Driver's degree of dependence on collision avoidance systems

the12th COE Postdoctoral and Doctoral Researchers Technical Presentation

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Background

- Development of ITS technology for safety and serviceability is expected.
- If the driver is too dependent on the support system, there is the possibility that the driver could become unable to avoid an accident without a support system, even under normal situations.
- If the timing for the information to be provided is inappropriate, the driver might find the system unnecessary or even useless.

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Support system (1/2)

- Inevitable danger
  - In the case of the ETC system, the gate bar doesn't open for any reason.
- Unnecessary or even useless systems
  - In the case of the car navigation system, it navigates the familiarity directions politely or the wrong direction.

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Support system (2/2)

- To avoid the inevitable danger…
  - Don't rely on the support system excessively
- To make useless system available…
  - Support without disturbing the driving
  - Dispel distrust of the support system

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Objective

- Based on an analysis of the driver's behavior, we evaluate the driver's degree of dependence on the support system.
- We also investigate the correlation between the driver's degree of dependence and the driver's behavior.

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Driving simulator

- HONDA driving simulator
  - 6-axis motion base
  - Function of scenario editor
    - Event, Environment
    - Other cars' movement
  - Collectable data
    - Car movement
    - Car operation
    - Other cars' position

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Experimental condition

- 10 subjects (graduate students)
- 2 days
- Measurement indices
  - Vehicle's position coordinates (X,Y), Vehicle's speed [km/h]
  - Brakes opening, acceleration opening [%]
  - Subjective evaluation of driver (NASA-TLX questionnaire, interview)
  - DS's replay data and video images

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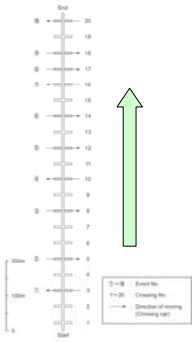
Experimental course

- 20 intersections
- 10 events
- Speed limit set at 30km/h
- Total length of 800m



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Simulation of support system

- Crossing collision avoidance assist system
  - If there is a crossing vehicle, an alarm will sound at about 27.5 meters from the intersection.

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Experimental procedure (1/2)

- Phase I (R1-R4)
  - Driving without the support system
  - Measurement of behavior during normal driving
- Phase II (R5-R11)
  - Driving with the support system
  - Measurement of behavior during using system
- Phase III (R12-R16)
  - With the support system sometimes operating abnormally or erroneously without driver's knowledge

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Experimental procedure (2/2)

- Event

Day	Phase	Round	3	5	8	10	12	14	16	17	18	20
1	I	R1			○				○			
		R2						○				
		R3							○			
		R4			○							○
	II	R5		●								○
		R6			●				○			
		R7						●				
		R8		●					○			
		R9		●					○			
		R10			●					○		
		R11				●					○	
2	III	R12	●				✕				○	
		R13			●						○	
		R14					▲					
		R15			▲			▲				▲
		R16					✕				○	

○: Without system, ●: With system, ▲: Incorrect alarm, ✕: Missing alarm

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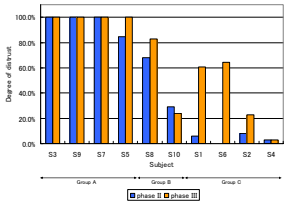
Brake operation (1/2)

- Overall brake ratio



Group A
- Overall brake ratio 100%-90.0%
- S3, S5, S7, S9

Group B
- Overall brake ratio 89.9%-50%
- S8, S10

Group C
- Overall brake ratio 49.9%-0%
- S1, S2, S4, S6

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Brake operation (2/2)

- Driver's behavior at an intersection

		Alarm	
		On	Off
Driver	Brake	*a*	*c*
	No Brake	*b*	*d*

Distrust of incorrect alarm

Distrust of missing alarm

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Distrust

- Degree of distrust

Distrust of incorrect alarm (Alarm ignorance ratio)

$$\alpha = \frac{N(b)}{N(a)+N(b)}$$

$N(a)+N(b)$: intersection with alarm
$N(a)$: the number of times of braking
$N(b)$: the number of times of no braking

