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Beyond cruise control

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Automated driving aids that will soon be fitted to cars will warn motorists of possible accidents. They may even help them actively to avoid crashes

DRIVING fast along a road outside Turin, snow-capped mountains beckon in the far distance. A dog suddenly runs out into the road. A collision looks inevitable when the driver fails to respond. At the last moment, the car executes a smooth, mathematically precise swerve around the dog and then returns to its lane. Throughout the manoeuvre, the driver s hands do not touch the wheel. The Lancia Nea is no computer simulation, but a real, road-going vehicle though, as a technology demonstrator, not something the public can buy. (The dog is a remote-controlled toy on wheels.)

Motorists are understandably sceptical about cars that supposedly drive themselves. However, while auto-pilots for road vehicles remain a pipe-dream, car drivers may be surprised to learn how much technology designed to assist them is coming soon to their local showroom. These new models will not, of course, drive themselves. But their computer-aided sensors, decision-making software and the rest are intended to help motorists become both much safer and far better drivers. Even weekend drivers could soon be avoiding accidents with the skill of Michael Schumacher.

The idea of driver assistance started with the cruise-control devices that first appeared in American cars in the 1970s. When switched on, cruise control relieves the driver of the task of accelerating or braking to maintain a constant speed on a highway. Next came adaptive versions of cruise control, which appeared in Japan more recently. These relieve the driver of having to brake or accelerate in order to maintain a constant distance from the car in front. In the rest of the world, adaptive cruise control (ACC) has been an option only on luxury models, such as the Mercedes S-class and the Jaguar XKR. By the end of 2001, however, ACC will find its way into more ordinary cars. Fiat, for instance, is about to make it an option on its mid-range Punto models.

Researchers are tinkering with even cleverer forms of driver assistance including collision warning, hazard avoidance, lane keeping, urban stop-and-go cruise, rural cruise and even control systems that stop cars from breaking the speed limit. The underlying idea is to add assistance to the driver, rather than take control away from him. Apart from some applications that may prevent cars from speeding illegally, the motorist will still have to decide personally whether to switch the driver assistance on or to drive unassisted. And because the driver can always override the computer assistance, he will remain in charge of the vehicle at all time and therefore be legally responsible for it.

The last thing that the car companies want is to be held liable for a driver s incompetence or lack of attention, no matter how much he is assisted. It is bad enough when components such as tyres and structural members fail mechanically and cause accidents. Product liability in such instances has cost the car makers billions of dollars so far. The thought that class actions might ensue for computer-assisted accidents sends shivers through the motor industry.

Driving me crazy

Most of the new generation of assistance devices are derivatives, in one form or another, of the adaptive cruise-control system. ACC works by detecting the distance and speed of the vehicle ahead. The easiest way to do this is to use a small onboard radar system. This has the advantage of being accurate, reliable, cheap, capable of working at night and, given the right operating frequency (76-77 gigahertz is usually chosen), unaffected by rain or the moisture in fog.

The distance between the two vehicles is calculated, to within a few centimetres, using the time that it takes for pulses of the radar beam to travel to the car ahead and bounce back. By contrast, the speed of the car ahead is determined by measuring how the frequency of the radar beam echoed back has been altered by the Doppler effect. The difference in frequency between the transmitted and received signals (ie, the Doppler shift) gives a measure of how much faster or slower the vehicle ahead is travelling just as the drop in pitch of an ambulance s siren indicates that it has passed you and is now getting farther away rather than closer.

Although ACC may not seem all that different from conventional cruise control, many safety engineers see the addition of radar detection as the key to a whole array of new sensors capable of improving the driver s knowledge of his immediate surroundings. In doing so, all the additional information pouring into the car gives the driver a far better early-warning system of trouble ahead extending, in a sense, the perimeters of the vehicle and creating what researchers like to think of as a virtual crumple zone .

Well, maybe. But not all safety experts think that ACC is such a great idea. Robert Ervin, a senior researcher at the University of Michigan s Transportation Research Institute, says that not enough is known about a driver s readiness and ability to intervene in an emergency, when he is relying on such semi-automated systems. What research there is suggests that it is hard for humans to remain vigilant when something they are watching out for happens only rarely. Dr Ervin finds that drivers using ACC tend to divert their attention away from driving. Because headway conflicts are the biggest burden in driving, removing them may cause drivers to reduce their vigilance unintentionally.

