



Driver intention modeling for partly automated driving

Benefit and necessity of a driver and situation adaptive approach

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Motivation: The vision of self-driving cars



Source: www.youtube.com



Deutsches Zentrum
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in der Helmholtz-Gemeinschaft.



“What is the ideal balance between human and machine?”

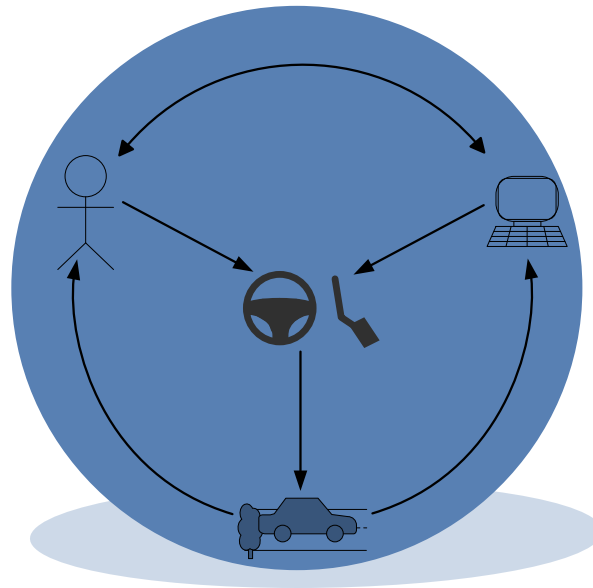
Chris Gerdes, Professor @ Stanford University, CA

Source: www.ted.com





...Cooperation!

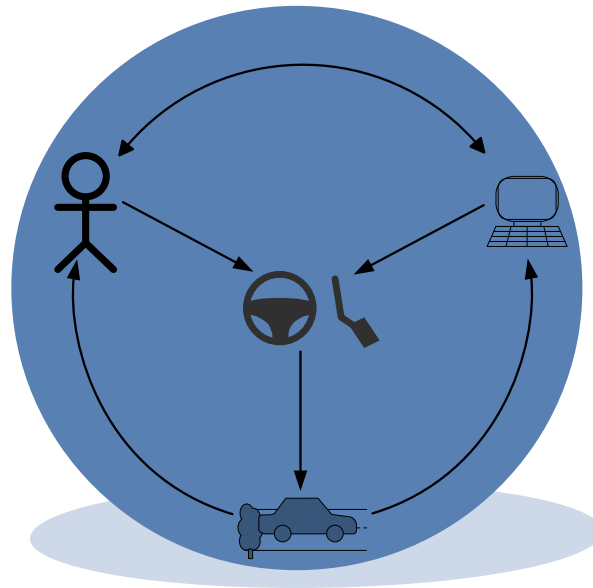


Source: adapted Löper et. al., AAET, 2009





...Cooperation!

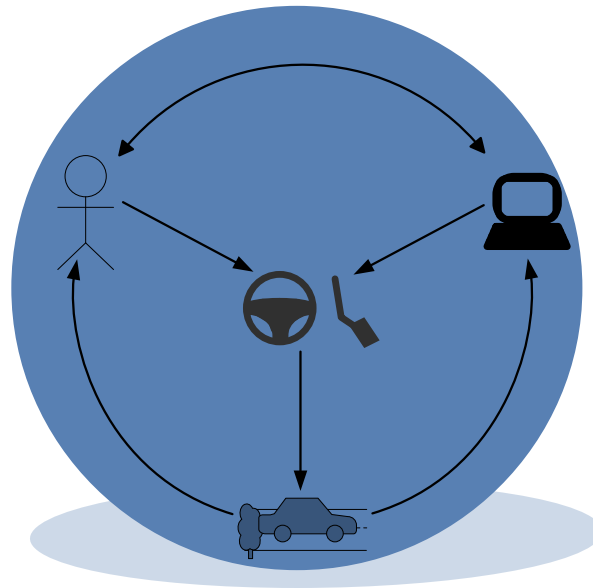


Driver: permanently monitor and take over control at any time

Source: adapted Löper et. al., AAET, 2009



...Cooperation!



