CLEPA
European Association of Automotive Suppliers

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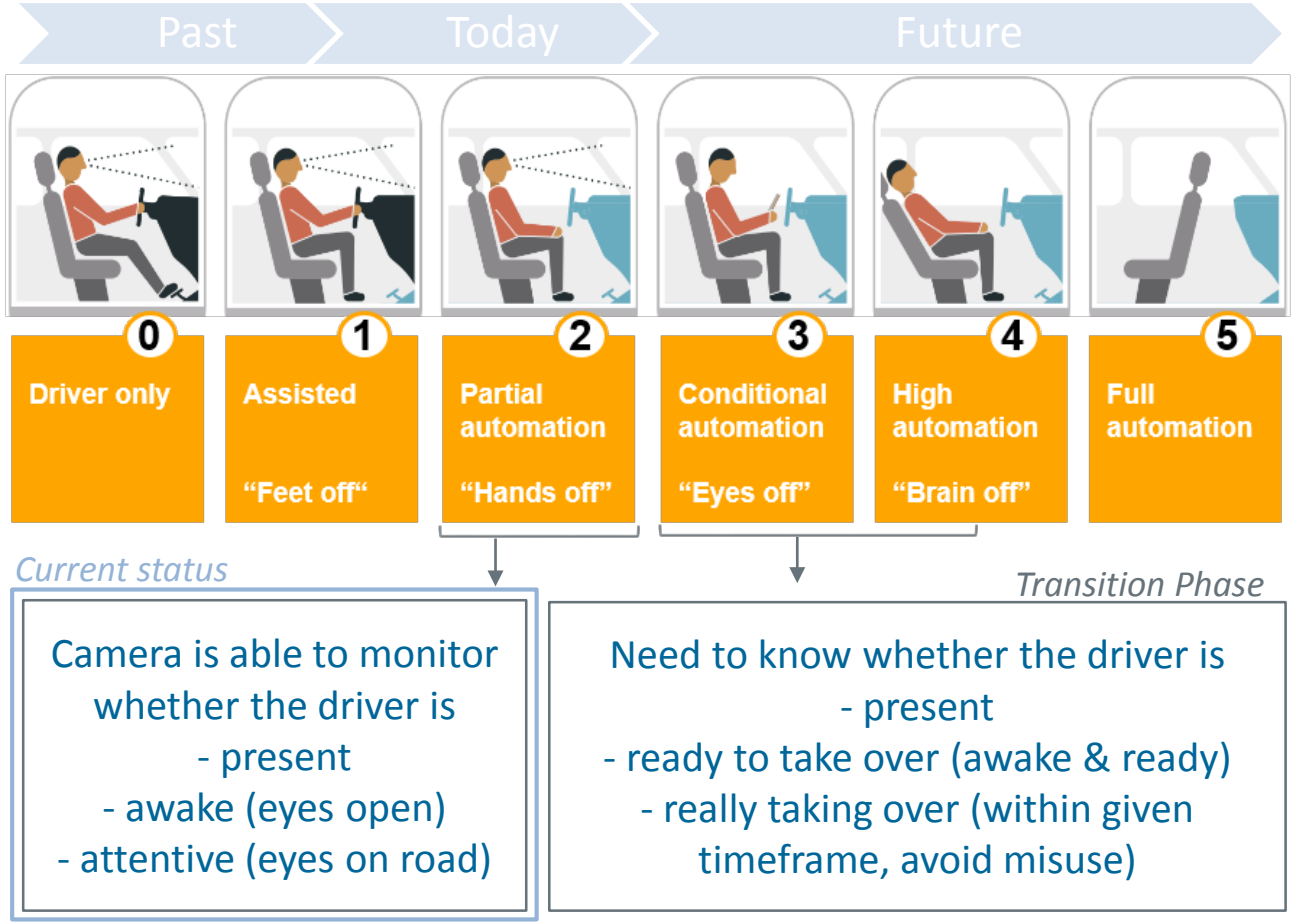
Informal Document - ACSF-19-04

