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Take-over behavior for truck drivers in time critical situations

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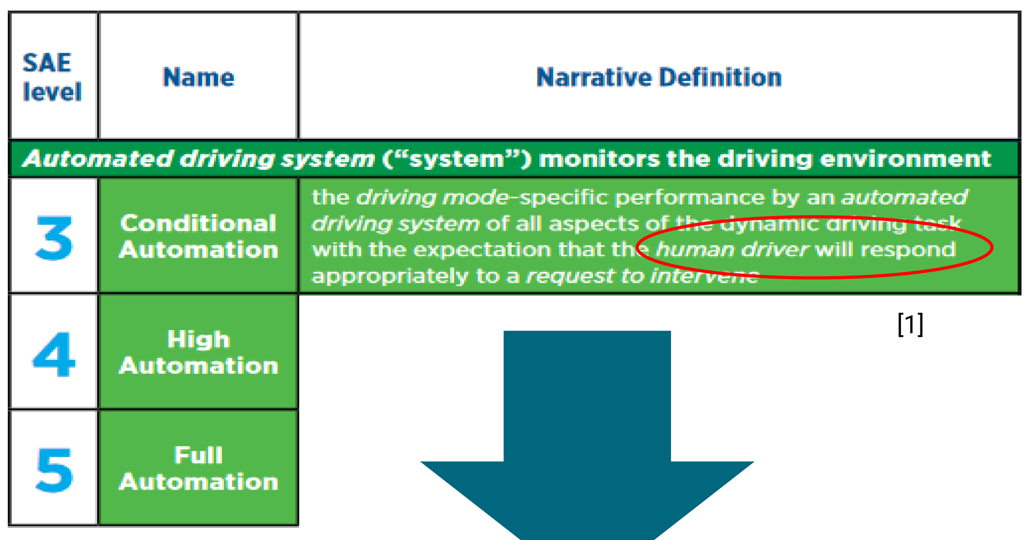
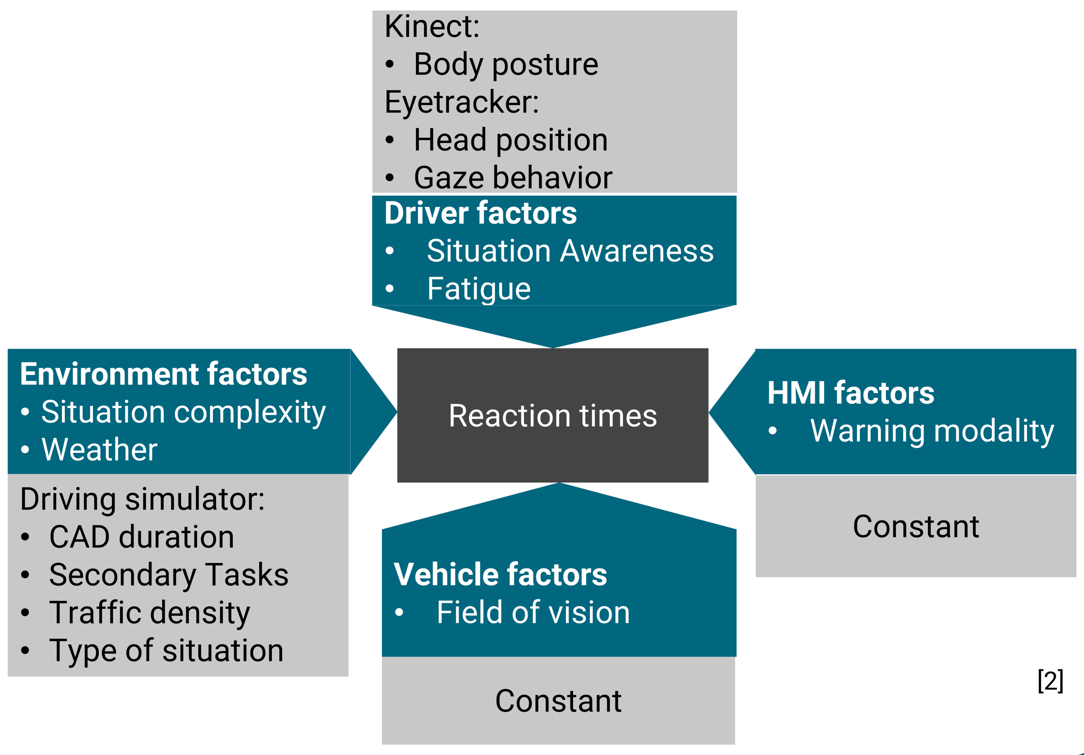
Motivation & Research Question

