Huma-Centered Research on Advanced Mobility

Seoul National University of Science and Technology

Safety Engineering

Yoon Sol Hee

Introduction

Seoul National University of Science and Technology (SEOULTECH)

- National University located in Seoul
- Campus size: 504,922 ㎡
- Undergraduate schools: 10 colleges, 34 departments, and 6 divisions
- Graduate schools: 6 (1 general graduate school, 2 special graduate schools, and 3 professional graduate schools)
- Ranked #1001-1200 in QS World University Rankings 2026
- Ranked #151-200 for Asian University Rankings (Eastern Asia)

Introduction

Yoon, Sol Hee, Assistant Professor (solhee.yoon@seoultech.ac.kr)

- Ph.D in Industrial Engineering (Human factors)
- Department of Safety Engineering, Human Factors and Ergonomics Lab

Previous Experience:

- Hyundai Mobis, HMI Design Team
- LG Electronics, Creative Innovation Center

Research Focus:

Human Factors in Transportation Safety, Human-Automation Interaction

Research Field

Human-Centered Challenges in Automated and Advanced Mobility

- Increasing level of vehicle automation introduces ***new human roles***: monitor, supervisor, or passive passenger
- Shift from ***manual to cognitive control*** creates new safety risks
- Lack of understanding about ***how humans perceive*** *and* ***interact*** with automation
- Need for human-centered frameworks for **trust, readiness, and shared control**

Research Field

SEOULTECH

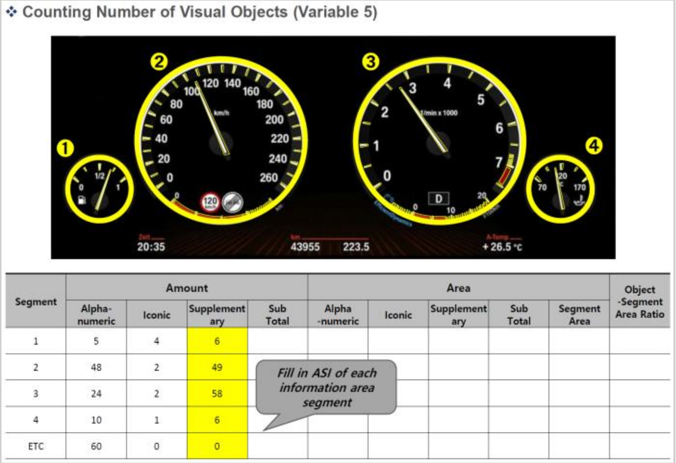
Human Factors & Ergonomics (HFE) Lab

- Our research focuses on **Human Factors in Advanced Mobility Systems**
    - Driver-Automation Interaction and Takeover in semi-autonomous vehicles
    - Risk Assessment Models integrating human readiness and road complexity
    - Human-Machine Interface (HMI) Design for accessibility and trust in automated mobility
    - AI-based Driver's Behavior Modeling

- Research Skills
    - Define the problem space from the human perspective
    - User test, User Experiment & Analysis
    - Optimization of design solutions and Design guidelines

Research Portfolio and Key Achievements

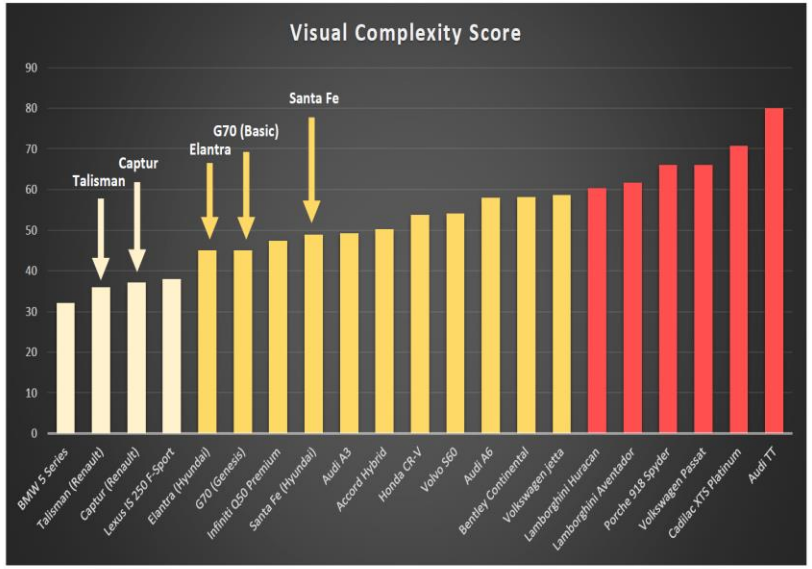
- **Effects of interface complexity on drivers' safety**
  - The complexity of IVIS has steadily increased. Is it advisable to provide more and more information to drivers?
  - Quantify the level of complexity and investigate its effects on driver safety.



