Eyes On the Road

Technology to detect distraction and fatigue

AUTOLIV
April 15, 2014

Agenda

- Distraction
- Drowsiness
- EyesOnRoad hardware
- Conclusions

Background

- *Distraction* is cited as the main cause in 78% of crashes and 65% of near-crashes in NHTSA 100-car study (2006)
- *Distraction* is a contributing factor in more than 20% of all accidents including fatalities and serious injuries
- *Sleepiness* as an accident factor has been reported at 1-3%
  - In post crash interviews, drivers tend *not* to report ”*I fell asleep at the wheel*”
- *Sleepiness* may be a contributing factor in 10-30% of light vehicle accidents (Anund & Patten, 2010)

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Distraction

“Driver distraction is a diversion of attention away from activities critical for safe driving toward *a competing activity.”*

Lee, Young, and Regan (2009)

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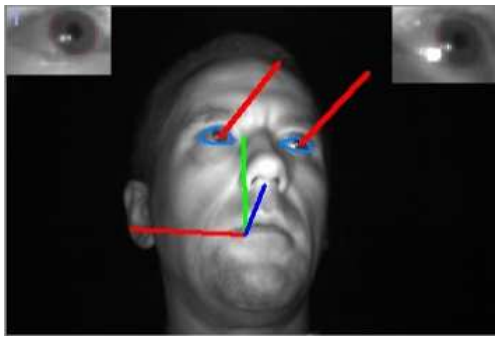
Different approaches to distraction detection

- Positive verification of Eyes-OFF-road (using ”Gaze-tracking”)
  - High demands on detector at all gaze angles
- Positive verification of Eyes-ON-road (using direct detection/classification)
  - If no eye(s) detected → infer driver ”eyes-off-road”



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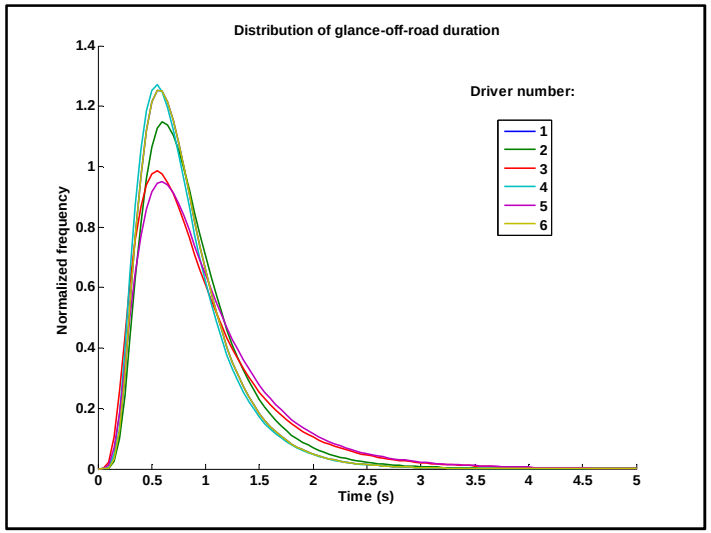
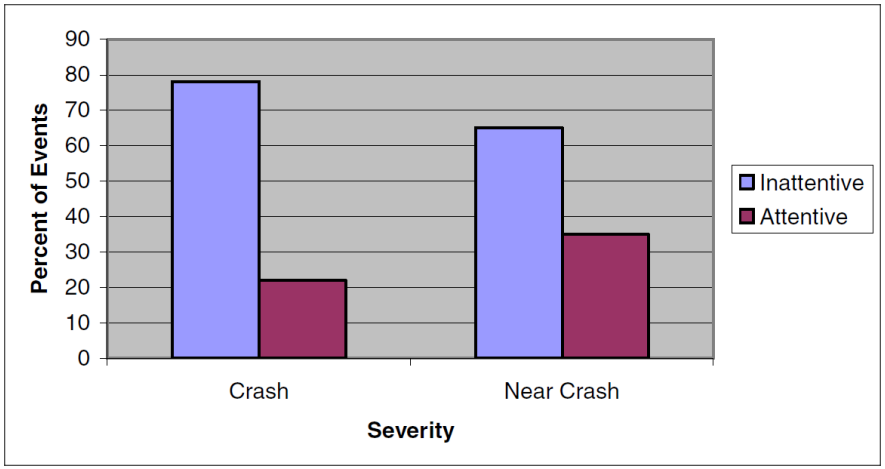
For how long does the driver look away?