Is it possible to estimate the reaction times based on driver, HMI, vehicle and environmental factors with remote sensors?

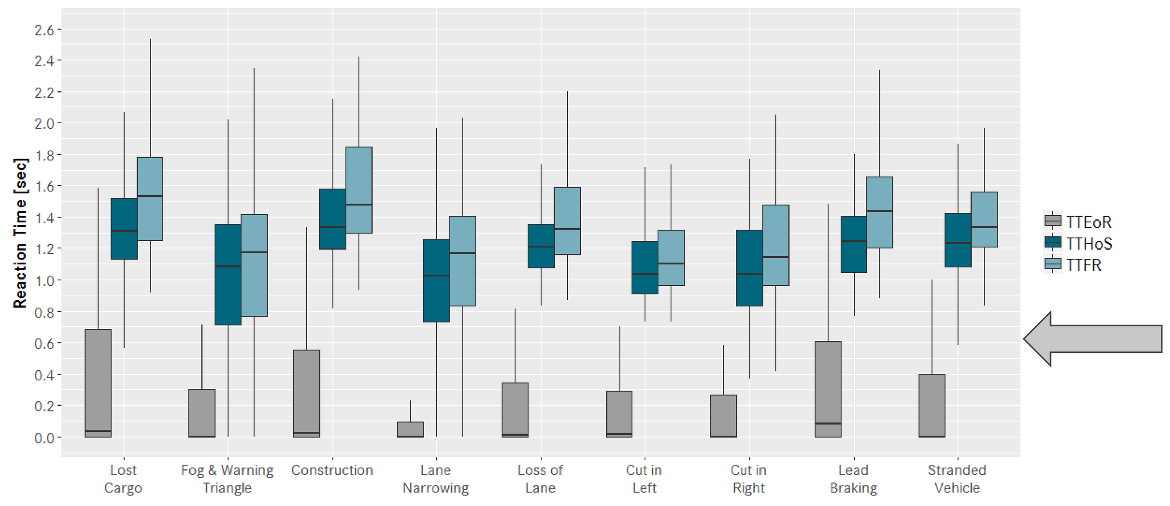
- Which remote sensors are suitable?
- Which algorithms are suitable?
- Which factors are relevant?
- How can cognitive processes of take-over be modelled?
- How should driver and truck cooperate in critical take-over situations?



