Center for Automotive Research at Stanford

Stanford's Automotive Affiliates Program

The Center for Automotive Research at Stanford is a partnership of academia and industry with the goal of advancing research and education in the automotive realm and addressing the needs of individual mobility in the 21st century.

Overview

The Center for Automotive Research at Stanford (CARS) is addressing the future of individual mobility, which is presenting immense challenges to industry and academia. Recent statistics show that 34,000 people died in motor vehicle traffic crashes in the United States in 2009, and 1.2 million lives were sacrificed worldwide. Driver error is by far the most common factor that leads to a vehicle accident. Studies also show that the risk of a crash or near-crash due to dialing on a cell phone is 3-6 times higher compared to the non-distracted driver. Another significant study recently calculated that the impact of traffic congestion in the United States leads to unproductive time of about 36 hours for the average commuter each year. In addition it is well known that the transportation sector in the U.S. alone (with the automobile being the largest sub-sector) emits 1.9b tons of CO_2 per year, burning 4.7b barrels of petroleum. And yet, the automobile is (after housing) the second biggest item on an individual's list of expenditures. This makes it not only a very significant financial asset but also a highly valued consumer product that in the recent past has, in many cases, also contributed to financial distress on the part of consumers.

As an industry / academic partnership in the automotive realm, CARS is dedicated to pursuing radical new approaches to these challenges and helping to lead the world into an age of transportation that is safer, more environmentally friendly, and more enjoyable. Therefore, research in four different domains is being initiated:

Driver Assistance helps the driver navigate various traffic situations by using sensors (cameras, laser, radar, GPS…) that detect the environment of the vehicle and by using computer algorithms that process all sensor data, detect obstacles, categorize situations, plan the path, and drive actuators. Driver assistance systems can improve traffic safety and efficiency to a large extent as well as they can also add convenience and enjoyment to the driver. The ultimate vision for this technology is fully autonomous systems, which perform all driving tasks without driver interaction. Despite technical challenges open questions in this field remain regarding legal aspects, human factors, or economic considerations.

Alternative Energy for vehicle propulsion offers solutions to reduce the environmental impact of the transportation sector and to become less dependent on non-renewable resources. With electric mobility currently being the most prominent sector of alternative

vehicle propulsion, consumers will need to adapt to a different use of mobility (e.g. limited vehicle range), which presents challenges that need to be addressed with suitable information systems etc. Energy generation, distribution, and storage systems for those alternative solutions also need to be developed to fulfill the needs of future consumers.

Connected Mobility addresses all aspects of integrating the automobile into existing communication networks (i.e. data and voice communication via internet and phone) and establishing mobility specific networks (i.e. vehicle-to-vehicle and vehicle-to-infrastructure communication). Through these links it will be possible to increase traffic safety and efficiency and to enrich the individual mobility experience. While it is undisputed that information & communication technologies can help to improve those aspects, other challenges arise such as driver distraction through new media in the car or implementation of a viable mobility communication infrastructure.

Mobile Society address the needs of a mobile society through alternative usage concepts (i.e. carsharing, car companies as mobility provider), vehicle concepts (i.e. vehicles optimized for a specific, and most frequent use case), or concepts that specifically recognize changing demographics or values (i.e. needs for the elderly, interests of the younger generation). New mobility concepts will especially help to increase the efficiency of individual mobility by reducing energy use, emissions, land use, and cost while also improving the individual mobility experience.

CARS does not contemplate the challenges and the four domains as an engineering / design task only. The program is proposing a much broader examination in order to integrate aspects in the fields of economics / business, psychology / sociology, resources / environment, and politics / policies. Figure 1 gives an overview of the different competences in the different domains and fields at Stanford University.

