A Technical Platform for Driver Inattention Research

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Abstract

An integrated attention monitoring system is presented. This system, including a novel head- and gaze-tracker, a lanetracker, and CAN bus integration, provides a unique opportunity to study how inattention affects driving behavior. Preliminary road tests show that the head- and gaze-tracker is robust to lighting variations, vibrations, and is reliable. Real-time data on natural driver visual behavior in real vehicles, together with real-time context recognition and prediction, provides exciting opportunities for attention assistance. Changes in visual scanning patterns and gaze fixations during driving situations that are distracting should be measurable by comparing visual behavior with vehicle performance and task actions. We also hope to guide development of human-system interfaces by learning about the visual demands of interiors and about visual behavior in general. This research should have a very positive impact on risk prevention and road safety.

Keywords: Attention, distraction, eye-tracking, and driver behavior.

Introduction

Driver inattention is the most prevalent primary cause of collisions, accounting for an estimated 25-56% (Wang, et.al. 1996). To be able to assist drivers, we need to be able to collect real-time data on driver visual behavior, recognize what the driver is doing (contextual information such as maneuvers, actions, and states), predict what the driver would likely do next, and assist the driver (design an interface). The importance of context is underlined. Attention support systems should ideally detect the co-occurence of inattention and safety critical events in the traffic environment, e.g. sudden braking of a lead vehicle and eyes-off-road. A description of the need for attention support systems can be found in Victor (2000).

From our ongoing research efforts (Victor, 2000), we believe research should concentrate on more than just the visual demand of new information systems and fatigue. Such causes as loose objects in vehicles (e.g. spilling a drink, dropping a lit cigarette, shooing an insect), interactions with other persons or animals, and involuntary visual occlusion represent a substantial portion of crash causes (Wierwille and Tijerina, 1996).

The integrated attention monitoring system, presented below, will be used in future research on how inattention affects driving behavior. Our research objectives are to reduce the risks for inattention (visual- and mental distraction and fatigue) by a) providing knowledge about visual demands and visual behavior that can guide development of human-system interfaces, b) to develop and potentially automate current methods (ISO 15007, SAE J-2396) to measure visual behavior, c) to possibly create and evaluate attention support systems, and d) to develop algorithms that recognize driving context.

Ocular-based indicators of attention

Without the presence of modern in-vehicle distracters, approximately 90-95% of all driver's fixations have been calculated to be less than or equal to 8 degrees from the center or expansion (Cole & Hughes, 1988; Rockwell, 1972). It is expected that changes in visual scanning patterns and gaze fixations (number and length) will occur with the introduction of modern in-vehicle information systems (e.g. Wierwille, 1993a), these seem to be the most promising ocular-based indicators of attention (Stern and Ranney, 1999). Rockwell (1988) found that there was a correlation between risk taking and average glance duration. Increases in fixation pauses also occur as a function of difficulties in perception as well as task demands (Stern and Ranney, 1999). Further, the differences between experts and novices in the use of information systems is an important issue, as they have been found to adopt different strategies when obtaining and manipulating visual information (Mourant, 1972; Rockwell, 1972). There is also strong evidence that in-car single glance times and numbers of glances will increase with age (Wierwille, 1993b).

Recognizing context

It is equally important to study glance duration and frequency under specific driving situations. Less glance duration and frequency during driving situations that are more demanding should be measurable by comparing visual behavior with vehicle performance (Stern and Ranney, 1999). Developments in real-time recognition of contextual information seem promising. Liu (1998, 1999) discusses applications for- and research with real-time recognition of driving- and eye movement behavior. Oliver and Pentland (2000) used vehicle performance data, eye movement data and lane position data to model and recognize seven driving maneuvers: passing, changing lanes right and left, turning right and left, starting and stopping. Their research aim was to ultimately improve the human-machine interface in driver assistance systems and to prevent potential dangerous situations by this context recognition.

The Volvo/ANU head and gaze-tracker

Working in collaboration with Volvo, the Robotics Systems Lab at Research School of Information Sciences and Engineering at the Australian National University has developed a unique system for tracking both head and eye movements. A presentation of this system can be found on www.volvo.com under -> The Volvo group -> Research and Technology -> Technology News.