Sufficient time reserves for safe take-over necessary

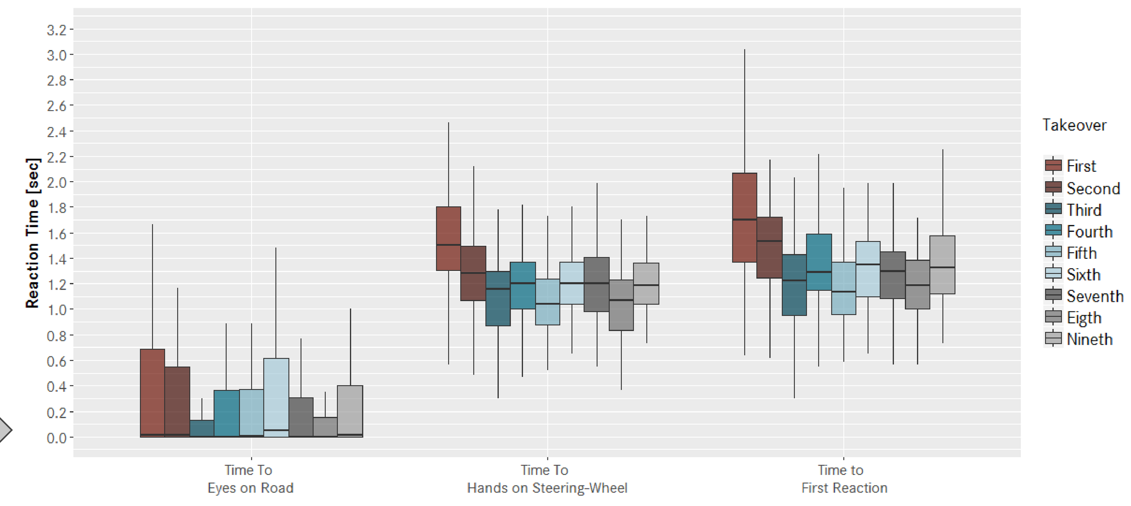


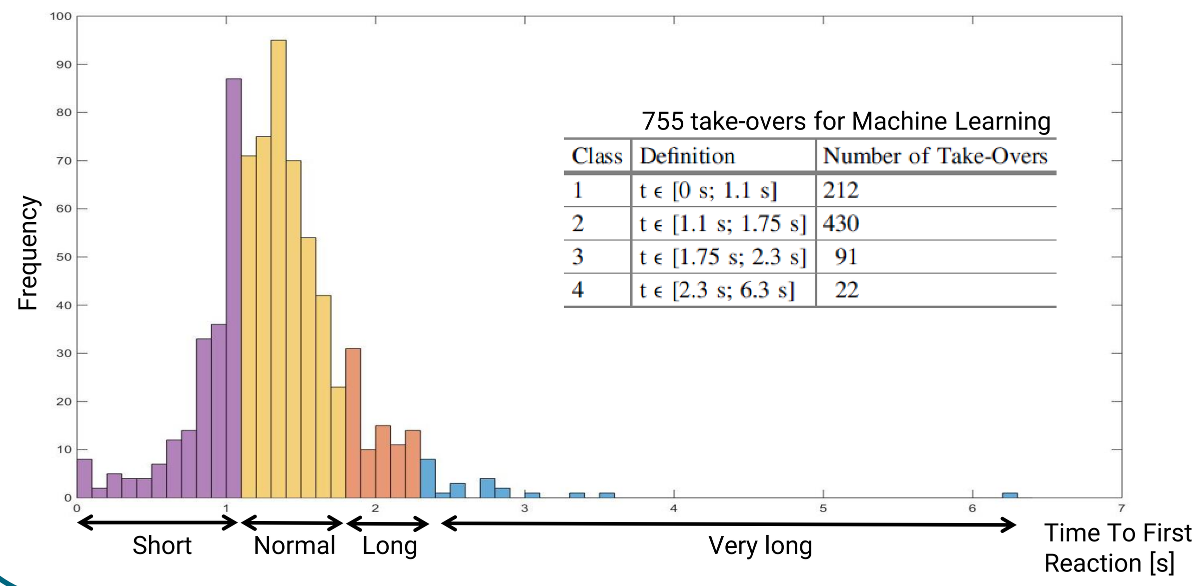
Experiment



* TTEoR: Time To Eyes on Road; TTHoS: Time To Hands on Steering Wheel; TTFR: Time To First Reaction

- Moving-base simulator with independent variables *CAD duration, NDRT, Situation type*
- 95 participants generated 755 take-overs
- Temporal differences for *Situation type*
- Learning was observed





755 take-overs for Machine Learning

Class	Definition	Number of Take-Overs
1	t ϵ [0 s; 1.1 s]	212
2	t ϵ [1.1 s; 1.75 s]	430
3	t ϵ [1.75 s; 2.3 s]	91
4	t ϵ [2.3 s; 6.3 s]	22

