Automotive Pervasive Computing

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Welcome to the special issue on automotive pervasive computing. As you will see, the automotive telematics community has moved well beyond the problems of connecting vehicles to each other and the infrastructure, and now the focus is turning to interactions between the vehicle and its occupants. In many ways, this evolution mirrors the transition from wireless and mobile systems to ubiquitous and pervasive computing—once we consider the users and their interactions, we immediately face a rich new space of problems and opportunities.

This year, the car celebrates its 125th birthday. In 1886, Karl Benz applied for a patent for a motorcar ("Benz Patent-Motorwagen"). This first car was a mechanical device and its sole focus was providing individual transportation. Since then, cars have changed enormously. Safety and comfort became major drivers of innovation in this field. In the last 30 years, computing technology has changed cars fundamentally. Many mechanical functions are now computer controlled. Computing power available in the car makes new features possible. Many car components are linked by digital networks. Innovation in the automotive industry is largely due to information technology.

We expect that cars will undergo a massive change in the next 30 years. Users' experience while in the car will play a major role. Functions that make driving simpler and safer will become reality, due to in-car sensing and processing. Already, cars come equipped with utilities for supporting the driver (adaptive cruise control, lane keeping, and so on), and such functionality will likely be extended toward semi- and fully autonomous driving. In this issue, we present a snapshot of ongoing research in automotive pervasive computing that illustrates some of these trends.

The first article, "Monitoring, Managing, and Motivating Driver Safety and Well-Being," by Joseph Coughlin, Bryan Reimer, and Bruce Mehler,

explores a holistic approach, combining a wide variety of information sources to develop a more complete picture of driver behavior and vehicular safety. The authors consider driver performance not only at a particular point in time, but also longitudinally, in order to understand factors such as age-related performance degradation. This approach borrows the notion of "wellness goals" to improve driver attention and performance through monitoring, introspection, and persuasive interfaces. By relating biometrics to cognitive load, the system can better understand driver performance. Ambient interfaces can then provide feedback to drivers in unfavorable situations and train them to avoid such situations in the future.

The next article, "On-Road Prediction of Driver's Intent with Multimodal Sensory Cues," by Anup Doshi, Brendan Morris, and Moham Trivedi, considers the problem of inferring driver intent in the context of lane changes. The insight behind this work is that active safety systems can't operate in a vacuum. Rather, they must work in concert with the operator. To do so, they must understand the operator's intentions. This requires fusion across a broad platform to interpret driver behavior. The article focuses in part on the challenges in moving from the laboratory to the real world on the road, including the problems of driver independence and task-calibrated performance. Using correlations across time significantly improves the resulting system.

Whereas the second article explores new ways to get information from the driver, the third considers new ways to get information to the driver. In this article, "Feel Your Route: A Tactile Display for Car Navigation," Susanne Boll, Amna Asif, and Wilko Heuten describe a tactile interface for navigation systems. This directly combats the rising tide of "demanding" interfaces in our vehicles; each on its own is reasonable, but taken together they present a growing

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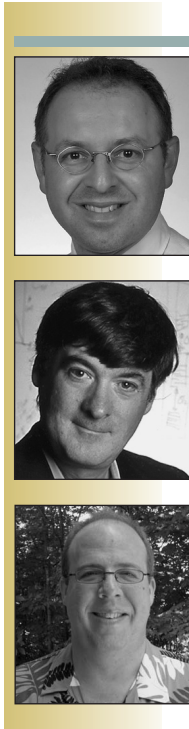
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demand on our all-too-limited attention. So, rather than use our already overtaxed visual/auditory systems for directions, the authors explored a waist belt that communicates directions via targeted vibration. The belt uses both timed pulses and compass points, handling a variety of interesting intersection designs. Significantly, when drivers have high cognitive load, the system leads to better wayfinding.

These are just a few examples of the sorts of user-facing applications and services one can imagine. Unfortunately, developing, deploying, and evaluating such applications are difficult due to the unique vehicle environment. In the final article, "Evaluating Application Prototypes in the Automobile," Holger Hoffmann and Jan Marco Leimeister describe an environment that seeks to let experimenters deploy prototypes of their systems in vehicles to get more accurate feedback. This is significant; simulators give drivers license to "make mistakes" without real penalties, skewing the results of any user testing. The authors walk through their

platform with a case study around a virtual co-driver. The system described is an extremely promising venue for carrying out future work in this space.

We hope you enjoy reading this special issue as much as we enjoyed putting it together for you. More important, we hope you join us in working in this extraordinarily exciting area for pervasive and ubiquitous computing! **P**