Investigating the Feasibility of Vehicle Telemetry Data as a Means of Predicting Driver Workload

Phillip Taylor, Department of Computer Science, University of Warwick, Coventry, UK
Nathan Griffiths, Department of Computer Science, University of Warwick, Coventry, UK
Abhir Bhalerao, Department of Computer Science, University of Warwick, Coventry, UK
Zhou Xu, Jaguar and Land Rover Research, Coventry, UK
Adam Gelencser, Jaguar and Land Rover Research, Coventry, UK
Thomas Popham, Jaguar and Land Rover Research, Coventry, UK

ABSTRACT

Driving is a safety critical task that requires a high level of attention from the driver. Although drivers have limited attentional resources, they often perform secondary tasks such as eating or using a mobile phone. When performing multiple tasks in the vehicle, the driver can become overloaded and the risk of a crash is increased. If a vehicle is aware that the driver is currently under high workload, the vehicle functionality can be changed in order to minimise any further demand. Traditionally, workload is measured using physiological sensors that require often intrusive and expensive equipment. Another approach may be to use vehicle telemetry data as a performance measure for workload. In this paper, the authors present the Warwick-JLR Driver Monitoring Dataset (DMD) and analyse it to investigate the feasibility of using vehicle telemetry data for determining the driver workload. They perform a statistical analysis of subjective ratings, physiological data, and vehicle telemetry data collected during a track study. A data mining methodology is then presented to build predictive models using this data, for the driver workload monitoring problem.

KEYWORDS

CAN-Bus, Data Collection, Driver Monitoring, ECG, EDA

1. INTRODUCTION

Drivers have limited attentional resources that must be divided between the various driving tasks, including perceiving the driving environment and controlling the vehicle speed and direction (Young & Regan, 2007). These resources are often also allocated to tasks unrelated to driving, such as holding a conversation in the vehicle, using a phone, or choosing a radio station (Stutts, Reinfurt, Staplin, & Rodgeman, 2001). The attention of a driver may also change with the time of day, fatigue, and tiredness. In some cases, the demand for attentional resources can become too high for the driver to handle, causing them to be inattentive, lowering driver performance, and increasing the risk of a crash.

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crash (Stutts et al., 2001; Regan, 2005; Regan, Hallett, & Gordon, 2011). Understanding how drivers divide their attention to tasks, and when drivers are inattentive, is therefore important to ensure driving safety and to aid the driver in managing their attentional resources.

The attention of a driver can be managed by either increasing their attentional resources, or by decreasing their demand. For instance, the resources available are lowered for a driver that is tired or fatigued, which can be increased by opening a window, cooling the interior of the vehicle, or encouraging the driver to take a break (Dong, Hu, Uchimura, & Murayama, 2011). The demands of a driver can be reduced, through both design and real time adaptation in the vehicle. Intuitive interfaces with lower complexities, for instance, are less demanding to use than those that are more complicated (Regan et al., 2011). Further, if the vehicle is able to determine the current inattention status of the driver, it may be possible to change the information provided to them or withhold certain event updates entirely.

The allocation of attentional resources can be considered as driver workload, which describes the impact of tasks on drivers (Mehler, Reimer, & Coughlin, 2012; Dong et al., 2011). Workload is usually measured using subjective or physiological measures, or by analysing the performance or behaviour of the driver. Subjective measures require that drivers report their perceived workload demand, either while driving or afterwards. Reporting while driving can itself increase the workload levels, and other biases can be introduced because of the different perceptions and limited memories of drivers. To produce continuous measures of workload, physiological parameters and driver performances can be used. Physiological measures include Heart Rate (HR) and Skin Conductance (SC), which both increase during periods of increased workload (Mehler et al., 2012). To gain reliable measurements, however, the equipment is often intrusive and impractical for everyday driving. Other methods measure the driver’s head position or eye parameters using a driver facing camera, but these are expensive and can be unreliable in poor light conditions (Reimer, Mehler, Wang, & Coughlin, 2012). An alternative approach, is to use telemetry data to estimate driver performance and behaviour (Mehler et al., 2012).

In this paper, driver workload is investigated using subjective, physiological, and performance based measures in the Warwick-JLR Driver Monitoring Dataset (DMD). Specifically, we induce increased workload in the form of cognitive distraction using the N-back task in a study with thirteen participants. Differences are observed in subjective responses, the HR, Electrodermal Response frequency (EDR), SC, and several driving parameters taken from the vehicle telemetry data. Predictive models are then built using the telemetry data to output the workload status of the driver, given by the physiological measures. The performance of these models is then used to assess the feasibility of using vehicle telemetry data as a means of assessing driver workload.

The remainder of the paper is structured as follows. Driver workload monitoring is discussed in Section 2. The study is outlined in Section 3, and statistical analysis of the data collected is presented in Section 4. A data mining methodology is proposed in Section 5 for building predictive models for the driver distraction problem. In Section 6 the results of applying this methodology to the data collected are presented. Finally, Section 7 concludes this paper.

2. DRIVER WORKLOAD MONITORING

Drivers who are inattentive are more at risk of being involved in a crash than those who are not (Stutts et al., 2001). A taxonomy of driver inattention is provided by Regan et al. (2011), who divides it into diverted (performing tasks unrelated to driving), restricted (fatigued or unwell), misprioritised (prioritising unimportant driving tasks above critical tasks), neglected (lack of due care because of familiarity to the road environment), and cursory (rushed or panicked driving). Dong et al. (2011)
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