E-Distraction: The Challenges for Safe and Usable Internet Services in Vehicles

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Abstract

The availability of Internet information in the vehicle can provide wide and enduring benefits for drivers, passengers, commercial vehicle operations, service providers and transport systems managers. However, there is considerable evidence that complex in-vehicle information systems can distract the driver. These in-vehicle Internet (IVI) services should not be available if they are dangerous to road users. Road safety is paramount and systems must be designed that do not distract drivers dangerously. Presentation of IVI information would be clearly inappropriate in the format that we experience on our desktop computers. Although there are many challenges to be overcome, it is argued that it is possible to design safe integrated IVI systems. This paper discusses some preliminary Human Factors solutions for designing safe driving-compatible interfaces. It is hoped this Driver Distraction Forum can contribute further solutions to this problem.

Keywords: in-vehicle Internet, distraction, road safety and usability.

Benefits of In-Vehicle Internet (IVI)

The availability of Internet information in the vehicle can provide wide and enduring benefits for drivers, passengers, commercial vehicle operations, service providers and transport systems managers. These can be broadly considered in terms of end users and service providers.

The availability of in-vehicle Internet information can assist the driver by supporting their primary vehicle control task and enabling ‘office on the move’ type activities if appropriately managed. IVI can influence the driving task in a very fundamental and broad fashion. For example, dynamic digital map and traffic updating will help avoid roadwork delays with the added advantage of improving business efficiency. Such systems are currently under development (Infomove, 2000). In contrast, in situations of low driver arousal, IVI entertainment and information can provide a stimulus to combat driver fatigue or boredom.

Car passengers employing IVI do not have any of the potential considerations of task interference that a driver IVI interface must consider. Therefore, the passengers' IVI is a more straightforward HCI design issue, enhancing their journey offering them all the commercial, entertainment and support for the driver functions that the information may provide. Rear seat passengers could have access to location specific information relating to cities, towns and historical features of interest (Jameel, et al., 1998).

IVI stakeholders have a great opportunity to exploit the significant emerging in-vehicle market. Service providers, in the broadest sense will have huge potential to advertise, provide subscription connections, sell products and inform the user of personally tailored data. For example, this may include current vehicle status, augmenting in-vehicle systems, servicing requirements and locations, personal restaurant recommendations, parking availability, hotel reservations, and so on. The flow of information need not be one way either, with the driver sending and responding to email, purchasing products or more interestingly, providing information relating to their vehicle or driving performance to assist traffic and fleet management systems. This data can, in turn, be used to fine tune route guidance advice by considering the real volumes of traffic on the network and their current status, for example, users with fog lamps or windscreen wipers active on a particular section of road or activiation of airbags in automated accident reporting (Orski, 1999). Thus, the availability of IVI can support not only the driver, but their passengers, a diverse range businesses and even the management of the road transportation system as a whole.

IVI Considerations

The benefits of IVI services have been highlighted to illustrate the supplier push and consumer pull for these systems rather than attempt to downplay their safety risk. There is a strong possibility that road safety will be compromised by the increases in mobility and efficiency. Tingvall (1995) argues that mobility and efficiency must become the product of improved safety rather than an economic rationalism for the risk of death and injury.

Tingvall (1995) also reminds us how victim blaming pervades the road transport system. This is a crucial issue to any discussion of driver distraction. Tingvall argues that the road transport system (government, service suppliers, and manufacturers) must assume some responsibility for providing drivers with potentially dangerous systems; liability warnings to drivers on the appropriate or recommended usage of systems are not sufficient. Since accident avoidance is paramount, safe systems that do not dangerously distract drivers must be designed. Furthermore, IVI should not be available in vehicles if there is any belief that they will be dangerous to road users.

Standard safety evaluation methods are needed to prevent dangerous IVI systems from making it on to the roads. However, evaluation criteria by their nature are often applied too late to be useful for the system designers (e.g., prototype testing). Designers and engineers need accessible and useful guidelines for creating services and interfaces that are compatible with safe driving. Information is needed sooner on how to design safe and usable systems that will have a chance of passing any evaluations. In this paper our aim is to target the problems in advance and then discuss ways to assist in ensuring that dangerous systems are never designed in the first place.

