
Naturalistic driver behavior analysis for a benchmark of driver state monitoring system requirements

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Abstract

The level 3 automated driving systems expect that the driver stays in the loop to monitor the environment and control part of the driving task. Thus, the human driver's readiness for taking over is important. In this regard, the United Nations are discussing to make a legislation for driver monitoring systems. Among the potential measures of driver's behavior monitoring discussed in the United Nations (UN), we investigated the driver eye blinks times and head movements time using manual driving conditions on the highway. The results indicate that the drivers blink their eye four or more times for 60 seconds. We also found that the driver's head movement is observed more than once during 35 seconds of driving time.

Author Keywords

Level 3 autonomous vehicle, Take-over request, Driver state monitoring system, Driver readiness, Driver availability

Introduction

The existing automated driving systems function as supportive automation and some advanced systems allow the driver to be out-of-the-loop for extended periods, but the systems still expect that the driver

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stays in the loop to monitor the environment and control part of the driving task [1]. So, the interaction between the driver and the automated driving system must be considered until the fully automated vehicle will be able to drive on the public road [2].

Criteria for deeming driver availability (UN)

The UN/ECE ACSF (Automatically Commanded Steering Function) informal working group is discussing about potential measures to identify driver availability to resume manual driving [3]. The driver shall be considered available by the system, when the driver is present in the driving seat with safety belt fastened, and at least one of the following conditions are met:

- *Input to any driver-exclusive vehicle controls during the last 180s*
- *Driver has blinked at least 3 times during the last 60s*
- *Driver shows conscious head or body movements during the last 30s*
- *The driver did not have his eyes continuously closed for the last 30s*

Among those measure, we focused on the driver eye blinks times and head movements time period.

Method

Participants

For this study, 52 younger and late middle age (LMA) drivers were participated (see details in Table 1) and they met the following criteria: age between 25-35 or over 55, drive on average more than twice a week, be in self-reported good health.

	Younger Age		Late Middle Age	
Gender	Male	Female	Male	Female
#Subject	13	13	13	13
Age	27.54 (2.90)	30.46 (3.10)	60.69 (1.89)	57.08 (2.06)

Table 1: Participants overview

Experimental setup and procedure

The experiments were conducted in an instrumented vehicle for collecting time-synchronized data. The vehicle consists of six video cameras (two for a driver and four for road environment monitoring), high speed and low speed CAN logger, lane position and headway recorder, driver gaze tracking system, and physiological measurement system.

Following informed consent and completion of a pre-experimental questionnaire, participants received about 20 minutes of urban and rural road driving experience and adaptation time on the instrumented vehicle. The main driving experiment began when a subject was confident in safe driving with the instrumented vehicle. In an experiment session, participants drove in good weather through 20.8km of highway (about 20 minutes). The highway has two lanes in each way.

Definition of Blinking & Head Movement

We analyzed the gaze data measured by Facelab gaze tracker. In order to determine whether or not eye blinking, the blinking state of the driver is set to 1 "close" and 0 "open". (1 = yes, 0 = no).

The head rotation data of the driver, the Y-axis rotation data was used to detect a case in which the head is rotated left or right. One rotation is defined as the

period of head movement in the right or left direction with respect to the Y axis and then back in the forward direction.

Results

Eye blinking analysis

Group	Younger Age		Late Middle Age	
	Male	Female	Male	Female
Avg.(times)	22	19	20	18
Min.(times)	6	4	5	5

Table 2: Eye blinking of participant's overview

Head Movement analysis

	1 st highway	2 nd highway
Avg.	12 sec	12 sec
Min	2 sec	2 sec
Max	35 sec	40 sec

Table 3: Head rotation duration results data

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