Segment	Amount				Area					Object -Segment Area Ratio
	Alpha-numeric	Iconic	Supplementary	Sub Total	Alpha -numeric	Iconic	Supplementary	Sub Total	Segment Area	
1	5	4	6							
2	48	2	49							
3	24	2	58							
4	10	1	6							
ETC	60	0	0							

Development ofvariability and quantity measures on visual complexity

User experiment environment

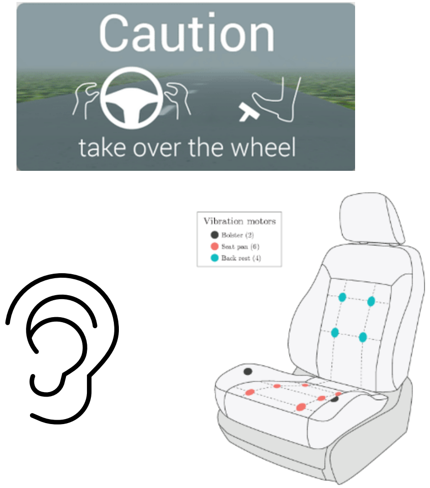


Assessment of Perceived Visual Complexity Level

Research Portfolio and Key Achievements

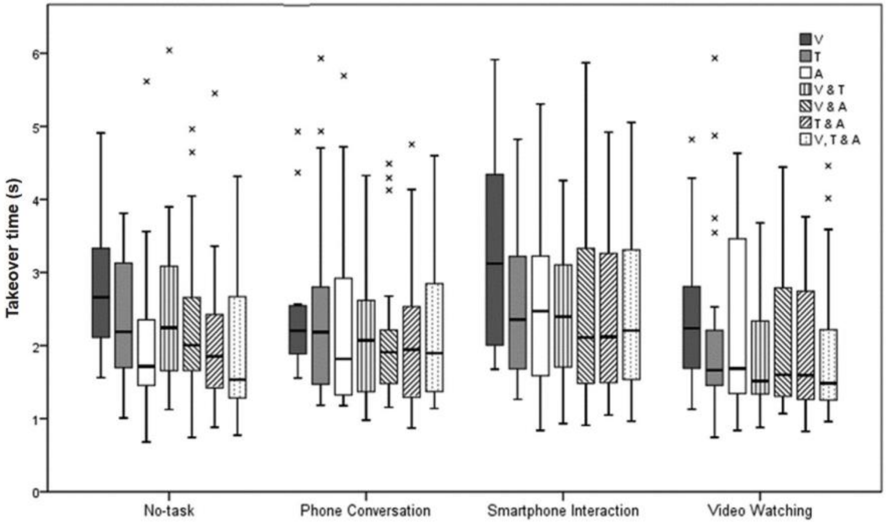
• Effects of NDRT and TOR modalities in AV environment

- Compared subset of three TOR modalities. Visual (presented in center fascia), Auditory (Sound alert for takeover), Tactile (Vibration in driver's seat)
- NDRT demand of resources: Visual(V) /Auditory (A) / Motor (M) resources
- No tasks = {Ø}; Phone call = {A,M}; Texting = {V,M}, Video Watching = {A,V}



TOR modalities (Visual, Auditory, Tactile)

