Visual Demand Evaluation Methods for In-Vehicle Interfaces

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ABSTRACT

The primary aim of the research presented in this paper is developing a method for assessing the visual demand (distraction) afforded by in-vehicle information systems (IVIS). In this respect, two alternative methods are considered within the research. The occlusion technique evaluates IVIS tasks in interrupted vision conditions, predicting likely visual demand. However, the technique necessitates performance-focused user trials utilising robust prototypes, and consequently has limitations as an economic evaluation method. In contrast, the Keystroke Level Model (KLM) has long been viewed as a reliable and valid means of modelling human performance and making task time predictions, therefore not requiring empirical trials or a working prototype. The research includes four empirical studies in which an extended KLM was developed and subsequently validated as a means of predicting measures relevant to the occlusion protocol. Future work will develop the method further to widen its scope, introduce new measures, and link the technique to existing design practices.

Keywords: Driver Distraction, In-Vehicle Information Systems, Keystroke Level Model, Methodology, Occlusion

INTRODUCTION

Advancements in computing technology have been keenly felt in the automotive industry. In-vehicle information systems (commonly referred to as IVIS) have the potential to substantially improve the safety, efficiency and comfort of the driving experience (Hole, 2007; Bishop, 2005). Examples of IVIS functionality include navigation, travel and traffic information, email and internet services. However, IVIS must be carefully designed, so their use does not dangerously distract drivers from fundamental, safety-critical tasks (Salvucci, 2001). Distraction is a well-established causal factor in road accidents, and the results can be fatal (e.g., Wang et al., 1996; Green, 2000; Stutts et al., 2001). A concern is that the introduction of new in-vehicle technology may increase exposure to distraction, and lead to an increase in distraction-related accidents (Stevens & Minton, 2001). Furthermore, it is possible that drivers may prioritise some IVIS tasks highly if they are viewed as supporting primary driving goals (e.g., use of a navigation system to reach an unknown destination on time), meaning that it is not possible to rely on drivers' judgement in engaging with devices at safer times (Cnossen

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et al., 2004). In this respect, given the largely visual nature of driving, it is clear that IVIS user-interfaces are required that utilise few visual resources.

Visual distraction has been defined to be a characteristic of both the driver (motivation to engage with the system) and the interface itself (according to layout of information, density, number of screens, etc.) – Pettitt et al. (2006a). An individual driver’s willingness to engage with a system is influenced by many factors, such as the priority of the secondary activity, driver experience and the current driving environment, and is clearly difficult to quantify. In contrast, the latter component (often termed the visual demand of a user-interface) lends itself to quantification and is recognised to be an essential design aim (Young et al., 2003).

User trials involving the use of simulators or instrumented vehicles enable the IVIS designer to assess the visual demand of alternative user-interfaces. Unfortunately, such methods are notoriously time consuming and expensive to conduct, especially as considerable post-hoc video analysis is required to extract specific metrics (e.g., the number and length of glances made towards an in-vehicle display). In this respect, the occlusion technique is seen by many as a breakthrough in the quest to discover simple, low-cost evaluation methods. In occlusion, participants carry out tasks with an in-vehicle system (stationary within a vehicle or vehicle mock up) whilst wearing computer-controlled goggles with LCDs as lenses which can open and shut in a precise fashion. Consequently, by stipulating a cycle of vision for a short period of time (e.g., 1.5 seconds), followed by an occlusion interval (e.g., 1.5 seconds), glancing behaviour is mimicked in a controlled fashion. Figure 1 shows a participant carrying out a task with an in-vehicle system (whilst stationary) using occlusion goggles.

Following considerable research, the occlusion technique has now reached a level of maturity where an ISO standard has been published setting out in detail how the method should be implemented (ISO, 2007). In this standard, two specific metrics are noted:

- **Total Shutter Open Time (TSOT)** - the amount of visual exposure to an IVIS during occlusion trials
- **The Resumability ratio (R)** - said to be indicative of the ‘degree to which a task can be done without visual control’ (ISO, 2006, p. 25), calculated as the ratio of TSOT and static task time (the time required to carry out the task with full vision available, as would be the case in a stationary vehicle).

It is generally recognised that TSOT is the primary measure from occlusion trials. There

![Figure 1. Participant carrying out IVIS tasks with occlusion goggles: left (with vision); right (without vision)](image)
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