Submitted by Industry

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**

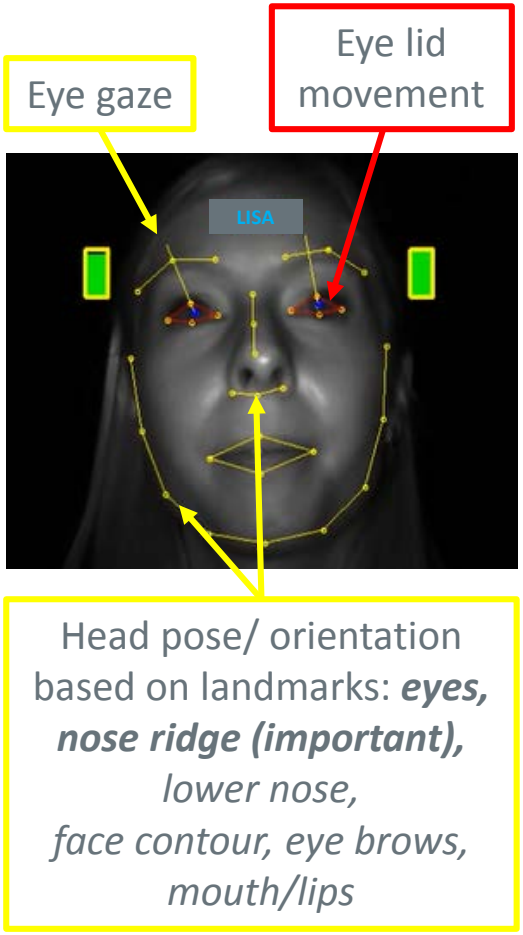
Driver Monitoring via Interior Camera
Head-Eye-Tracking System

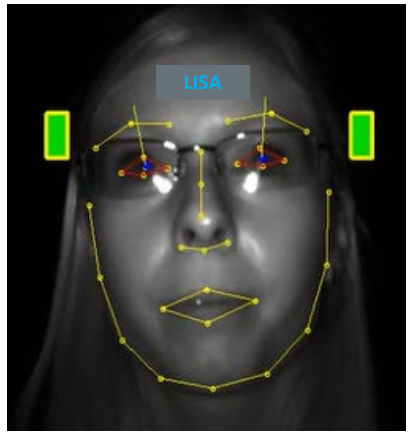
Head-Eye-Tracker (based on visual features)

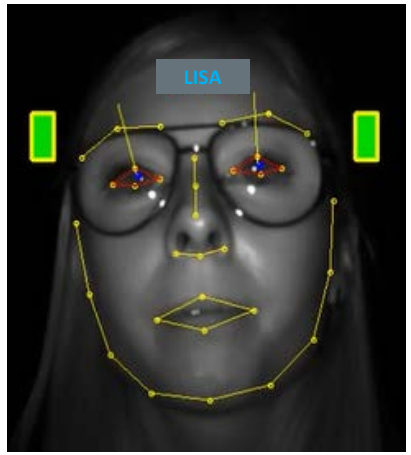
- Global Shutter Camera
- IR Illumination (850 nm or 940 nm)
- Potential Mounting Positions:

Occlusions are handled dynamically

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







The Interior Camera can look through 'normal' glasses

and through

sunglasses[1]

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

[1]Exception: IR blocking sunglasses

Driver Monitoring via Interior Camera
Current Use Cases (Examples)

Driver Drowsiness Detection

Diagnostic from **Eye Lid Behavior**

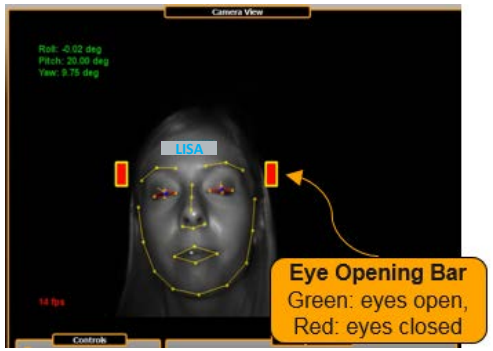
- Developed from real driving tests using EEG/EOG expertise

Eye lid open

Eye lid closed

→ based on blink duration and velocity

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



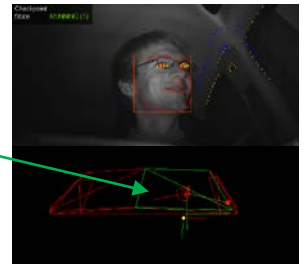
Detection if the eyes are open, closed, or partially open/closed: Percentage of Closure (PerClos)[1]

Alert → Slightly drowsy → Drowsy → Sleepy

Driver Attentiveness Detection

"On-road" gaze classification

→ Fusion of head pose and eye gaze: "Virtual window" defined for on-road



- Glance duration (eye gaze being off-road) and frequency
- Gaze area (e.g., mirrors, cluster)
- Vehicle speed (influences classification sensitivity)

Attentive → Distracted

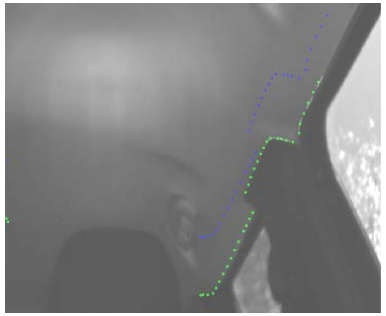
[1] Knippling, R. and P. Rau (1998) *PERCLOS: A valid Psychological Measure of Alertness as Assessed by Psychomotor Vigilance*

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 Truth[1] data
  - Ground Truth and Reference System

[1]Ground 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