Driving-simulation based user experiment

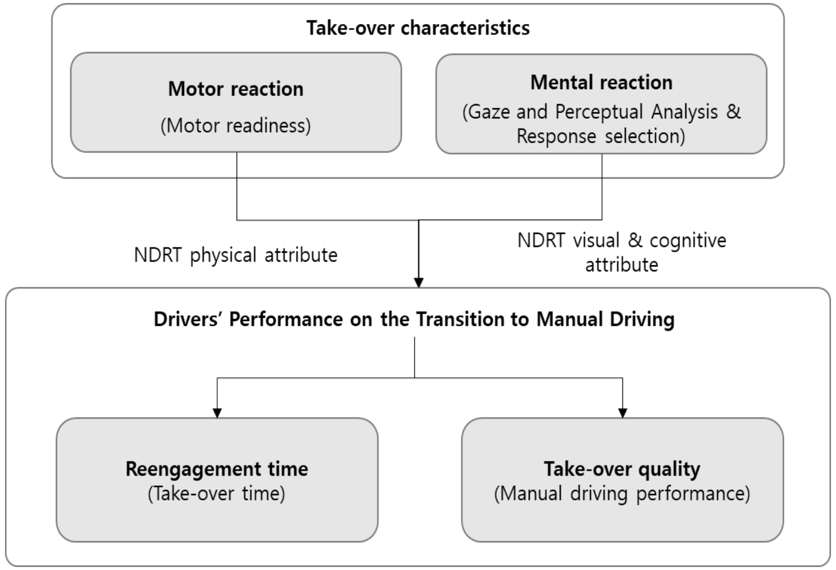


Time to make takeover decisions

Research Portfolio and Key Achievements

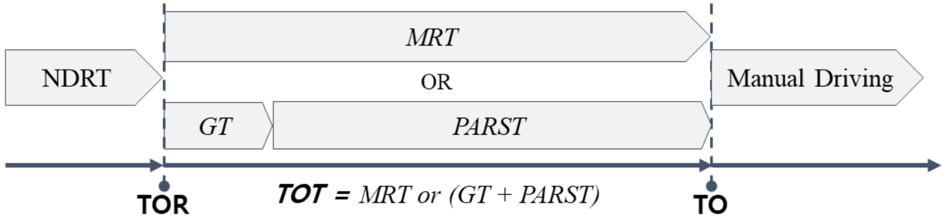
• Effects of Non-Driving Related Tasks in Takeover

- Categorization of non-driving related tasks (NDRTs). Which types of resources do the NDRTs require?
- Modeling takeover time based on drivers' motor and mental reaction



Conceptual Framework of takeover process

Driving-simulation based user experiment



$$\text{Let } TOT = \begin{cases} GT + PARST & \text{if } (GT + PARST) > MRT \\ MRT & \text{otherwise} \end{cases}$$

where, $MRT = f\{\text{Place of interaction, Hand in use, Action type}\} = \beta_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13}$

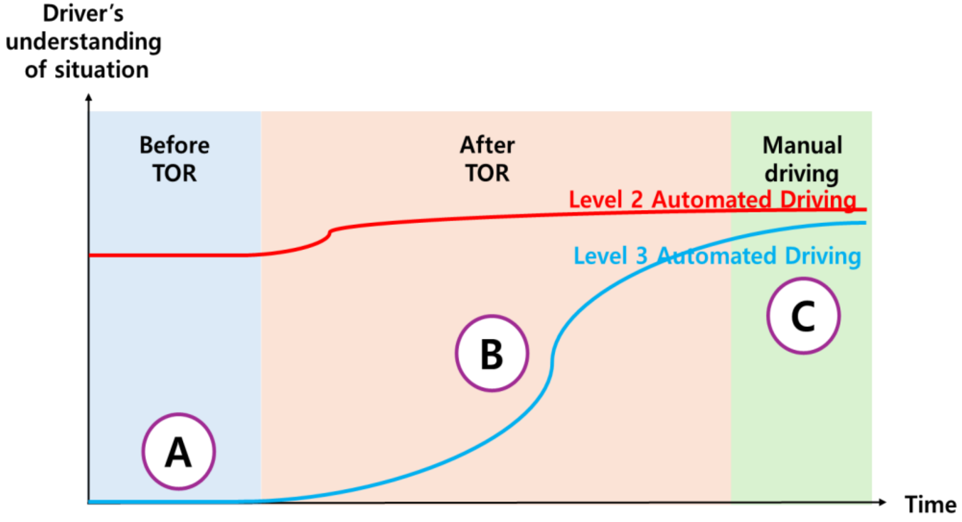
$GT = f\{\text{visual fixation position}\} = \beta_{30} + \beta_{31}X_{31}$, where $GT = 0s$ if drivers "on-the-loop"