Distrust of missing alarm

$$\beta = \frac{N(c)}{N(c)+N(d)}$$

$N(c)+N(d)$: intersection without alarm
$N(c)$: the number of times of braking
$N(d)$: the number of times of no braking

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Mental workload

- Task load index (AWWL: Adaptive weight workload)
  - In order to measure the mental workload of the driver every 2 rounds.
  - Questionnaire items are "Mental Demand", "Physical Demand", "Temporal Demand", "Performance", "Effort", and "Frustration".
  - Comprehensively evaluate the questionnaire items.
  - If score is high, drivers increase the workload of the driving.

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Results: Distrust (1/2)

- α : Distrust of incorrect alarm
  - All subjects decreased the speed or stopped at all the intersections with alarm. (0%)

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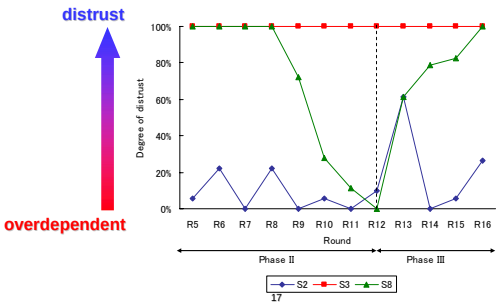
Results: Distrust (2/2)

- β : Distrust of missing alarm



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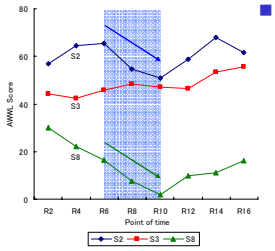
Results: Mental workload (1/3)

- AWWL (Adaptive Weight Workload)



- Phase II
  - The subjects depended on the support system, AWWL score decreased.

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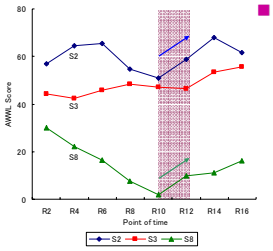
Results: Mental workload (2/3)

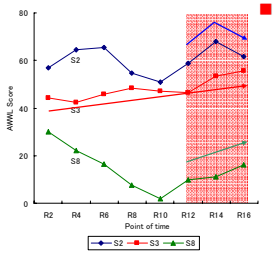
- AWWL (Adaptive Weight Workload)



- The first system defect
  - The subjects depended on the support system, AWWL score increased.
  - Frustration and Effort arising.

Results: Mental workload (3/3)

- AWWL (Adaptive Weight Workload)



- Phase III

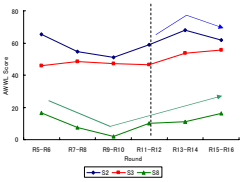
  S2
  - AWWL score increased, but once he got used to the condition, AWWL score started to decrease.

  S8, S3
  - AWWL score increased.

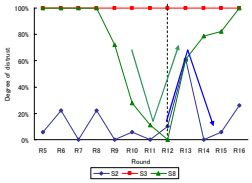
Comparison

- The two lines showed a similar tendency.
  - Similar results suggest an association between Mental workload and distrust of missing alarm.

Mental workload



Distrust of missing alarm



Summary

- In the case of false alarm, all drivers don't ignore. Therefore distrust of incorrect alarm is 0%.
- As for distrust of missing alarm, every driver is different.
- The drivers depended on the support system, AWWL score decreased.
- The data of the DS's behaviors and task load index while driving are analyzed to estimate the degree of the subjects' reliance on the system.

Future work

- Analyze the physiological data (lines of sight, electrocardiogram, electroencephalogram, etc.)
- To find a correlation between the results obtained and the above analysis
- Based on the physiological data, we perform a real-time measurement to analyze the degree of reliance .

Thank you for listening !!