Driver: permanently monitor and take over control at any time

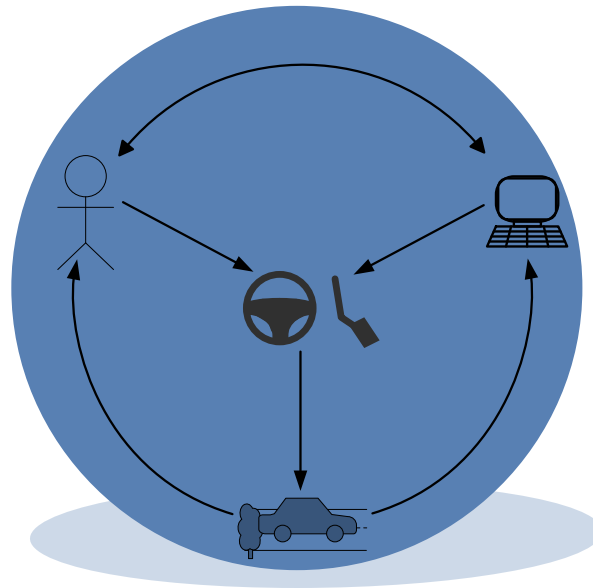
+

Automation: control in lateral and longitudinal direction

Source: adapted Löper et. al., AAET, 2009



...Cooperation!



Driver: permanently monitor and take over control at any time

+

Automation: control in lateral and longitudinal direction

=

Partly automated driving

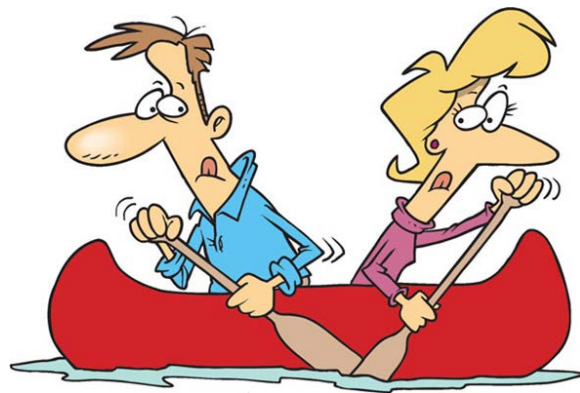
Source: adapted Löper et. al., AAET, 2009





Goal of cooperation: Driver and automation follow same intentions

In reality as in real life:



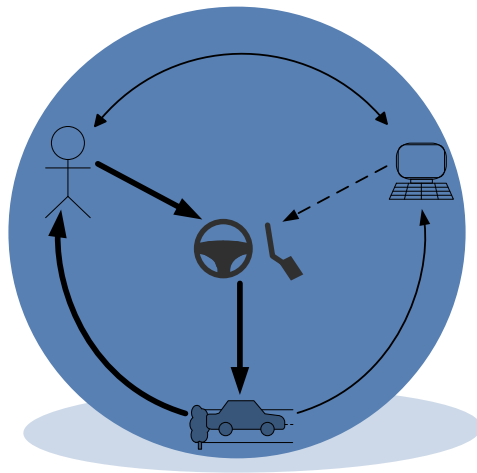
Source: www.thisimeimeanit.com (left), www.jetson.net.au (right)



