Towards a Mobile, Context-Aware In-Car Communication System to Reduce Driver Distraction

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Abstract—Driver distraction causes a number of car accidents around the world. Several researchers have focused on understanding and providing solutions to this phenomenon. In-car communication systems (ICCSs) were introduced in order to reduce driver distraction. Most ICCSs, however, are not widely accessible as they are built-into the car. This is the reason why several mobile ICCSs have recently been introduced. The usability of existing mobile ICCSs has not, however, been extensively investigated. Driver distraction can be caused by external conditions (e.g. driving, weather and road conditions), but most ICCSs do not take these conditions into account. This paper presents an investigation into a mobile, context-aware ICCS in order to develop a model that can be used to reduce driver distraction.

Index Terms—Adaptive user interfaces, context awareness, driver distraction, in-car communication systems, interaction design, mobile computing.

I. INTRODUCTION

People today are spending a lot of time in their cars. Studies show that people often use their mobile phones whilst driving to communicate with friends, family and colleagues. This behaviour, however, can cause driver distraction.

Driver distraction occurs when the driver is no longer able to safely control the car due to an external event. This external event can also be the usage of a mobile phone or any other mobile device. Speech-based interfaces have been extensively used to design in-car interfaces as studies show that they can mitigate the effects of driver distraction [1, 2].

Several car manufacturers are introducing ICCSs as part of infotainment systems, including navigation and entertainment systems. These ICCSs aim to reduce driver distraction caused by the use of mobile phones whilst driving. ICCSs are synchronised with the mobile phone via Bluetooth and facilitate hands-free and eyes-free communication. Some examples of recently introduced ICCSs include IQon from SAAB and Entune from Toyota.

Adaptive user interfaces (AUIs) have been recently introduced for automotive applications [2, 3]. These interfaces adapt the interaction between the driver and the application according to the current driving situation (e.g. difficult or easy). Adaptive user interfaces depend on adaptation factors (e.g. speed and weather), adaptation mechanisms (e.g. linear equations and neural networks) and adaptation effects (e.g. postponing a call) [2, 3]. These elements provide a basis to infer the current driving situation.

Section II of this paper discusses related work, Section III highlights the requirements for a mobile, context-aware ICCS and Section IV contains the conclusion and future work.

II. RELATED WORK

The following sub-sections discuss ICCSs, driver distraction, adaptive interfaces and context awareness.

A. In-Car Communication Systems

ICCSs are software systems developed to handle communication-related tasks in cars. They are included in broader ICCSs called in-car infotainment systems. Infotainment systems often include navigation systems, car information, safety, entertainment and communication [4].

Infotainment systems are very useful to drivers as they allow the driver to be connected to the external world when driving a car. The disadvantage of the integration of these systems into cars is the increase in information that the driver has to deal with, which can be a cause of driver distraction.

Several mobile applications that aim to reduce driver distraction have been introduced. Most of these applications, however, are still not completely hands-free (e.g. Vlingo InCar [5]), as they require the user to press a button to enable the speech recognition engine.

B. Driver Distraction

Driver distraction occurs when the driver’s attention is, voluntarily or involuntarily, diverted away from the driving task to the extent that the driver is no longer able to drive adequately or safely [6].

Visual, manual and cognitive distractions are identified as the main forms of driver distraction. Visual distraction occurs when the driver neglects to look at the road and instead focuses on another visual target. Manual distraction occurs when a driver removes one or both hands from the steering wheel. A study showed that sending text messages is more distracting than simply talking on a mobile phone [7]. A study in the United State revealed that 26% of all mobile phone users send text messages whilst driving [8]. Cognitive distraction occurs when the driver’s attention is absorbed by any thoughts to the point where safe navigation through the road network is difficult [9].

The consequences of driver distraction can be dramatic. In USA the use of a mobile phone while driving has been indicated as a factor in crashes that have led to 995 deaths in
C. Adaptive Interfaces and Context-Awareness

AUIs are interfaces that are able to adapt to a specific user. AUIs also provide feedback about the user’s knowledge and can predict the user’s future behaviour [11]. Adaptive systems also include those that detect common user tasks and make these tasks more accessible. The adaptation of the interface occurs when there is a change in the context.

Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application [12].

Context-awareness can be used to design safe mobile phone systems [13]. Adaptation effects such as burden-shifting, time-shifting and activity-based sharing can potentially contribute to reducing the mobile phone-based driver distraction.

III. PROPOSED SOLUTION

The design of a mobile, context-aware ICCS is proposed based on obtaining sensor-based inputs from the mobile phone, determining the level of distraction and selecting the most appropriate adaptation effects.

The following sensors can be used: accelerometer (speed, altitude), orientation and compass (vehicle angle), GPS (current location), camera (daylight), microphone (noise level). Real-time sensor-fusion can be used to improve the accuracy of the input variables.

These variables can be used to determine the current context of the car. From the context of the car, the distraction level of the driver can be inferred. Neural networks are a good candidate to determine the distraction level because they have the ability to work well with noisy data [14], such as the data provided by mobile phone sensors.

Once the distraction level is determined, the ICCS can perform one or more adaptation effects. Potential adaptation effects are: postponing the incoming events’ notification, alerting the driver, notifying the caller about the status of the driver and placing the call on hold.

IV. CONCLUSION AND FUTURE WORK

This paper has identified issues that occur when people use their ICCS whilst driving. Most existing ICCSs do not adapt to current driving situation. The usability of existing mobile ICCSs has not been thoroughly investigated. Therefore a mobile, context-aware ICCS is proposed to address both the usability and safety issues found in existing ICCSs.

Further research will include an investigation into the usability of existing mobile ICCSs. A literature study will identify the most suitable techniques to use to detect the driver distraction. A model for a mobile, context-aware ICCS will be developed. A prototype based on this model will be implemented and tested in terms of usability and safety.

REFERENCES


Patrick Tchankue received his Masters degree in 2010 from Nelson Mandela Metropolitan University and is presently studying towards his PhD at the same institution. His research interests include In-Car Communication Systems, Interaction Design, Multimodal Interfaces, Adaptive Interfaces, Context-awareness and Neural Networks.