- Most glances off road in highway driving are shorter than one second.
- Glances away from road longer than two seconds may have a negative impact on safe driving (cf NHTSA design guidelines)





Number of events with cause **inattention to the forward roadway** in the 100-CAR study (Neal et al.)

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EoR system

- Detects if the driver:
  - looks away from the road
  - is sleepy/drowsy
- Use for
  - Road Focus Reminder
  - Adaptivity for Active Safety functions like LDW and FCW
  - Enabling advanced automated driving systems

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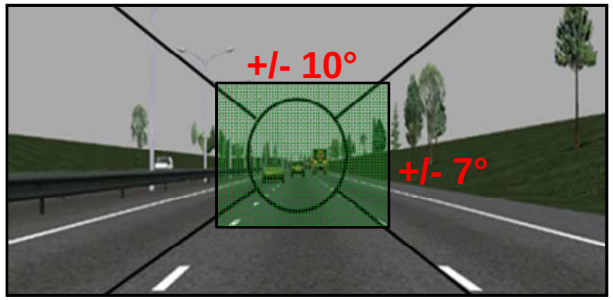
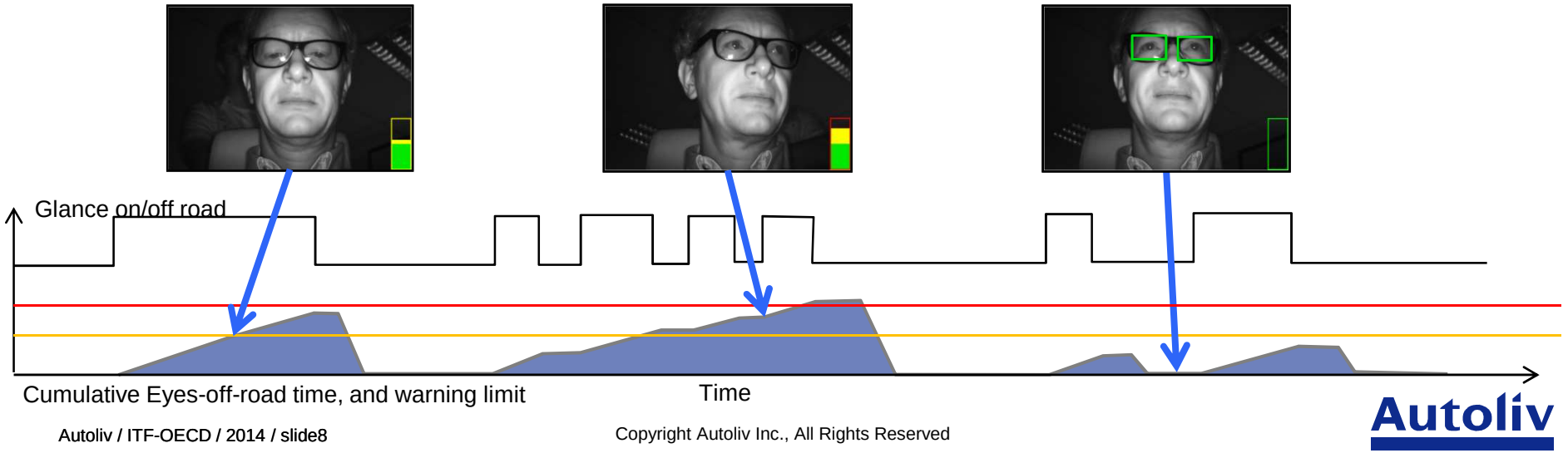
Visual Distraction Detection

- An algorithm identifies status of ‘eyes-on-road’ to determine if the driver is looking forward

- A timer identifies both **single long glances** and **repeated short glances** of Eyes Off Road





