REFLEKTAS – USAGE OF REFLEXIVE DRIVER REACTIONS IN ADAS-DEVELOPMENT

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ABSTRACT: In common lane-keeping systems drivers are warned of lane-departures by acoustic, visual or haptic devices. Thus, an association between the signal and the desired action has to be established. Because the association is vulnerable to interference and decay, the functionality of cognitive systems is suboptimal. The new approach uses behavioural strategies. By eliciting a steering-reflex, the attention of the driver is attracted and the correct reaction is initiated. This principle was explored with 23 participants in a driving simulator. First results already demonstrate the functionality of the principle. Eliciting the appropriate reaction prevented road departures

1 Introduction

One goal which was set by the European Commission is to halve the number of road fatalities between 2000 and 2010. They want to achieve this by harmonisation of penalties and they promote new technologies to improve road safety [1]. Other countries have their own, smarter goals like the "Vision Zero" in Sweden [2]. One way to improve road safety is to develop new driver assistance systems in order to prevent fatal crashes. Because lane departures are a major cause of fatal crashes, many lane-keeping systems are developed.

2 The cognitive and the behavioural approach in the design of Lane Keeping Assistance Systems

Classical cognitive systems use acoustic, visual or haptic devices to warn the driver. Visual information of the vehicles status could be found everywhere in the cockpit and centre console. Different blips are used for different acoustic information or warnings. In case of the haptic devices, for example some car manufacturers produce a vibration at the steering-wheel [3] or on one side of the driver's seat [4]. And there are some researches on assistants which use a smooth force on the steering wheel in the direction of the middle of the lane.

In doing so an association between the signal and the desired action has to be established in the context of learning processes. The drivers have to learn the different associations. These also vary between the different car manufacturers. The associations are subjected to interference and decay. Therefore the functionality of these cognitive systems is suboptimal.

In contrast, our new approach uses behavioural strategies to prevent road departures. Established, stable and irreversible stimulus-reaction links which are involved in reflexes are used, which lead to a better reliability, even in situations with a higher workload. There is no need for extra attention to process the new incoming information by the driver.

Furthermore the reaction times are much shorter – reflexes have the shortest latencies with 20-120ms – as reflexes involve other neural structures than cognitive processes. There is no moment of shock which delayed a driver's reaction, because the reaction is reflexive.

As Figure 1 illustrates, reflexes comprise the brainstem and spinal cord, whereas consolidated behaviour and intended actions involve higher regions like the cerebellum or the association cortex. Consequently cognitive information processing requires more time to produce an action in comparison to reflexive reactions.

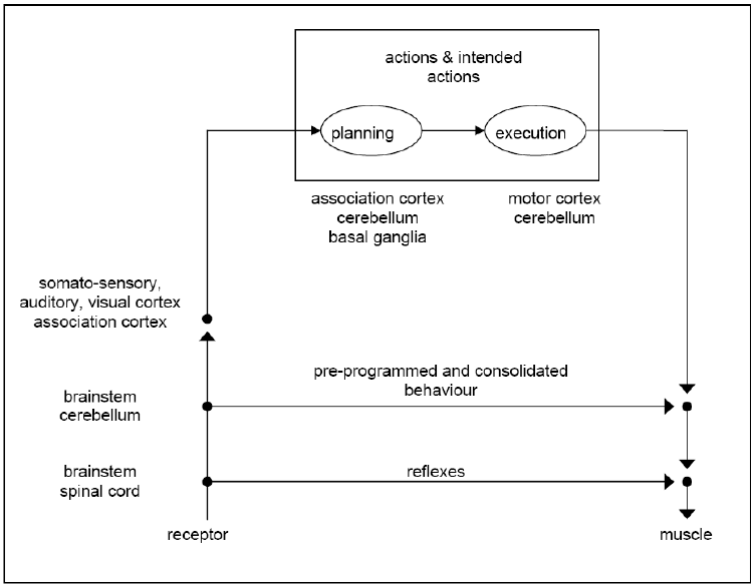

Fig.1. Scheme of the different levels of the sensomotor process and neural structures, which are involved in these processes. The suggested hierarchical order is simplified. In favour of a better illustration many afferent and efferent connections are ignored [5]

3 The new approach of Lane Keeping Assistance

The aim of the development of the new lane keeping assistance is to overcome the disadvantages of conventional cognitive systems. Primarily we want to achieve faster reaction times and less incorrect reactions. The innovative idea is to elicit a steering-reflex by a jerk at the steering wheel to initiate the correct reaction and simultaneously enhance the driver's attention. The drivers' reflexive response starts even before he recognises what he is doing. But at this

moment of recognition he is still turning the steering wheel in the right direction. He has only to control the end of the reaction and fulfil the task.

The jerk is triangular and symmetric and proceeds into the same direction in which the driver begins to leave the lane, thus a reflexive reaction against the deviation is provoked. This principle was successfully analysed in several studies in a driving simulator at the German Aerospace Center.

