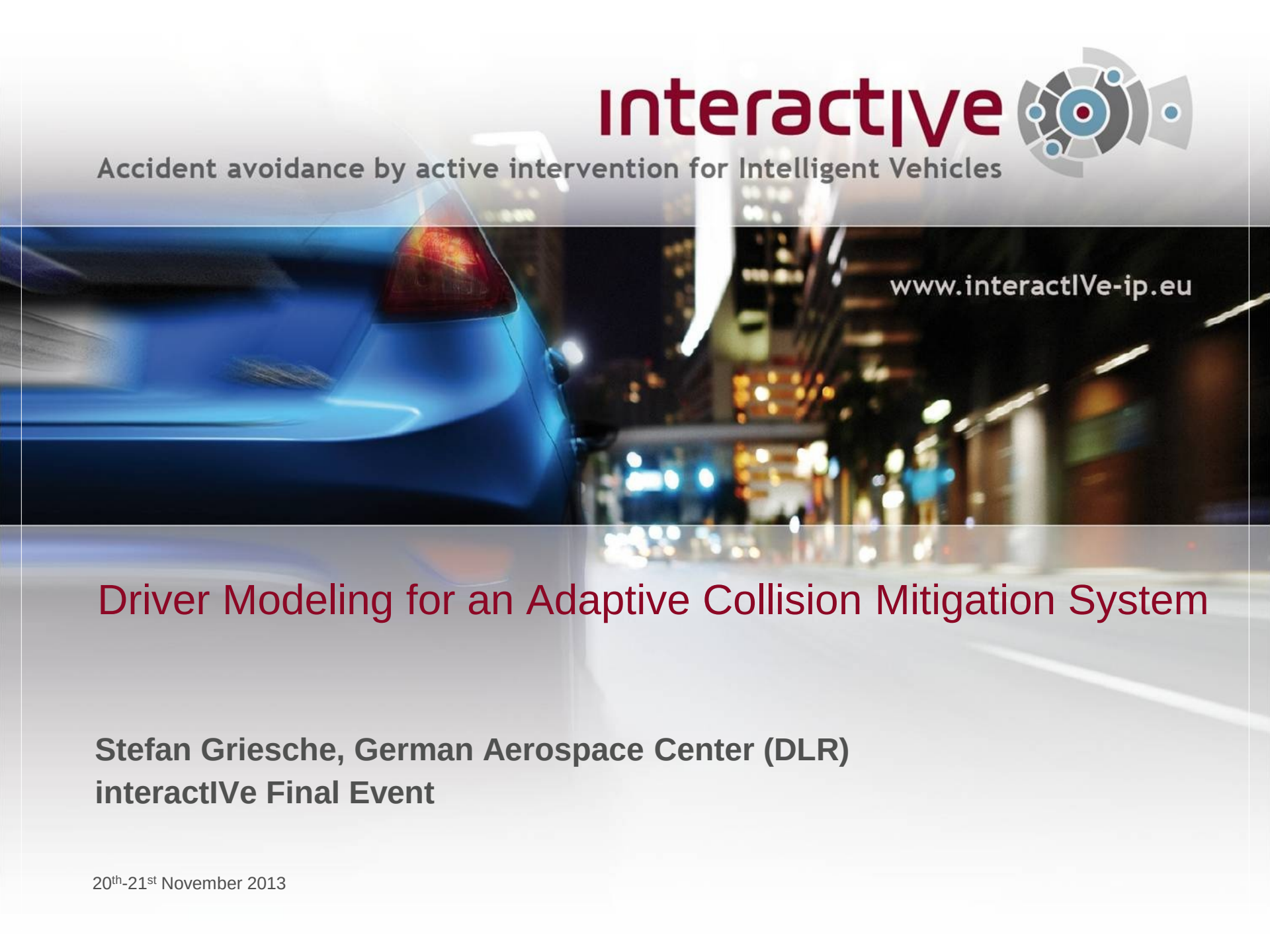


Driver Modeling for an Adaptive Collision Mitigation System

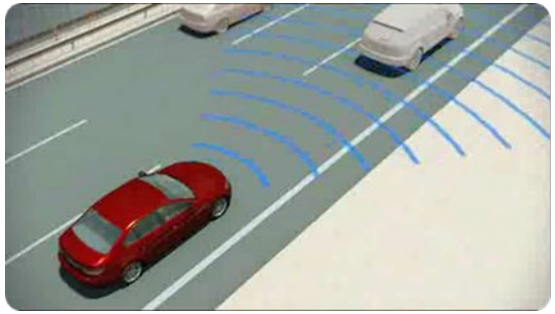
Stefan Griesche, German Aerospace Center (DLR)

interactIVe Final Event

20th-21st November 2013

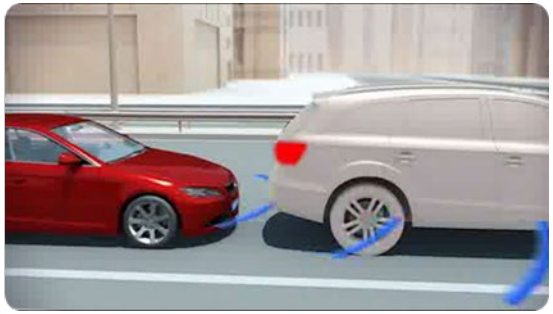
Collision Mitigation System (CMS)

Analyze criticality of the situation



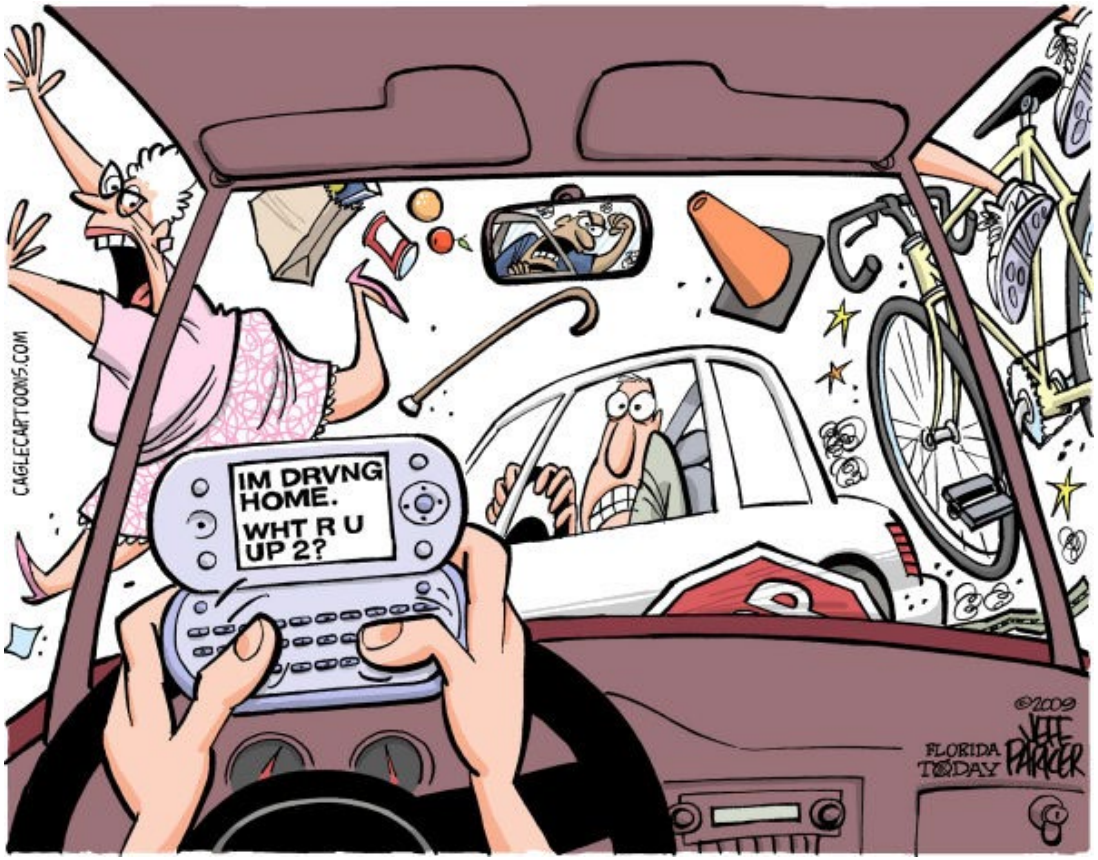
Visual+acoustic warning if situation critical

