The relevance of side check-glances in reference driver models

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Originally: Quantification of driver’s side-glance frequency and duration in straight highway driving

Reference driver models to assess ADS through virtual simulations

- A safety target for Autonomous Driving Systems (ADS)
- Skilled and attentive human driver
- Run simulations with reference driver and with system
- Compare safety performance
- If the system is better: considered safe for that scenario

Background

- There is the need to define what to include in reference models
- Glances to side mirrors or windows could make a driver aware that a crash is imminent

Aim and objectives

Aim

- To assess the need of including side check-glances in reference driver models in virtual simulations used to assess autonomous vehicles

Objectives

- Quantify, as a function of context, the frequency and duration of side mirror and window glances in no-lane-change highway driving
- Quantify the impact side check-glances may have on crash avoidance as a function of actions a driver may take, once aware of the imminent crash

➔ Should side check-glances be included in reference driver models?

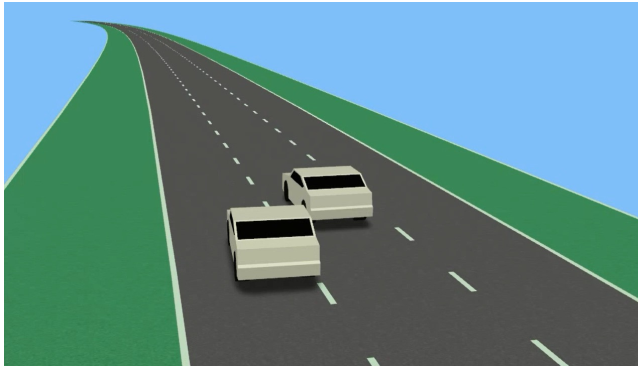
Data – glances

Quantification of glances from naturalistic driving data

- **Data**
  - From L3Pilot, highway driving around Gothenburg – baseline driving
  - View of the driver from the two A-pillars and the passenger B-pillar
- **Method**
  - Manual annotations of side check-glances – to side mirror/window
  - 20 drivers
  - 20 minutes of annotated data
- **Outcome**
  - Glance frequency and duration

Data – crash kinematics

- **Data**
  - Reconstructed side-swipe crashes from Volvo Cars
- **Method**
  - Setup for simulation toolchain
- **Outcome**
  - Dataset for virtual safety assessment



Now the reference driver model….

Simple models of the drivers responses

Driver braking

- Deceleration: 5 m/s^2 [1]

Driver acceleration

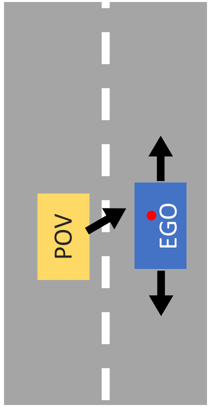
- Acceleration: 2 m/s^2

Steering – S-maneuver

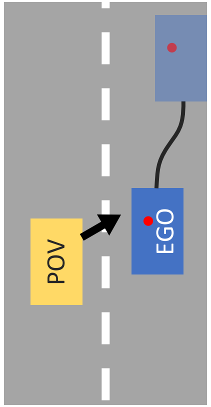
- Lateral acceleration threshold (due to centripetal acceleration): 5 m/s^2 [2]
- Steering wheel angle rate 720 deg/s [1]

Response time

- Response time from Principal Other Vehicle (POV) cross Ego lane to maneuver initiation: 0.5 s [3]
- Sensitivity analysis with reaction time of 0 s