The method employed is *Image processing using template matching feature tracking* (fig.1). A technical description of an earlier version of this system can be found in Matsumoto and Zelinsky (2000). Stereo cameras are used to record data in real time from a number of templates (measuring points) on the face under study.

Figure 1. Images from the Volvo/ANU head and gaze-tracking system. The two images on the bottom right illustrate the output from the stereo cameras, with the tracking templates shown as boxes and reference points as white dots. The top row shows images taken in a Volvo V70 car and the bottom row shows images from a Volvo FH12 truck.

The integrated attention monitoring system

The novel head and eye-tracking system is integrated with vehicle performance data from the multiplex buses found on modern vehicles, e.g. the Car Area Network (CAN) bus. These systems are further integrated with a lane tracker for measurement of latitudinal control performance. Together, these devices provide the opportunity for research based on real-time measurement of visual- and driving behavior.

The following technical platform for research on inattention will be used in future research.

- a) A **Volvo S80 car** with a RTI navigation system and Nokia 6110 handsfree cellphone or
  b) A **Volvo FH12 heavy truck** with cellphone and the Dynafleet fleet management system.
- A VCT2000 logger to collect **vehicle performance data** from the CAN bus, i.e. speed, pedals, gear, steering wheel angle, turn indicator, telematics control use, and display control use, etc.
- The **Volvo/ANU Head- and gaze-tracker** to collect glances (number and length), scan paths, time-off-road-scene, over the shoulder head turns, eye-closure, etc.
- The logging edition of the **Assistware SafeTrac lane tracker** to collect data on lane exceedencies, percentage time over line, SD lane position, and lane position variance.
- A National Instruments NI-DAQ measurement card with **16 experimenter annotation switches** to collect experimenter input on tasks, events and for synchronization.
- The **VAT2000 logging tool**. All data from the CAN bus, the head and gaze-tracker, the lane tracker, and the NI-DAQ measurement card will be synthesized and logged in this software.
- The images from the head and gaze-tracker and the lane tracker will be time coded and mixed together with images from a scene camera inside the car and images from the VAT2000 logging system for **offline video analysis**, e.g. for validation purposes and for collection of additional contextual information.

Results

Preliminary road test results

Preliminary road tests show that the Volvo/ANU system robustly tracks head pose, gaze, and eye closure in real-time, in real vehicle environments. The method is robust to variations in the lighting intensity (e.g. night driving, passing through a wooded area on a sunny day), vibrations and bumps, distortion and occlusion of features, rotation on the X-, Y- and Z-axis, translation along the Z-axis, and employs a smart tracking of features. Tracking reliability has been demonstrated at greater than 95% reliability. Head pose and gaze can be measured when the driver is wearing glasses. Head pose only can be measured if sunglasses are worn. The system can differentiate between targets such as the speedometer and tachometer. Natural head and eyes movements can thus be measured effectively. However, a full description of the accuracy and performance is still forthcoming.

A video showing a driver wearing glasses in a Volvo FH12 heavy truck driving on a bumpy country road into the sun with a shadow cast across the face by the sun visor can be viewed on **www.volvo.com** under -> The Volvo group -> Research and Technology -> Technology News. Results of experiments using this system integrated with the multiplex bus and the lane tracker are also forthcoming.

Conclusions

We believe that the technical platform outlined above provides a unique opportunity to study how inattention affects driving behavior. This platform will provide real-time data on natural driver visual behavior in real vehicles, will enable us to develop real-time context recognition and prediction (what the driver is- and will be doing), and provides opportunities to assist the driver in attending. We hope to help guide the development of human-system interfaces by learning about the visual demands of interiors and about visual behavior in general. There is a strong possibility that the Volvo/ANU system can potentially automate current methods of measuring visual behavior. In future research we hope to create and evaluate attention support systems that use algorithms which recognize driving context in real-time. This research should have a very positive impact on risk prevention and road safety.

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