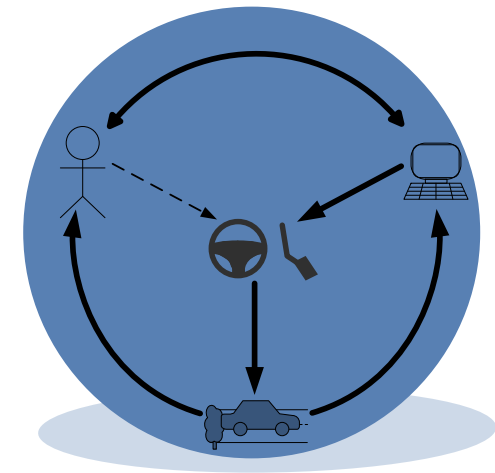


Conflict prevention by driver intention modelling

Driver Only

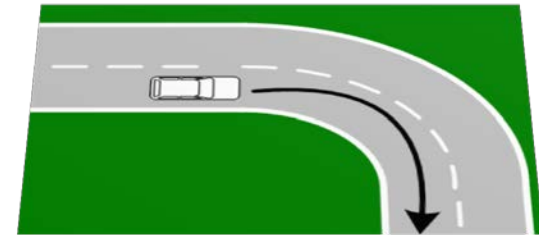
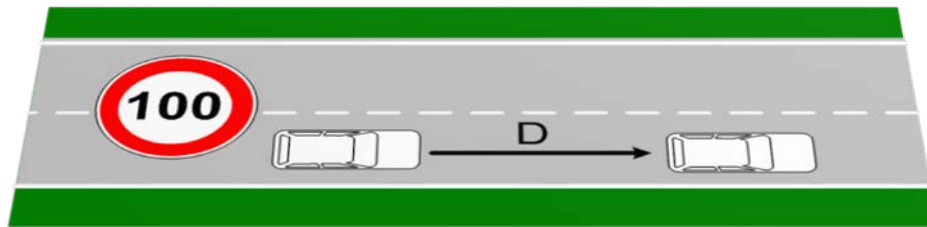