IVI Systems

Traditional access to Internet information has been via the networked desktop PC. However, IVI is currently available from various media (GSM, WAP and numerous proprietary systems) and utilizing numerous devices (cellular telephone, personal digital assistants (PDA) and integrated in-vehicle systems). This paper primarily considers the usability challenges to be overcome for the safe in-vehicle use of built-in and docking of existing (telephone and PDA) systems that integrate with in-vehicle systems.

IVI Distraction

Inattention is the most prevalent proximate cause of crashes accounting for between 25 and 56% in the United States (Wang, Knipling & Goodman, 1996). These inattentive crashes could be divided between those caused by visual distraction and mental distraction (looked-but-did-not-see), with slightly more being caused by visual distraction. The primary causes of the visual distraction were ‘reaching for loose objects’ and interacting with passengers (Wierwille & Tijerina, 1996). These statistics will certainly change as the potential for distraction increases with IVI systems. The cognitive, visual and manual components of driver distraction will be discussed further in the following three sections.

Cognitive distraction is a profound concern for road safety. There is clear evidence that you have to keep your mind on the road and not just your eyes. For example, performing a cognitive task on a hands free cellular phone has a negative impact on driving performance in cars, be it in a driving simulator (e.g., Alm & Nilsson, 1995) or on the real road (e.g., Brookhuis, de Vries, & de Waard, 1991).

A specific issue for cognitive distraction is the problem of IVI loading time. The information once requested should be available immediately to the driver. The driver should have instant feedback. Unfortunately, there will be a variable delay before the information is ready to read. This delay will depend on the quantity of information, demand on the provider and the demand on the device loading the information. The feedback for existing wireless services is long and unpredictable. Drivers will have to wait an uncertain time for the information. Yet every second of delay is a risk for distraction and frustration.

The dangers of distraction are well established, but we know little about the hazards of driver frustration. It would not be unreasonable to suggest that frustration is another form of distraction, a type of emotional distraction. Furthermore, with the apparent increasing incidents of ‘road rage’, there is no tolerance for more frustrated drivers. Whatever the consequences of frustration, we can be certain that it does not have a positive impact on road safety.

Another concern for IVI is the dynamic and inconsistent nature of the information, it changes from hour to hour or day to day and by location. It is also inconsistent in structure and format. The unfamiliar and unpredictable nature of this information will inevitably increase the cognitive demands on the driver.

Currently, there are no standard predictable appearances and structures to information on the Internet. Designers exploit different colors, layout menu structures, flashing banner advertisements etc. Such methods provide good opportunities to guide the desktop user and increase revenue opportunities for the site provider but are inappropriate for presentation in-vehicle. Similarly, the presentation and structure of information can also be hugely variable too. It is this variance that underpins the flexible and chaotic nature of the World Wide Web (WWW) and makes the cognitive demands of IVI incompatible with driving.

Vision has been stated to be the largest single source of environmental feedback available to the driver and is the major information processing input in driving (Sabey & Staughton, 1975; Wierwille, 1993). A considerable body of research has investigated the visual distraction imposed by in-vehicle information systems. For example, ‘Eyes off the road’ inattention has been stated to account for 13% of crashes (Wang et al., 1996). IVI is a complex example of just such a system. IVI systems producers (e.g., Delco, Visteon, Clarion; Orski, 1999) propose that the solution to in-vehicle presentation of complex, distracting displays is the application of speech interfaces for in-vehicle systems. However, this may not reduce distraction. Users’ familiar method of interaction with Internet information is via a visual display and they may feel compelled to interact via this medium. Adopting an auditory interface will require users to formulate a strategy for use, they may feel more compelled then to ‘just glance at the display’. As systems designers we need to consider carefully the user expectations and models of system functionality and design to support use and prevent misuse of the IVI device.

