INTEGRATING NOMADIC DEVICES IN AN ADAPTIVE DRIVER-VEHICLE ENVIRONMENT

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Abstract: Nomadic devices such as mobile phones and PDAs are becoming increasingly ubiquitous and essential for daily use in modern society, see (EU Communication). At the same time the automotive vehicle is benefiting from an increasing range of new technologies to provide the driver with more information and driving aids. But little work has been carried out to explore and analyse the interaction between these nomad devices and the automotive systems, and their impact on safety. The AIDE project plans to safely integrate these into a seamless and safe automotive environment to benefit the driver and society at large.

Keywords: automotive, cellular, driver, multimedia, safety, telematics, user interfaces

1. INTRODUCTION

Today, a wide range of new in-vehicle technologies are being introduced on the market, including Advanced Driver Assistance Systems (ADAS) and In-vehicle Information Systems (IVIS), as found in (COMUNICAR web site). Moreover, the in-vehicle use of Nomad Devices (NDs), such as mobile phones, personal digital assistants and other portable computing device, are increasing rapidly (Bellotti, 2003).

These new technologies have great potential for enhancing road safety, as well as enhancing the quality of life and work, e.g. by providing in-vehicle access to new information services.

However, the safety benefits of ADAS may be significantly reduced, or cancelled out altogether, by unexpected behavioural responses to the technologies, e.g. system over-reliance and safety margin compensation. Moreover, IVIS and nomad devices may induce dangerous levels of workload and distraction. Finally, potential conflicts between different independent systems interacting with the driver further increase the risk for mental overload and unexpected behavioural effects, see (Trbovich, 2003).

The AIDE project, see (AIDE web site) is a generic Adaptive Integrated Driver-vehicle InterfacE (AIDE) that employs innovative concepts and technologies in order to:

(1) Maximise the efficiency, and hence the safety benefits, of advanced driver assistance systems,

(2) Minimise the level of workload and distraction imposed by in-vehicle information systems and nomad devices.

(3) Enable the potential benefits of new in-vehicle technologies and nomad devices in terms of mobility and comfort, without compromising safety.

2. USING HANDHELD DEVICES IN CAR: OPPORTUNITIES AND ISSUES

The "intelligent-car" upcoming scenario can have a great impact in improving the quality of life of a number of citizens by reducing wastes of time and enhancing the interaction of the travellers with the environment and the context, see (Jameel, 1998). A variety of hardware devices are being used to provide such services, ranging from fixed multimedia and navigation computers to portable devices. Hand-held devices, such as palmtop computers and cellular phones, are of particular interest, since they are personal devices through which information can be seamlessly accessed both in car and outside, following the user in a variety of situations.

Palmtop computers were born as tools providing a mobile electronic version of the typical information available on paper organizers such as address book and agenda. Now, they have become a multimedia platform able to be on-line through wireless connection.

Figure 1 Snapshot from car cockpits integrating palmtop computers.

Most of the PDAs today have a 3.5" transflective TFT touch screen display, with 16 bit (64,000) colours. Resolution is 320 x 240, while top models have a 400 MHz CPU, with 64 MB expandable RAM. Typical communication options, that are either built-in in the device or can be added through expansions, include 802.11b WLAN, Bluetooth, IRDA and GPRS/UMTS. Additional functionalities (e.g. GPS, LAN connectivity) can be easily added through Compact Flash, PCMCIA, bluetooth, serial communication, etc.

New generation mobile phones are characterized by an ever increasing computing power. This, coupled with their large band wireless communication capabilities is making such devices very powerful tools for mobile entertainment, business and multimedia interaction. However, mobile phones are typically limited in terms of screen size, input modalities, memory footprint, battery life and expansion capabilities, see (Rist, 2002). The market has also recently shown some hybrid models which closely combine the features of typical palmtop computers and of cellular phones.

Figure 2 – Snapshot from a car cockpit integrating a smart phone.

These features, combined with ease of handling, make hand-held computers a powerful and interesting tool, able to support the driver and the passengers in a variety of contexts (Bellotti, 2003).
However, introduction of additional multimedia tools in vehicle raises serious concerns in terms of safety, which have to be considered in the user characterization. Moreover, typical PDA applications are quite powerful and complex and require an attentive interaction on the user's part. Several applications provide similar functionalities as their desktop computer counterparts. On the other hand, the driver is a very specialised user, who should be completely engaged in the driving task – a very risky task, and cannot devote much (if any) attention to interacting with a computer (Salvucci, 2001).