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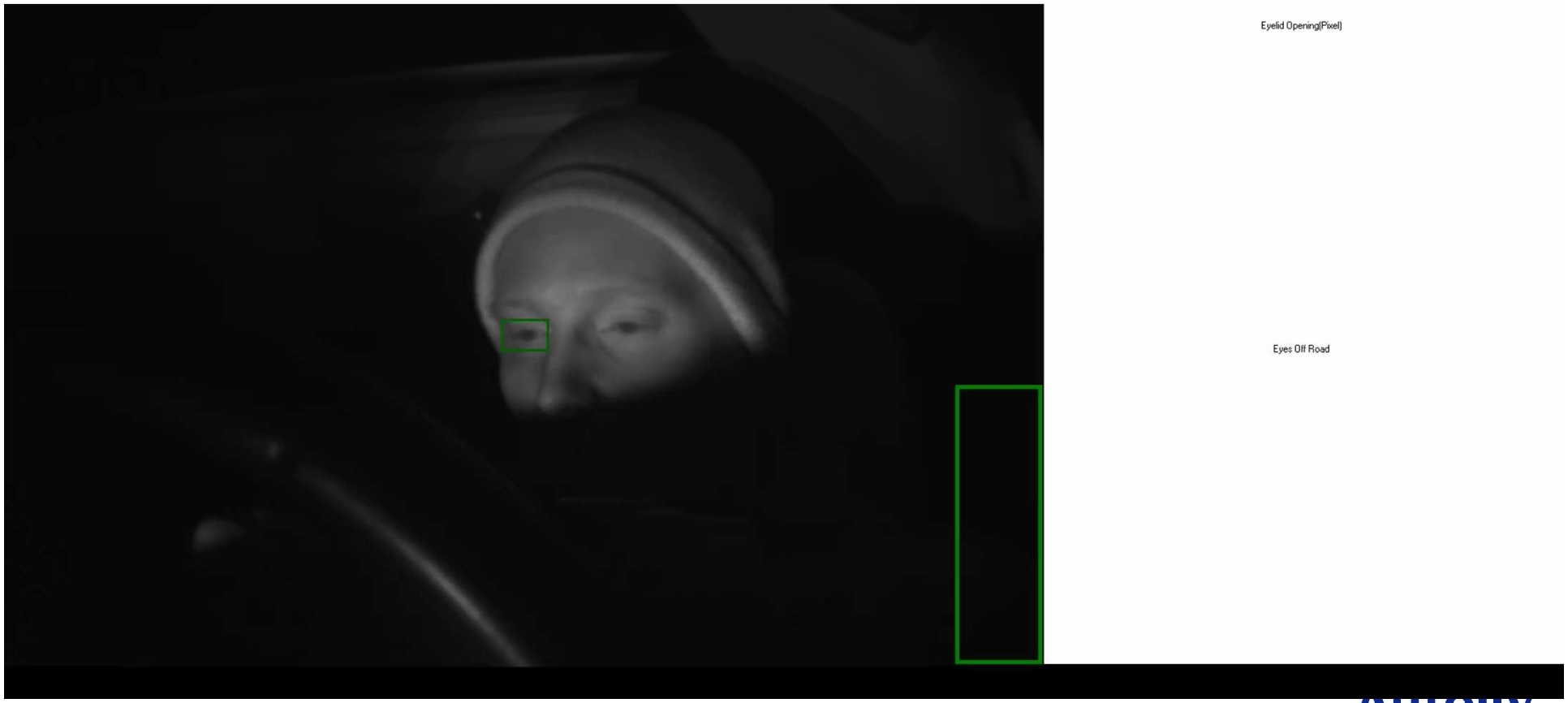
Eyes On the Road video (with head movement)