4 The Studies

The first of a number of studies explored systematically different adjustments of the jerk to find the most effective one. Therefore a high number of variations between the strength and the duration of the jerk have been tested. Afterwards the jerk which was identified as the most appropriate was further examined. A total of 23 participants took part in the study. The average age of the sample was 40 years (SD=11). They drove for about one hour on a simulated rural road.

Figure 2 shows the HMI-Lab at the German Aerospace Center which is used in the studies.

Fig.2. The HMI-Lab at the German Aerospace Center

The usual cause for failures in lane keeping is distracted attention of the driver. Thus, we simulated such a condition by presenting a distracting task to the driver. While the drivers worked on this task, the system simulated a tendency of the car to leave the lane on one side by means of adding a defined steering angle. The distracting task was realized in two different forms, simulating different forms of impaired attention.

One half of the participants had to track a ball which moved across the scene with their eyes. The ball changed its size from time to time. The participants

were asked to indicate such an event by means of two buttons on the steering wheel.

The other half of the participants had to solve easy mathematical tasks which appeared on a screen in the centre console. These drivers had to indicate if a presented solution was right or wrong with the same two buttons on the steering wheel, Due to the distraction tasks, the participants did not recognise the tendency of the car to leave the lane. As the car reached a pre-defined distance to the lane-edge, the assistant was activated.

Afterwards the additional steering angle was deactivated in order to avoid any artefact in the steering movements due to it. The subjects continued normal driving and after a few minutes, the process started again.

5 Results

All studies which have been carried out demonstrated the functionality of the principle. The jerk produced the reflexive response regularly and immediately after the assistant has been activated. The participants reacted with a reflexive steering-movement directed to the correct side. The compensatory corrective actions following the reflex did not build up and the participants did not over-compensate. Moreover there was no steering in the wrong direction. This also indicates that the jerk that was used was able to evoke the desired reflex.

Figure 3 shows an idealised reaction pattern for a departure to the right side of the lane.

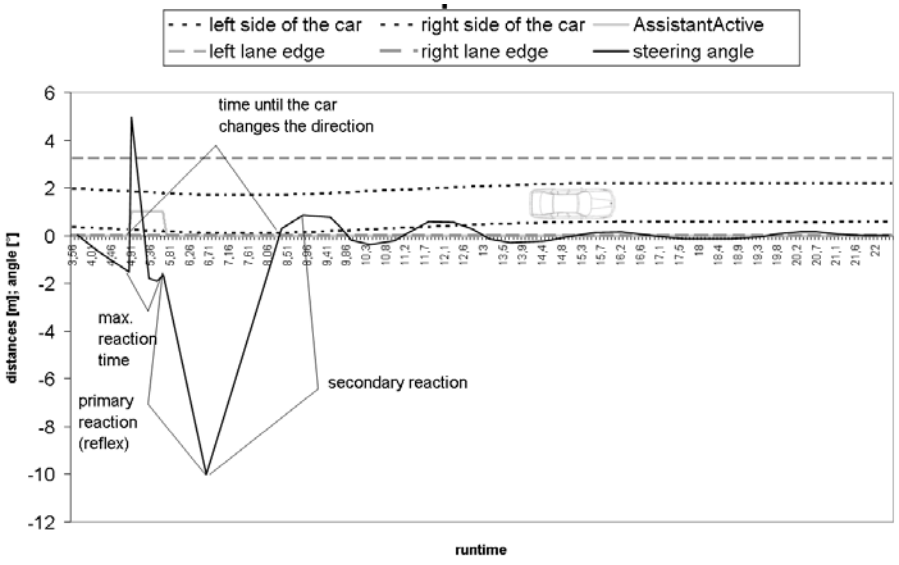

Fig.3. Idealised reaction pattern, explanation of the different measures

In order to better characterise the reaction, different measures were calculated. A difficulty in the analysis of the reaction is that the participants react so fast that the reset of the steering wheel produced by the system merges into the start of the participant's reaction. Therefore no exact reaction time can be

calculated but only the maximum of the reaction time, which surely describes an event quite a while after the reaction started. The maximum reaction time of course is a very conservative measure and heavily overestimates the actual reaction times.

Another important measure is the time from the onset of the assistant until the car changes the direction. Furthermore the primary reaction (the reflex) and the secondary reaction (compensatory reaction) have to be described. At the end of the second component of the compensatory reaction which could be described as an idealised damped oscillation the car follows its usual track in the middle (or nearly in the middle) of the lane.

In addition to the objective data from the simulation, subjective data was collected. After each study the participants were asked if they liked the system and felt comfortable with it. In the first studies the participants stated that the system helped them not to leave the roadway and that they felt safe with the system.

Detailed analyses of the gathered data are under way.

6 A look into the future

Further studies will examine the reactions of drivers with different steering modalities, like holding the steering wheel with only one hand.

Also the status of the drivers' vigilance will be varied. Could the reflex triggered with the accurate result during microsleeps?

The usefulness of a number of systems designed to apply principles of our behavioural approach is currently under examination and will be presented in the future.

7 References

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