Years of Human Factors research in the field of in-vehicle Human-Machine Interaction have highlighted well-established general requirements, such as avoiding cognitive and sensory overload, allowing customisation of information, reducing complexity, using a graphical user interface only when necessary (Marcus, 2002). These concerns are to be carefully considered when designing applications for PDAs usable in an automotive environment.

3. ON-VEHICLE PDA APPLICATIONS AND USE CASES

There is a wide range of applications that have been implemented on a PDA and may be of use to the driver and the passenger. We categorise these applications into four main types and analyse the requirements – especially in terms of user interaction of each type:

- Business applications. This covers a range of applications that are extensions to the normal office applications applied to the PDA such as Scheduler, Email, Task Manager, Contacts. These would be either synchronised online or over the air with the equivalent office applications. There may be specialist applications for particular industries and roles (e.g. a salesman who has an online database of products and prices).

  In addition, there are productivity applications to allow documents to be displayed and edited (e.g. word processor, spreadsheet, and databases).

  These applications are highly attention-demanding and may not be used directly by the driver, apart from very limited, selected functionalities.

- Entertainment applications. There is a wide range of applications in this category – covering a wide cross section of games and entertainment. Also there are applications that support other leisure activities such as golf. These kinds of applications should probably not be used while driving.

- Personal communication. These applications cover some of the applications described above such as email. In addition there are peer to peer applications for limited range communication (typically via Bluetooth) that enable short text messages, and whiteboard drawings to be shared.

- Personal communication applications are very useful to the driver but interaction has to be immediate and unobtrusive.

- Tourism applications. There are a number of specialist applications that provide tourism support. This would typically be in the form of a map (perhaps supported by GPS input) and associated tourism information associated with particular locations and views. These applications may be very useful in a car environment provided they give the necessary information without distracting the driver.

The use of nomadic devices in the car presents a wide variety of possible cases characterized by different devices, applications and driving scenarios. In AIDE, the main nomad devices explored are the mobile phone, PDA and handheld GPS which are the most widespread tools and thus have the greater impact on safety.

Use cases to be explored cover the following categories, which are already - or are likely to become - quite common for people in a car:

- Mobile phone -
  - Answer a call
  - Make a call
  - Read a text message
  - Create a text message.
- PDA
  - Check address (and link to GPS)
  - Check an agenda item
  - Create and manipulate an agenda item
  - Check an e-mail
- GPS
  - Enter trip address/location
  - Review map data
  - Turn-by-turn route guidance
  - Access real-time traffic information

The way the driver is “allowed” to carry out the above functions, with the mentioned devices, depends on the driving situation. E.g. if the driver is in a high workload environment then incoming calls may be “delayed” till after this critical point.

4. AIDE: MANAGING HANDHELD DEVICES ACCORDING TO SAFETY PRINCIPLES

The analysis of the application areas sketched above shows a great potential for PDAs usable in cars. However, the use of such applications directly by the driver, but also by other passengers, raises serious safety concerns.

In general, the recent academic and scientific debate has highlighted the lack of a methodology by which a designer can decide which devices/information should be made available to drivers while the vehicle is in motion, which ones should be made available to drivers only when the vehicle is stopped, and which ones should not be made available at any time. A radical approach would probably ban the use of nomad devices in car.

The EU co-funded COMUNICAR project, see (COMUNICAR web site) has tackled problems concerning integration of information and entertainment systems since 1999, and has developed a system, the Information Manager (IM), which allows the HCI designer to control at fine level the delivery of messages to the driver, see (Amditis, 2002).

At the highest level of abstraction, the IM is a module that continuously gathers data from the internal and external environment and - according to safety-related criteria – controls the provision of relevant information messages to the driver.

The system decides the presentation of the information relying on safety-related rules which take into account two main classes of factors: factors concerning the external environment (e.g. visibility, external temperature, road type) and factors directly concerning the driving task (e.g. pedals activity, steering wheel activity). The IM receives information concerning such factors from a variety of sensors and of ADASs, which are available in the car. On the basis of a risk level parameter, which is estimated in real time, the IM decides what messages should be provided and in what format.