Partly Automated





Design of the automation level partly automated





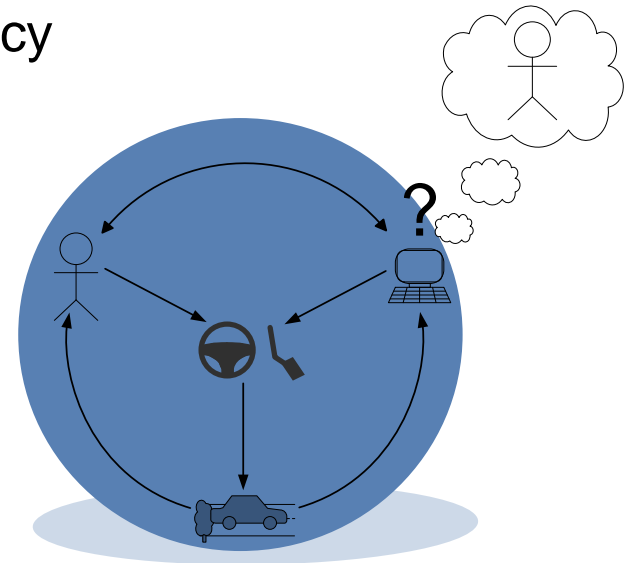
Research question

Adaptive driver
intention model

VS

Non-Adaptive driver
intention model

under
a high system transparency





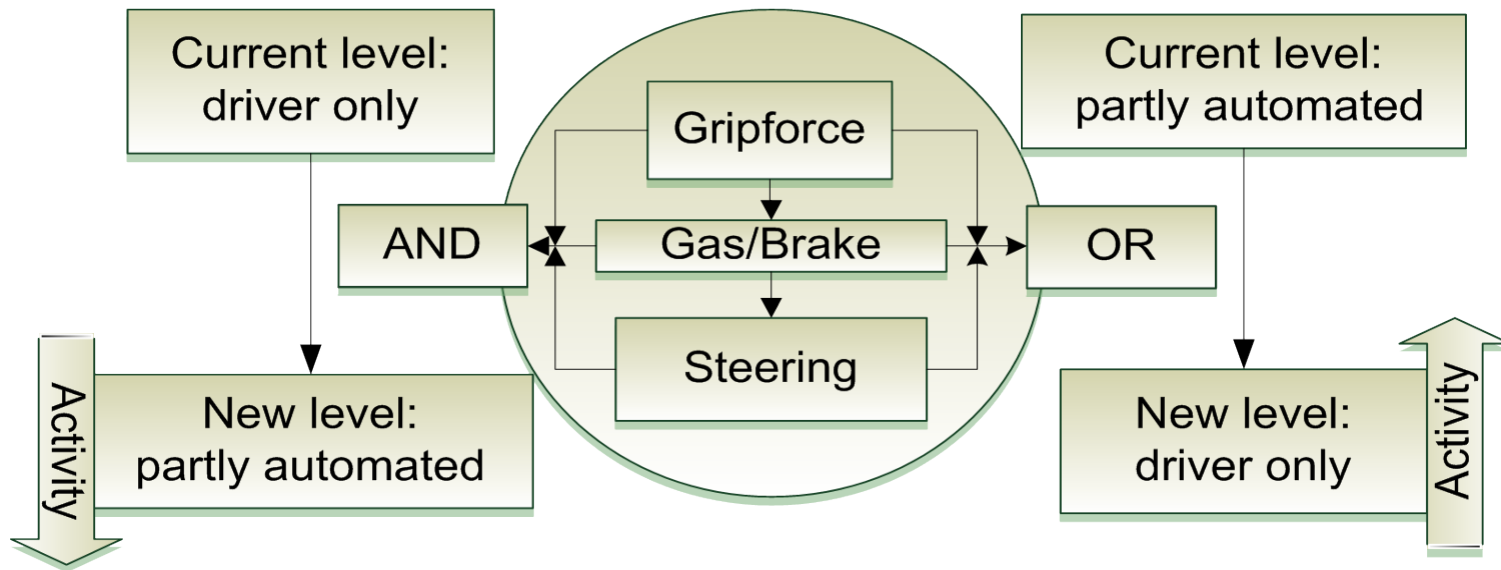
Concept part... Done!