Pilots do it, why not motorists?

Hence the need for something to jar them, periodically, back to their senses. So, hot on the heels of ACC, expect to see safety systems that warn of potential collisions ahead. Forward crash warning uses the same radar-sensing technology as adaptive cruise control, and could be used with or without the ACC activated. Imagine you are driving along a road and another vehicle suddenly pulls out ahead at a distance less than that needed by the ACC s deceleration setting to slow your car down in time. In such circumstances, an alarm would be triggered to warn you to take emergency measures.

It is now common in America to fit a collision-warning system (CWS) to commercial vehicles, especially large trucks. Eaton Corporation, a leading manufacturer of automotive components based in Cleveland, Ohio, supplies CWS units for around $3,000 to fleet owners wanting to reduce accidents and related costs (such as litigation and insurance). The system has front and side radar and can track up to 20 vehicles at a time. Warnings are sent to the driver only on those vehicles in the truck s own lane. When the truck is travelling around a bend, a sensor calculates the turning rate, and the shape of the radar-reporting zone is changed to match the line of travel. Eaton claims that fleets using CWS see a 73% reduction in accidents. Meanwhile, Delphi Automotive Systems of Flint, Michigan, is developing a collision-warning system that detects objects 360° around the car.

If government-sponsored research goes as planned, a number of buses in America will get CWS by the end of 2001. But CWS will need to be a whole lot cheaper and smarter if it is to be fitted to private cars. Professional drivers are far more tolerant of alarms than everyday drivers. So careful thought will have to be given to deciding what hazards to report to the average driver and from what quadrant ahead, either side, or the rear as well. If the alarm goes off too frequently, many motorists will switch the CWS off, or simply ignore its warning.

Even weeekend drivers could soon by avoiding accidents with the skill of Schumacher

Closer to market, however, is a modification to ACC known as an emergency braking aid. This uses the radar sensing and brake activation of ACC to improve the braking response. A small, additional braking force is provided when the radar sensors detect an emergency. The system does its stuff during the four-tenths of a second that it takes from when the foot first hits the pedal to when the brake pressure rises to its working threshold. Although the device shaves only one-tenth of a second off the braking lag, it is enough to reduce speed by 5kph in most cases and every little bit helps in an emergency. This is already standard equipment on DaimlerChrysler s Mercedes S-class and SL-class cars.

Much further ahead are the full emergency braking and forward collision-avoidance systems under development at Fiat, Nissan, DaimlerChrysler, Volvo and elsewhere. Here again, the technology is based on the ACC concept, although the sensors used in this case take into account stationary objects as well as moving ones. Nissan s Advanced Safety Vehicle, a concept car developed with Japan s Ministry of Transport, has automatic brake activation to stop the car, or at least reduce its collision speed, when the driver fails to respond. Plenty of problems with such systems remain to be solved. The single radar beam used in ACC, for instance, still gives too many false alarms for avoidance systems to be effective. Braking systems that automatically bring a vehicle safely to a standstill, or dramatically reduce the energy dissipated in a crash, look like taking at least three more years to perfect.

On the straight and narrow

Safety devices that warn the driver, or even correct his actions, when the car wanders from its lane, rely on visual sensors. A small digital camera keeps an eye on the road ahead, with the images produced being processed continuously so as to track the white lines making the lane. Any sideways deviation from that pattern causes the system to issue a warning. Lane-departure aids are about to be introduced in Japan by Subaru, Honda and Mitsubishi. Meanwhile, DaimlerChrysler has already started fitting lane-deviation systems to the trucks and buses it sells in Europe.

The type of alert varies. Mitsubishi uses visual and aural messages along with vibration of the steering wheel. DaimlerChrysler uses a drumming noise that resembles the sound produced when driving over lane-marking studs. The noise is fed to loudspeakers on either the left or right of the car depending on the direction of drift. DaimlerChrysler researchers say that people respond to such a warning intuitively, and automatically steer in the correct direction. Meanwhile, over in Munich, BMW is experimenting with   force feedback   expressed as a slight increase in resistance of the steering wheel   to nudge drivers back into maintaining good lane discipline.