$PARST = f\{\text{Resource allocation, Cognitive Load, Cognitive Engagement}\} = \beta_{20} + \beta_{21}X_{21} + \beta_{22}X_{22} + \beta_{23}X_{23}$

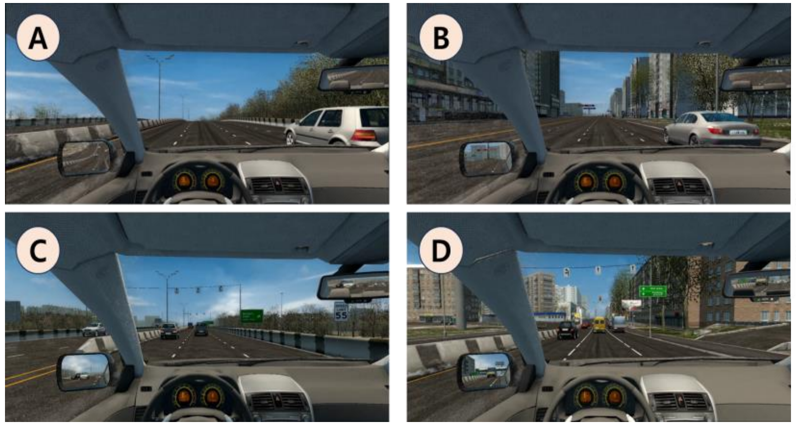
Modeling of takeover process based on user experiment data

Research Portfolio and Key Achievements

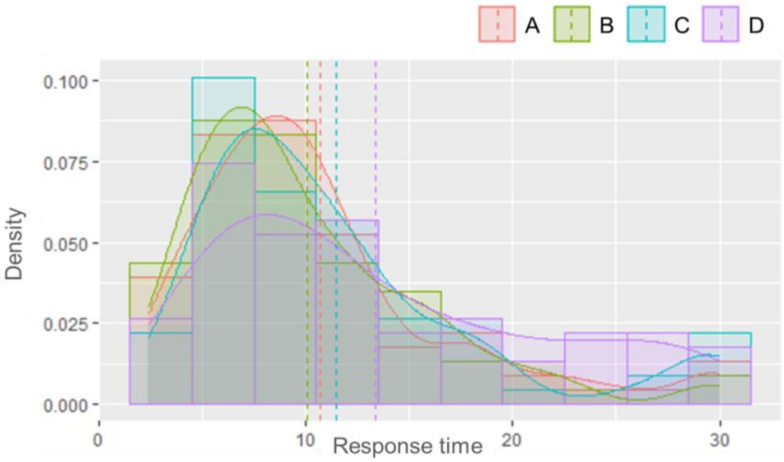
- **Situation Awareness formation during takeover process**
  - Automation level changes the way drivers establish SA on surroundings during the takeover process
  - What factors influence the formation of SA? (E.g.: Environment (Traffic density, road type); TOR lead time)
  - Drivers often believed they had enough understanding of the situation, even when their SAGAT score were low
  - Average time for SA readiness was 10 seconds, but some participants said they were not ready to drive even after 20 seconds of the TOR