Autonomous braking if driver reaction missing



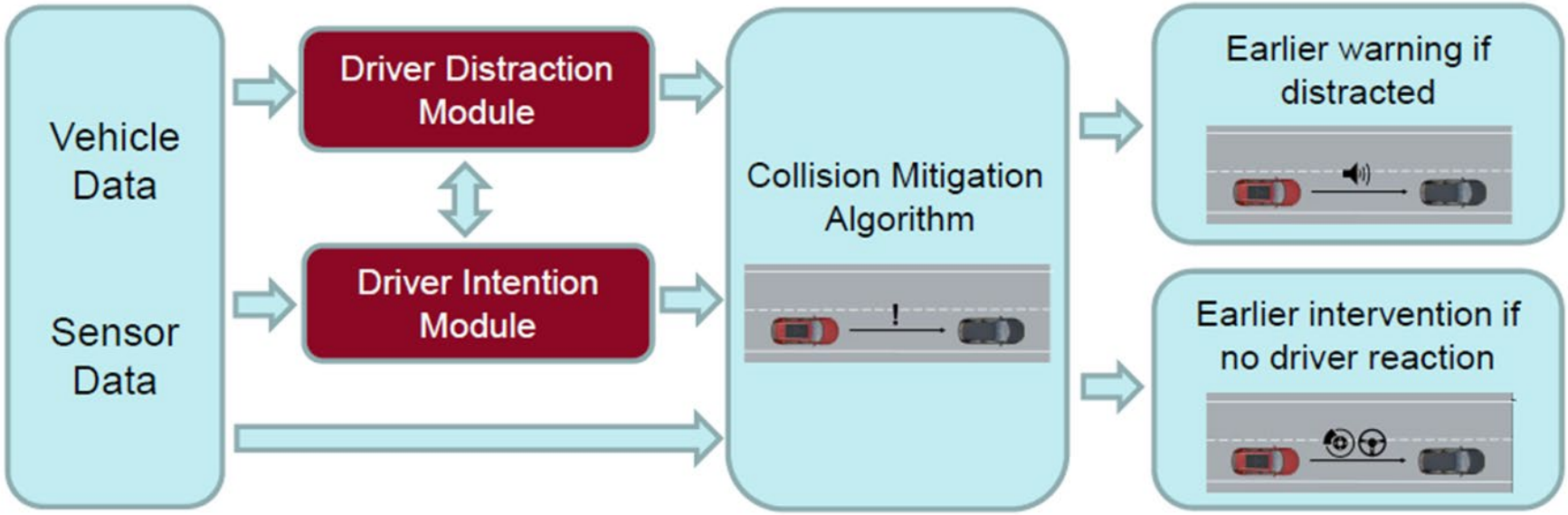
Source: http://www.bester-beifahrer.de

Study results: Visually distracted drivers have an additional response time between 300 ms and 500 ms

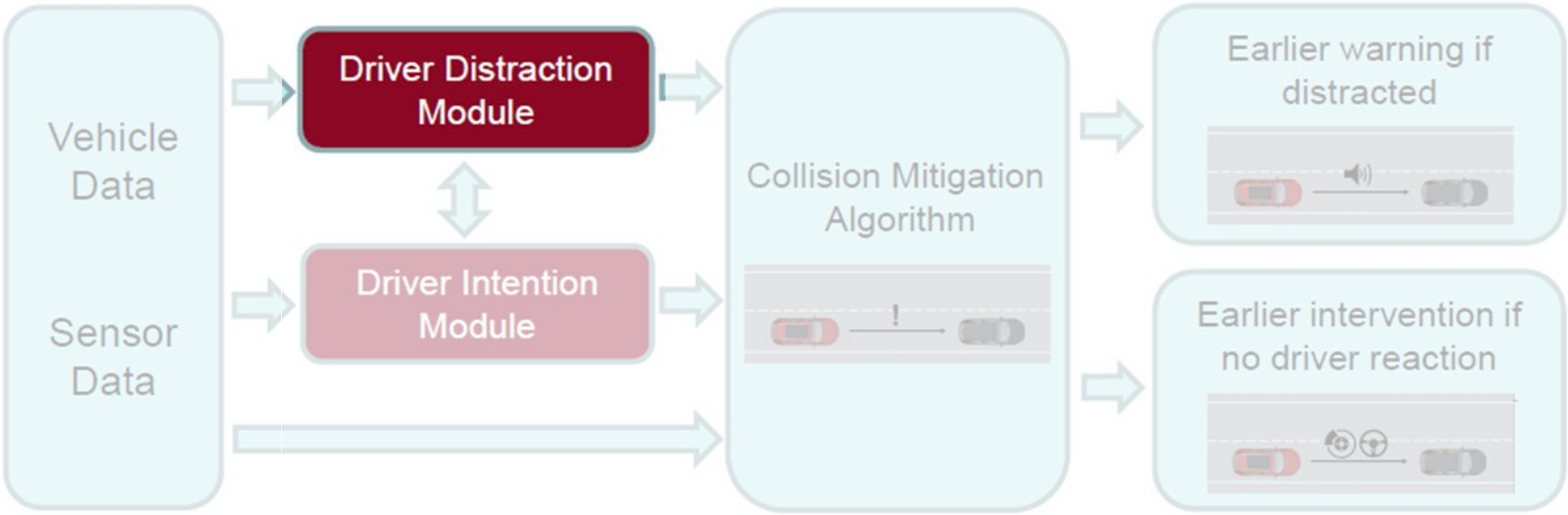


Source: http://www.cagle.com/category/cartoonist/page/155

Driver-adaptive CMS



Focus: Driver Distraction Module



Todays topic…Clear!