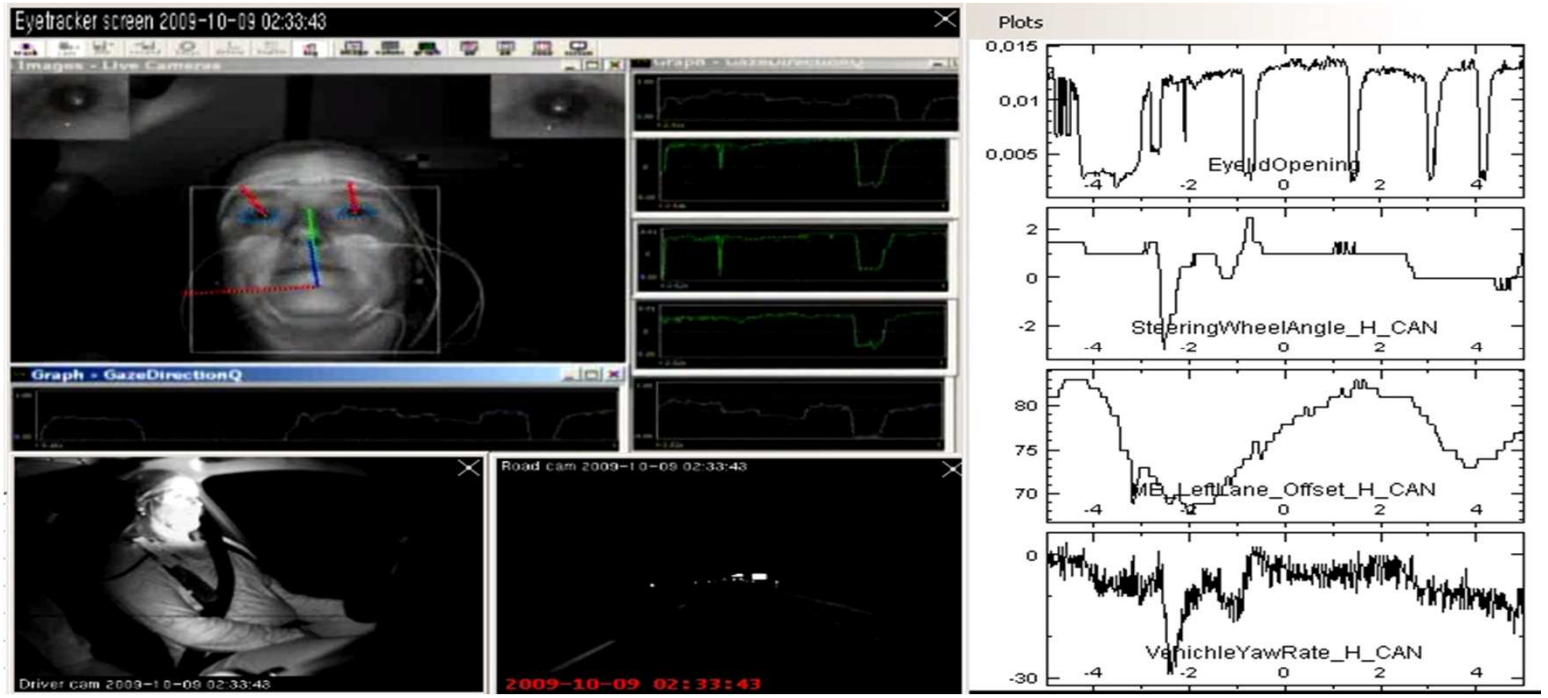
Eyes On the Road video (without head movement)

Detecting ’Eyes on the road’

- Robust detection approach

  - Detects eyes directly – not dependent on clear view of entire face
  - Shorter chain of events
  - Works with any type of glasses

Drowsiness
Data collection



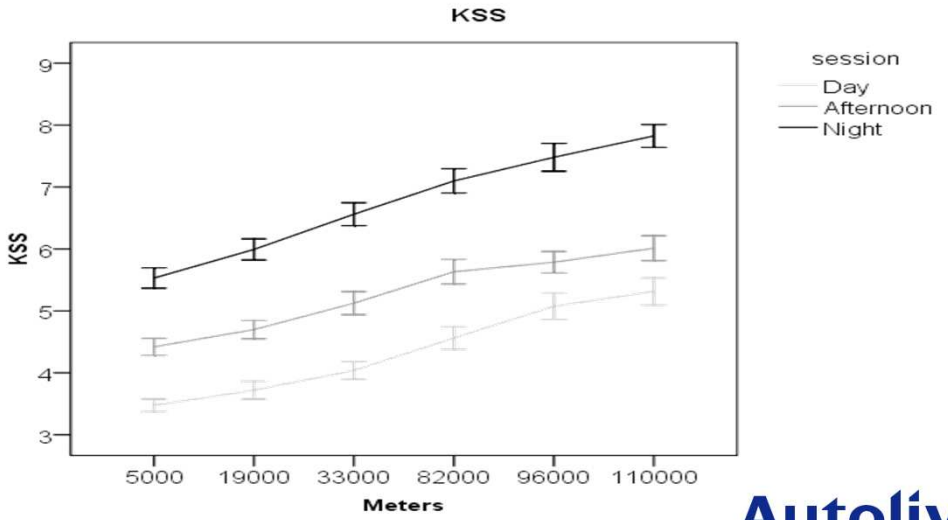
Public roads, 83 drivers, each 3x100 minutes, day & night

KSS – Karolinska sleepiness scale

KSS	Verbal description
1	extremely alert
2	very alert
3	alert
4	rather alert
5	neither alert nor sleepy
6	some signs of sleepiness
7	sleepy, but no effort to keep alert
8	sleepy, some effort to keep alert
9	very sleepy, great effort to keep alert, fighting sleep

+ Validated
+ Simple to collect
+ Simple to understand – immediately ready for analysis

- Training needed
- Some offset for inexperienced participants?



