Investigation of Driver‘s Eye & Head Movements

Possible Applications in Automated Driving (Studies)

Rico Auerswald (BASt) auerswald@bast.de

Timo Pech (Technische Universität Chemnitz) timo.pech@etit.tu-chemnitz.de

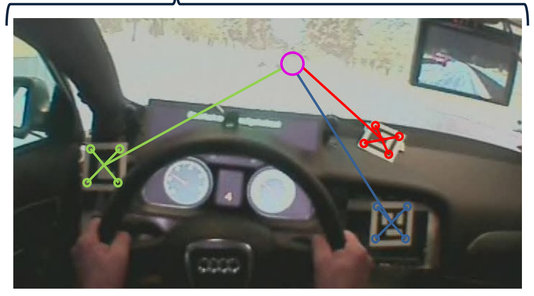
Motivation

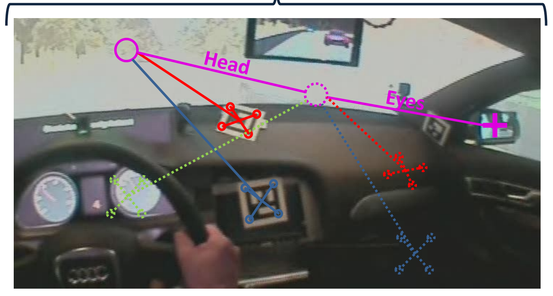
Driver’s direction of gaze is a key indicator for the focus of attention while driving. In general, directing gaze includes both head and eye movements. Eye tracking still remains challenging in terms of (internal) validity and reliability whereas a head rotation does not necessarily matches with gaze focus (Stahl, 1999). Despite potentially poorer resolution of head tracking, Pech et al. (2014) showed a possibility to estimate driver‘s gazes to the side mirrors. The study presented in this poster aimed on further improvements of head tracking firstly by evaluating the correlation between head and eye movements and secondly by estimating gaze positions out of measured head rotations.

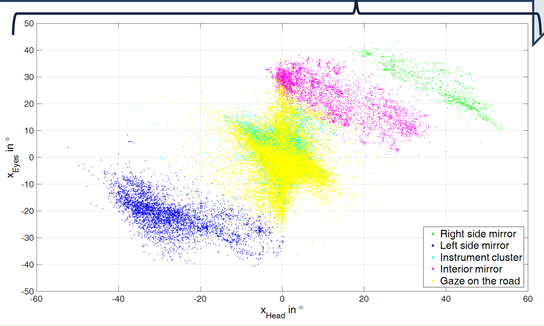
Data analysis

Data basis was a simulator study including mirror glances evoked by lane change manoeuvres (n=66). A head-mounted eye tracking system was used as measurement unit. Steps in data analysis:

Determining ahead position of head & eyes (median) → Extraction of head & eyes rotations (head: displacement of marker positions) → Calculating gaze vectors out of shifts in head & eyes position → Customary ocular motor range (CMOR) according to Stahl (1999) → Correlation of head & eyes rotation → Linear regression of gaze position with head rotations





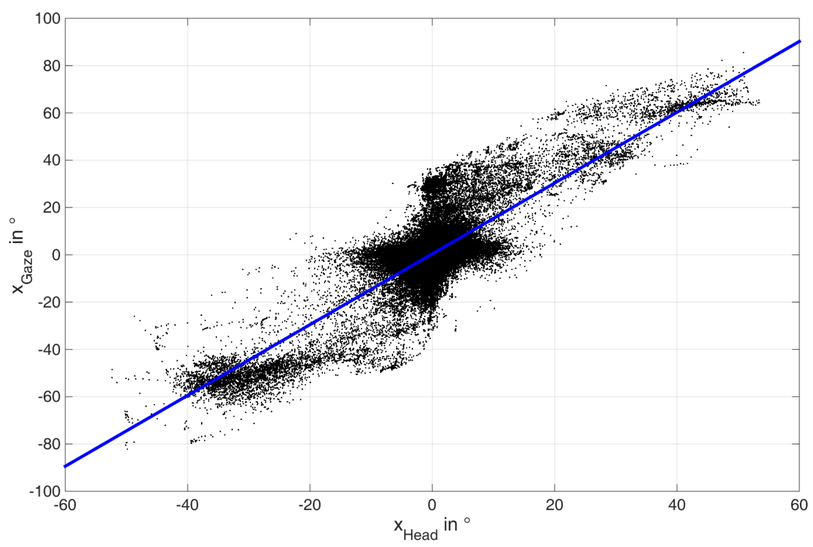


Results

Only horizontal rotations of head and eyes revealed a correlation in our data set. Based on the full oculomotor range of 106° (Stahl, 1999) only 29% were usually retrieved by eye movements (COMR=30.4°, SD=9.1°). The analysis of combined head and eyes rotations revealed a strong correlation (r_{xy} = 0.43) justifying an approach to model an estimation of gaze positions out of head rotations. For this purpose we computed a linear regression revealing:

$$\hat{y} = 1.5\, x_i + 0.41°$$

We found a strong impact of head rotations to gaze movements - about 70% variance of the gaze movements were explained through head rotations.



Applications to automated driving

In general

With the introduction of higher levels of automated driving, driver monitoring will gain more relevance. Known methods based on steering wheel activity will not sufficiently meet future requirements of driver's state assessment, as drivers can drive hands-off. Therefore, measures using the driver's gaze should be taken into account. Besides applications in R&D head tracking seems to be preferable compared to eye tracking due to higher reliability and usability or even because of users’ acceptance. The basic idea in this study, estimating the gaze position with head tracking, can contribute performance improvements in assessing the driver’s state.

In research methodology

In an upcoming driving study with a test vehicle from BASt we will investigate the influence of the surrounding traffic environment to transitions in which the driver has to take over vehicle control during highly automated (L3) driving. Because of missing driver’s steering input before and during a transitions phase, we will use gaze tracking to assess the drivers’ (re)orientation of attention on surrounding traffic conditions, non-driving related tasks and vehicle HMI. The method of this study has the potential for closing the gap in case of missing eye tracking data.

References

Pech, T., Lindner, P. & Wanielik, G. (2014). Head tracking based glance area estimation for driver behaviour modelling during lane change execution. In *2014 IEEE 17th International Conference on Intelligent Transportation Systems (ITSC)* (S. 655–660).

Stahl, J. S. (1999). Amplitude of human head movements associated with horizontal saccades. *Experimental Brain Research, 126* (1), 41–54.