Now…Driver Modeling

Requirements to the driver model

EMIC - cost-efficient emergency intervention for collision mitigation

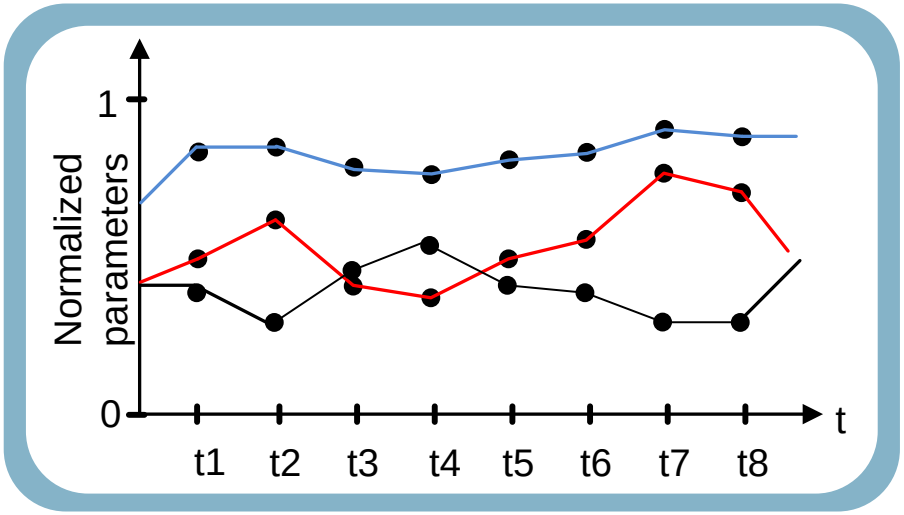
No additional sensors

Instead search abnormal patterns within the driver behavior

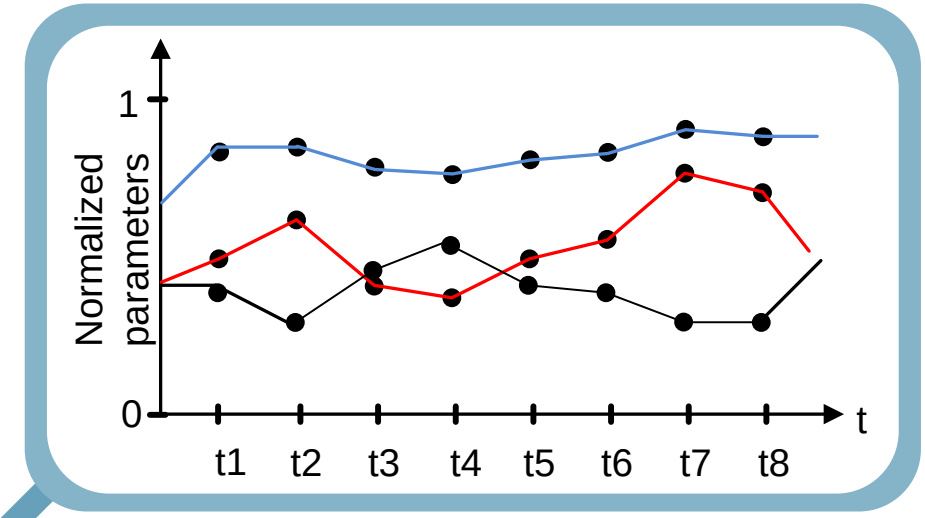
- Steering angle
- Brake pedal position
- Acceleration throttle pos.
- Lateral deviation

Main task: Learn natural driving behavior for each individual driver

Starting point: Driving behavior as multivariate time series



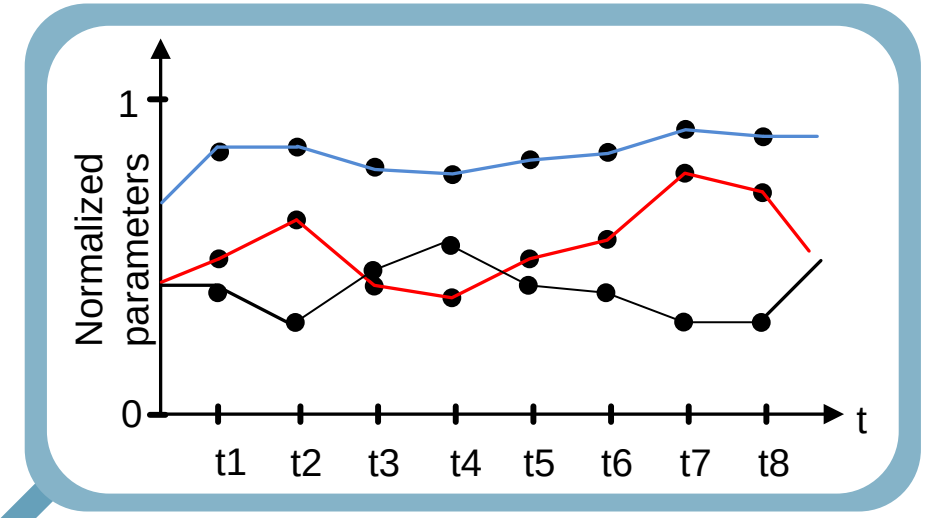
Driving behavior as data matrix



Data Matrix

$$\begin{pmatrix} A(t_1) & A(t_2) & A(t_3) & A(t_4) & A(t_5) & A(t_6) & A(t_7) & A(t_8) \\ B(t_1) & B(t_2) & B(t_3) & B(t_4) & B(t_5) & B(t_6) & B(t_7) & B(t_8) \\ C(t_1) & C(t_2) & C(t_3) & C(t_4) & C(t_5) & C(t_6) & C(t_7) & C(t_8) \end{pmatrix}$$

Driving behavior as data matrix

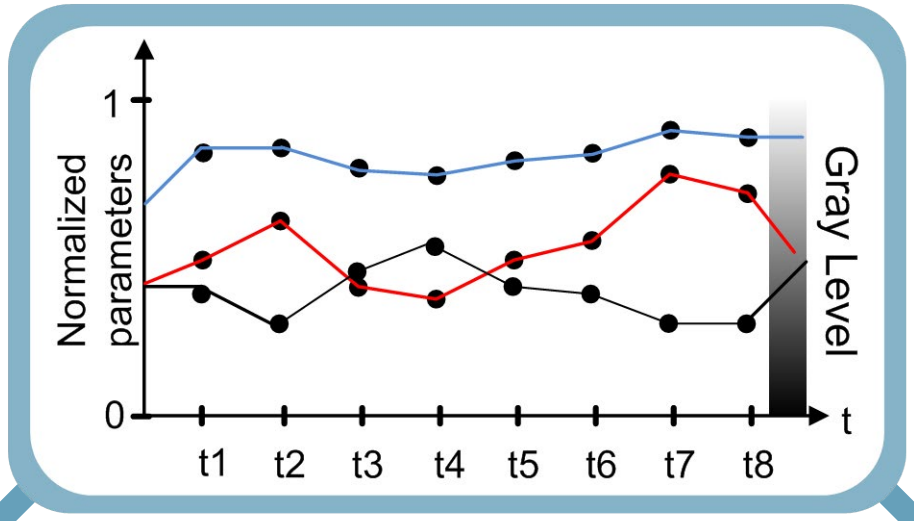


Data Matrix

$$\begin{pmatrix} A(t_1) & A(t_2) & A(t_3) & A(t_4) & A(t_5) & A(t_6) & A(t_7) & A(t_8) \\ B(t_1) & B(t_2) & B(t_3) & B(t_4) & B(t_5) & B(t_6) & B(t_7) & B(t_8) \\ C(t_1) & C(t_2) & C(t_3) & C(t_4) & C(t_5) & C(t_6) & C(t_7) & C(t_8) \end{pmatrix}$$