Example of driver sleepiness indicators

- Blink duration:

  Mean blink duration (Dinges, 2005)

- Lane Keeping variability:

  Variability in Steering wheel position or Lane Position. e.g. using Generic Variability Indicator (Sandberg 2008)

GVI (Sandberg 2008)

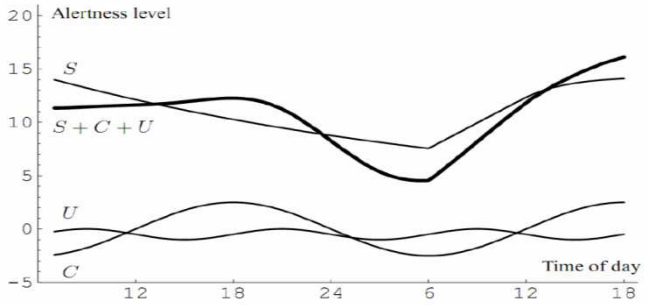
$$G = \frac{1}{N}\sum_{i=1}^{N} w(z_i)\,|\,z_i\,|^k$$

$$z_i = x_i - (\delta\,\bar{x} + (1-\delta)\,p)$$

$$w(z) = \frac{c_L}{1+e^{-\alpha_L(z-\beta_L)}} + \frac{c_R}{1+e^{-\alpha_R(z-\beta_R)}}$$

- Time-of-day:

  Expected drowsiness with regard to time of day – circadian rhythm (Åkerstedt. T. & Folkard. S. 1997)



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Evaluation Method

- Fitness is the mean value of sensitivity and specificity
- Fitness is related to the *proportion of the time* where the *algorithm is correct*

$$sensitivit\quad y = \frac{A}{A + C}$$

= probability of correct classificaticon of **drowsy** driver

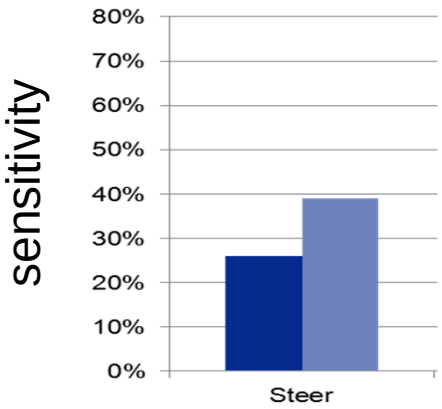
$$specificit\quad y = \frac{D}{B + D}$$

= probability of correct classification of **alert** driver

$$fitness\quad = \frac{sensitivit\quad y + specificit\quad y}{2}$$

Drowsiness tests on roads

Forced Minimum 99.5% specificity



Sensitivity = TP/(TP+FN)

probability of correct classification of **drowsy** driver

Specificity = TN/(TN+FP)

probability of correct classification of **alert** driver

True positive = correctly identified
False negative = incorrectly rejected
True negative = correctly rejected
False positive = incorrectly identified

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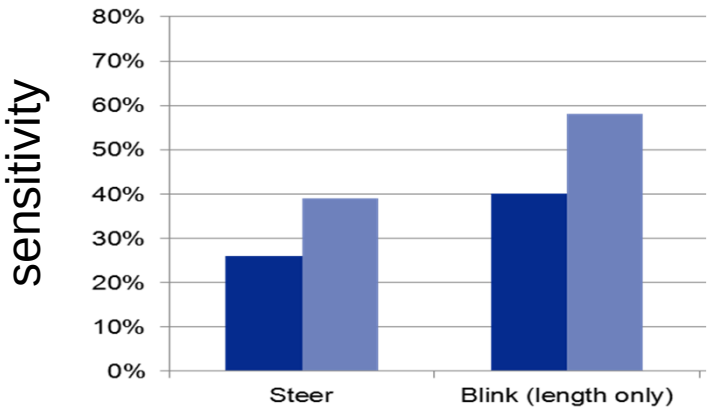
Drowsiness tests on roads