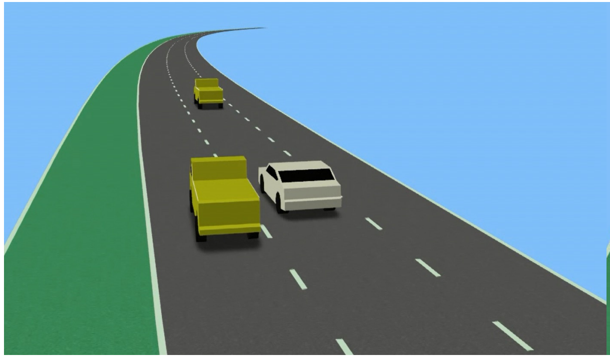
Driver brakes/ accelerates

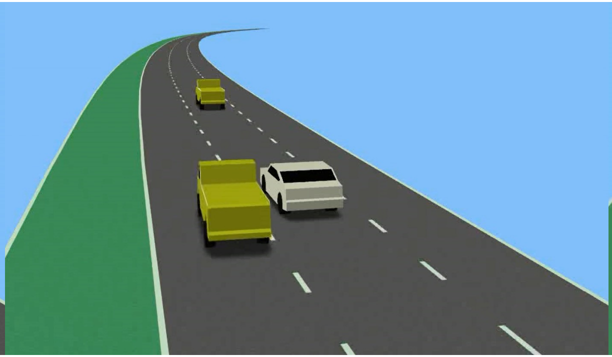


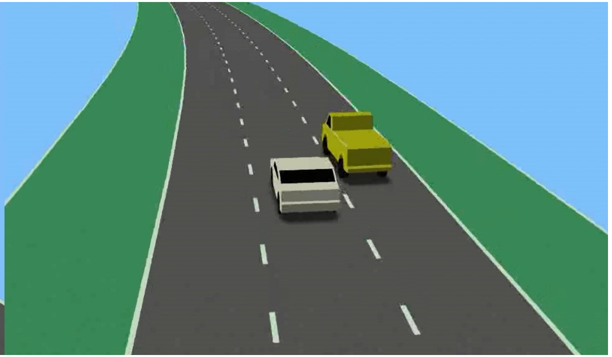
Driver steers

[1] Brännström, M., Coelingh, E., & Sjöberg, J. (2014).
[2] Sander, U. (2018).
[3] Markkula, G., Engström, J., Lodin, J., Bärgman, J., & Victor, T. (2016).