Too complex ☺

Better: Multivariate time series as an image by gray level mapping

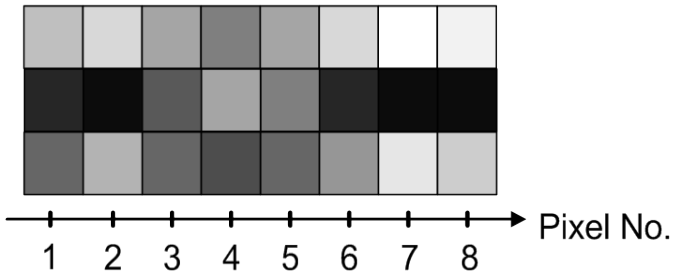


Data Matrix

$$\begin{pmatrix} A(t_1) & A(t_2) & A(t_3) & A(t_4) & A(t_5) & A(t_6) & A(t_7) & A(t_8) \\ B(t_1) & B(t_2) & B(t_3) & B(t_4) & B(t_5) & B(t_6) & B(t_7) & B(t_8) \\ C(t_1) & C(t_2) & C(t_3) & C(t_4) & C(t_5) & C(t_6) & C(t_7) & C(t_8) \end{pmatrix}$$

Too complex ☺

Data Image



What‘s the advantage of a transformation into an image?

1. Connection to pattern recognition in image processing

2. Possibility to introduce a design metaphor which helps to understand and visualize the behavior of driver model easily

Design metaphor: Human memory & mental representations

What‘s the advantage of the design metaphor?

1. Concept for the designer of the driver model to manage the huge amount of data images

2. Concept to learn and store only relevant knowledge

Design metaphor: Human memory & mental representations …a simple example

Cluster experiences in categories



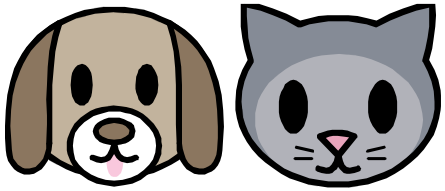



Source: office.com

Design metaphor: Human memory & mental representations …a simple example

Cluster experiences in categories

For each category build mental representations of prototypes

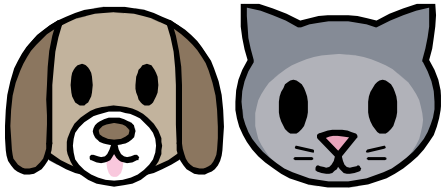


Source: office.com

Design metaphor: Human memory & mental representations …a simple example

Cluster experiences in categories

For each category build mental representations of prototypes



Remember prototype and compare with current experience

Source: office.com

Design metaphor: Human memory & mental representations …a simple example

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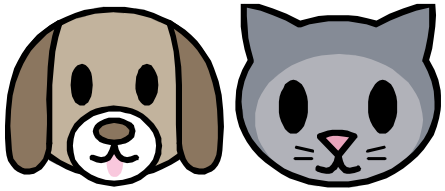

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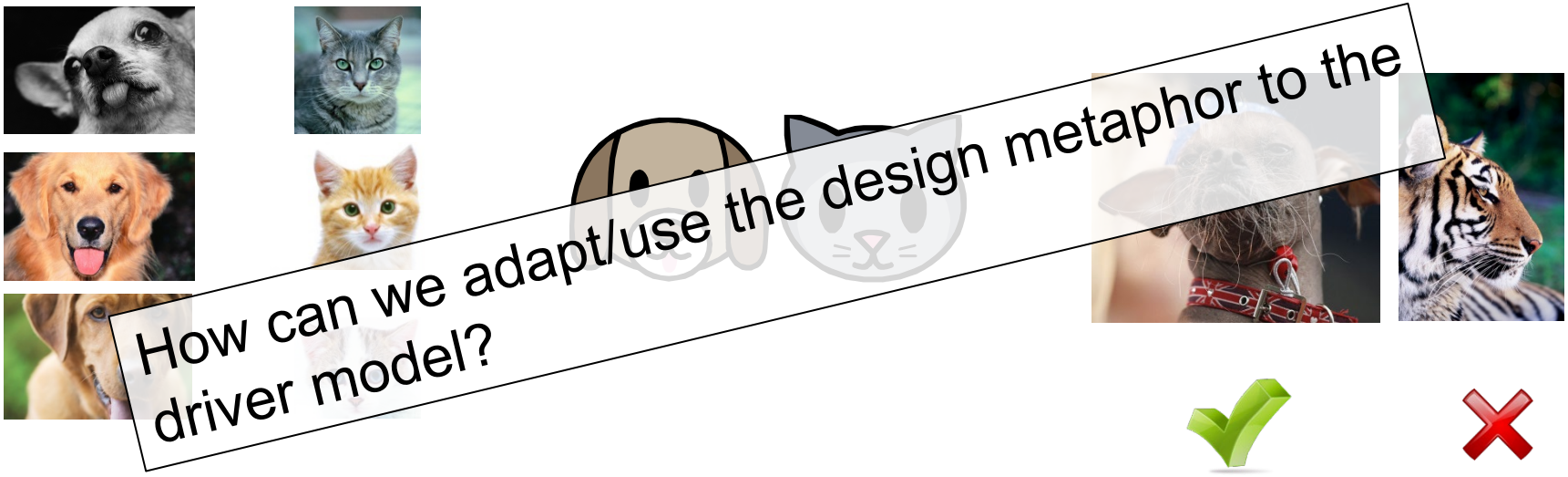