Forced Minimum 99.5% specificity



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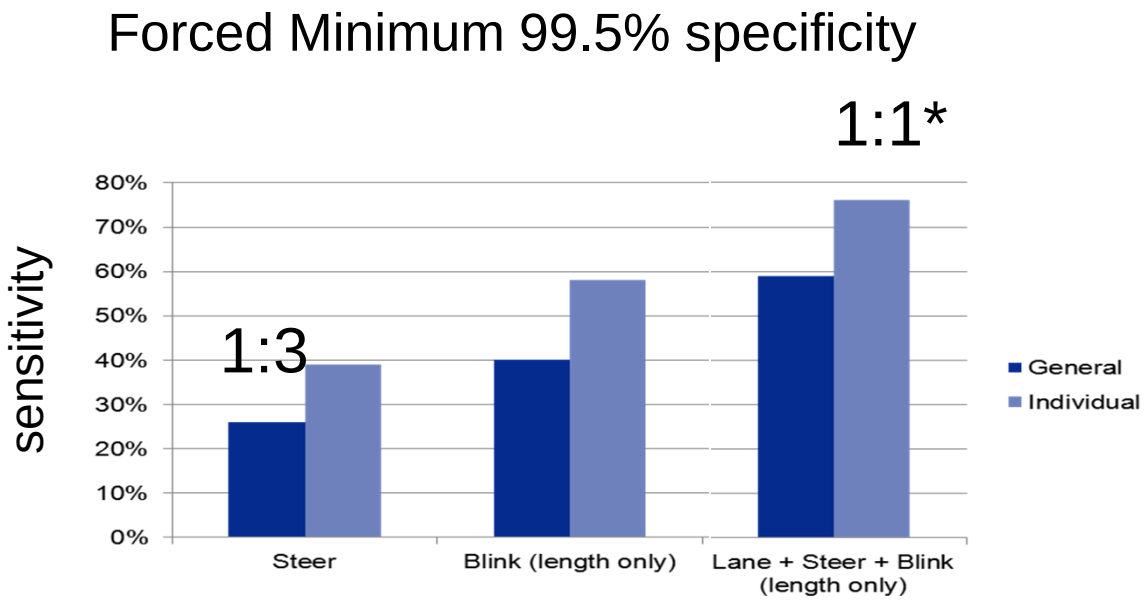
Drowsiness tests on roads



* 80% sensitivity and 99,5% specificity results in an estimated *real world* ratio of about 1:1 ratio between true and false positives

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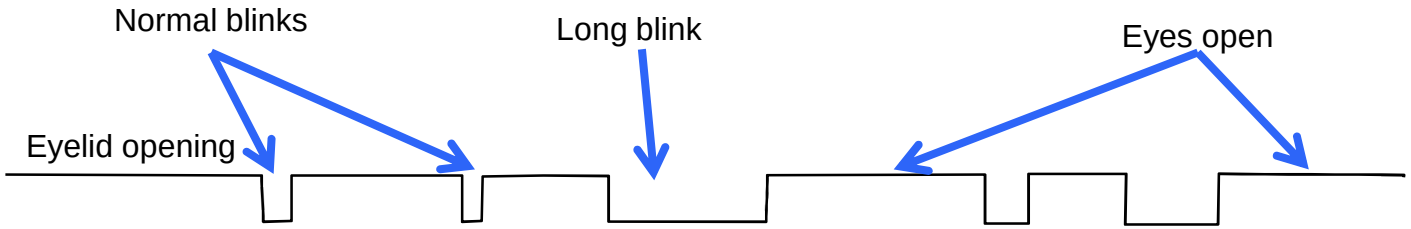
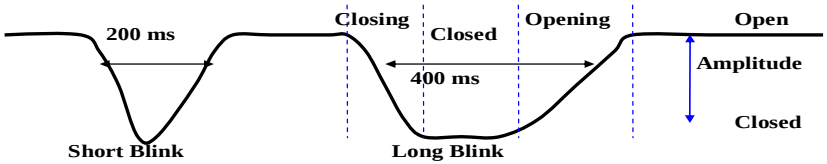
Drowsiness detection