Now...modelling





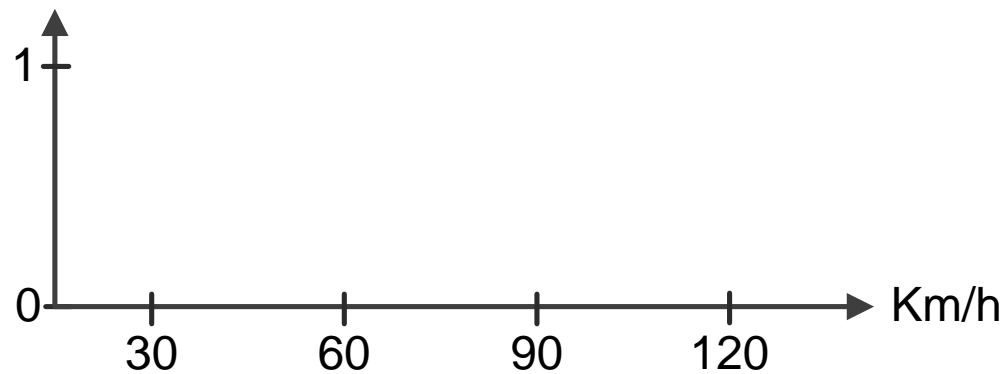
Non-adaptive approach





Adaptive approach: Fuzzy Logic

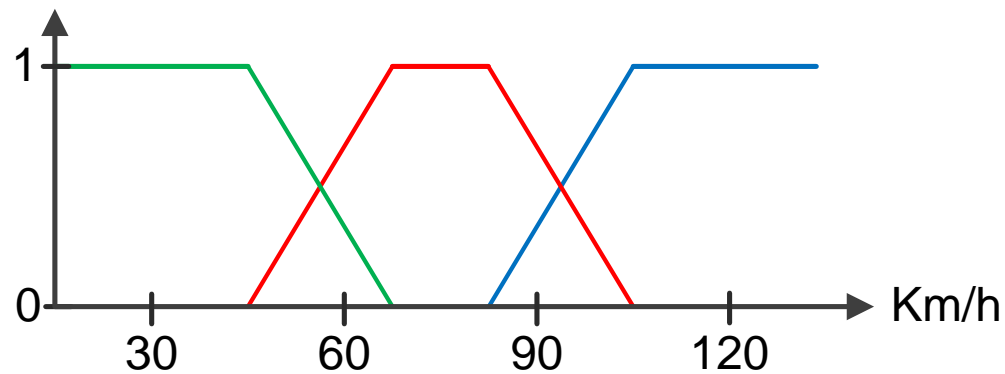
➤ Fuzzy sets and linguistic variables





Adaptive approach: Fuzzy Logic

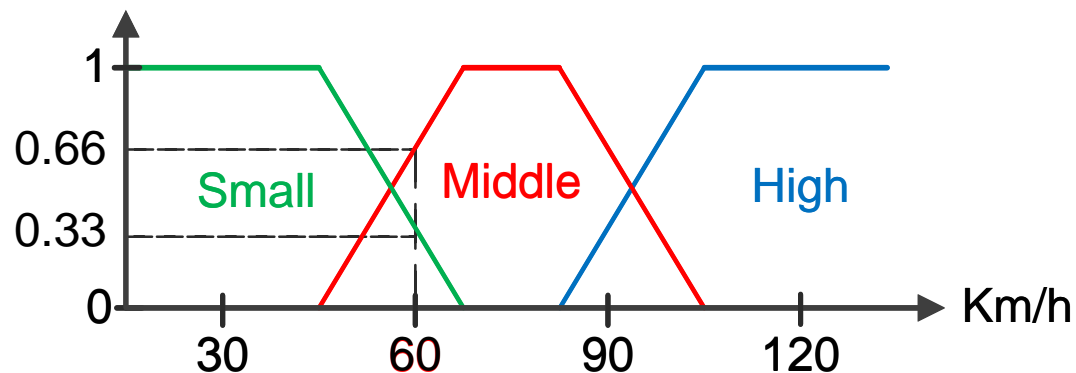
→ Fuzzy sets and linguistic variables





Adaptive approach: Fuzzy Logic

➤ Fuzzy sets and linguistic variables



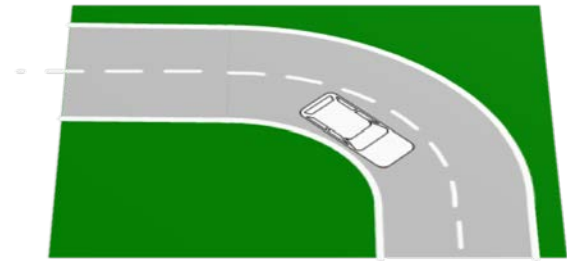
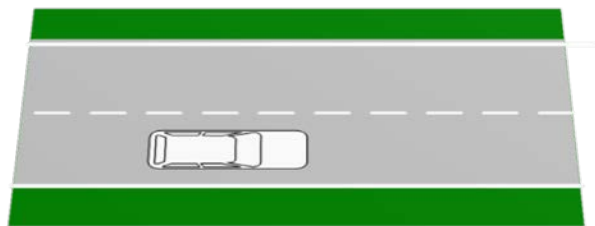
➤ Fuzzy rules:

IF Velocity Middle ≥ 0.3 **THAN...**

IF Velocity Middle ≥ 0.3 **AND** Distance Small ≥ 0.9 **THAN...**

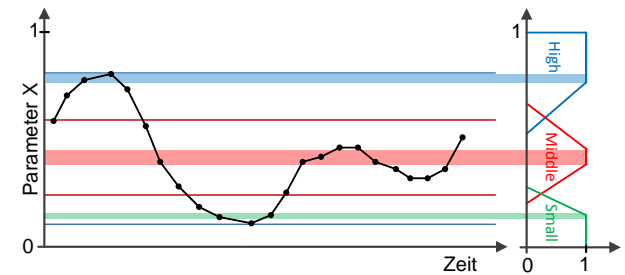
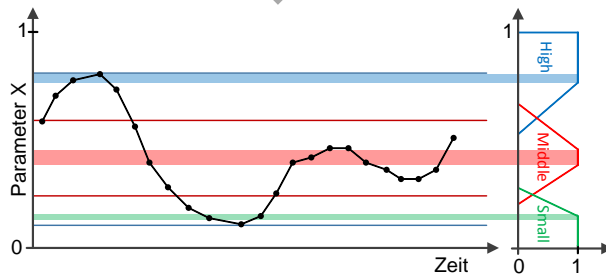


Adaptive approach: Driver and situation adaptation



90 sec.