Source: office.com

Design metaphor: Adaptation to driver model

Cluster car following situations

For each situation build mental representation of natural driving behavior

Remember natural driving behavior and compare with current behavior

Design metaphor: Adaptation to driver model

Cluster car following situations

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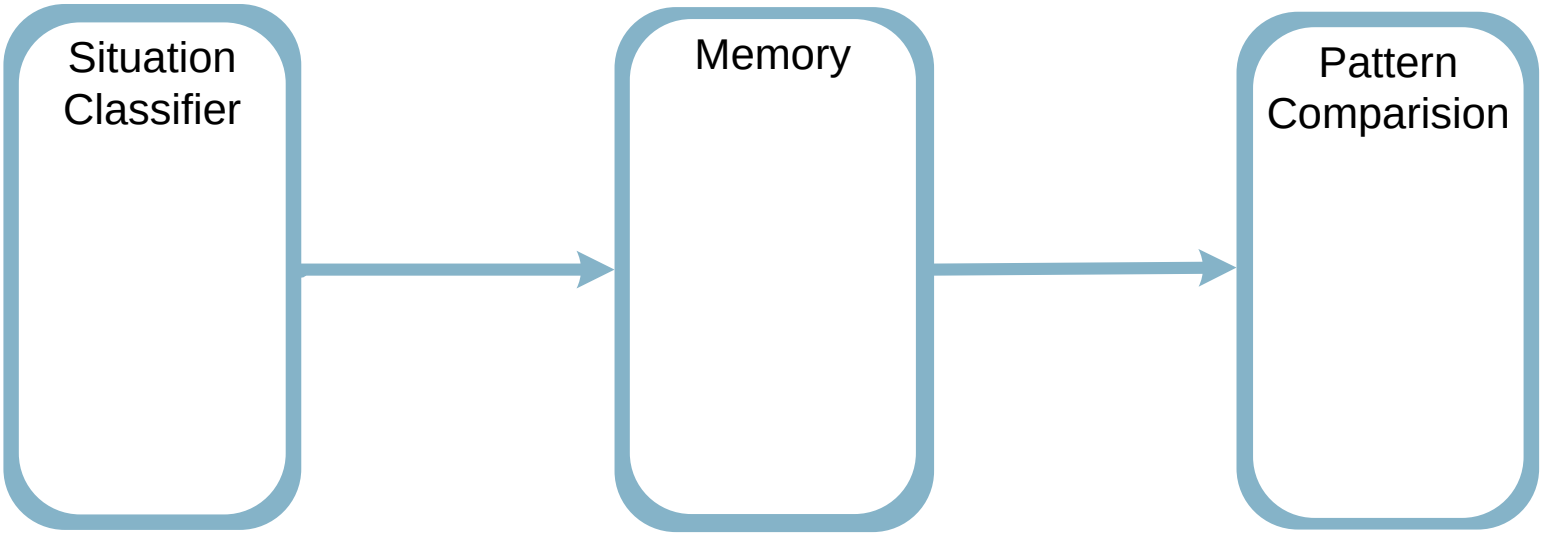
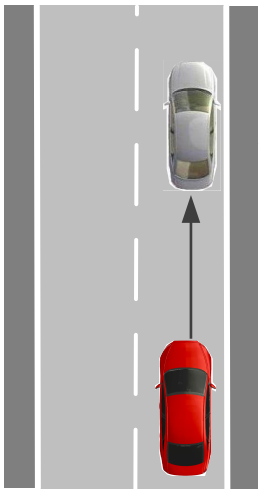
Remember natural driving behavior and compare with current behavior



Siutation Classifier: Composition of states into a situation number



State Transformation

Distance	State
> 50m	0
< 50m & >= 25m	1
< 25m & >= 15m	2
< 15m & >= 10m	3
< 10m & >= 5m	4
< 5m	5

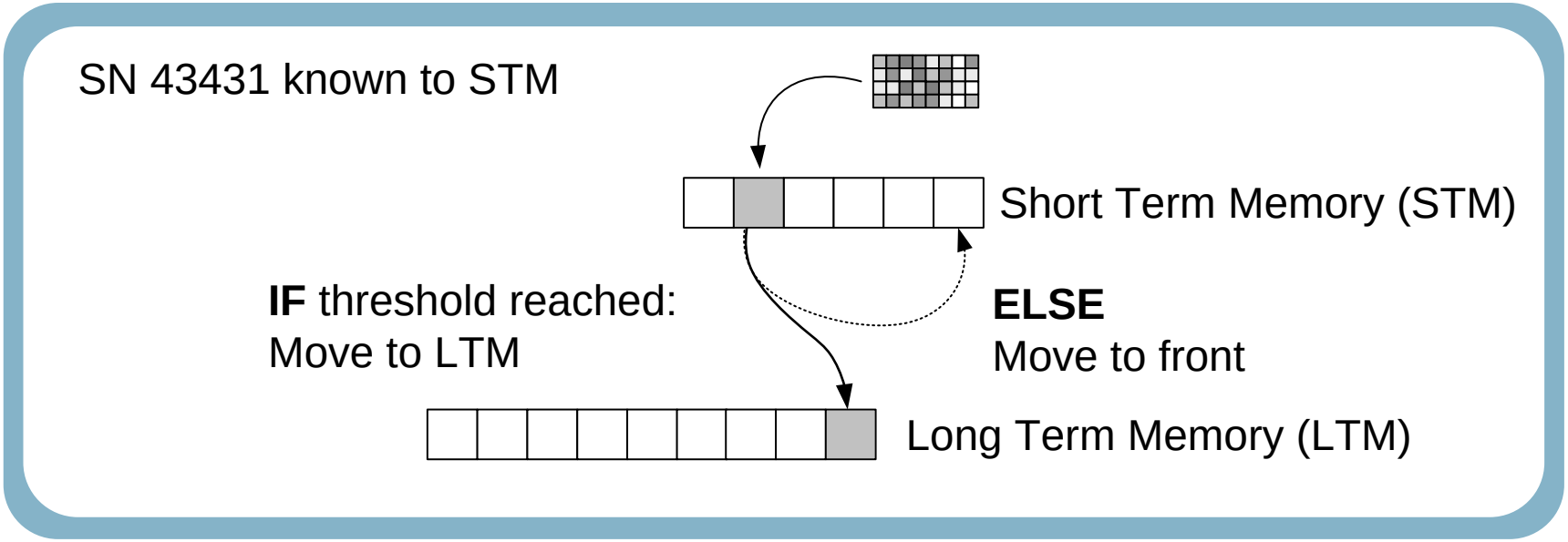
State Composition

Parameter	State
v_Ego	4
v_Lead	3
a_Lead	4
t_BrakeDuration	3
Distance	1

Situation Number: 43431

Situation Classifier

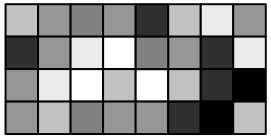
Memory: Rule based organization of short and long term memory cells by situation numbers



Memory

Memory: Learning phase - Iterative process of classifying situation and storage of data

