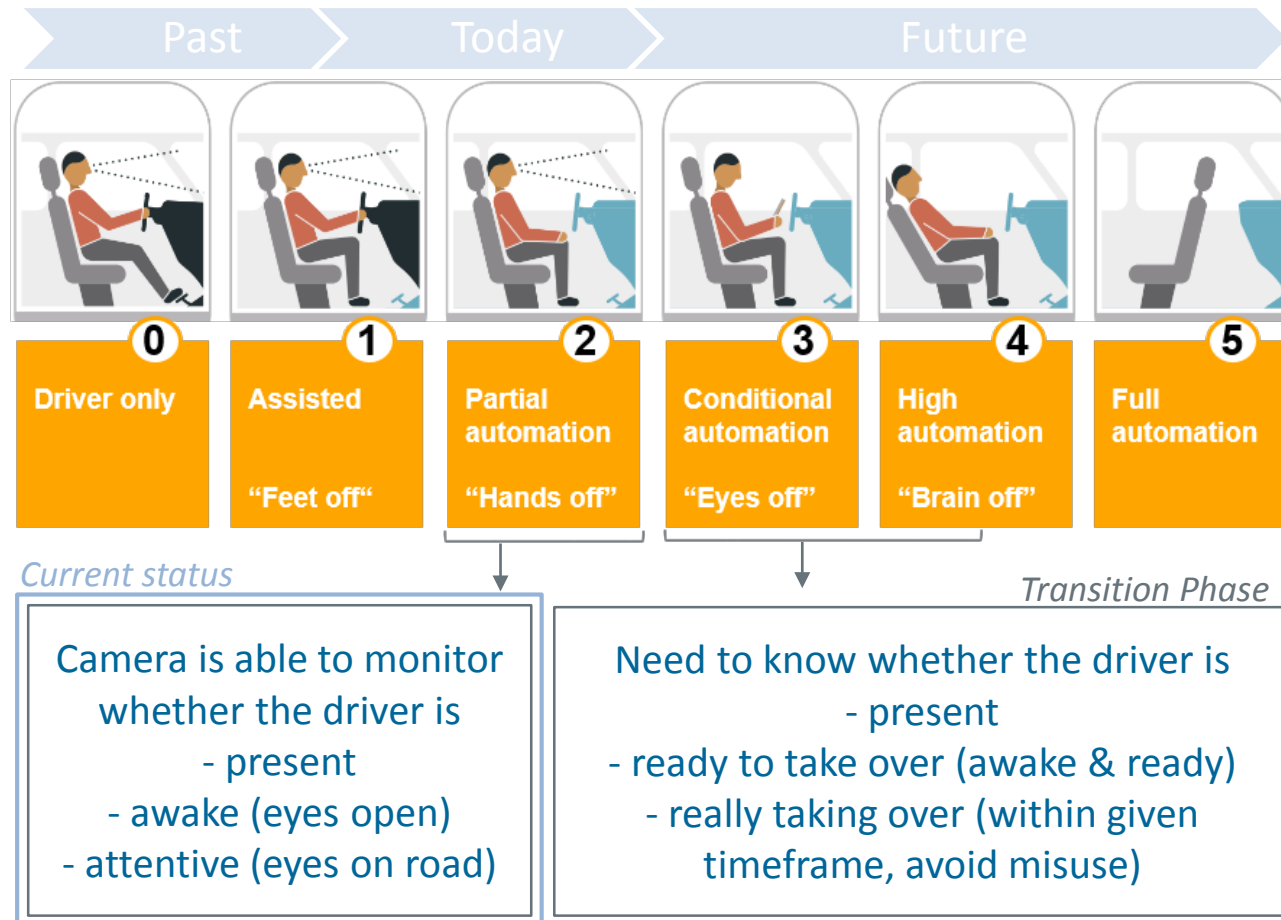


Interior Camera - A solution to Driver Monitoring Status



Driver Monitoring in the Context of Automated Driving

Ensure Smooth Transition Phases



One key factor in take-over scenarios is
Driver Availability Recognition

Drivers are attentive when their
eyes are on the road

To know if a driver has the eyes on the road,
it is crucial to **monitor the eyes**