- EOR detects blinks and blink duration
- EOR can detect closing & opening rates





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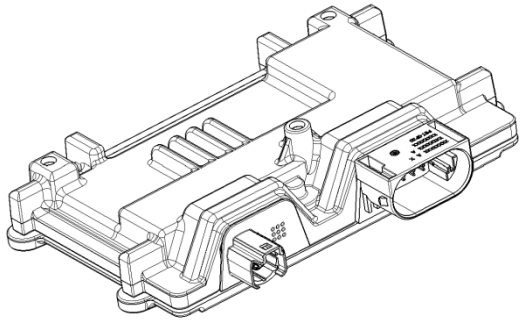
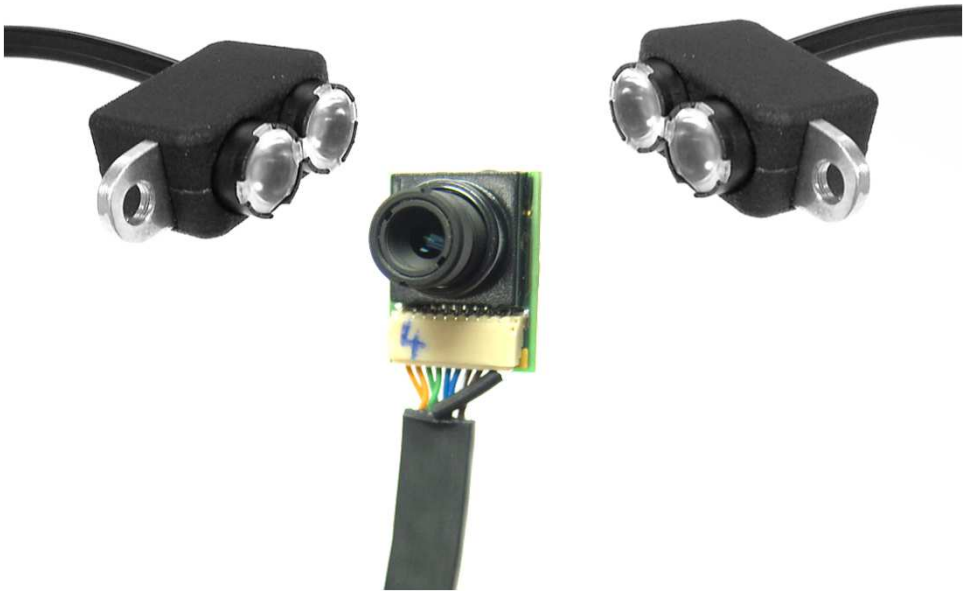
Basic Hardware Setup

- One camera – simple, cost effective
- IR-illumination
- ECU
  - Central Safety Domain Controller
  - Or integrated with camera





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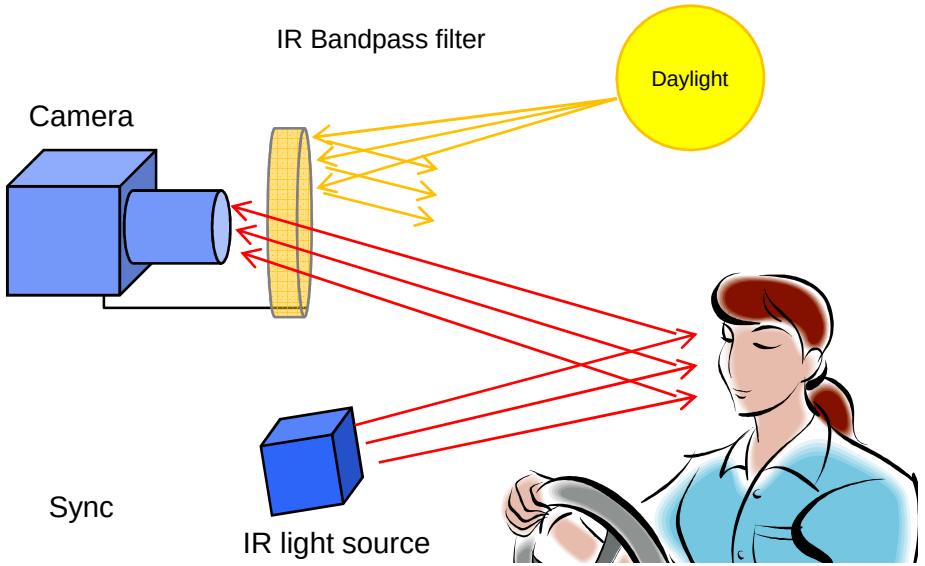
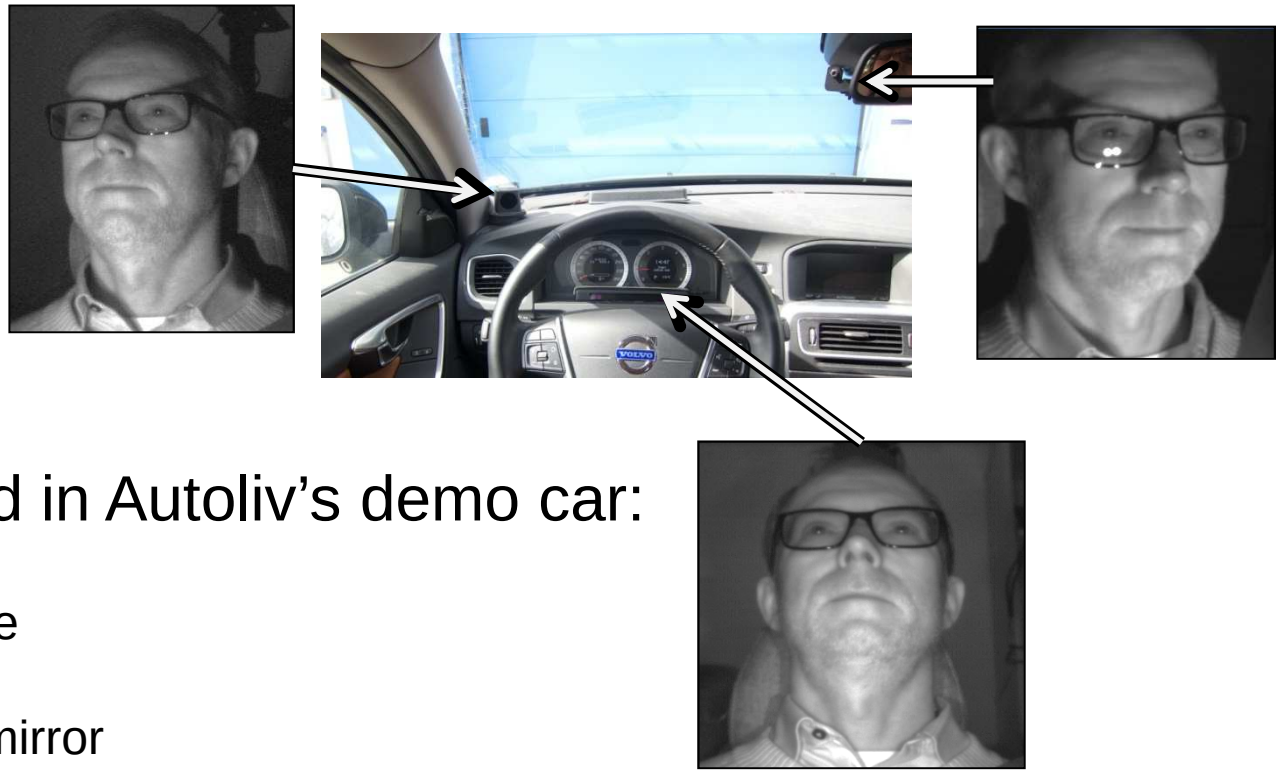
IR-illuminator

