

Consistency Evaluation System for ADAS ECU and Meter Display

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Advanced Driver Assistance Systems (ADAS) generate complex signals in electronic control units (ECUs), and these signals must be accurately conveyed to the driver via the meter display. Traditionally, verification of ADAS ECU outputs and Human-Machine Interface (HMI) indications on the meter has been performed separately and mainly by manual visual inspection. This approach requires substantial man-hours and is vulnerable to human error. This paper proposes a Hardware-in-the-Loop (HIL) based automated evaluation system that synchronously verifies the consistency between ADAS ECU signals and meter displays. Icons shown on the meter are captured by a camera, converted into semantic signals through image recognition, and compared with semantic signals generated on the ADAS ECU side on a common timeline. The system has been deployed in actual vehicle development and has significantly reduced test effort while remaining adaptable to multiple vehicle models and frequently changing specifications.

As ADAS functions become more advanced, ECUs generate diverse information such as lane departure warnings, collision avoidance alerts, and speed or distance control signals. These must be reliably presented using icons, text, and animations on the meter. Conventional methods often evaluate ECU signal correctness and visual HMI behavior separately and manually, making it difficult to handle the growing number of scenarios and increasing the risk of oversight. The goal of this study is not to improve ADAS algorithm performance but to establish a robust mechanism for evaluating specification conformance, ensuring that vehicle implementations comply with defined HMI and signal specifications despite frequent changes and partial ambiguity in mass-production development.

HMI evaluators must cope with heterogeneous conditions: different meter designs per vehicle, varied icon sets, and market-specific specifications. Attempting to rule-check all combinations of icon positions, colors, timings, and animations leads to combinatorial explosion. HMI specifications are often incomplete; detailed thresholds, such as blinking duty ratio or permissible icon deformation, may not be fully documented, forcing evaluators to rely on personal experience. Existing work has reported HMI tests using image recognition and simulation-based ADAS verification, but comprehensive consistency evaluation between ADAS ECU signals and HMI displays has been limited.

This study focuses on synchronously comparing camera recognition results with ADAS CAN signals. Recognition outputs on both sides are converted into independently coded signals and aligned on a shared timeline. For defined specification areas, formal conformance checks are executed; for undefined areas, expert judgment is systematized through review rules and training on real data judged acceptable, and the learned patterns are used as evaluation metrics. Furthermore, to reduce the number of combinations between system behavior and HMI display, it focus on the “meaning” communicated to the driver. While ECU behavior may be complex, the meaning of HMI is simple. By synchronizing and comparing interpreted HMI displays with signals, causal relationships can be expressed more clearly, helping to resolve conventional issues.

Proposed evaluation system consists of an ADAS signal evaluation unit on a HILS bench that generates expected CAN signals; an HMI judgment unit using a fixed camera and a CNN model trained on expert-curated images; independent coding units that convert recognition results into semantic signals; and a timeline comparison unit that automatically judges OK/NG. Implemented with Vector CANoe/vTestStudio, Matlab/Simulink, and a 3-megapixel camera, the system has been validated on lane recognition, lane keeping, and collision avoidance functions, covering 84 HMI items across three vehicle models and achieving up to about 76% automation and roughly 70% man-hour reduction. Despite remaining challenges such as efficient expansion of training data, handling complex animations, and integrating CI/CD and cloud-based execution, the proposed system establishes an automated, extensible method for evaluating consistency between ADAS ECU signals and meter HMI displays, reducing human error and improving judgment consistency for future ADAS and HMI verification.

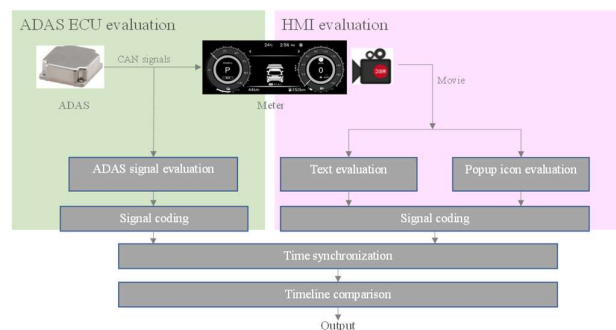


Fig.1 Proposed HILS