SA formation in autonomous vehicles



Snapshot of experimental conditions



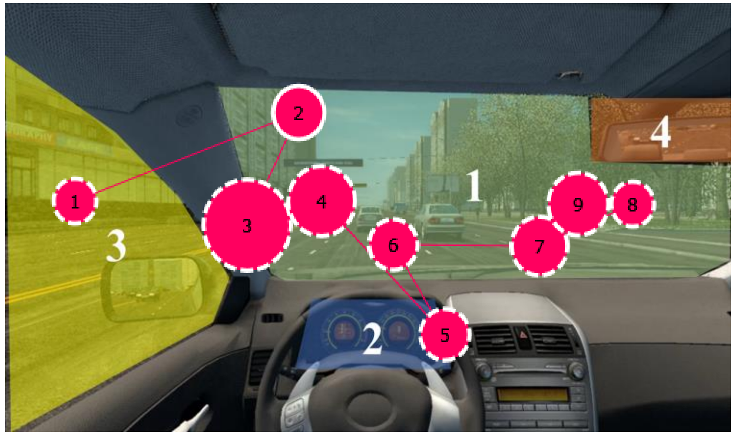
SA readiness for driving

Research Portfolio and Key Achievements

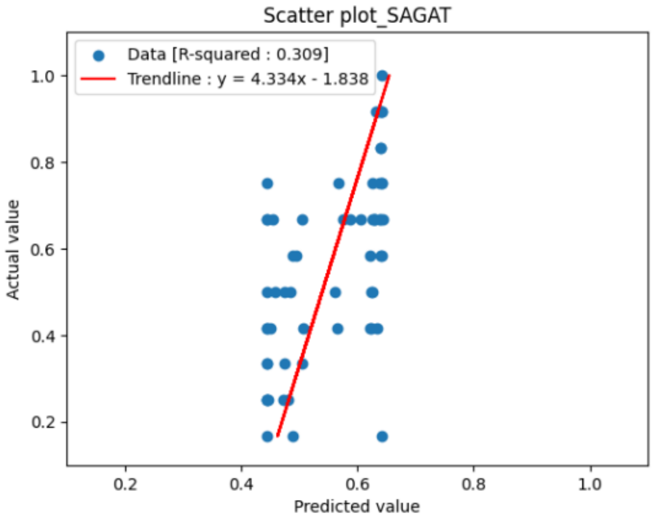
- **Predicting the SA level with glance behaviors**
  - RQ: Can the level of situational awareness (SA) be predicted solely based on the drivers' real-time gaze behavior? Which specific gaze behavior features account for the level of SA?
  - Estimating SA level with random forest regression, Overfitting & narrow range of predicted value, Data augmentation with Gaussian distribution

Variable
average_dwell_time_AOI1
average_dwell_time_AOI2
average_dwell_time_AOI3
average_dwell_time_AOI4
average_fixation_duration
average_fixation_duration_on_AOI1
average_fixation_duration_on_AOI2
average_fixation_duration_on_AOI3
average_fixation_duration_on_AOI4
dwell_time_AOI1
dwell_time_AOI2
dwell_time_AOI3
dwell_time_AOI4
first_AOI_dwell_time
number_of_fixations_AOI1
number_of_fixations_AOI2
number_of_fixations_AOI3
number_of_fixations_AOI4
number_of_fixations_on_AOI1_per_visit
number_of_fixations_on_AOI2_per_visit
number_of_fixations_on_AOI3_per_visit
number_of_fixations_on_AOI4_per_visit
number_of_fixations_total
number_of_swichs_between_AOIs
number_of_visit_AOI1
number_of_visit_AOI2
number_of_visit_AOI3
number_of_visit_AOI4
time_to_first_fixation_on_AOI
total_dwell_time
total_fixation_duration

