Advanced Driver Assistance Through Massive Sensor Fusion

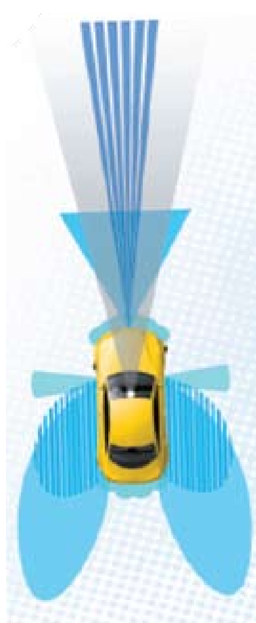
Advanced driver assistance systems (ADASs), as the name suggests, are automotive systems designed to assist in all aspects of driving, including safety, drivability, and fuel economy. The availability of a wide range of sensors, including those in the chassis that measure lateral and longitudinal acceleration, steering wheel angle, yaw rate, and wheel speed, and sensors of the vehicle environment (GPS, infrared sensors, ultrasonic sensors, cameras, and rain, light, solar, and humidity sensors) allow the integration of several sources of information to aid the driver in decision making.

Suitable sensor fusion algorithms must be developed to design a global security system that ensures normal driving commensurate with traffic and weather, and optimizing time, distance, and/or fuel, and driving under emergency situations by commanding the braking system, steering wheel angle, and/ or powertrain under unexpected conditions necessitating a fast response.

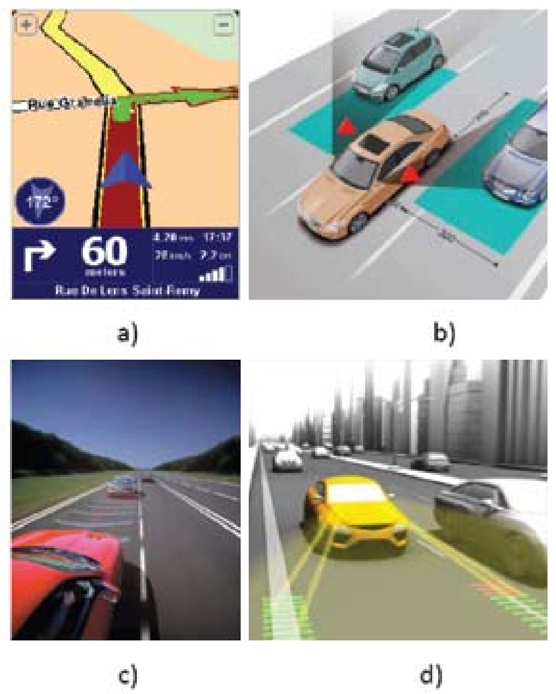
Limited ADAS Functionality Available Today

The low cost and wide availability of these sensors have led to new control strategies such as the navigator (figure a), blind spot detection (figure b), adaptive cruise control (ACC) (figure c), lane keeping (figure d), electronic parking assistance, and the advanced front-lighting system. The antilock braking system and electronic stabilization systems developed over the past 20 years may be viewed as precursors of the ADAS vision.

The majority of ADAS systems currently produce acoustic alarms or suggestions on a display so that the driver closes the loop; in other words, they are decision support systems. In the future, we can expect them to be integrated into the vehicle as active systems. For example, systems are currently being designed to include the information from cameras (such as currently used in ACC or parking systems) in the lateral dynamics controller, for example, to compute the nominal reference trajectory.



Car sensor information equipment with ADAS system (Source: Hella KGaA, Germany)



ADAS examples: a) Tomtom navigator, b) blind spot detection (Mercedes), c) adaptive cruise control (Delphi), d) lane-keeping system (Continental).

Contributor: Luigi Glielmo, Università del Sannio, Italy

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ADAS systems will also take advantage of new wireless self-powered accelerometers and strain gauges in tires, which will be integrated with pressure/temperature sensors (Figure 1). In fusion with other sensors, these sensors will be able to estimate tire-road friction coefficients and tire forces, the most important variables in active safety systems. Integration with in-vehicle cameras and human body sensors will enable monitoring of driver-vehicle interaction aspects, such as drowsiness of the driver, on the basis of body position, facial posture, eye movements, and the ability to control the vehicle.

