Development of a Method for Evaluating the Usability of In-Vehicle Information Systems (IVISs)

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Abstract. This project involves the development of a model-based method for the evaluation of design concepts for In-Vehicle Information Systems (IVISs). The evaluation method is aimed specifically at assessing the usability of the Human Machine Interface (HMI) associated with these systems. It is aimed at the very early stages of design and is intended to provide designers with a quick and easy method of evaluating HMI concepts. The evaluation method will be validated and refined using the results from user trials conducted in a driving simulator and on-road, in an instrumented vehicle.

Keywords: Driving, Usability, Ergonomics, Interface, Evaluation, Design

1 Project Overview

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Research Area: Evaluation of the usability of in-vehicle interfaces.
Research topic description: This project involves the development of a method for evaluating the usability of In-Vehicle Information System (IVIS) design concepts.

2 Introduction

Secondary driving tasks are those which are not directly related to the primary task of driving, and typically include any functions relating to communication, comfort, navigation and 'infotainment'. Traditionally, secondary functions have been operated via a series of hard switches mounted on the vehicle's dashboard. Today, in the premium sector, and increasingly with volume brands, these functions are integrated into a single menu-based interactive system, with only the most high-frequency and high-importance controls left as hard switches. These 'In-Vehicle Information

Systems' (IVISs) make use of a screen-based interface, which reduces the cluttered appearance of the dashboard and is an aesthetically superior solution to the traditional layout.
The ease with which a driver can interact with an IVIS is determined by the Human Machine Interface (HMI). The HMI influences a driver's ability to input information to the IVIS, to receive and understand information outputs, and to monitor the state of the system. A HMI which optimises the interaction between the driver and IVIS will enhance the 'usability' of the system and consequently improve the driver's experience of using it. Usability is comprised of many factors such as effectiveness and efficiency of use, learnability, user attitude and acceptance, flexibility, and safety [1], [2]. All of these factors, plus many more, are important in the design of a HMI, although the relative importance of each of these factors will depend on the specific application. When considering the usability of an IVIS specifically, factors such as effectiveness and efficiency of use, learnability, and safety are likely to be most important because secondary tasks must be easy to use and to learn, and, perhaps most crucially, must not present a risk to the user in terms of safety.

3 The Current State of The Art

A review of the literature has identified a necessity for an evaluation method for IVIS interfaces which is targeted specifically at the concept stage of the design process. There has been a tendency in the past to leave consideration of human-machine interaction until late in the design process when much of the design has already been finalised. This has meant that even if usability issues have been identified it is usually too late or too costly to make the necessary changes to design.
The review has also shown that existing methods for in-vehicle interface evaluations are largely qualitative, relying heavily on subjective opinions of usability, which are susceptible to bias. Examples include an evaluation method for automotive cockpits in which ergonomics experts rated attributes of the cockpit design on a rating scale where the levels of satisfaction were denoted by sad or smiley faces [3], and a checklist of statements which evaluators had to assess as being 'true' or 'false' [4]. It is evident that these evaluation techniques are open to bias from evaluators and are a relatively crude method of assessment. A more quantitative method, based on measurable attributes of usability, such as interaction times, performance error rates or user eye movements, is desirable because it would allow different interfaces to be compared directly and would also remove experimenter bias from evaluation. However, aspects of usability such as aesthetic appeal and user satisfaction are virtually impossible to assess objectively and it is therefore likely that the completed evaluation technique will comprise a mix of objective and subjective measures, which will combine to give an overall estimate of IVIS usability.

4 Objective

The objective of this project is to develop a method for evaluating the usability of IVIS interfaces. The evaluation method will be developed for use by automotive manufacturers in the concept design phase of IVIS development. This method will

have an advantage over other, mainly subjective, IVIS evaluation techniques because it is based on quantitative metrics and therefore allows different interfaces to be directly compared. Evaluation at an early stage in the design process will also ensure that only those concepts which offer a real advantage over existing IVISs will be taken forward for further development, resulting in a time and cost saving to automotive manufacturers. It is hoped that the evaluation method will also facilitate the development of new HMI concepts for use in vehicles.

5 Methods

The evaluation method will be developed as part of an iterative process, in which the findings from various stages of the research will feed back into the project to aid the development of the method.

5.1 Modelling Primary and Secondary Driving Tasks

The primary driving task and a selection of sample secondary driving tasks will be modelled individually, and then combined into a single model of driving. The main element of the model will be the Critical Path Analysis technique, which will be used to predict task interaction times. This will be used specifically to model efficiency of use, which is one of the main facets of IVIS usability. Efficiency is useful as an indicator of the safety of the interaction because it signifies how much time a driver spends interacting with secondary tasks and how this could potentially conflict with primary task performance. The model will be incorporated into an evaluation method which will also include measures of wider aspects of usability, including learnability, flexibility and user satisfaction.

5.2 Validation of Evaluation Method

The evaluation method will be applied to various existing and potential IVIS interfaces to predict levels of usability for these systems. A series of user trials will also be conducted using a driving simulator and in on-road tests, using an instrumented vehicle. The trials will be used for the empirical evaluation of the usability of the same selection of IVIS interfaces. These results will be used to validate the predictions from the evaluation method. The method, including the task interaction time model, will then be refined according to these results.

6 Conclusions

The research element of this project will contribute to further understanding of what constitutes usability for In-Vehicle Information Systems and how these aspects of usability can be evaluated using a combination of objective and subjective techniques.

This work will address the deficiencies of existing evaluation techniques by taking a more quantitative approach and also by focussing on very early-stage concept design.

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