Zero-Human–AI Collaboration for Reliable Embedded Automotive Control Systems

Reshaping driver assistance through human-centered AI integration

CONF42 DEVOPS 2026

Speaker Introduction

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Specialized in embedded automotive control systems and AI integration for safety-critical applications. Leading research initiatives in human-machine collaboration and advanced driver assistance technologies.

CHALLENGE

The Limits of Traditional Automation

Rule-Based Systems

Excel in predictable scenarios but struggle with dynamic real-world conditions

Static Decision Logic

Cannot adapt to real-time perception, prediction, and evolving environmental complexity

Limited Context

Lack situational awareness and driver state monitoring capabilities

SOLUTION FRAMEWORK

Human-Centered Collaborative Architecture

AI and human cognition operating as complementary partners rather than competing entities

Multisensor Perception

Camera, radar, and lidar fusion for comprehensive environmental awareness

Driver State Monitoring

Gaze tracking, physiological signals, and behavioral analysis

Dynamic Authority

Adaptive allocation between human and AI based on context and readiness

Validation Methodology

01

Simulation Testing

Controlled virtual environments testing thousands of edge case scenarios and failure modes

02

Controlled Experiments

Laboratory settings with instrumented test tracks measuring precise system responses

03

Naturalistic Driving

Real-world validation across diverse conditions, driver populations, and traffic patterns

RESULTS

Measurable Safety Improvements

Critical Incident Reduction

- Significant decrease in lane departure events across all test conditions
- Lower collision rates in both simulated and real-world scenarios
- Smoother takeover behavior during authority transitions

Human Factors

- More calibrated driver trust levels reducing over-reliance
- Improved situational awareness during automated driving
- Reduced cognitive load during complex driving tasks

Multisensor Perception Performance

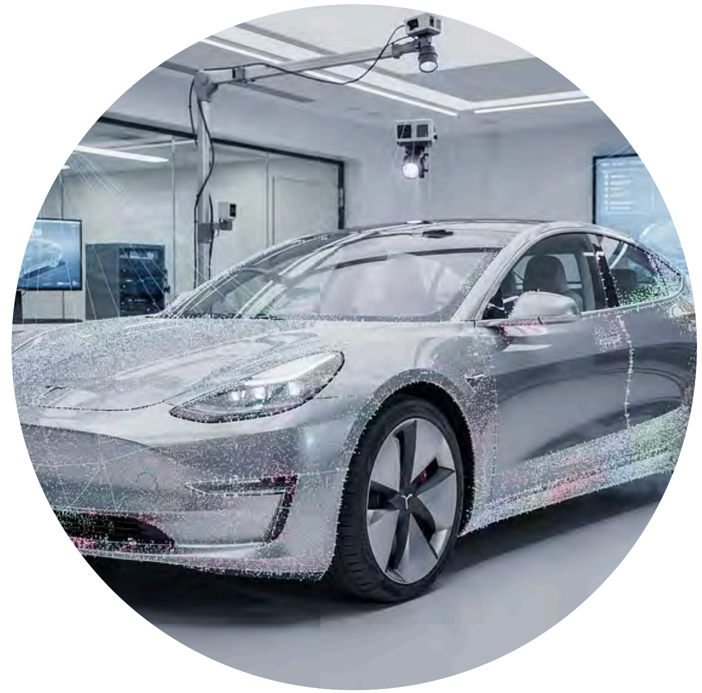
Fusion architecture significantly outperforms single-sensor approaches across environmental conditions

Camera

High-resolution visual data for lane markings and object classification

Radar

All-weather velocity and distance measurements with penetration capability



Lidar

Precise 3D spatial mapping for obstacle detection and path planning

Driver State Classification Accuracy

Advanced monitoring system achieves over 90% accuracy in detecting critical cognitive states

1

Fatigue Detection

Gaze patterns and physiological markers

2

Distraction Recognition

Behavioral cues and attention monitoring

3

Readiness Assessment

Real-time capability evaluation

SYSTEM ARCHITECTURE

Model Predictive Control Integration

Real-Time Performance

Millisecond-scale control loop execution maintaining safety-critical responsiveness

Multi-Objective Optimization

Balances competing demands:

- Safety constraints and collision avoidance
- Passenger comfort and ride quality
- Energy efficiency and system longevity
- Regulatory compliance requirements

Multimodal Feedback Architecture

Diverse communication channels reduce cognitive load and improve response times during critical transitions

Visual Displays

Heads-up displays and dashboard indicators providing situational context

Auditory Alerts

Spatial audio cues and voice notifications for time-critical information

Haptic Feedback

Steering wheel and seat vibrations for intuitive directional guidance

Dynamic Authority Allocation

1 Context Assessment

Continuous evaluation of environmental complexity and risk factors

2 Readiness Monitoring

Real-time driver state analysis and capability determination

3 Adaptive Handoff

Seamless authority transfer preserving safety and driver agency

APPLICATIONS

Real-World Implementation Scenarios

Intent-Aware Adaptive Cruise Control

Predicts driver intentions and adjusts following distance based on traffic flow and driver preferences

Cooperative V2V Coordination

Vehicle-to-vehicle communication extends perception range beyond sensor limitations and improves traffic flow efficiency

DEVOPS INTEGRATION

Safety-Critical Deployment Strategies

Continuous Validation Pipelines

Automated testing frameworks ensuring regression-free updates and maintaining safety certification requirements

System Observability

Real-time telemetry, anomaly detection, and performance monitoring across distributed fleet deployments

Human-Centered Deployment

Gradual rollout strategies with driver feedback loops and adaptive feature enablement based on acceptance patterns

From Automation to Augmentation

> The future of automotive control systems lies not in replacing human drivers, but in merging machine precision with human intuition to create more adaptive and transparent mobility systems.

Machine Precision

- Millisecond reaction times
- 360-degree awareness
- Consistent performance

Human Intuition

- Contextual understanding
- Ethical decision-making
- Creative problem-solving

Thank You!

Questions and Discussion.?

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