

DARPA

DARPA Challenge Puts Innovation on the Move

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Dan Komaromi
Vice president, sensor development
Autonomous Vehicle Systems

The DARPA Grand Challenge, a race organized by the Defense Advanced Research Projects Agency, is designed to promote the invention of revolutionary technologies for autonomous vehicles. Customized vehicles compete against the clock while navigating a treacherous course without a driver, or any human guidance. Using advanced sensors, computerized guidance systems and global positioning satellites, each entry must be able to drive itself and follow a 132 mile route that includes hairpin turns, pools of water, at least one tunnel and a variety of obstacles.

Ever since March 2004, when the first Mojave Desert race ended in a series of dismal mishaps, Michael Vest has turned his home in Rancho Bernardo into a “Monster Garage” for robotics. Vest, who is president of Autonomous Vehicle Systems (AVS), leads a team of 25 people who have modified a 1987 Humvee so it can literally drive itself.

The Flying Fox

Dubbed the Flying Fox, this vehicle is built on the chassis of an all-terrain vehicle by AVS, a collaboration between Michigan State University, University of California San Diego, American Institute of Aeronautics and Astronautics and industry professionals. AVS uses RTI Data Distribution Service (formerly NDDS) to communicate with advanced sensor systems that work in various ranges of electromagnetic spectrum to provide the ‘eyes’ and ‘ears’ for autonomous ground vehicles and integrates with a modular software system that allows sensors to be added or removed as the mission requires. Some sensor systems include adaptive vision, Ladar; other sensors attached to the vehicle to provide feedback as to the vehicle state or health. Flying Fox is among the first to demonstrate a neuroscience-inspired adaptive vision system in an off-road environment that allows the vehicle to learn the best path through training examples and generalize unseen terrain based on automatically derived features.



The majority of processing is performed by eight conduction cooled 1.8 Ghz CompactPCI processors mounted in a conduction cooled rugged chassis custom design by SBS Technologies. The chassis is designed to handle the temperatures, shock and vibration beyond those expected in the Grand Challenge. Additionally, a high-speed Intel dual-Xeon workstation was dedicated for vision based guidance of the vehicle. A global positioning system (GPS) and an inertial navigation unit determined the vehicle’s path and a series of actuators controlled the throttle, braking and steering. The chassis runs the QNX real-time operating system, and the vision processor operates under Linux. All interprocess communication is handled by RTI.

“RTI was a key part of the system that allowed the information to flow from one module to the next,” says Dan Komaromi, vice president, sensor development at AVS. Komaromi and his team started designing the vehicle during last year’s challenge. “We were researching this for a long time, but we wanted something where we could use our existing computing boards and processors based on the needs of the sensors, and let that determine what kind of processors we use, then have a uniform way to quickly get the data with minimal latency.”

Why RTI was Chosen

To reduce the latency, RTI used a protocol that transported the information over an Ethernet network. As soon as the information came in from the sensor, it went to the



actuator command to instruct the vehicle to turn or brake. "It allows us to plug into various components very easily into the system," explained Komaromi. "We selected RTI because of their proven track record in synchronized, distributed communications and their understanding of the critical design requirements of autonomous vehicles. RTI's history of working with Stanford University is invaluable and this experience is evident in the refined RTI Data Distribution Service architecture that makes it seamless to arrange real-time, dynamically configurable communication between multiple vision and laser sensors and the embedded processing modules."

Despite modifications for autonomous operation the Flying Fox is fully human drivable. Originally in service with the US Marine Corps, it had been rebuilt from the ground up and used extensively for personal off-roading.

The Grand Challenge

The Grand Challenge was conceived in 2002 by DARPA director Anthony Tether. DARPA has sponsored autonomous-vehicle research for more than a decade in hopes of meeting a Congressional mandate that one-third of all military vehicles be autonomous by 2015. To accelerate progress the agency decided to enlist outside help. The first race, in March 2004, offered a \$1 million purse. When no one finished, the purse was upped to \$2 million. In October 2005, the second year of the race, five robots, including the Flying Fox successfully completed the grueling 131.2-mile course.

"All of the winners achieved something that the naysayers had said was impossible just a few years ago," pointed out Gary Bradski who is a machine-learning expert at Intel Corp and member of the winning team. "Previously, DARPA spent at least a billion dollars on autonomous-vehicle development," he said, "but in less than three years the Grand Challenge has surpassed all previous efforts. The Grand Challenge encouraged researchers to take the big risk, because it was okay to fail. As a consequence, we have made incredible progress. I predict that not only military vehicles, but also consumer vehicles, will start incorporating some of our discoveries within the next three to five years."

About RTI

RTI supplies middleware and distributed data management solutions for real-time systems. With innovative technology and deep expertise in distributed applications, RTI provides an unequalled competitive advantage to customers developing systems that benefit from high-performance access to time-critical data. RTI solutions have been deployed in a broad range of applications including command and control, intelligence, surveillance, data fusion, simulation, industrial control, air traffic control, railway management, roadway traffic monitoring and multimedia communications. Founded in 1991, RTI is privately held and headquartered in Sunnyvale, California.