Individual differences such as age (Brouwer, et al., 1991) and experience (Mourant, 1972) have been shown to radically affect the ability to interface with in-vehicle systems.

Some drivers will be able to use complex IVI functions safely but some will not. Consequently, IVI must be designed within the abilities of all drivers, unless access to IVI requires some additional driver testing.

The modern vehicle has become increasingly complex with the introduction of more convenience systems with greater functions. These controls and systems now crowd the dashboard. For example, in-car entertainment functions are commonly available via a steering wheel stalk or buttons. The introduction of IVI functionality into the car poses several physical ergonomics challenges. Principally, these are primary task conflict, physically constrained workspace, unfamiliar interface methods and poor control location. To expand on these points, IVI controls must not interfere with the safe execution of the driving task. That is, the driver must not accidentally activate IVI controls when attempting to indicate a turn or set their automatic cruise control.

Packaging an IVI system in the modern vehicle is a significant challenge as the use of the IVI system has lower priority to driving and control placement would therefore 'lose out' to driving task related controls. The poor but rational placement of IVI controls raises another concern that difficulty in locating controls while in transit may lead to unnecessary distraction from the forward view when the driver has to move off their normal sight line to actuate a control. Once IVI system controls are 'at hand', the user may experience a mismatch between their expectations of interaction and the input methods available. For example, a mouse would be clearly unsuitable for in-transit use, and users rarely browse the web using keypad or speech recognition.

Human Factors Solutions

This section describes a sample of recent design advice available to system producers. This advice is more general and does not specifically concern IVI.

The BSi Code of Practice (BSi, 1996) sets out to provide recommendations to assist designers, manufacturers, suppliers and installers regarding safety-related issues affecting systems used by drivers in-transit. It overviews key human factors design considerations, e.g., control and display location, training, system interaction, etc. The document provides both normative data and references to supporting text.

The EC has taken a first step towards legislation in encouraging safe practice in the design of Human Machine Interfaces in road vehicles. According to this EC statement of principles (1999), "information and communication systems intended for use by the driver while driving must not distract, disturb or overload drivers." This document lists a set of principles on the overall design, installation, information display, interaction and behavior of in-vehicle information systems. Given the problems of IVI it is uncertain that these services will 'pass' these requirements. However, it is not currently known how adherence to this EC statement will be tested.

The TRL Checklist (Stevens, et al., 1999) provides a structured screening tool to identify systems that will be unsafe for use in-transit in-vehicle. It has two parts, the assessment protocol and the supporting text, providing material and a substantial set of references to advise the assessor.

Green et al. (1995) proposed some preliminary human factors guidelines for the design of safe and usable driver information systems. These included both general and system specific guidelines. The general guidelines cover basic human factors principles (e.g., consistency and priority), manual controls, dialogue and visual and auditory display design. They state that guidelines must be built around specific design experience for them to be useful: The specific guidelines apply mainly to navigation systems, however there is some advice for designing telephones and traffic information systems.

Campbell et al. (1998) formulated some guidelines for the development, design and evaluation of advanced traveler information systems and commercial vehicle operations. These provide some good general guidelines on display legibility, content and use of color. There is also relevant advice on the selection of control types and control design.

Good Practice

The following section provides common sense advice for systems producers to aid human machine interface design. We would strongly recommend obtaining and applying the guidelines indicated above. As a designer, if there is any concern that a task is too distracting, then seriously consider re-design or removal of the function in question. A brief summary of some of the practical design advice available from research:

- Average glance duration should be less than 1.2 seconds (Wierwille, 1993).
- No glances should be longer than two seconds (Wierwille, 1988; Zwahlen, 1988).
- Total task time should be less than fifteen seconds (Green, 1999).
- Must not significantly effect lateral and longitudinal control of the vehicle, driver workload, and situation awareness (Vidulich, 1994).

Basic HCI considerations (e.g., Hix & Hartson, 1993).

