Chapter 2.11
Designing and Evaluating In-Car User-Interfaces

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ABSTRACT

The introduction of computing and communications technologies within cars raises a range of novel human-computer interaction (HCI) issues. In particular, it is critical to understand how user-interfaces within cars can best be designed to account for the severe physical, perceptual and cognitive constraints placed on users by the driving context. This chapter introduces the driving situation and explains the range of computing systems being introduced within cars and their associated user-interfaces. The overall human-focused factors that designers must consider for this technology are raised. Furthermore, the range of methods (e.g., use of simulators, instrumented vehicles) available to designers of in-car user-interfaces are compared and contrasted. Specific guidance for one key system, vehicle navigation, is provided in a case study discussion. To conclude, overall trends in the development of in-car user-interfaces are discussed and the research challenges are raised.

INTRODUCTION

The motor car is an integral part of modern society. These self-propelled driver-guided vehicles transport millions of people every day for a multitude of different purposes, for example as part of work, for visiting friends and family, or for leisure activities. Likewise, computers are essential to many peoples' regular lives. It is only relatively recently that these two products have begun to merge, as computing-related technology is increasingly implemented within road-going vehicles. The functions of an in-car computing system can be broad, supporting tasks as diverse as navigation, lane keeping, collision avoidance, and parking. Ultimately, by implementing such systems car manufacturers aim to improve the safety, efficiency, and comfort and entertainment of the driving experience (Bishop, 2005)

Designing the user-interface for in-car computing systems raises many novel challenges, quite unlike those traditionally associated with interface design. For instance, in many situations, the use of an in-car system is secondary to the complex and already demanding primary task of safely

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controlling a vehicle in 2D space, whilst simultaneously maintaining an awareness of hazards, largely using the visual sense. Consequently, the level of workload (physical, visual, and mental) when using displays and controls becomes a critical safety-related factor. As a further example, in-car computing systems have to be used by a driver (and possible also, a passenger) who is sat in a constrained posture and is unlikely to be able to undertake a two handed operation. Therefore, the design (location, type, size, etc.) of input devices has to be carefully considered, accounting in particular for comfort, as well as safety, requirements.

This chapter aims primarily to provide the reader with an overall awareness of novel in-car computing systems and the key HCI design and evaluation issues. The focus is on the user-interface, that is, "the means by which the system reveals itself to the users and behaves in relation to the users' needs" (Hackos & Redish, 1998, p.5). Topics of relevance to both researchers and practitioners are raised throughout. Given the complexity of the driving task and the wide range of computing systems of relevance, the chapter principally provides breadth in its consideration of the subject. Nevertheless, some depth is explored in a case study investigation on the design and evaluation of user-interfaces for vehicle navigation systems.

TYPES OF IN-CAR COMPUTING SYSTEMS

Technology is increasingly being seen to have a critical role to play in alleviating the negative aspects of road transport, such as congestion, pollution and road traffic accidents (Bishop, 2005). Many technological initiatives are considered under the umbrella term, intelligent transport systems (ITS), where "ITS provides the intelligent link between travelers, vehicles, and infrastructure" (www.itsa.org, September, 2006). In this respect, in-vehicle computing systems are an important facet of ITS. Specifically, there are two core types of computing and communications systems which are either being implemented or developed for use in vehicles:

- **Information-based systems:** These systems provide information relevant to components of the driving environment, the vehicle or the driver. Examples of systems include navigation (facilitating route planning and following), travel and traffic information (traffic conditions, car parking availability, etc.), vision enhancement (providing an enhanced view of the road ahead, when driving at night, in fog or in heavy rain), driver alertness monitoring (informing the incapacitated driver if they are unfit to drive) and collision warnings (presenting warnings or advice regarding hazards).
- **Control-based systems:** These systems affect the routine, operational elements of the driving task. Examples of systems include adaptive cruise control (where the car is kept at a set time gap from a lead vehicle), speed limiting (the car speed cannot exceed the current limit), lane keeping (the driver's vehicle is kept within a given lane), self parking (vehicle automatically steers in low speed operation to position itself within a selected parking space) and collision avoidance (the vehicle automatically responds to an emergency situation). Clearly, such systems fundamentally change the nature of what we consider to be 'driving.'

It is important to note that there is a third category of in-car computing system, those which do not provide any functionality to support the driving task. These systems are an important consideration though, as they can negatively influence safety, particularly through the potential for distraction (Young, Regan & Hammer, 2003). Such systems may aim to enhance work-oriented productivity

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