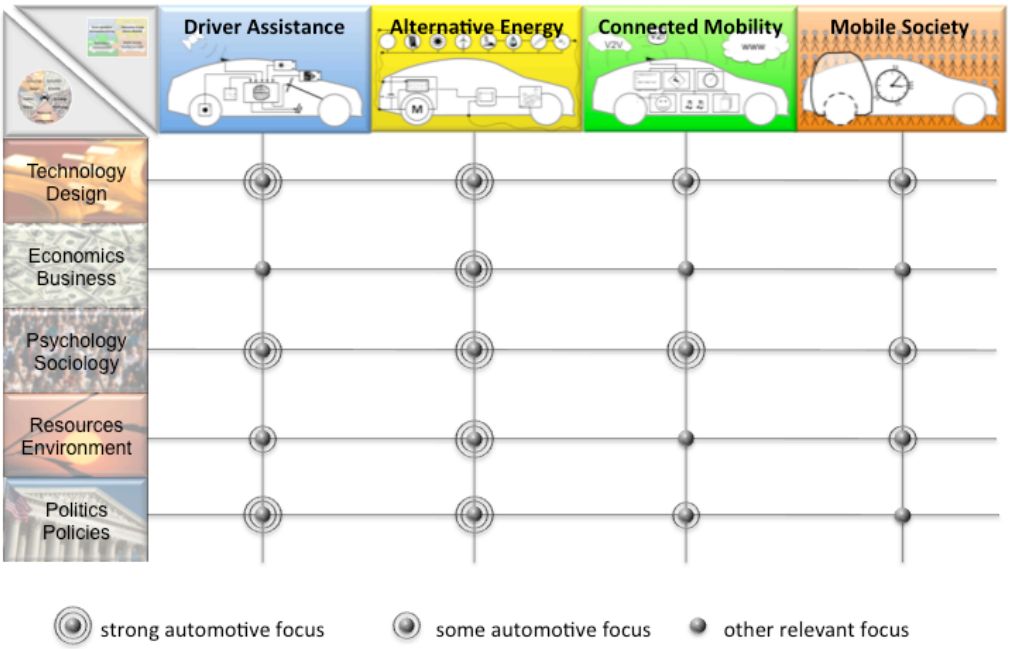

Figure 1: Automotive Competences at Stanford University

CARS Organization and University Partners

CARS was established on October 1, 2008. In March 2010, CARS moved into the Volkswagen Automotive Innovation Lab, or VAIL, a new 8,000 square foot state-of-the-art facility that has since become the epicenter for all automotive activities at Stanford. The facility includes 7 fully-stocked bays for cars, a covered outdoor space for additional cars, and extensive research and meeting facilities.

The founding faculty and directors of CARS are Professor Chris Gerdes (Mechanical Engineering), Professor Clifford Nass (Communication), and Professor Sebastian Thrun (Computer Science, now at Google Inc.). Sven Beiker serves as the Executive Director overseeing CARS operations and, together with the Program Administrator Adele Tanaka, serving as the main contact for affiliates.

In addition to the core of CARS in the aforementioned departments, the alliance also maintains strong relationships with the School of Law, the Graduate School of Business, and the School of Earth Sciences. This network includes faculty from across the University, a large number of undergraduate, masters, and Ph.D. students, and industrial affiliates.

CARS Affiliation for Industrial Partners

To foster the automotive community and infrastructure, CARS offers a specifically tailored affiliates program. The annual membership fee is $32,000. At this time (August 2012) CARS counts 17 industrial affiliates from the U.S., Asia, and Europe. A list of the affiliates can be found at: http://me.stanford.edu/groups/design/automotive/about.html

Industrial partners who are members of CARS receive the following benefits:

• Symposia, expert discussions, network events on selected topics
e.g. exploration of the legal framework for autonomous driving
• Focus workshops on topic chosen by affiliates
e.g. internet applications in the automobile and fields for collaboration
• News update on automotive research topics
e.g. automotive news and events at Stanford and in Silicon Valley
• Student class, seminar series, presentations
e.g. class on autonomous driving, visions for the future of the automobile
• Job opportunity exchange for students and companies
e.g. announcements of internships, introduction between students and industry
•Assistance in arranging contact with research labs
e.g. introduction to researchers in individual field of interest, project kickoff
•Access to facilities and infrastructure
e.g. use of automotive research building, basic needs of visiting scholars

Information	Newsletter & Research Updates	1-2 per month	
	Monthly Conference Call	1 per month	
	Annual Affiliates Meeting	1 per year	
Interaction	Industry & Academia Mixers	1-2 per ½ year	National Robotics Week – Block Party Vehicle Concept Showcase Following Workshops, Class Presentations, Lectures
	Round Table, Symposia, Workshops	1-2 per ½ year	Autonomous Driving – Policies & Standards Connected Vehicles Electric Mobility – Non-Technical Aspects
	Invitations to Lectures & Presentations	3-4 per month	Regular Class Lectures Special Lectures (Gordon Murray, GM EN-V…)
	Interaction with Automotive Class	1-2 per month	ME302: The Future of the Automobile ME185:Electric Vehicle Design S574: Strategic Thinking – Automotive Industry
Initiation	Independent Studies	2-3 per ¼ year	Risk Assessment for Autonomous Driving Peer-to-Peer Carsharing, Electric Mobility Vehicle Automation for Wireless Charging
	Post-Doc Fellowship	1-2 ongoing	Legal Aspects of Autonomous Driving Cellular- and Server-Based Vehicle Comm
	Research Program	1 ongoing	Wireless Charging of Moving Vehicle
Contacts	Student Resume Book	1 per year	
	Posting of Internships / Jobs	1 per month	
	Introduction to Research Groups	5 per month	
Support	Access to Facilities / Infrastructure	5 per month	Access to VAIL, Network, Parking…
	Coordination of Campus Visits	4-8 per month	
	Assistance with Additional Programs	2-3 per month	Getting Research Programs Started

Figure 2: Benefits of CARS membership

CARS uses the membership fees to support its staff, seminars / events, and building infrastructure. All CARS affiliates are strongly encouraged to establish a direct research relationship with research groups at Stanford University. Those relationships will define detailed aspects of research questions and methods and intellectual property. Long-term visitors to CARS are arranged and managed by the respective faculty member.