Driver features: Characteristic Values and Timeseries for gaze analysis, Head position, Area of Interest, Tablet interaction, TTs, Pupil diameter, Number of takeovers

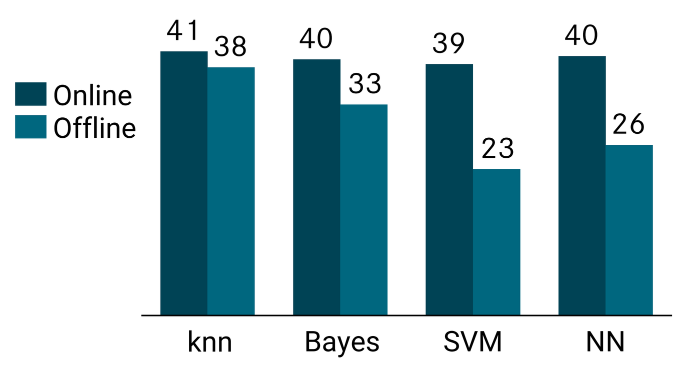
+

Environment features: TTCs, situation type, Traffic density, CAD Duration, Secondary Task

↓

244 Features

4-Class Classification



Misclassification rate [%]

[3]

Rank	Feature
1	Trial Number (# of take-overs)
2	Time to Collision
3	Blink Duration
4	Avg. Yaw Head Angle 2sec before RtI
5	Take-over Situation type
6	Head Roll Average 2sec before RtI
7	Min Head Pos. Change X-Y-Z
8	Head Pos. Change X 0.5sec before RtI
9	Head Pos. Change Y 3sec before RtI
10	Min Head Pos. Change X-Y-Z 10sec before RtI
11	Pupil Diameter 0.5sec before RtI
12	Gaze Pitch St. Dev. 5sec before RtI
13	Sum of tablet taps 5sec before RtI
14	Avg. Head Pos. X-Y-Z 2sec before RtI
15	Gaze Pitch St. Dev Total