Eye gaze can only be monitored with
a **visual system**

**Interior Camera is suitable
for Driver Monitoring**

Driver Monitoring via Interior Camera

Head-Eye-Tracking System



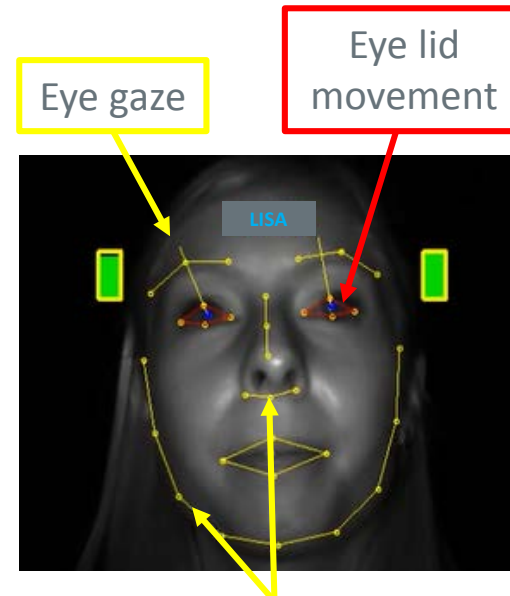
Head-Eye-Tracker (based on visual features)

- Global Shutter Camera
- IR Illumination (850 nm or 940 nm)
- Potential Mounting Positions:

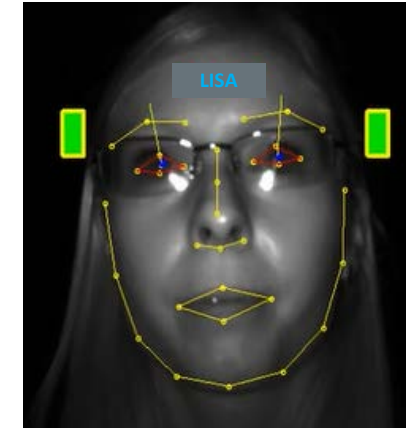


Occlusions are handled dynamically

- First SOP: February 2018
- More SOPs: 2019, 2020 and 2021

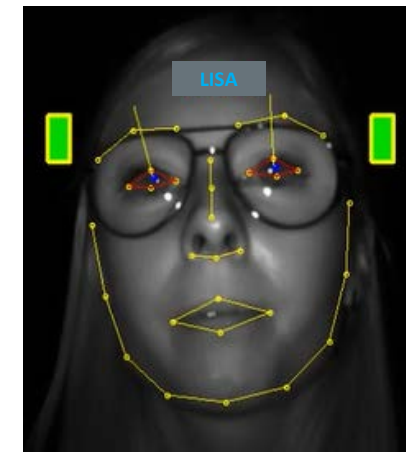


Head pose/ orientation based on landmarks: **eyes**, **nose ridge (important)**, lower nose, face contour, eye brows, mouth/lips



The Interior Camera can look through 'normal' glasses

and through sunglasses¹



(also deals with e.g. face masks, beard)

¹Exception: IR blocking sunglasses

Driver Monitoring via Interior Camera

Current Use Cases (Examples)



Driver Drowsiness Detection

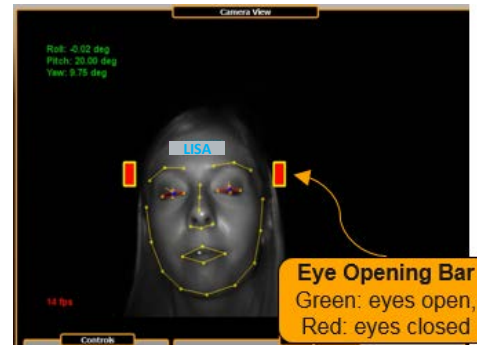
Diagnostic from **Eye Lid Behavior**

- Developed from real driving tests using EEG/EOG expertise



→ based on blink duration and velocity

- E.g. 4 levels derived from Karolinska Sleepiness Scale (KSS)

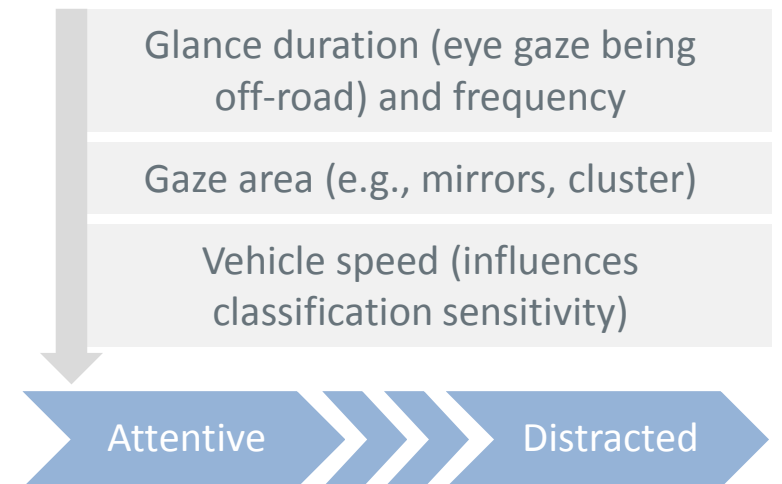
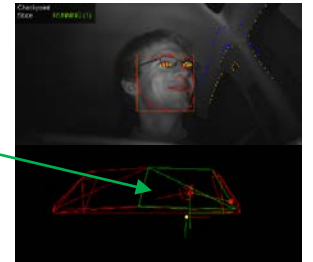


