **Ambiguity**: Guidelines often lack measurable thresholds or actionable detail.
   - **Lack of user differentiation**: Most assume a homogeneous driver population.
2. **Workshop-Based Customisation**
   Participatory workshops with diverse user groups and experts refine these requirements. The goal is to:
   - Translate abstract guidelines into measurable design criteria
   - Adapt them to specific user profiles (e.g., novice vs. experienced drivers)
   - Resolve conflicts between competing needs (e.g., simplicity vs. multimodal feedback) This phase emphasizes personalization, acknowledging differences in cognitive capacity, experience, and perception.
3. **User Testing and Validation**
   Iterative testing with representative users combines simulations and interviews. This phase validates assumptions from earlier stages and uncovers unmet user needs. A set of Key Performance Indicators (KPIs) is used, including mode confusion rate, recognition accuracy, reaction time, and subjective measures (trust, workload, safety perception).

Next Steps / Future Work

The project follows a **two-phase validation plan**:

- **Virtual Simulation**: Controlled, safe testing environment to identify usability issues and refine HMI designs.
- **Proving Ground Testing**: Realistic vehicle conditions to evaluate system performance and user interaction under higher ecological validity.

Future work will focus on:

- Further refining HMI guidelines based on testing outcomes and workshops.
- Developing **profile-specific design recommendations**
- Contributing to more **harmonised, operational, and inclusive regulatory standards**
- Supporting real-world deployment of adaptive HMI systems that dynamically adjust to user needs