SN 43431 with stored images



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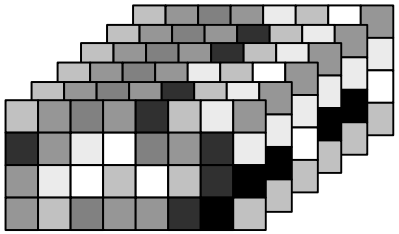
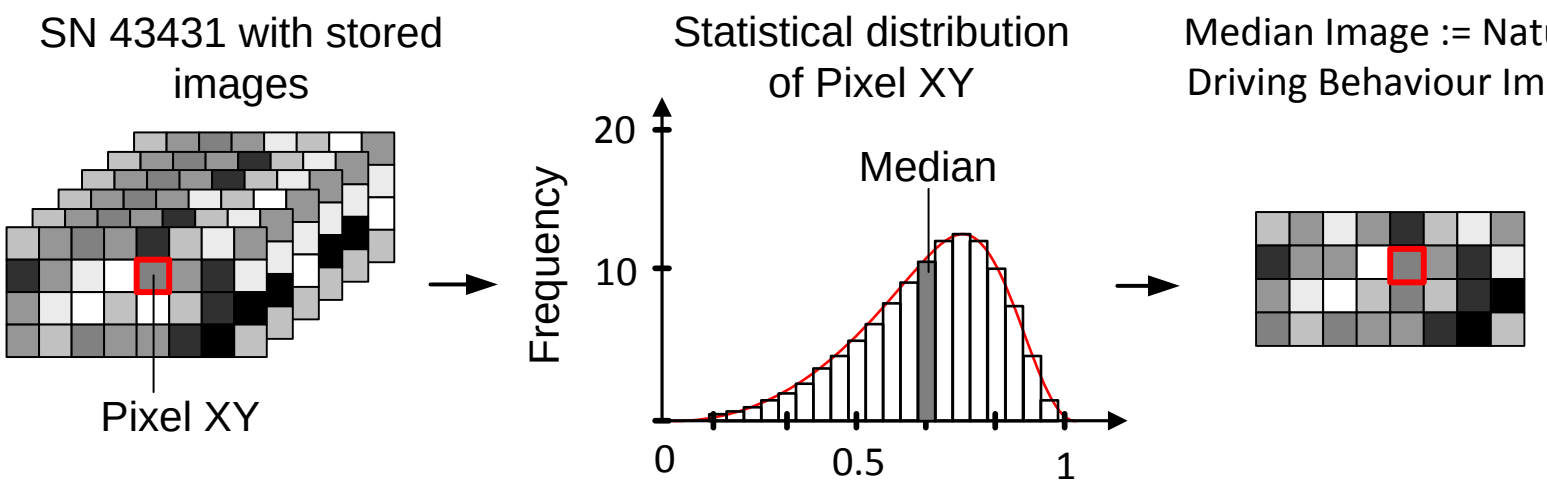