DaimlerChrysler plays drumming sounds to the driver when the car drifts from its lane

Outside of Japan, lane-departure systems   like collision-warning systems   will be introduced first in trucks and buses because of their cost. But they are still far from perfect. They can have difficulty tracking lane markers around bends, and so may be limited (at least initially) to use on expressways.

A more exotic form of ACC for country roads is being developed on prototype cars by an international consortium of European car manufacturers. This attempts to integrate anti-collision radar and road-recognition video sensors with global positioning information and a navigation map. The idea is to create a detailed and constantly moving map of the road ahead, which engages the car   s brakes and accelerator to ensure that corners are not taken at the wrong speed. All the driver has to do is steer correctly.

The region behind a vehicle is also benefiting from the use of radar or cameras to eliminate blind spots and warn of overtaking vehicles. Ultrasonic detectors work like radar but are better for short distances (ie, up to five metres). They have already been tested as parking aids and could also be used to detect pedestrians behind the vehicle. Another form of driver assistance being developed in Europe is intelligent speed adaptation (see article).

Many of these new driving tools are being developed in parallel and conceived as integrated systems. But their introduction is creating a whole set of fresh problems for vehicle designers. The demands of handling so much more digital information within the vehicle, not to mention all the additional power-draining activators needed to do the job, are creating the need for more powerful computing and more accurate GPS navigation, as well as beefier batteries and electrical systems.

Then there is the whole issue of   drive-by-wire   the use of digital signalling instead of mechanical linkages to connect the driver to the vehicle   s throttle, brakes and steering units. When drive-by-wire arrives, the impact on the various forms of driver assistance will be profound.

All together now

When will all the disparate driver aids come together? One engineer at Fiat reckons that, realistically, it will take seven years to combine forward and sideways collision-warning systems with collision avoidance. The main problem is that all the systems under development are based on a simple highway environment. As yet, none is suited for use on complex urban roads. To manage that, the systems will need to recognise, predict and respond correctly to children, animals, wheelchairs, road signs, pedestrian crossings, car doors suddenly opening, and weak traffic participants such as bicycles and motorbikes.

It is for these reasons that aids for stop-and-go city driving have yet to appear. Urban driver assistance will need a much richer set of onboard sensors including lasers, as well as radar, video and ultrasound to provide the necessary accuracy and redundancy. Even then, the best that might emerge is a vehicle that promises merely to mitigate the effects of accidents rather than avoid them. The fully automated motor car is still a long way off. So motorists will have to get used to a world of semi-automation.

Not all automotive engineers are happy with even semi-automation. Some ask how driver assistance will affect traffic safety and flow. Others warn that combining ACC with automated steering is asking for trouble. The driver would be encouraged to tune out and become too dependent on the aid to handle situations manually when disaster strikes. They point to the lessons learned from the Three Mile Island nuclear accident, which showed that operators must never be allowed to become too dependent on automatic controls. Best that they be fully integrated into the control loop like the train driver with a dead-man s handle that applies the brakes if the hand falters.

Dr Ervin notes that before even semi-automated cars hit the roads, questions need to be answered about such issues as cognition, perception, psychology, risk adaptation and vigilance. Beyond those lie even more fundamental questions about the roles of operators in control systems generally. Should they be well-trained system managers who sit above the system but step in when things go wrong? Or should they be integral components that are wired into the system but free to exercise their special hands-on experience and decision-making abilities as a team member the instant an emergency happens?

Such differences in control philosophy go to the heart of a country s historical and social beliefs. In parts of Europe and Asia where greater faith has been placed in *dirigisme* or central planning, there is a tendency to distrust the lowly operator and build control systems that report to a higher command. The same is largely true for societies that have nurtured an unshakeable faith in technology, as America had before Three Mile Island and the Apollo accidents.

Whatever the design philosophies that researchers come up with, car makers the world over are going to be introducing various forms of driver assistance long before they have answered questions beyond the simple ones of whether they can make the technology work. While all assistance is welcome, it would be a serious mistake if the driver were ever excluded, in even the smallest of ways, from the minute-by-minute task of having one eye on traffic and obstacles to the side, and the other on what was happening in the rear-view mirror, while at the same time keeping both firmly on the road ahead.