Constant lighting conditions, independent of darkness/direct sunlight:

- Ultra short IR flash, synchronized with camera exposure time
- Filter blocks most of daylight
- IR intensity matches sunlight



Camera locations – many options



EOR tested in Autoliv's demo car:

- A-pillar base
- Cluster
- Rear view mirror

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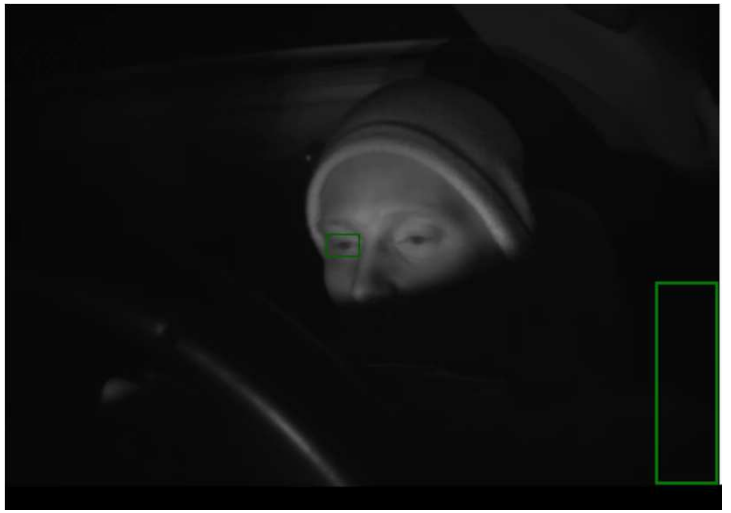
Validation
Field Operational Test

- Autoliv, Volvo Cars, ÅF
- Starts in April
- 10 cars


Conclusions

EOR with appropriate HMI design can:



- Remind driver to focus on the road
- Wake up drowsy driver (better than with today's sensors)
- Improve FCW, LKA… (less FP, more TP)
- Enable future automated driving: make sure there is an alert driver behind the wheel during handover

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Thank you for your attention!

Comments and questions greatly appreciated:

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