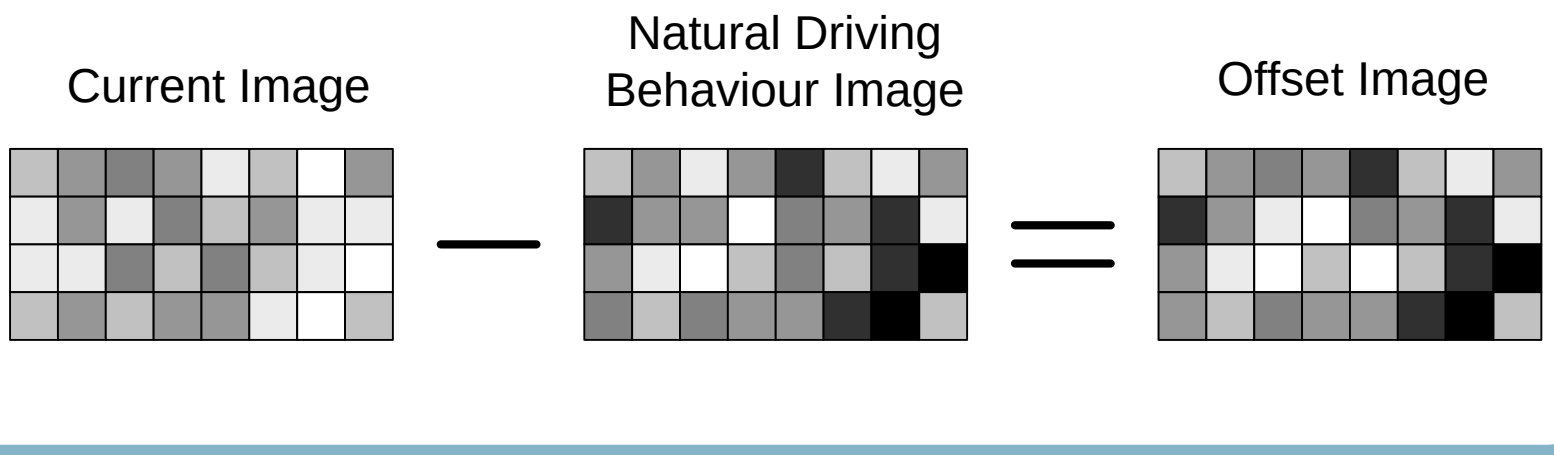
Memory

Memory: Build up a mental representation



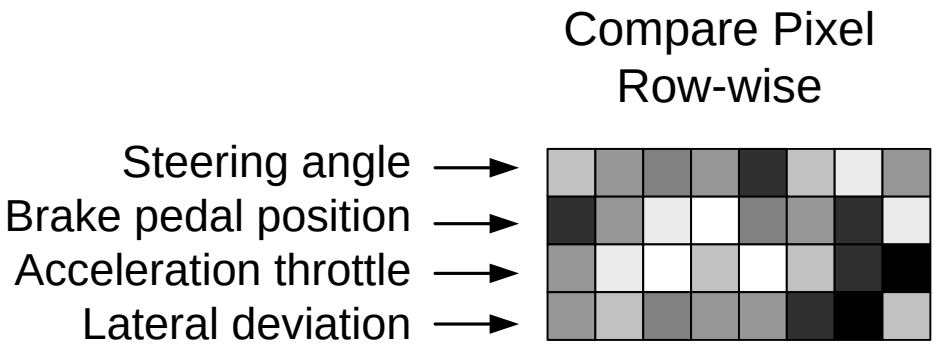
Memory

Pattern Comparison: Calculation of an offset image



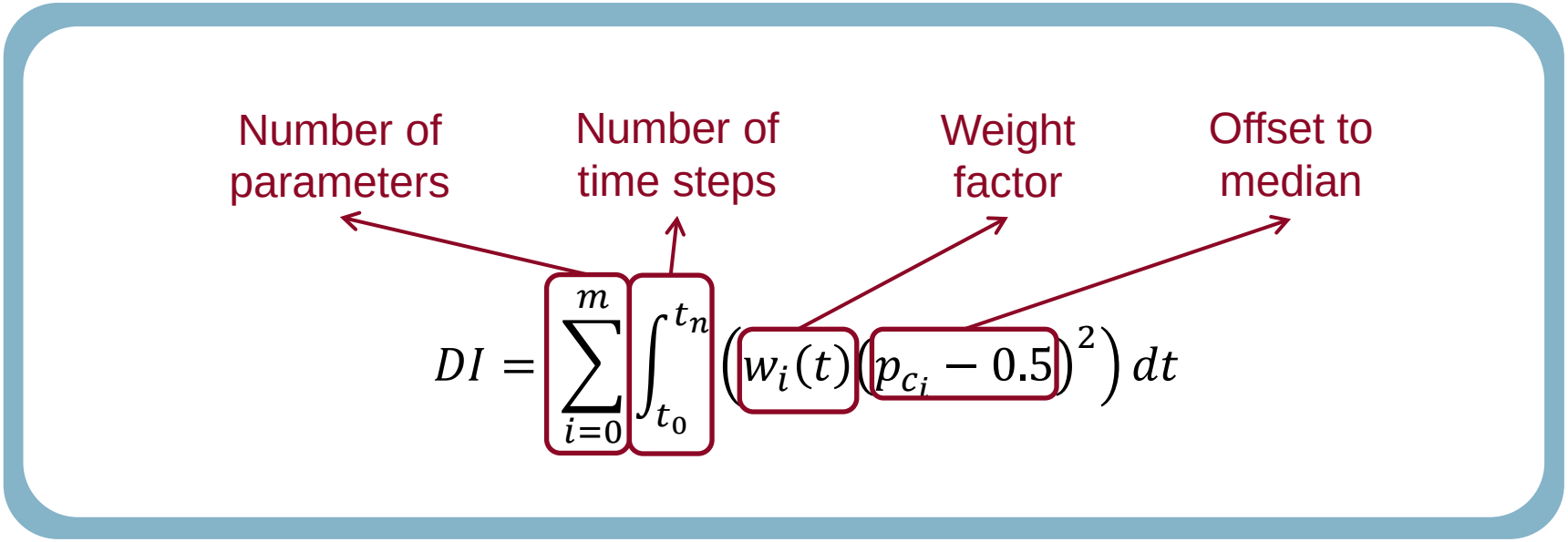
Pattern Comparision

Pattern Comparison: Apply image processing approaches to offset image



Pattern Comparision

Pattern Comparison: The Distraction Index (DI) is the final output and is a linear value between 0 and 1



Pattern Comparision

Driver modeling… Done!

Now…Evaluation

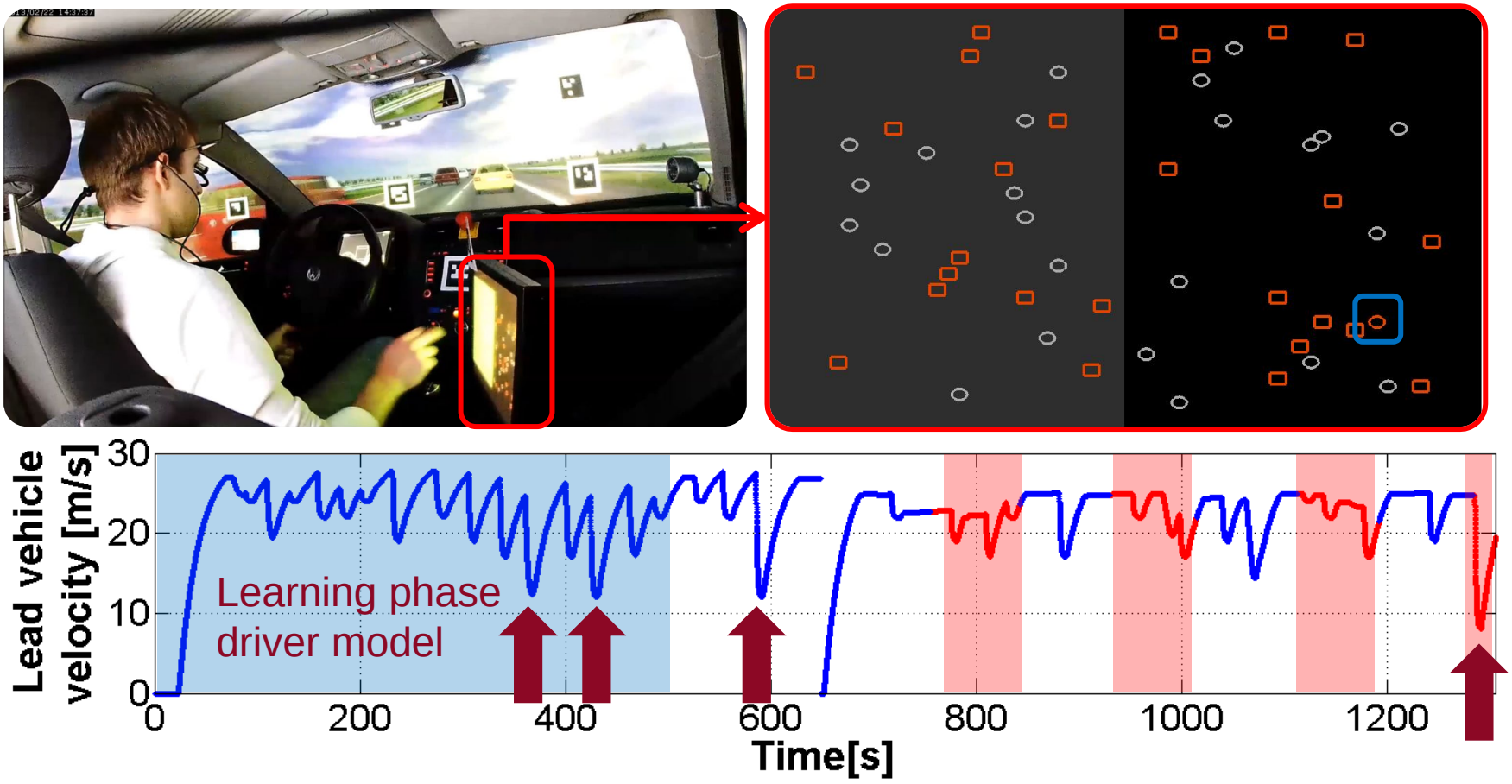
Evaluation: Study design

Training (10 min)

Normal driving (10 min)

Distracted driving with critical situation (10 min)

Scenario – Distracted driving: four phases with a secondary task (red coloured)



Evaluation results: Model configuration

Memory

STM: 30 Cells

LTM: 50 Cells

Threshold: 20

Image

Size: 4x50 Pixel, 1 Pixel = 100ms

Gray Levels: 30

Inputs: Steering angle

Brake pedal position

Acceleration throttle position

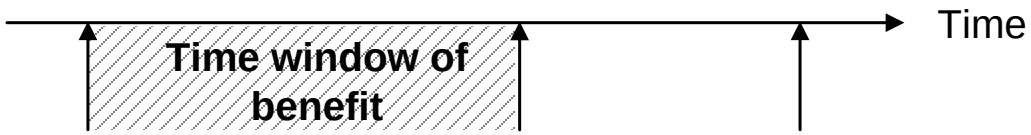
Lateral deviation

Evaluation results:

11 participants (8m/3f), 27 critical situations, 10 under distraction

90% True positive by distraction

Activation of CMS between 40ms and 200ms earlier



Activation acoustic warning by 300 ms additional RT

Activation acoustic warning by normal RT

Potential Collision

Evaluation results:

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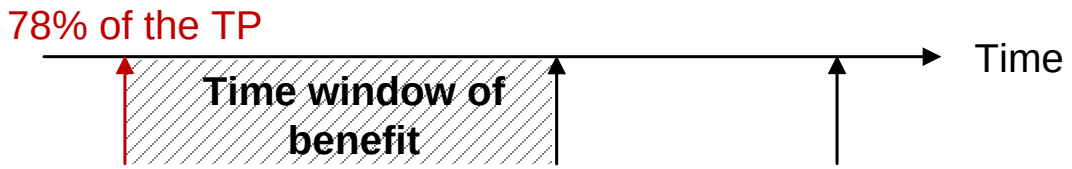