- The user should not be required to remember anything to use the system
- Feedback from controls should be effectively instantaneous
- Displays should only attract drivers' attention when necessary. Movement and/or flashing of graphical elements should be avoided unless these are absolutely necessary.
- Visual clutter should be minimized, maximum contrast should be used between display elements, colors should used sparingly and consideration for color blindness should be given.
- Keep backgrounds simple and muted.
- Group information logically. Consider the frequency and sequence that functions will be used and design user interactions to support this.
- Learn about the users behavior and needs
- Let the user set the pace and initiate interaction
- Prioritize information
- Accommodate for experience
- Restrict information when necessary

Access

The need to support multiple vehicle users and provide appropriate and varied information presentation and control interaction forms the core of an acceptable IVI system. Jameel et al. (1998) proposed a user interface architecture that considers the provision of information (Internet, in-vehicle, etc), management of content (HTML, WTML, XML, etc), with a 'Presenter' (user inputs, system status monitor and configuration manager). This system provides varied interaction to better meet the drivers' and passengers differing needs. The significant benefit to such architecture is the management of information to meet the drivers' dynamic capabilities. This dialogue management is considered to be fundamental to the successful implementation of IVI.

There is also a need for some technique for distinguishing between the driver and passenger. Otherwise the passenger will not be able to access services that are too distracting for the driver. The passengers should have access to functions. However, there must be some consideration about whether the passengers' interaction with a device will distract the driver. For example a display screen that the driver can see will distract them if the passenger is using it. Screens could be tilted to face the passenger to avoid this problem. A 'smart seat' that knows there is a passenger might prevent driver access.

Humans have sophisticated information management systems and are often excellent at ignoring irrelevant information. Dialogue managers can assist in preventing the presentation of information at inappropriate times to reduce driver distraction and overload. For example, a hard braking situation would be an inappropriate time for the system to tell drivers they have an email message. The dialogue manager should block information when it detects that the driver is too busy or will be occupied with more important tasks. These same systems can also learn patterns of driver behavior and pre-load remote information so that it can be instantly presented whenever the driver requests.

Presentation of IVI information would be clearly inappropriate in the format that we experience on our desktop PCs. For example, flashing advertisements, very small fonts, and form dialogues with 50 choice 'pop up' options, are all common elements in mainstream Internet sites. Some form of pre-digested data presentation or in-vehicle information management is required. The Wireless Application Protocol (WAP) standard for use in cellular telephones offers promise for adoption in an in-vehicle context. Information is reformatted to present data in a simplified way that is more suitable for an in-vehicle HMI.

Vehicle users should be able to access the Internet using conventional interfaces while the vehicle is stationary. However, the vehicle systems must lock out some functionality during driver in-transit use. Multi-function controls provide a solution to the problem of restricted space for controls. Although, multi-function controls do impose workload to navigate to the system of choice, e.g., IVI, audio, climate controls. Speech interfaces offer much promise for in-vehicle interaction. Advances in recognition technology have improved performance radically in recent years (e.g., Graham et al., 1999). The vehicle remains, though, a difficult domain for the application of this interface method. It has numerous users, an uncompromising auditory environment, a largely untrained user group, unfamiliar functions available, and no clear need (regardless of the marketing drive &/or availability) for IVI systems.

Conclusions

There can be little doubt that IVI will increase the availability of information and entertainment in the vehicle. However, it will be a serious challenge to ensure IVI systems do not impose unreasonable distraction on the driver. Our challenge as human factors professionals and system designers is to support the economic, marketing and user desire for IVI functionality while ensuring that attention and safety are not compromised.

Customers are becoming increasingly demanding and it is clear now that functionality alone is no longer the feature that sells. Vendors succeed on their potential to differentiate from competition in terms of usability and customer service. These business goals can be compatible with policy and product regulation.

Mohan (2000) argues that access is the real value of a transportation system and not mobility. This introduces an interesting paradox for IVI. The Internet brings the world to your computer. Why bother driving if you have safe and convenient access to everything you need from within your own house? Perhaps it is possible that the Internet can contribute to road safety.

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