The COMUNICAR Information Manager is a Rule-based decision system which encodes the knowledge of car driver behaviour experts. However a Rule-based system relies on a closed-world assumption. The system is able to manage only the situations that have been foreseen by its designers.

In AIDE we will also explore a probabilistic information management system, based on Bayesian Networks or simple decision trees, which is able also to cope with unexpected situation, even if their behaviour is not completely deterministic. This raises concerns on the car manufacture' part, who traditionally consider a probabilistic system not suited to the automotive environment.

An accurate performance evaluation comparison will be important to track the future directions of car information management systems.

A detailed description of the COMUNICAR's Information Management System and of preliminary laboratory tests is reported in (Hoedemaeker, 2003)

AIDE builds on the COMUNICAR results and will extend the proposed approach by adding also NDs in the range of systems and applications that will be managed by the intelligent safety system. AIDE adopts a user centred design approach (involving expert studies, virtual and real prototype design and development and extensive user tests) in order to understand in depth the requirements and provide suitable solutions.

In particular, the AIDE safety system will manage and control issues such as:

- Which ND function may be used?
- In what driving scenarios and situations?
- What parts (or functions) of a program may be used (again according to the detected environmental and driver's condition)?
- What interaction formats are more suited and may be used?

These issues are very challenging considering nomadic devices, since typical applications are complex and provide a variety of meaningful functions and services. This will require the exploration of several alternatives – which are possible thanks to the high flexibility and potential of handheld computers – in order to understand the solutions most suitable to support the user in terms of safety and quality of the service provided.

In a user-centered design approach, evaluation of the impact of the system on the user will be continuously pursued since the early phase of the project.

This will involve expert evaluation of sceneries, and of virtual prototypes, lab test and final road-test with end-user.

A lot of work has been done concerning the impact on safety of the use of cellular phone in cars as described in (Trbovich, 2003). Much information is available on PDAs and more complex mobile devices as described in (Salvucci, 2001).

Also, there are recommendations being produced – see (Augello, 2005) which give specific guidelines for the integration and use of NDs in the automotive vehicle that can be used to aid the safe integration of these devices.

Thus AIDE's experimental analysis will collect qualitative and quantitative data in order to address issues such as:

- What are the most suited applications?
- What should be their interface?
- How should they adapt to the driver and to the context?
- What rules should manage the use of NDs in car?
- What is their perceived added-value?
- What is the clients' willingness to pay?

5. INTEGRATING NOMAD DEVICES IN THE VEHICLE

Besides the strictly HMI issues discussed above, AIDE will deal with the integration of nomad devices within the car environment. Today this is a major problem for both vehicle manufacturers and device and application suppliers, as every device has its own proprietary connection hardware.

Another issue is how to reconcile the AIDE concept with the need to control in some way what is an independent device that, if equipped with a Bluetooth interface, may remain in the user's pocket or briefcase.

From the driver safety point of view, the use of nomad devices also poses a problem if the device is mounted or used in an unsafe way. And this is not usually in the control of the vehicle or device manufacturer.

The solution proposed in AIDE is to create a specification for a "nomad device gateway" that may include physical, electrical, electronic, functional and application-level connectivity. This gateway will then be subject to the same management as the in-vehicle interfaces with input-output devices and driver information and ADAS systems.

This will be accompanied by the recommendation of guidelines for safe integration and use of nomad devices. A "Nomad Device Forum" has been organised to provide a pan-European platform for nomad device issues, and to build a consensus on stakeholders' requirements and on the proposed AIDE solution.

6. CONCLUSION

The use of Nomad Devices is rapidly growing, and the location of their use is not limited to the home or office. In the context of the automotive vehicle their use is seen as having a potential impact on safety - both for the driver and other road users.

Already this is being recognised as legislation in parts of the world try to tackle the use of particular forms of these devices (esp. the mobile phone) in the vehicle – by mandating the use of hands free interfaces for example.

The driver interface is also becoming increasingly sophisticated and complex as more features and functionality is added to the car. As a result, the increasing workload on the driver becomes more and more critical and potentially impacting on safety. The addition of nomad devices further increases this potential risk, and at present is more difficult to manage as they are separate from the vehicle interface.

This problem is recognised, and is one of key the objectives of the AIDE project to solve. AIDE shall explore the way the driver interacts with the vehicle interfaces and the nomad devices, and investigate ways to best manage these discrete systems into a single unified and safe system.

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