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Driver distraction based lane-keeping assistance

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ABSTRACT

Driver assistance systems could be much more effective, if they were adaptive to the driver's state. Following the idea of a lane-keeping assistance system, which is adaptive to the use of in-vehicle information systems (IVIS), two field experiments were conducted. The first experiment concerned the influence of typical IVIS tasks on lane-keeping. Most IVIS tasks increased the lateral deviations, but in the majority of cases the drivers were still able to stay in their lane.

The second experiment concerned two questions: (1) how much lateral support would be needed and (2) how drivers accept this kind of support. The results show that all lateral support algorithms increased the lane-keeping performance with the algorithms providing a higher amount of assistance proving the most useful. All assistance systems were rated as helpful and were considered to increase driver safety, both by the drivers who did not have problems in lane-keeping without assistance.

In light of these results an adaptation of a lateral support system to the IVIS-use seems to be useful and worthwhile.

1. Introduction

Driver inattention is one of the major factors in traffic accidents. The National Highway Traffic Safety Administration estimates that in 25% of all crashes some form of inattention is involved (Wang, Knipling, & Goodman 1996). Distraction (besides drowsiness) as one form of driver inattention may be characterised as: "any activity that takes a driver's attention away from the task of driving" (Ranney, Mazzae, Garrott, & Goodman 2000). Naturalistic driving studies, like the "100-Car Naturalistic Driving Study" by Dingus et al. (2006), show in detail what kind of activities drivers engage in and what the likelihood of accidents for each kind of secondary task is. In almost 80% of crashes and 65% of near-crashes the driver was inattentive. In the majority of these cases the driver was occupied by a non-driving related task. The use of wireless devices and passenger related distractions are the most frequent causes of driver inattention.

Although in the last few years many European countries have prohibited the use of wireless devices while driving, it should not be expected that the amount of distraction in driving will necessarily decrease. Even without the distractions caused by mobile devices, the amount of distraction due to in-car information systems will increase. Multimedia devices, which allow the driver to select their favourite song out of thousands or the connection between the navigation system and Google search functions, provide plenty of opportunities to reduce the attention paid to the roadway. Even if new laws restrict the use of such in-car devices in the future, distraction will still be a problem in other forms, e.g. from roadside events or passengers in the car. Thus, OEMs and automotive suppliers will need to find a way to deal with this problem.

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One method that minimizes crashes rather than distractions is the development of new driver assistant systems. With the evolution of adequate lane tracking, lane departure warning systems which attract drivers' attention when lane departures occur were introduced recently onto the market. The naming is still not consistent with "Lane-keeping assistant" or "lateral control assistance" often being used. These systems track the lane markings in front of the vehicle and compute the time until the vehicle will cross the marking. If the driver does not show an intention of leaving the lane by using the indicator, the system will initiate a warning or start assistance.

Authors of several studies (Rimini-Döring, Altmüller, Ladstätter, & Rossmeier, 2005, Alkim, Bootsma, & Hoogendoorn, 2007) reported overall effects of lane departure warning systems. Alkim et al. (2007) reported a decrease in unintentional lane changes due to a lane-keeping assistant by 30–35% depending on the type of road. Different traffic and accident analyses (Abele et al., 2005; Alkim et al., 2007; McKeever, 1998) postulated a reduction of "head-on" and "left roadway" accidents by 25%, as well as a reduction of accident severity.

Subjective evaluations are rare. In Kozak et al. (2006) the different warnings were rated as helpful. The participants of the study by Alkim et al. (2007) judged the lane departure warning system as annoying but effective. Studies of the German EMPHASIS Project (Buld et al., 2002) showed that steering torques are less annoying than lane departure warnings in the form of a vibrating steering wheel.

It is debatable whether current warning algorithms are as good as they could be. An attentive driver does not need any lane-keeping support. But lane-keeping assistance systems do not yet account for the driver's state. If it was possible to recognize drivers' distraction reliably, the system could give just as much assistance as the driver needs. This would allow for a greater safety margin without annoying the driver with false alarms in normal driving situations. There are different concerns when estimating the driver's state online. Interpreting the driving task as a control loop as shown in Fig. 1 provides several possibilities for such estimations.

The perception of the driver could be assessed with driver monitoring systems. Pohl, Birk, and Westervall (2007) adjusted a lane-keeping assistant based on head-orientation and head-position. They concluded the system was useful to detect visual distraction, but the acceptance of this system remains unclear.

Another possibility is to monitor the use of the steering wheel and the pedals. Sensor data like steering wheel angle and lane position in combination with driver models might give hints of unusual driver behaviour. Based on vehicle sensor data, Torkkola, Massey, and Wood (2004) were able to distinguish between attentive and inattentive drivers by using self-learning algorithms. The accuracy was high, but a cross validation was missing. Furthermore, the algorithm was not used to adapt an assistance system.

Secondary tasks the driver is performing may also be taken as indicators of distraction. Dingus et al. (2006) showed in-vehicle information systems (IVIS) to be one source of inattention. Most of the tasks on an IVIS require visual attention which is likely to lead to a reduction of attention paid to the road ahead. Although IVIS use is only one source of distraction, it might show the usefulness of a driver state adaptive lane-keeping support.

Following the idea of adapting lane-keeping assistance to IVIS-interactions, two field experiments were conducted.

The first experiment was designed to evaluate the influence of typical IVIS tasks on lane-keeping performance. If driving performance decreases due to IVIS-use, an adaptation of lateral assistance each time the IVIS is used might be beneficial.

Naab (2000) concluded that driver assistance systems will only be accepted by the driver, if the system accounts for the personal driving style. Kompass and Huber (2007) summarized the idea in No. 3 of their 10 golden rules of driver assistance:

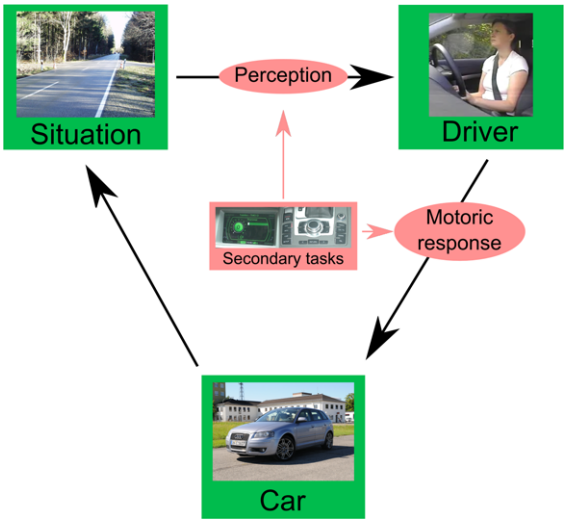

Fig. 1. Driving task as a control loop.