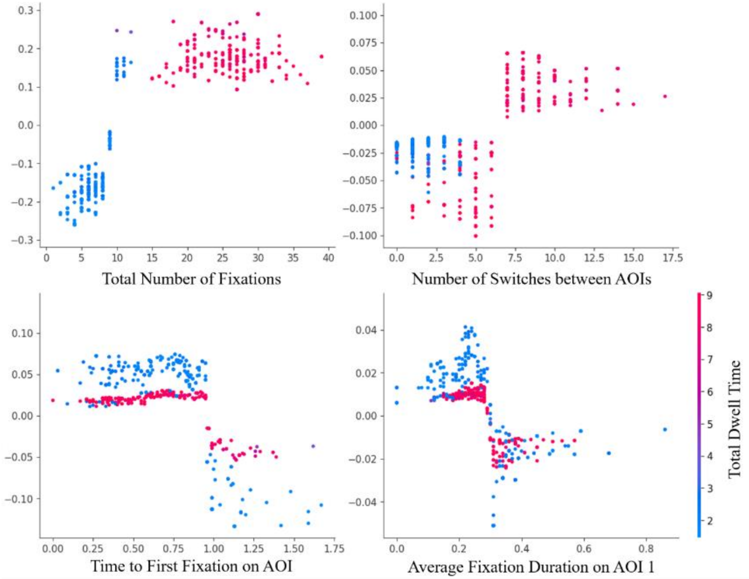
Elicited glance behavior features



Scan path before after TOR



Scatter plot of predicted & actual value of SAGAT

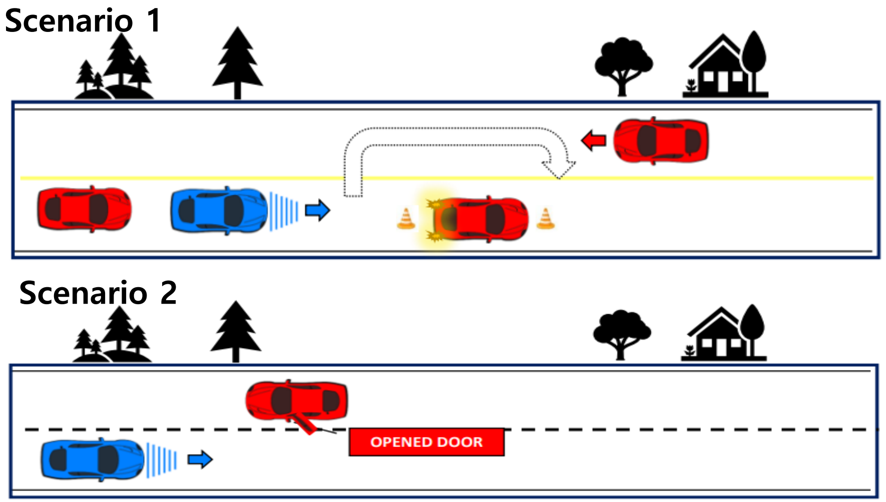


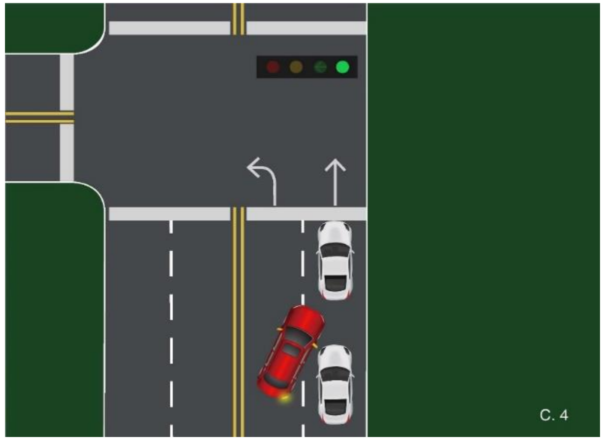
Dependence plot of selected features

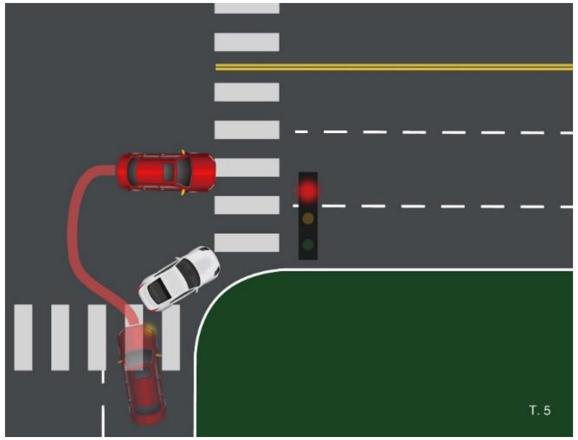
Research Portfolio and Key Achievements

• User Perception in Ambiguous Driving Scenario

- How should AVs solve/drive in potentially ambiguous driving scenarios?
- What factors influence users' perceptions in ambiguous driving scenarios? E.g.: Moral, Ethical, Legal, utility, and safety perception
- How do we have to design AV's behavior in those situations?