90 sec.



Linear interpolation





Activity display

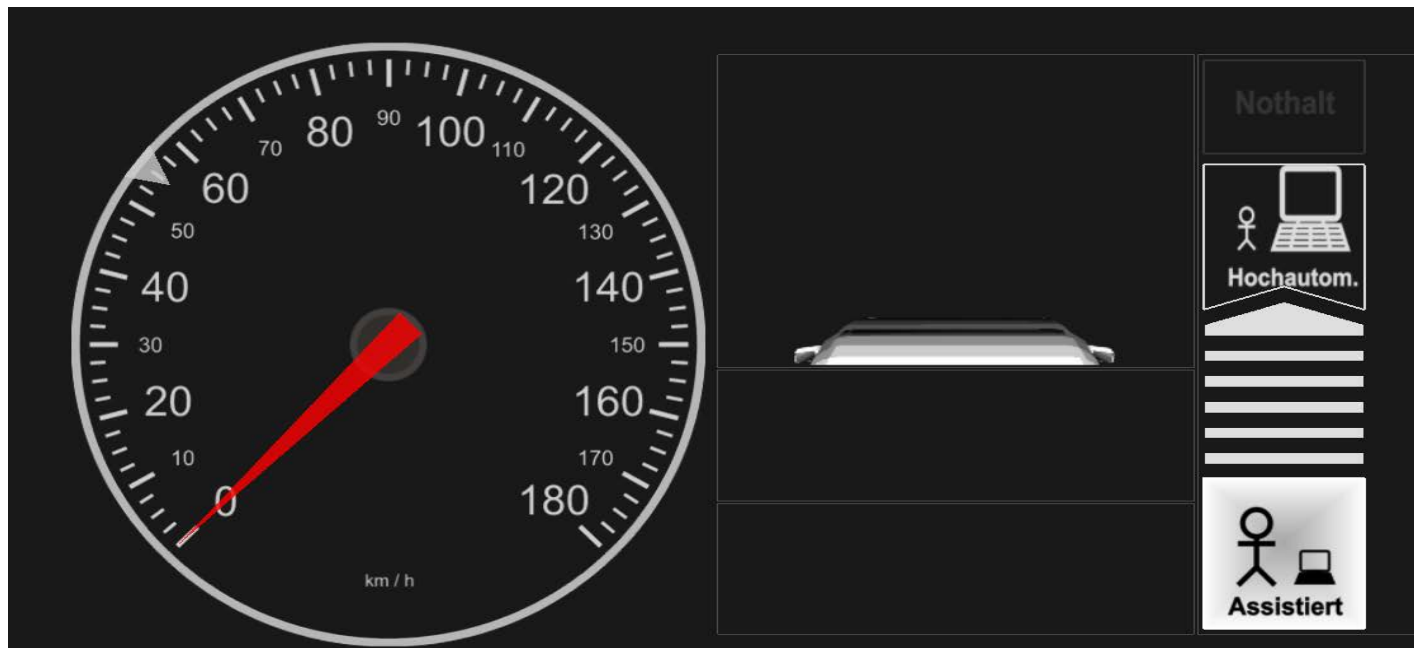


Fig.: Example of a transition



Modelling part... Done!

