

Solutions for Intelligent Cooperative Vehicles

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Researchers reveal maneuvers that are considered to be essential for autonomous operation of unmanned vehicles on urban roads

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The Intelligent Control Systems Laboratory (ICSL) at Griffith University, Australia, has developed a number of separate solutions relevant to ITS applications. These solutions have been implemented on laboratory-scale prototypes of intelligent autonomous vehicles—or cooperative mobile robots. They are at a stage of readiness for further in-field testing and implementation on test vehicles, with a goal of increasing driver safety.

The solutions developed to date by the ICSL feature:

Lane keeping: An autonomous vehicle, using this system, is able to navigate itself along a roadway delineated by vertical barriers forming a lane or corridor. This is achieved using an ultrasonic radar system that scans the path in front of the vehicle for the position of the barriers. A control algorithm uses this data to position the vehicle in the middle of the corridor during forward motion.

Obstacle avoidance: An autonomous vehicle employing this behavior can avoid static obstacles in its path using opto-reflective infrared sensors mounted around its periphery. A rule-based algorithm is used to select an appropriate maneuver for the vehicle to perform in order to avoid the obstacle. The algorithm is lane-based, which means the maneuvers performed by the vehicle obey the rules dictated by the lane in

which it travels.

Overtaking behavior: The vehicle performing the overtaking maneuver communicates with the vehicle it is overtaking, using an inter-vehicle communications link in order to safely and efficiently overtake. The vehicle being overtaken assists the overtaking vehicle in its task by maintaining its speed and trajectory at steady levels until the maneuver is completed. The overtaking behavior requires the two vehicles cooperate in order to achieve one common goal of safe and efficient travel for both vehicles.

Unsignalised intersection traversal: Autonomous vehicles require this behavior in order to safely and efficiently navigate themselves through an intersection of any number of roads in any direction. The solution developed by the ICSL features static, infrared roadside information beacons which transmit to the vehicle the configuration and conditions of the intersection prior to its entry into an intersection. The vehicle reaches a stop line at the intersection and communicates with all other vehicles in the immediate vicinity, using a short-range radio communications link to determine if there are vehicles in its path.

Distance and tracking control: Using this behavior, autonomous vehicles may form themselves into platoons of two or more vehicles that travel along a road, maintaining a safe

Maneuvers have been tested by laboratory-scale prototypes of intelligent autonomous vehicles—cooperative mobile robots—which are believed to be the world's first behaviorally complete cooperative road robots.

longitudinal distance between each consecutive vehicle. One vehicle takes the role of leader and navigates itself autonomously through the road corridor. The following vehicle(s) track a laser-based signal emitted by the vehicle in front of them and control their velocity in order to maintain a safe longitudinal stopping distance to the vehicle in front.

Formation driving: Two or more vehicles may use this behavior to arrange themselves into formations of various longitudinal and lateral distances separating the vehicles.

Tele-control of road vehicles: A radio link is established between vehicle(s) and a remote computer in order for the navigation of the vehicle(s) to be carried out remotely by a human operator. An extension to this operation is currently under development to allow Internet control of vehicles. Using technologies such as web-browser-based programming languages and multimedia tools, the ICSL is developing a sophisticated control environment to be used as a WWW front-end to intelligent control systems. Specifically, the control of multiple distributed cooperative

vehicles is under examination. This involves two-way transfer of data—namely status information from the vehicles to the user and commands from the user to the vehicles using wireless communications.

Vision-based obstacle avoidance: A novel vision-based system is under development that will allow autonomous road vehicles to detect and avoid both dynamic and static obstacles in real time as well as detect and calculate the direction and speed of motion of moving obstacles.

Vehicle data logger: This project involves the development of a device to provide a detailed and useful log of a road vehicle's activities by utilizing state-of-the-art, intelligent data collection and storage methods resident in hardware and software. It is intended to enhance driver safety, increase road capacity and may be applied in numerous applications such as fleet management, driver training and law enforcement.

Assist and warning systems

Although all the above behaviors developed by the ICSL have been implemented on laboratory-scale prototypes, they have been developed with the final implementation on real vehicles in mind. The systems have the flexibility of accepting data from different sensor types more relevant to the conditions found on public roads, rather than those found in the laboratory environment. The implementation of these individual systems onto road vehicles may take one of two forms: driver assisting or driver warning systems.

It is the intention of the ICSL to configure the laboratory-scale prototype vehicles as behaviorally complete cooperative vehicles, whereby all behaviors required of an autonomous road vehicle are resident on-board the vehicle.

Driver-assisting systems actively control functions such as the steering, brakes and/or throttle of the vehicle in order to assist the driver in safe and efficient driving. Typically, these devices are activated or deactivated manually by the driver at an appropriate time for correct system operation. To date, driver-assisting systems have yet to be developed to the point where they are able to safely activate themselves when appropriate. There also remains the question of how well this level of machine control will be accepted by human drivers.

Driver warning systems offer a less intrusive method of system implementation by merely warning a driver of changes in traffic conditions or potentially dangerous situations. Such systems may warn the driver by using lights, sounds, heads-up display and so on. However, the warnings generated by such systems may simply be ignored or misinterpreted by the driver. The vehicle still remains in the driver's control with all his or her inherent potential for human error.

The goal of the ICSL researchers is to develop driverless vehicles that surpass the capabilities of human drivers, thus providing society with a safer and more efficient road transport system. Most importantly, the human passengers in an autonomous

road vehicle must have complete faith in the safety such a vehicle offers. In the meantime, autonomous vehicle research, including that done by the ICSL, continues to provide a number of spin-off technologies to the benefit of the humans controlling the vehicles.

While a large portion of the research effort to date has focussed on individual solutions for autonomous vehicles, the problem of successfully integrating all of these individual solutions into one cohesive driverless vehicle system remains to be solved. Each individual solution may be considered as a behavior-based activity that may be integrated with all other behaviors to lead to a behaviorally complete autonomous road vehicle. In addition, the individual autonomous vehicles must cooperate with each other in order to travel on public roads without accidents.

It is the intention of the ICSL to configure the laboratory-scale prototype vehicles as behaviorally complete cooperative vehicles, whereby all behaviors required of an autonomous road vehicle are resident on-board the vehicle. The laboratory-scale prototypes developed by the ICSL have the ability of cooperating with other vehicles both implicitly by their behavior models and explicitly via direct communication. ■

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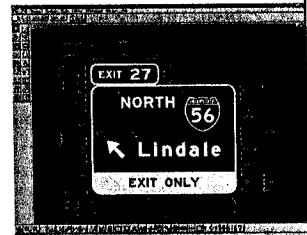
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