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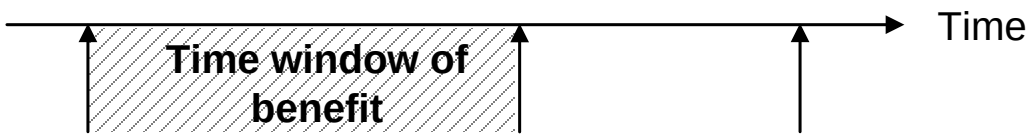
90% True positive by distraction

Activation of CMS between 40ms and 200ms earlier

83% True negative by none distraction

Activation of CMS between 40ms and 60ms earlier



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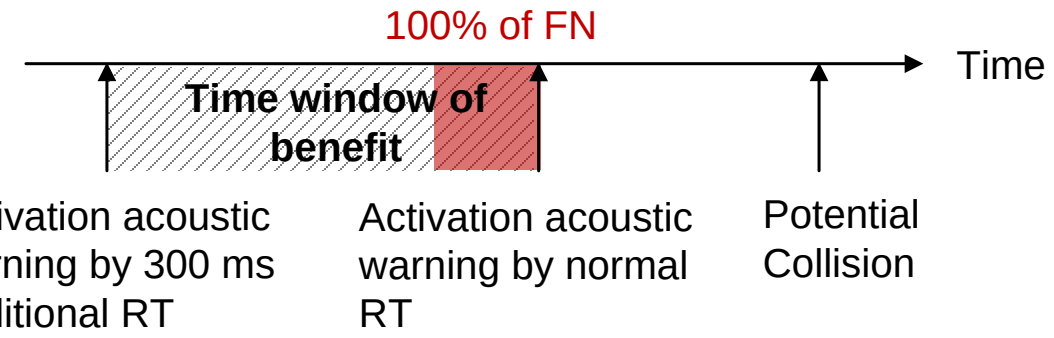
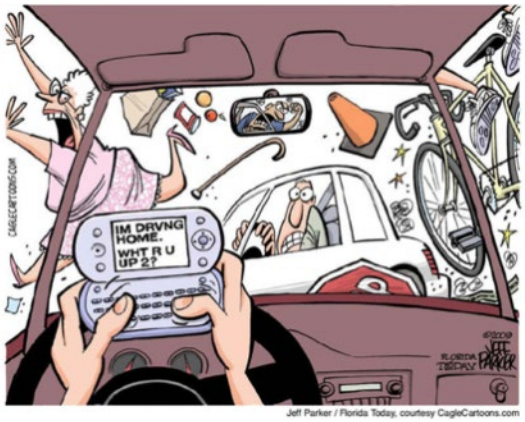
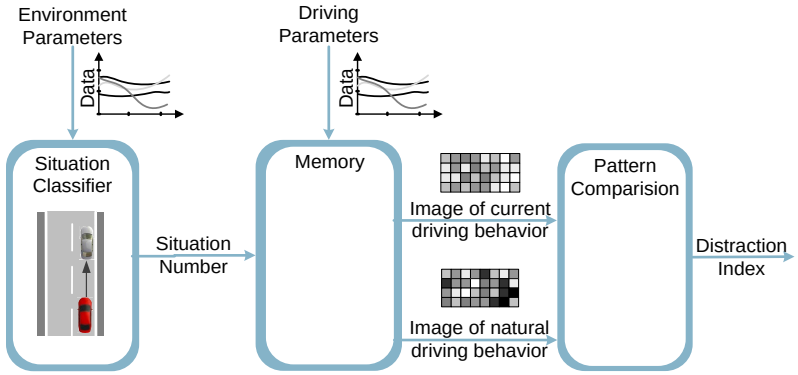


Conclusion: Driver model improved CMS in the simulation

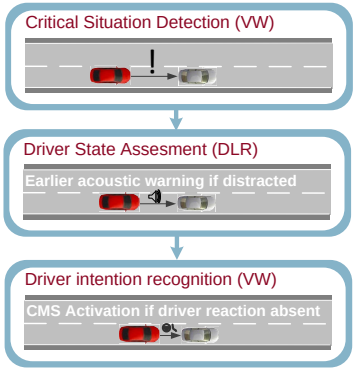
Issue



Evaluation



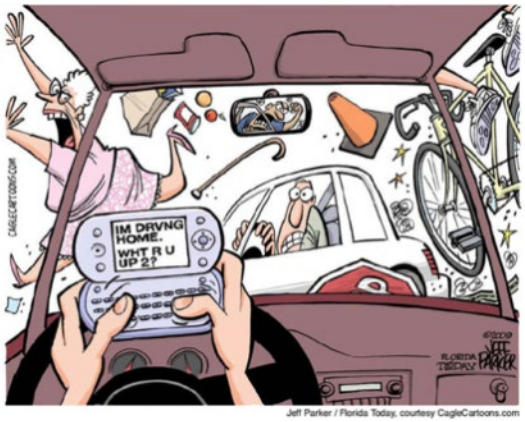
Model



Approach

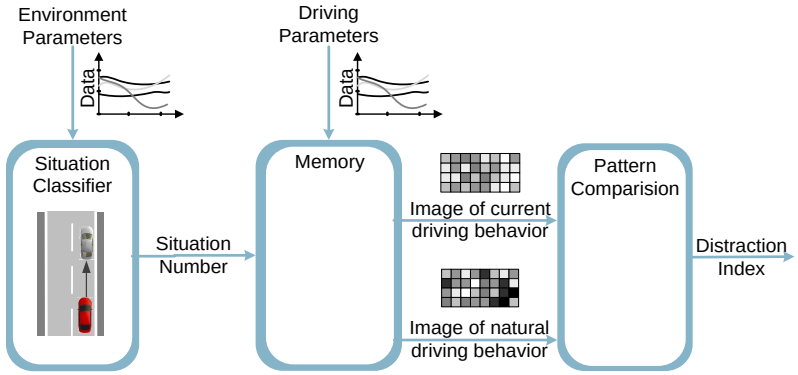
Outlook: Validate driver model on real traffic data

Issue

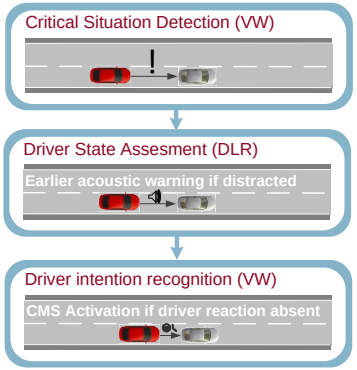


Evaluation

Model



Approach



Take home message

Behind every matrix is an image

and

sometimes a driver model can be explained with dogs and cats ☺

Acknowledgements

- **cost-efficient emergency intervention for collision mitigation team**

interactIVe

Accident avoidance by active intervention for Intelligent Vehicles

Thank you.

Co-funded and supported
by the European Commission

SEVENTH FRAMEWORK
PROGRAMME

Stefan Griesche, PhD Student
German Aerospace Center (DLR)
Stefan.Griesche@dlr.de

DLR Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center