Figure 1: Intelligent tire system proposed by Continental

A Role for Control

The main idea of ADAS is to introduce "prediction," a merged "look-ahead" of powertrain, chassis, vehicle environment, and driver's condition obtained through all available information, aimed at semiautonomous behavior of the vehicle in dangerous situations. Control technologies will play a central role in ADAS design.

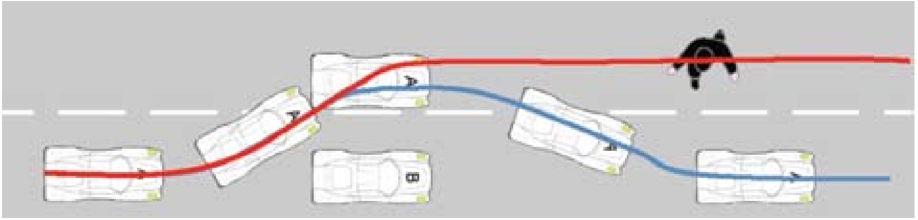
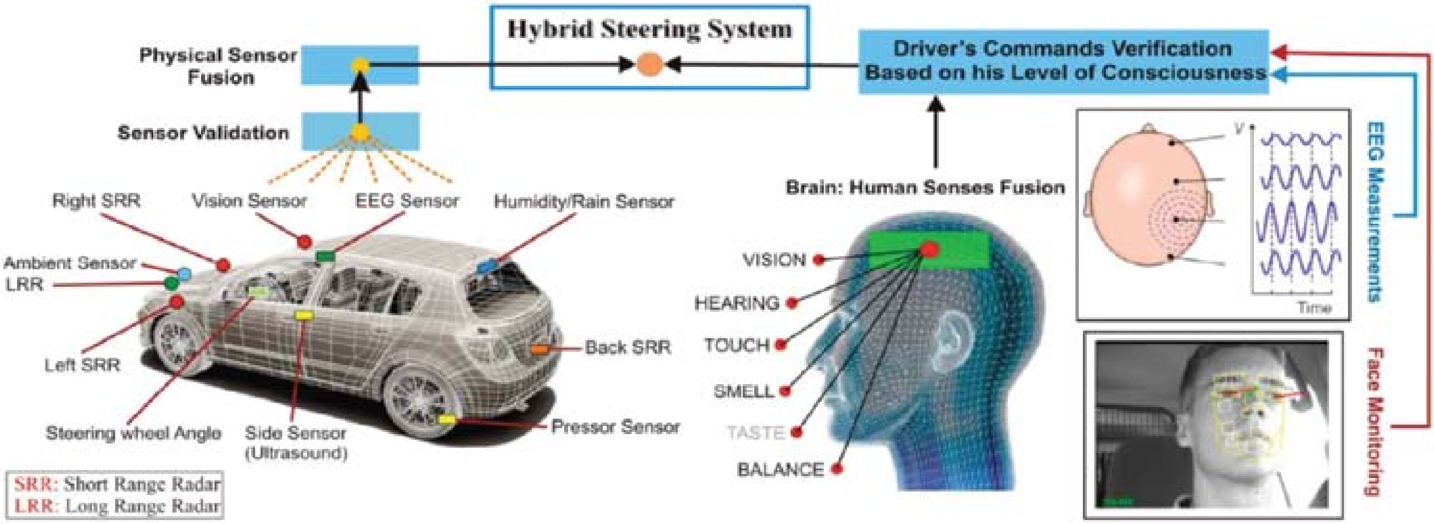


Figure 2

Figure 2 illustrates a possible scenario where vehicle A is performing a lane change and the steering wheel angle imposed by the driver determines a reference trajectory, shown with a red line. The electronic stability program module computes this trajectory, but it cannot take into account the possible presence of an obstacle on the trajectory, such as the pedestrian crossing the street. Cameras and infrared sensors could improve the reference generator module, which could generate a different trajectory that is both feasible and able to avoid the pedestrian, such as the blue one depicted above.

The figure below shows a possible future control loop scheme in which sensor information is merged with driver behavior. To this end, ADAS also includes improved human-machine interface (HMI) systems. The HMI will have bidirectional function in that the driver will take suggestions and alarms while driving and, conversely, will choose among different working options depending on his/her desires (sport driving, family cruise, minimum fuel consumption).



For further information: M. Rezaei, M. Sarshar, and M.M. Sanaatiyan, Toward next generation of driver assistance systems: A multimodal sensor-based platform, International Conference on Computer and Automation Engineering, 2010