# AutomotiveUI: Interacting with Technology in Vehicles

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Not so long ago, in-vehicle human-machine interaction was considered a settled affair: people knew how to operate the steering wheel and pedals, shift gears, and tune their radios. However, the introduction of computing devices into vehicles over the past decade or so has changed the relationship between the driver and the vehicle. Drivers want to do more than just drive—they want to interact with friends, coworkers, entertainment systems, and technology as they would in their home or workplace. Today, as a result of spectacular advances in pervasive computing, drivers have myriad sources of information and entertainment at their disposal from cloud-based services to systems embedded in the car. However, in-vehicle human-machine interaction is anything but a settled affair.

This fact provided the impetus for organizing the first AutomotiveUI conference, which took place in 2009 at the University of Duisburg-Essen. The conference organizers set out to bring together a community of researchers and practitioners interested in the technical and human aspects of in-vehicle user interfaces and applications.

By 2012, the AutomotiveUI conference series had grown into a vibrant community. The 2012 conference, held in Portsmouth, New Hampshire, had more than 170 attendees from four continents, representing government (8 percent), industry (49 percent), and academia (43 percent). This balanced mix of attendee affiliations indicates that the conference both advances science and demonstrates the applicability of scientific discoveries in the design, manufacture, and regulation of in-vehicle systems.

## THE ROAD TRAVELED

The interests of the AutomotiveUI community include many scientifically exciting areas, such as human-computer interaction, human factors, signal processing, and cognitive psychology (see the word cloud drawn from the AutomotiveUI abstracts). Since we explore these fields with a focus on driving, our work has the potential for high societal impact. The conference opened with a keynote address by Paul Green titled, "Using Standards to Improve the Replicability and Applicability of Driver Interface Research." Green highlighted how slight variations in methodological descriptions can produce very different research outcomes and discussed how to use certain standards to avoid such pitfalls and conduct replicable research.

A key aspect of the 2012 conference was to understand what information the driver is using in the vehicle, and the following seven podium session topics emerged (for other session topics, see the "Posters, Workshops, and Tutorials" sidebar).

### Driver Distraction

Many studies of driver distraction have focused on cell phone use, but AutomotiveUI attendees received additional insights into the distracting effects associated with display type and presentation (visual and auditory). Visual displays are major sources of in-vehicle distractions. Bryan Reimer and his colleagues examined the role of typeface in determining how much time users spend looking at a visual display. Their findings indicate that typeface design provides a low-cost method for reducing a display's visual demand.
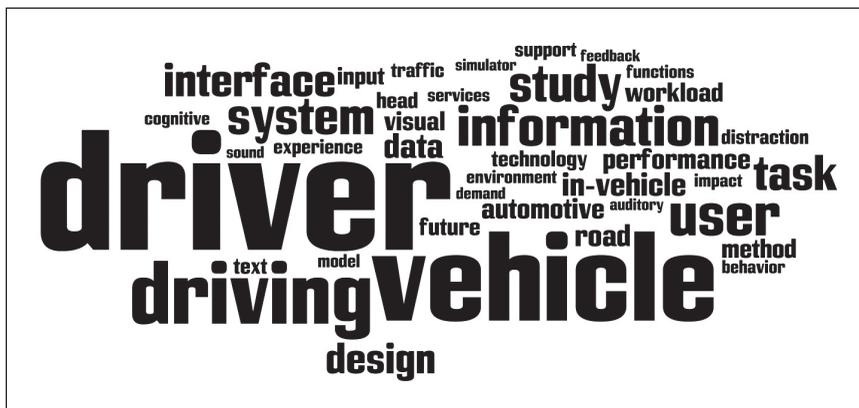


**A word cloud drawn from AutomotiveUI 2012 abstracts.**

Recent advances in pervasive computing make it possible to introduce *connected vehicles*—that is, vehicles which communicate with other vehicles, the roadside infrastructure, and remote databases. Joonbum Lee and his colleagues proposed a computational model for evaluating the distraction potential of interfaces in connected vehicles. For this work, Joonbum, a PhD student at the University of Wisconsin-Madison, received first place for the Intel Labs Best Student Paper Award.

Annegret Lasch and Tuomo Kujala explored another highly relevant problem: designing interfaces for in-vehicle music players. Perhaps their most important finding was that the kinetic-scrolling method prevalent in today's music players is more distracting than two simpler scrolling methods.

## Models

Two student-led papers in the modeling section also won Intel Labs Best Student Paper Awards. The second-place prize went to Sebastian Osswald, a PhD student at the University of Salzburg. Sebastian and his colleagues proposed a model of user acceptance for in-vehicle information technology, arguing that the model must consider the driver's perception of how safe it is to interact with the interface and his or her anxiety level when using the interface.

The third-place winner was Shannon Roberts, another PhD student from the University of Wisconsin-Madison. Roberts and her colleagues explored the role of feedback in improving driving performance, showing how feedback can help improve performance in some—but not all—situations.

The third paper in this session, by Steffen Hess and his colleagues, presented a model-driven user-interface design method focused on infotainment systems.

## Visual/Audio

The majority of today's in-vehicle human-machine interaction relies on

The traditional conference sessions were supplemented with a poster session featuring full, regularly reviewed papers; a poster session on work in progress; and an industrial showcase. The main conference was preceded by a day of workshops and tutorials attended by approximately 90 percent of the conference attendees.

