Towards Accident Free Highways:
Scaling Up Pervasive Computing for Human-Centered Active Safety

Mohan M Trivedi (mtrivedi@ucsd.edu)
University of California at San Diego

Vision and Research Directions:

Highway safety is important to all. According to the Transportation Research Board of the National Academies, each 1% improvement in safety results in annual savings of 400 lives, 30,000 injuries, and 2.3 billion dollars (in the US alone)! It is also recognized that collisions lead to congestion, thus collision prevention directly reduces traffic delays, fuel consumption and emissions. Pervasive computing technologies hold major promise to enhance automotive safety by introducing a new range of "human-centered" driver assistance systems. One of the key requirements in the design of an active safety system is the ability to accurately, reliably and very quickly identify the conditions which would lead to an accident and to induce corrective actions so that the accident can be prevented.

In order to develop effective countermeasures for enhancing the safe operation of an automobile in traffic, it is helpful to examine the full context in which driving occurs. The environment, vehicle and driver comprise the three main components that characterize the driver-vehicle system. Overall awareness of these three factors in the driving scenario allows for intelligent intervention in mitigating a dangerous situation. An intelligent vehicle aware of its dynamic surroundings and the driver's behavior would allow for a timely alert or even corrective action to avert a collision. Automobiles already have dozens of embedded sensors and processors. One can enhance the safety of an automobile by making them aware and responsive to the state and intent of the driver. By sensing and analyzing relevant information from both the interior and exterior of the vehicle, active safety systems will be able to provide more accurate predictions and allow the driver earlier awareness of dangerous situations. Holistic sensing of the dynamic state of the vehicle and driver can more accurately differentiate between intentional and unintentional maneuvers of the vehicle. Additionally, cooperation at different levels with surrounding vehicles could provide a more accurate and useful context to determine situational criticality, and provide alerts and assistance to drivers even earlier. Intelligent driver support (IDS) systems may provide an ideal application domain for addressing some of the challenging multidisciplinary research problems in pervasive computing. Human centric, pervasive computing environments with integrated sensing, processing, networking, and displays provide an appropriate framework to develop effective driver assistance systems. One can view such systems to be interfaces for efficient and safe driver-vehicle interactivity. Design of such interfaces is indeed a multidisciplinary endeavor where expertise in various fields, such as engineering, computer and cognitive sciences, and psychology is required. Systematic efforts are required to understand and characterize driver behavior, situation criticalities, interactivity patterns from real-world, distributed, multi-modal sensory massive datasets. Some of the illustrative research activities that can offer critical insights include,

- Learning, classification and prediction of driver behavior, activity and intentions using vehicle embedded sensors. This basically requires driving "ethnography" studies which can

utilize naturalistic driving studies such as the 100 car study or the upcoming 10,000 driver study supported by the National Academies.

- Learning, modeling and classification of vehicle trajectory patterns using infrastructure based as well as vehicle based sensor networks.
- Learning, modeling and classification of vehicle-human interactivity patterns using infrastructure based sensor networks.
- Architectures for cooperative active safety systems utilizing vehicle to vehicle and vehicle to infrastructure communication channels which can support large scale real world traffic conditions.

Background and Experience:

Mohan Trivedi is a Professor of Electrical and Computer Engineering at the University of California in San Diego. He established the Computer Vision and Robotics Research Laboratory and *LISA:* Laboratory for Intelligent and Safe Automobiles promoting multidisciplinary research at UCSD. His team is pursuing research in machine and human perception, machine learning, distributed video systems, multimodal affect and gesture analysis, human-centered interfaces and intelligent driver assistance systems active safety systems for automobiles. CVRR Lab has played key role in several major research collaborative initiatives. These include an autonomous robotic team for Shinkansen track maintenance, a human-centered collision avoidance system, panoramic vision system for incident detection and also for driver assistance, vision based occupant protection system for "smart airbags. Trivedi's team also designed and deployed the *"Eagle Eyes"* system on the US-Mexico border in 2006. He served on a panel dealing with the legal and technology issues of video surveillance organized by the Constitution Project in Washington DC as well as at the *Computers, Freedom and Privacy* Conference. Trivedi is served as an "Expert Panelist" for the Strategic Highway Research Program of the Transportation Research Board of the *National Academy of Sciences.* He has given over 65 Keynote/Plenary talks at major conferences. Trivedi has received the *Distinguished Alumnus Award* from the Utah State University, *Pioneer (Technical Activities)* and *Meritorious Service Awards* from the IEEE Computer Society. He is a co-author of a number of papers winning *"Best Papers"* awards. Two of his students were awarded Best Dissertation Awards by the IEEE ITS Society (Dr. Shinko Cheng 2008 and Dr. Brendan Morris 2010). Trivedi is a Fellow of the *IEEE, IAPR,* and the *SPIE.*

Selected Relevant Publications:

(for complete list please see http://cvrr.ucsd.edu/publications/index.html)

Shinko Y. Cheng, Mohan M. Trivedi, "Turn-Intent Analysis Using Body Pose for Intelligent Driver Assistance", *IEEE Pervasive Computing, 5(4):28-37,* Oct-Dec 2006. (pdf)

Mohan Trivedi, T. Gandhi, Joel McCall, "Looking-In and Looking-Out of a Vehicle: Computer-Vision-Based Enhanced Vehicle Safety", *IEEE Trans on Intelligent Transportation Systems,* March 2007 (pdf)

Brendan Morris and Mohan M. Trivedi, "Contextual Activity Visualization from Long-Term Video Observations" *IEEE Intelligent Systems,* 2010 (pdf).

Anup Doshi and M. M. Trivedi, "Communicating Driver Intents: A Layered Architecture for Cooperative Active Safety Applications", *IEEE Conf Intelligent Trans. Systems,* Sept 2010.

Shankar Shivappa, Mohan M. Trivedi, and Bhaskar D. Rao, "Audio-visual Information Fusion In Human Computer Interfaces and Intelligent Environments: A Survey," *Proceedings of the IEEE,* Oct 2010. (pdf)