Detection if the eyes are open, closed, or partially open/closed: Percentage of Closure (PerClos)¹

Driver Attentiveness Detection

“On-road” gaze classification

- Fusion of head pose and eye gaze: “Virtual window” defined for on-road



¹ Knippling, R. and P. Rau (1998) PERCLOS: A valid Psychological Measure of Alertness as Assessed by Psychomotor Vigilance

Driver Monitoring via Interior Camera

Robustness and Safety Functionality

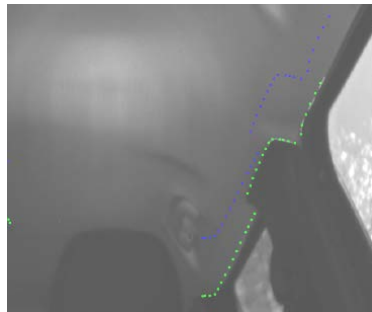


- **Fail Safe** Functions: Camera blockage, fake detection



Liveliness (e.g. eye blinks)

- **Online Extrinsic Calibration**
 - Misalignment calibration of the camera pose w. r. t. the car coordinate system
 - Robust against environmental light and occlusions



- **Algorithms Performance**

- Test Data base:

- Variety of faces and attributes to faces (e.g. hairstyle, glasses)
- Illumination
- Driving data sequences
- Ground Truth¹ data

- Ground Truth and Reference System

¹Ground Truth = Reference system

Driver Monitoring via Interior Camera

System Capabilities & Limitations



Requirement	Specification	Capabilities	Limitations
Driver Presence	Yes/No	✓ detects head and/or body	Must be within sensor range
Driver Readiness	Attentive	✓ eye gaze, head pose (position/orientation)	Must be within sensor range Reduced reliability if eyes are not visible to the camera
	Awake (drowsiness)	✓ multiple levels → direct detection of closed eyes; high correlation of drowsiness detection via eye opening, behavior: yawning, speaking, head movement	Must be within sensor range Reduced reliability if eyes are not visible to the camera



ANNEX

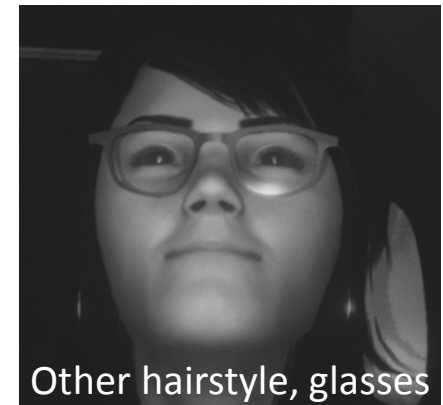
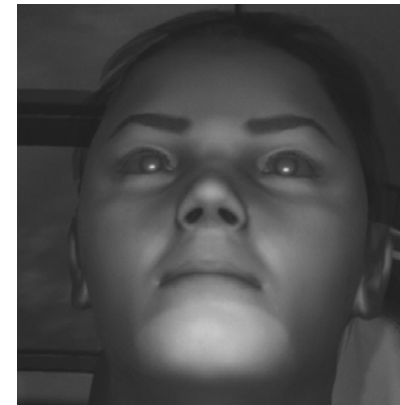
Possible Future Testing Concepts

Combination of Basic and Virtual Testing



- A. Normed dummy (incl. eye blinking, head movements)
 - Defined test scenario for basic functionality of Driver Presence and Driver Readiness (attentive, awake)
 - Physical test (spot sample), e.g. detect eye lid behavior (open/closed), body/ head rotation

- B. Virtual/ simulated tests
 - Cover variations for different people, situations, driving scenarios, etc.
 - Verification of the function



Other hairstyle, glasses