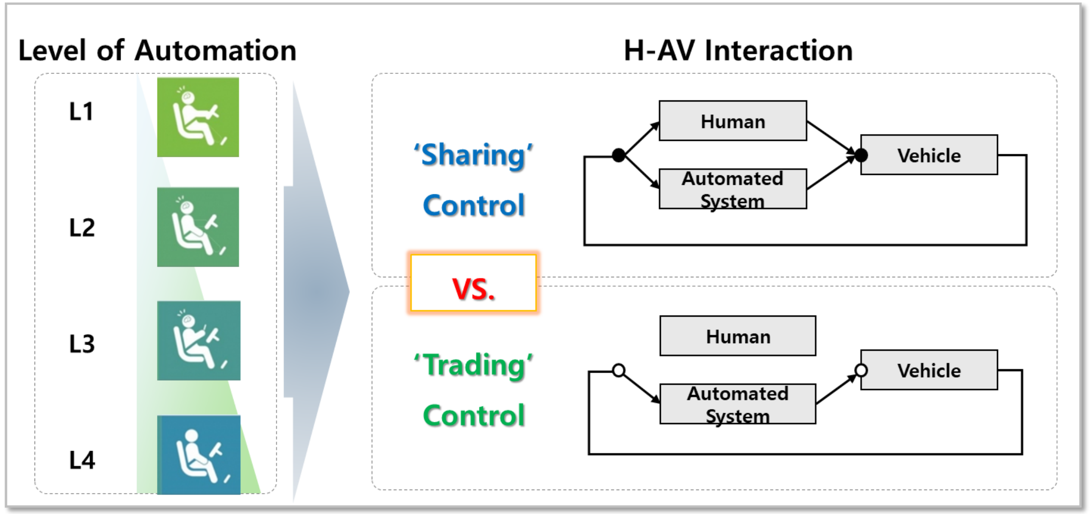


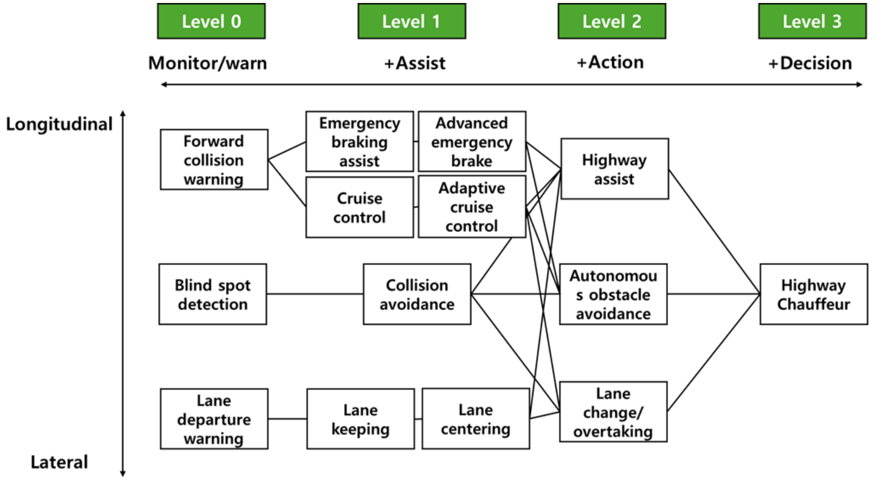




Ongoing Research

- **Enhancing Mode Awareness for Autonomous Vehicle Drivers**
  - As the complexity of automated functions increases, drivers often face confusion regarding what the vehicle can do autonomously and what their role is in each driving mode.
  - RQ: How can we make drivers perceive the current mode accurately and effectively? How can we reduce driver confusion between different modes of autonomous vehicle functions?

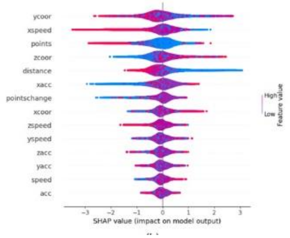




Ongoing Research

- **Human-Centric Explanation of Passenger Perceived Risk in Highly Automated Driving**
  - Complexity is not only objective (geometry, traffic, lighting) but also **perceived** (driver’s cognitive load)
  - Approach: Combine **static** (road design, signage) and **dynamic** (traffic, weather) features
  - User-based Simulation experiment to evaluate passengers’ perceived risk, and derive a Shapley value–based explanation model.
  - Human-interpretable AI systems for takeover and route recommendation. (XAI-based HMI Development)
  - Expected to serve as a foundation for adaptive interfaces aimed at calibrating trust in highly automated vehicles.

Automated Driving Scene Images



Shapley Value of Individual Risk Perception Factors

VLM (Visual Language Model)

Future Research Direction & Collaboration Opportunities

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Bridging Human Factors and Automation through Data & Modeling

Focus on:

- Cross-cultural trust and perception modeling.
- Ethical decision-making algorithms for autonomous mobility
- Human–centered predictive risk analysis

- **Potential contribution to a consortium:**
    - Provide human-centered design and validation frameworks
    - Developing a human-centered risk assessment and safety model for CCAM
    - Conducting user testing and simulation experiments

- **Open for partnerships requiring human perspective analysis**

Thank you for your time and attention