Chapter XV
Speech–Based UI Design for the Automobile

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ABSTRACT

In this chapter we discuss a variety of topics relating to speech-based user interfaces for use in an automotive environment. We begin by presenting a number of design principles for the design of such interfaces, derived from several decades of combined experience in the development and evaluation of spoken user interfaces (UI) for automobiles, along with three case studies of current automotive navigation interfaces. Finally, we present a new model for speech-based user interfaces in automotive environments that recasts the goal of the UI from supporting the navigation among and selection from multiple states to that of selecting the desired command from a short list. We also present experimental evidence that UIs based on this approach can impose significantly lower cognitive load on a driver than conventional UIs.
INTRODUCTION AND BACKGROUND

The US census bureau reported in 2005 that the average American spends over 100 hours driving to and from work every year and spends several hundred more driving on errands, vacations, to social engagements, and so on. A significant fraction of this driving is spent while engaged in concurrent activities, such as listening to the radio, listening to music on a personal music player, operating an in-car navigation system, and talking on or accessing information with a hands-free or hand-held cell phone. These secondary activities involve interactions between the driver and a device that can distract the driver from the primary task—that of driving safely to the destination. While it is understood that the safest option is for a driver not to engage in such activities and instead concentrate completely on driving, drivers seem intent on engaging in these distractions; thus, minimizing the impact on safety is a worthy area of research.

It has been estimated that at least 25% of police reported accidents in 1995 involved some form of driver inattention (Wang, Knipling, & Goodman, 1996). A study by Stutts et al. (2001) estimated that, of the drivers whose state was known at the time of the crash, at least 13% were distracted, with adjusting the audio system of the car accounting for 11% of these distractions. Since the advent of cellular phone technology, there has been a great deal of research on the effects of cellular phone use on driving performance (e.g., Ranney et al., 2004); however, only recently have studies begun to address the effects of use of other in-car systems on driving performance. In an analysis of the 100-Car Naturalistic Driving Study, Klauer et al. (2006) found that “Drivers who are engaging in moderate secondary tasks are between 1.6 and 2.7 times as likely to be involved in a crash or near-crash, and drivers engaging in complex secondary tasks are between 1.7 and 5.5 times as likely” (p. 28).

Since these studies, a number of electronics manufacturers have introduced products that incorporate personal digital music collections into automobile audio systems. Some automobile manufacturers have gone as far as bundling a personal digital music player with the purchase of a new car. Recent high-end car models also offer GPS-linked navigation systems. These systems offer functions such as address entry and point-of-interest search, both of which are usually implemented as multi-step tasks requiring significant attention from the user. Navigation and entertainment systems are among the first examples of highly complex automotive interfaces that are available for use while driving. We expect the amount of information available in the car to continue increasing drastically as more and more car systems become networked, and as car makers try to differentiate their products by offering new functionality.

Given this situation, it becomes necessary to design effective user interfaces that will enable drivers to operate devices such as radios, music players, and cellphones in a manner that distracts them minimally from driving, while still allowing them to obtain the desired response from their devices.

A compelling choice for UI design in the automotive environment is the speech-based user interface. By “speech-based” we mean an interface which uses utterances spoken by the user as a primary input mode. A speech based interface may also have other input modes, such as dedicated or softkey input, and may also have voice feedback and/or visual feedback. By being largely hands free, a speech-based interface can minimize the need for the driver to disengage their hands from the steering wheel. By presenting information aurally, it can allow a driver to keep their eyes on the road.

These qualities are by themselves not sufficient: automobile UIs must not only allow drivers to keep their hands on the wheel and their eyes on the road, but also must allow them to keep their mind on the task at hand—that of driving safely. Spoken input is typically used as substitute for tactile input. It is frequently unclear how tactile actions such as turning a knob, pressing a button, or selecting an item on a touch screen may best be replaced by simple spoken commands that
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