Research Project Examples

To date, CARS has initiated research activities in the following fields that give an overview of the breadth of topics that are being addressed:

On-Line Vehicle Data Mining
Conceptualization of a solution that enables real-time data collection on the vehicle and send it via WiFi and / or cell phone link to a backend server; basic concept for a student class and further research w/ affiliates.

Wireless Power Transfer to Moving Vehicles
Basic exploratory study to assess the possibility to transfer electrical power to a moving vehicle and maintain cruising speed; study to conduct simulations of the magnetic field that is supposed to transfer 20kW over 1 meter.

Behavioral Change of Electric Mobility
User studies in the light of emerging electric mobility; observation of consumer driving and charging behavior by comparing mobility patterns with electric and conventional vehicles; recommendations for an integrated / unlimited mobility concept.

Legal Aspects of Autonomous Driving
Exploration of legal and policy aspects of autonomous driving; collaboration with Stanford Law School Center for Internet and Society (CIS); objectives are to frame and document the research field, report to Congress, and organize a leading conference.

In addition to the initiation of interdisciplinary research activities, the founding faculty of CARS are the directors of research labs that are home for a number of projects, including:

Autonomous Driving, which lead to the autonomous car Stanley that won the DARPA Grand Challenge, a desert race for autonomous robots. Stanley emerged victoriously from 195 competing teams. To enable the robot to drive by itself, the researchers developed novel machine learning and probabilistic inference techniques. The researchers also produced the robot Junior, which won second place in the DARPA Urban Challenge. This race required robots to navigate a mock urban environment. Once again, researchers developed cutting edge software based on probabilistic techniques for perception, and advanced planning techniques for navigation. At present, this team is preparing a complex city-to-city mission in which the car drives autonomously, without human input.

X-by-wire Design, breaks the traditional mechanical connections between the driver and the vehicle so that cars can adapt their behavior to the driver or respond intelligently to their surroundings. These by-wire systems open new dimensions for vehicle customization in software, driver assistance and safety. Yet they also present challenges for diagnostics, redundancy and the coordination of multiple actuators. The lab is home to several student-built by-wire testbeds including X1, a modular chassis structure that

enables rapid prototyping of new design ideas and control algorithms. Current research on these testbeds includes safe control of cars at the handling limits (a regime where human drivers tend to make fatal mistakes) and on off-road terrain.

Human Assistance Research, which builds on the autonomous driving work as researchers are developing methods to warn human drivers of other nearby vehicles and to assist them in high-stress maneuvers. One key focus, which integrates computation, engineering, and psychology, involves the problem of merging onto the highway. Merging is usually perceived as high-stress maneuver, due to blind spots, the vastly different speed profiles of merging traffic, and the importance of determining the intent of drivers. Researchers are developing ways to help cars and drivers work as a team to make these challenging driving problems safe and enjoyable.

Driver Modeling and Research, which aims to detect negative emotions, drowsiness, inattention, and distraction using a wide range of sensors. The researchers are also interested in the psychology of personalization and adaptation of the vehicle, helping drivers develop mental models of intelligent cars. The ability of cars to understand what drivers are saying and of cars to speak to drivers raises a host of opportunities to motivate, support, and teach the driver and a host of problems involving distraction and cognitive overload. There is also very high interest in special categories of drivers, such as the elderly, teens, and new drivers.

Solar Car Project, which is a student-run organization that develops vehicles powered entirely by solar energy. In its 20-year history, the Stanford Solar Car Project has won a number of races in which alternative energy vehicles compete. The researchers are also interested in technologies that make cars more efficient users of energy, including new battery technologies.

Educational Activities

CARS faculty are passionately committed to training the next generation of researchers, inventors, designers and leaders for automobiles. CARS researchers frequently run project-based courses (the most prominent being the seminar class "The Future of the Automobile") in which groups of multidisciplinary students, among the brightest in the world, invent and research innovative products and services for the automotive industry. The bold and out-of-the-box thinking of these tremendously bright and creative students often results in new industry-changing approaches and ideas. These project courses provide an unprecedented opportunity for affiliate members to closely guide, mentor, and learn from unique teams of students involved in solving new problems.