Workshop topics included automotive natural user interfaces, cognitive load and in-vehicle human-machine interaction, electric vehicle information systems—challenges and chances of e-mobility, the social car (socially-inspired interaction for cars), human factors for connected vehicles: planned research and guideline development activities, and enhancing the "routine drives" experience.

Tutorials offered an introduction to automotive user interfaces, in-vehicle speech interaction, driver distraction, in-vehicle user interfaces and standards, location in the automotive context, and user experience design for vehicles.

the visual or audio channel, and the display of information can include many integrated features. Min Juan Wang and her colleagues proposed exploring 3D auditory interfaces for alerting drivers of safety-critical situations. Their findings from a focus group showed differences in perception between experienced and novice drivers.

Johan Fagerlönn and his colleagues recommended different approaches (including reducing the radio sound level and panning the sound to one side) to warn drivers of dangerous situations.

Lastly, Nora Broy and her colleagues argued that stereoscopic 3D visual displays could improve user experience without negatively affecting the user's workload.

## Driver-Vehicle Interface

Four short papers made up this session, which looked at advances in technology and the implications for driver-vehicle interfaces. First, Deanna Hood and her colleagues described preliminary efforts to use an electroencephalography-based brain-computer interface to control vehicle functions, including acceleration and steering. The authors said further research is needed to improve system accuracy and reliability.

Ronald Schroeter and his colleagues then presented concepts for social media applications that bring digital information to the driver. The work suggests that future research should evaluate how social media can be used

to improve the safety, joy, and eco-friendliness of driving.

Eshed Ohn-Bar and his colleagues showed that hand-gesture-based interfaces for an infotainment system can be effectively classified in a field setting.

Finally, Martin Murer and his colleagues showed that using buttons on the back of the steering wheel for text input holds promise, particularly if drivers can keep both hands on the wheel and eyes on the road.

## Navigation

Navigation is perhaps the oldest transportation-related application, so it's no surprise that our community is heavily engaged in improving navigation interfaces. In a road study, Peter Fröhlich and his colleagues showed how an in-car intermodal routing system can provide drivers with useful information regarding when to effectively switch to public transportation—for example, the system might reroute a driver to a train station to finish his or her commute instead of continuing on the current path to work.

Using online questionnaires and a simulator study, Daniel Münter and his colleagues proposed several relevant contextual factors for in-car navigation systems, such as traffic and the driver's sense of direction.

Finally, combining ethnographic techniques and data processing, Alexandra Zafiroglu and her colleagues explored the design space for automotive user interfaces. They argue that

"smart" vehicles can only reach their potential in combination with a smart roadside infrastructure.

### Multimodal Interaction

Multimodal interaction could let drivers interact with in-vehicle devices without unduly distracting them from the driving task. Sujitha Martin and her colleagues presented results on a new head-pose tracker that performs well, even when the driver performs spatially large head turns, which are usually problematic for algorithms.

Bastian Pfleging and his colleagues introduced a prototype user interface that combines speech interaction and gestures. Speech is used to identify the function of interest, while gestures are used for fine-grained manipulation. Initial results indicate that the system doesn't distract drivers more than currently used interfaces, yet this interface is more flexible.

Finally, Myounghoon Jeon and his colleagues explored cross-cultural differences in the use of in-vehicle technologies. They focused on technologies that rely on vehicle area network services and found that users in Austria, the US, and South Korea often approach these technologies differently. The authors argue that designers (as well as regulatory agencies) should take into account such differences.

### Workload and Demand

Cognitive load has been a key research topic in automotive user interfaces, which are moving away from traditional visual manipulative interactions to multimodal interfaces that include spoken and auditory demands. This session contained four short papers. Yan Yang and her colleagues described results from an on-road study exploring how auditory and visual demands affect driver behavior. Their results are consistent with the *Multiple Resources Theory*—for auditory and visual tasks that drivers rated as similarly demanding, driving performance was affected much more by visual tasks.

Martin Labský and his colleagues showed that positive correlations exist between the word error rates of a speech recognition system and lateral movement for native as well as nonnative speakers when traveling at 60 km per hour, but this same finding wasn't observed at speeds of 40 km per hour.

Andrew Kun and his colleagues looked at how the luminance of visual targets in a driving simulator can obscure pupillary changes in response to cognitive load. The authors presented a weighting function that might be useful in modeling the impact of pupillary light reflexes independently from pupillary changes due to cognitive demand.

Finally, Bruce Mehler and his colleagues presented a brief overview of the complexity involved in defining cognitive load and a review of key transportation research that defines the field. This work is illustrative of the need for more in-depth standardization of the terminology used to describe cognitive load.

### THE ROAD AHEAD

Technology will continue to be a part of the vehicle of the future, and our community must be on the forefront of change as we move forward in the next 5 to 10 years and beyond. In the years ahead, we expect researchers to explore many novel interaction concepts powered by advances in pervasive computing. Specifically, novel sensor and communication technologies make it possible to understand the driving context much better than at any time in the past. This understanding could play a key role in the development of user-centered autonomous vehicle features that tailor the level of automation to the user state and driving context, resulting in productive, enjoyable, and safe rides.

We also expect increased collaboration between the members of our community who are affiliated with government, industry, and academia. One tool for this collaboration will be the wider use of automotive user interface standards by our community, as Green suggested in his keynote address.

If you want to learn more about the AutomotiveUI community, you can follow our progress at www.auto-ui.org.

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