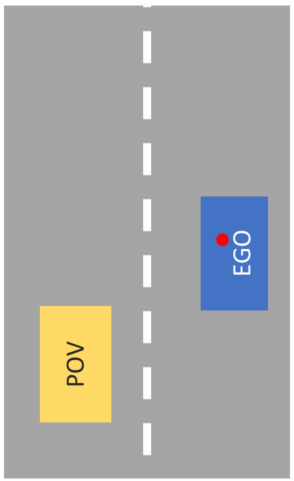
Simulation examples

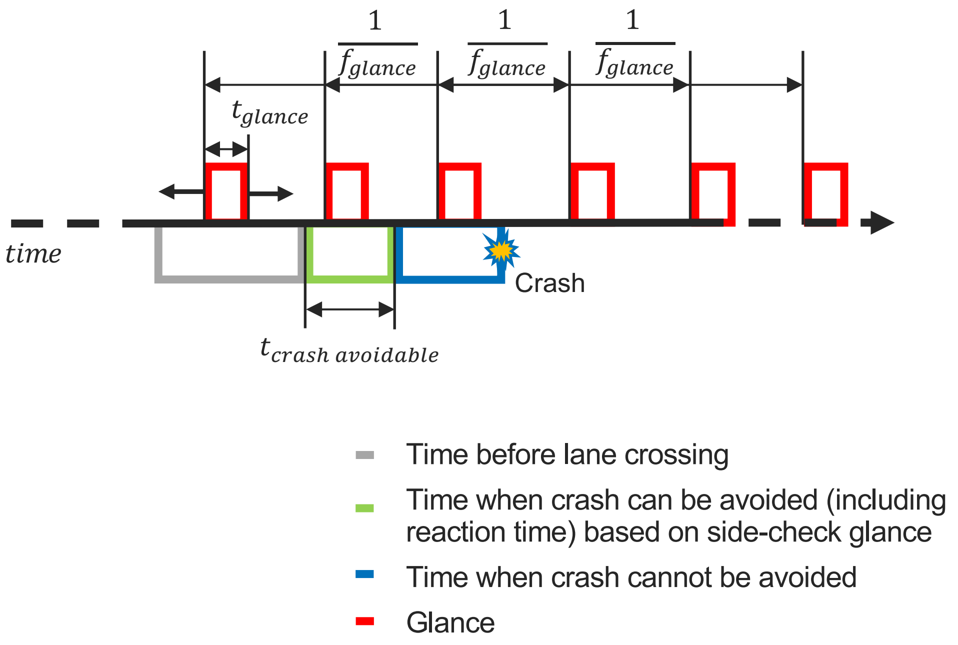

Steering


Accelerating


Braking

Glance frequency and crash avoidance



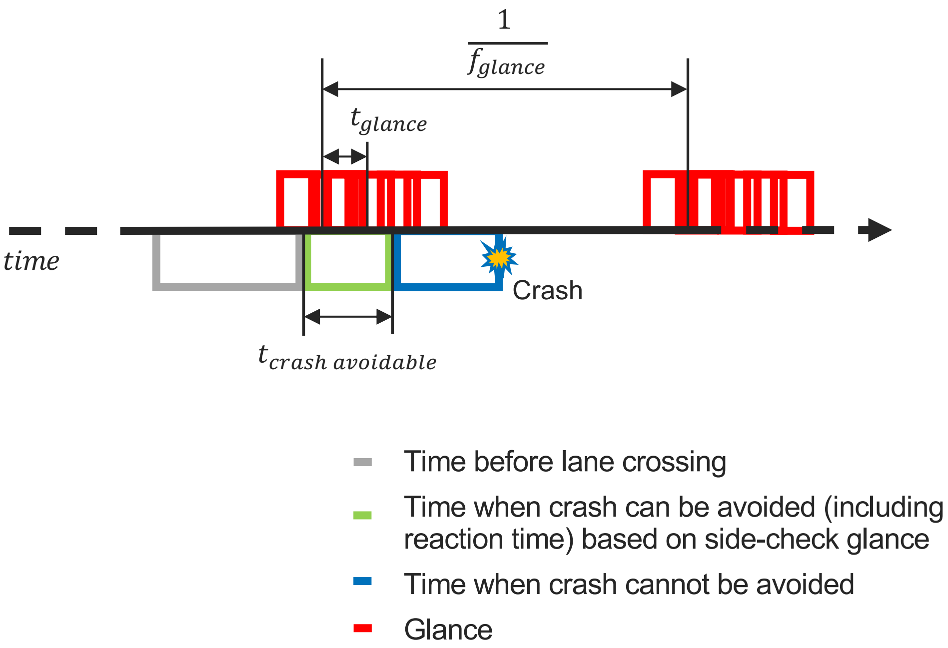


POV: Principal Other Vehicle

Glance frequency and crash avoidance

- Glance frequency and duration
- Time frame when:

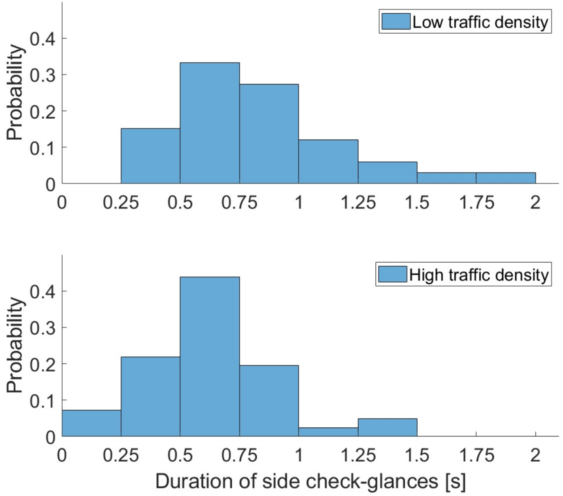
  if driver is looking ➔ reaction can avoid the crash
- Multiple simulations for each crash event, changing the glance time



$$Crash\ avoidance = (t_{glance} + t_{crash\ avoidable})\, f_{glance}$$

Results – quantification of side check-glances

	Low density traffic	High density traffic
Glance duration [s]	0.79	0.62
Glance frequency [glance/minute]	3.3	4.1



Results – crash avoidance

Percentage of crashes avoided computed as combination of:

- Possibility of avoidance
- Crash unavoidable

All crashes have equal weight, the results is the average

Assuming the driver always chooses the best response, i.e. the reaction with the higher probability of avoidance in each event, but not in combination

Type of evasive maneuver	Low-high traffic density	Reacting before lane crossing
Braking	0.6-0.7%	1.3%
Accelerating	0.8-0.9%	1.2%
Steering	1.0%	1.0%
Best out of all three	1.6-1.8%	2.3%

Limitations

- Simplified driver models
- A driver may identify the lane change earlier and thus respond earlier
- Uncertainty in annotations – an eye tracker would be more accurate
- Only Swedish data

Conclusions

- Adding side check-glances in reference driver model likely not needed – only 1-2% crash reduction
- We demonstrate a method to assess the need for reference driver model components related to glance behaviors
- Next steps:
  - To apply the UNECE ALKS model too as the basis
  - Expand to other reference driver model components
  - Include proactive behavior (conflict avoidance, driver models)

Thank you

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