All about the 'bots

MATT HARDEY and JANINA FREITAG look beyond the DARPA Urban Challenge

Team GRAY gets underway (above). The OxTS-developed RT3000 series (RT3050 shown below) inertial and GPS navigation system, successfully used in the DARPA Urban Challenge

The dream of driverless cars has come a huge step closer after six autonomous cars crossed the finish line of the world's biggest competition of unmanned vehicles.

The DARPA Urban Challenge demonstrated to the world how far autonomous vehicles have progressed over the last couple of years and leave us wondering what might lie ahead in the near future. However, there are two key factors that determine the widespread use of robotic technology – price and usability. Two companies have developed self-contained, off-the-shelf systems that can already be used for the commercial application of autonomous vehicles.

Unlike the last DARPA Challenge which was held in the vast, open Mojave Desert in Nevada, this year's competition tested the robots ability to navigate and interact in an urban environment. The unmanned vehicles had to find their way around a mock city with moving traffic and busy intersections while obeying traffic laws and avoiding obstacles. While the past two DARPA competitions were more physically challenging, the urban setting required vehicles that were able to make "intelligent" decisions based on their surroundings as well as the actions of other vehicles.

GPS outages

The urban environment was designed to mimic GPS outages and multipath effects which added considerable complexity to the unmanned vehicle competition. The urban setting of the race demonstrated the need for a vehicle guidance system that was able to reliably navigate the vehicles even when GPS signals were blocked or reflected near the buildings.

Loss of GPS quickly leads to false position measurements which can leave the vehicles unable to find their way around the course. Especially in an urban environment where buildings can cause poor GPS signals or reflections, continuous position and orientation measurements were critical.

GPS and inertial navigation

Most of the teams opted for a tightly coupled inertial and GPS navigation system which proved to be an invaluable vehicle guidance component. Incorporating highly accurate accelerometers and gyroscopes, a GPS-aided inertial navigation system can measure slight changes in a vehicle's motion and continue to give position and orientation measurements even during prolonged GPS outages. It was not surprising that all of the teams that made it to the finish line of the Urban Challenge had some sort of GPS-aided inertial navigation system onboard their autonomous vehicle.

Cost-effective technology

OxTS has developed a GPS and inertial navigation system which was used by several DARPA teams in the Grand Challenge 2005 as well as in this year's Urban competition. The aim of OxTS is to supply customers with Inertial and GPS navigation systems that are supplied in one compact box, are easy to use, and cost-effective. The RT3000 inertial and GPS systems run some of the most complex real-time algorithms for blending GPS and Inertial measurements, leading to highly accurate results.

To be able to use low-cost inertial sensors, OxTS are investing in precision calibration techniques. The company realised that only if the price of the traditionally expensive inertial technology comes down, will it make sense to equip a military convoy or large numbers of unmanned cars with the technology. Especially in the near future, when companies invest in a large number of robot cars, the price will play a key role in the decision process.

From ADAS to fully autonomous

In the short run, unmanned ground vehicles will be used on the battlefields to conduct military supply missions and thus limit human involvement in dangerous areas. In the long run, robot vehicles will be introduced to civilian commercial applications and will contribute to safer roads and enable better use of time and road capacity. Advanced Driver Assistance Systems are already being built in new car models to assist the driver and avoid dangerous manoeuvres or collisions.

Gradually, driver assistance systems will play an ever more important part until we see fully autonomous cars one day in the future. In order to make this happen, however, we first need to make this technology more reliable. The next step in making autonomous cars a reality is certainly to integrate all the different sensors, processors and other technical equipment in order to have a system that is compact, lightweight, fully integrated and contains all the necessary hardware and software to run a robot vehicle. Price will also play an important factor that will determine the widespread use of unmanned ground vehicles as well as supply convoys for military use and – in the distant future – the adoption of self-driving cars on our roads.

"Bot in a box" solution

Most of the DARPA teams, however, still seemed to have a very research-oriented approach. Some of the unmanned vehicles were cluttered up with different sensors, processors and other technical equipment. Looking around the team pit area before the big race, most autonomous cars had cables, wires, sensors and computers scattered inside. Amongst the "cobbled" systems in the DARPA competition, however, one team had a different approach.

Team GRAY was already looking beyond the DARPA Urban Challenge and has prepared itself for commercial applications. With its business oriented approach, the team has developed a self-contained, robust unit that provides most of the software and hardware required for unmanned vehicle applications. The AVS (Autonomous Vehicle System) is designed for unmanned military operations as well as commercial applications in vehicle development.

Team GRAY spent the last two years developing an "off-the-shelf" product that has all the technology needed to navigate a vehicle reliably and cost-effectively which will be critical for the development of autonomous vehicles in larger volumes. Paul Trepagnier, Team GRAY's head software developer, explains: "DARPA is not looking for a science project. They are looking for a system that can take supplies and troops to the front lines and if your system takes up the entire vehicle you cannot do that."

According to Paul Trepagnier, a further advantage of GRAY's compact, integrated "bot in a box" system, is that it cuts down on possible failure points that a team will have when using a great variety of different equipment.

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Robot test drivers

Team GRAY have already built five of the systems and believe there is a much bigger market for commercial use. If you wonder who would buy such a system at the moment you will be surprised to hear that tyre and car manufacturers have a keen interest in autonomously driving cars. Test drivers are currently used to test the durability of vehicles and its components which usually involves very repetitive tests that could easily be performed by robotic vehicles. Autonomously driving vehicles are also used to test cars to the limit of their capabilities without putting human test drivers at risk.

Commercial applications in mind

OxTS and Team GRAY both have developed autonomous vehicle technology that can combined be used as an off-the-shelf, compact solution for commercial applications. By trying to reduce the price, both companies are able to provide a complimentary and reliable, self-contained solution for autonomous car applications on a larger scale. TH

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