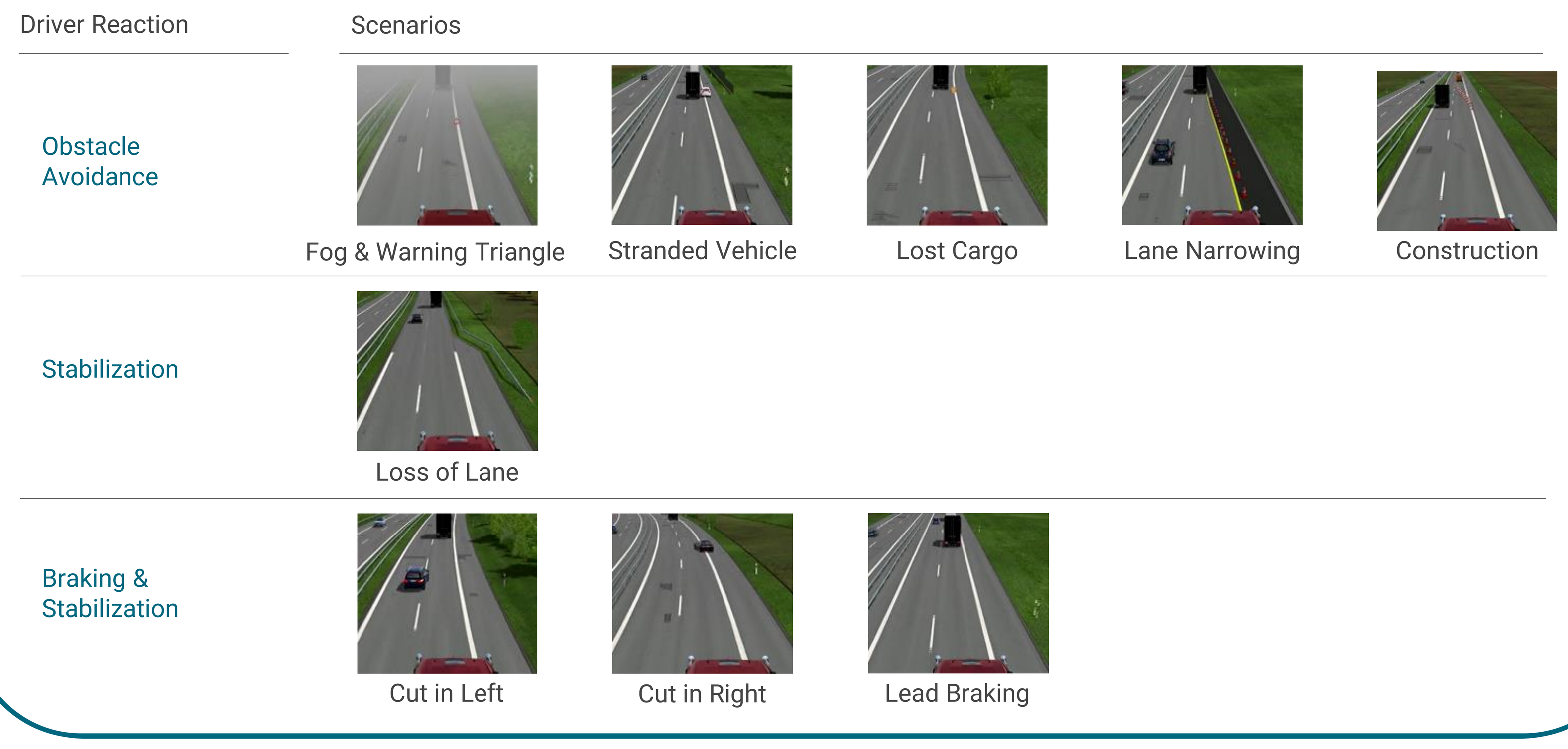
Conclusions

- The misclassification rate for 4 classes of features generated from eye-tracking and environmental features with a SVM was 39%.
- The misclassification rate for 4 classes of features generated from eye-tracking, body posture and environmental features with a SVM was 32%.
- Learning behavior could result from learning of the warning cascade or less attention towards NDRT (however visual attention towards NDRT was constant).

Eyes on Road	Yes				No			
Object Seen	Yes		No					
First ICUC					Yes		No	
Situation Type	Quick	Other	Quick	Other	Quick	Other	Quick	Other
# of TO	115	17	8	75	48	175	72	257
TTEoR	0.029 s (SD=0.147)	0.001 s (SD=0.012)	0.121 s (SD=0.302)	0.032 s (SD=0.140)	0.426 s (SD=0.487)	0.409 s (SD=0.594)	0.293 s (SD=0.349)	0.268 s (SD=0.340)
TTHoS	0.716 s (SD=0.407)	1.058 s (SD=0.426)	1.173 s (SD=0.366)	1.174 s (SD=0.396)	1.433 s (SD=0.624)	1.388 s (SD=0.536)	1.228 s (SD=0.317)	1.265 s (SD=0.343)
TTFR	0.861 s (SD=0.423)	1.234 s (SD=0.506)	1.354 s (SD=0.534)	1.303 s (SD=0.382)	1.445 s (SD=0.303)	1.580 s (SD=0.555)	1.347 s (SD=0.270)	1.429 s (SD=0.408)

Future Work

- How does behavior differ with regard to visible and non-visible take-over situations?
- How does take-over behavior differ in real-world conditions?
- Modelling differences in eye movements with ACT-R to explain cognitive differences



[1] **Standard, SAE International. 2018.** *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. J3016* 2018.
[2] **Vogelpohl, Tobias, et al. 2016.** *Übergabe von hochautomatisiertem Fahren zu manueller Steuerung.* Berlin : Gesamtverband der Deutschen Versicherungswirtschaft e.V., 2016.
[3] **Lotz, A. and Weissenberger, S. 2019.** Predicting take-over times of truck drivers in conditional autonomous driving. *Advances in Intelligent Systems and Computing.* Advances in Human Aspects of Transportation, 2019, pp. 329-338.