Now...results





Experimental setting: groupe design

Group A

Number: 5 male, 1 female

Age range: 22 - 27 years

Average age: 25 years



Adaptive Model (Adap)

Group B

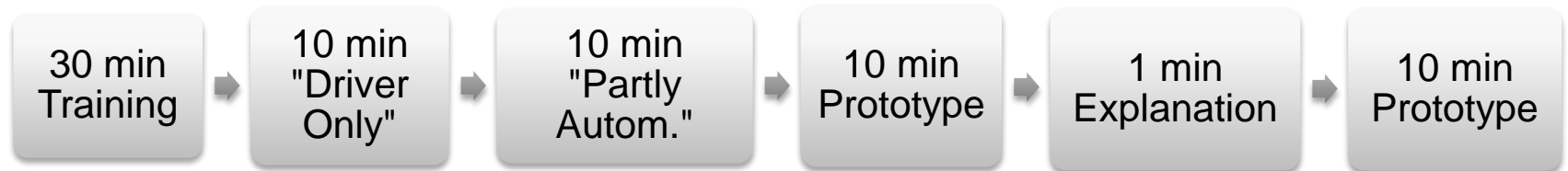
Number: 6 male, 1 female

Age range: 21- 46 years

Average age: 29 years



Non-adaptive Model (Non-Adap)





Experimental setting: Simulator





Experimental results

The transitions were...	Prototype	-3	-2	-1	0	1	2	3	
too early	Adap			1	21	2			too late
unreliable	Adap			1		3	14	6	reliable
incomprehensible	Adap					4	11	9	comprehensible

Table: Subject rating of the transitions



Experimental results

The transitions were...	Prototype	-3	-2	-1	0	1	2	3	
too early	Adap			1	21	2			too late
	Non-Adap		1	3	9			1	
unreliable	Adap			1		3	14	6	reliable
	Non-Adap		1	1	3	4	2	3	
incomprehensible	Adap					4	11	9	comprehensible
	Non-Adap		2			4	5	2	

Table: Subject rating of the transitions



Experimental results

The activity display helped to improve the...	Prototype	-2	-1	0	1	2
understanding of the automation	Adap		1	1	1	3
comprehension of the automation	Adap			1	2	3
controllability of the automation	Adap			2		4
driving in general	Adap		1	1	1	3
I had to look frequently to the activity display	Adap	2		3	1	
I wouldn't have needed the activity display	Adap		3	1	1	1

Table: Subject rating of the activity display



Experimental results

The activity display helped to improve the...	Prototype	-2	-1	0	1	2
understanding of the automation	Adap		1	1	1	3
	Non-Adap			1	1	5
comprehension of the automation	Adap			1	2	3
	Non-Adap				2	5
controllability of the automation	Adap			2		4
	Non-Adap			1		6
driving in general	Adap		1	1	1	3
	Non-Adap			2	2	3
I had to look frequently to the activity display	Adap	2		3	1	
	Non-Adap	1		2	2	2
I wouldn't have needed the activity display	Adap		3	1	1	1
	Non-Adap	4	2		1	

Table: Subject rating of the activity display



Experimental results

The prototype was...	Prototype	-3	-2	-1	0	1	2	3	
bad	Adap						4	2	good
uncomfortable	Adap						3	3	comfortable
difficult to learn	Adap						1	5	easy to learn
difficult to use	Adap						1	5	easy to use
useless	Adap					1	2	3	usefull
annoying	Adap					2	2	2	pleasant

Table: Overall evaluation of the prototypes



Experimental results

The prototype was...	Prototype	-3	-2	-1	0	1	2	3	
bad	Adap						4	2	good
	Non-Adap					3	1	2	
uncomfortable	Adap						3	3	comfortable
	Non-Adap		1	1	1		3	1	
difficult to learn	Adap						1	5	easy to learn
	Non-Adap		1			1	4	1	
difficult to use	Adap						1	5	easy to use
	Non-Adap		1		1	2	2	1	
useless	Adap					1	2	3	usefull
	Non-Adap					4	2	1	
annoying	Adap					2	2	2	pleasant
	Non-Adap			1	2	1	2	1	

Table: Overall evaluation of the prototypes



“[The autonomous car] has been one of those dreams that's always seemed about 20 years in the future.”

Chris Gerdes, Professor @ Stanford University, CA

Source: www.ted.com





Done. Thank You!

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