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From the pages of Design News

Controlling an Unmanned Car
Randy Frank – 7/18/2005

With the prize of $2 million for this year's event, the DARPA (Defense Advanced Research Projects Agency) Grand Challenge promises to be an exciting race. Unlike those in the recent Indianapolis 500, these cars have no drivers. Just finishing the course this year could make one team a winner. Sponsored by the U.S. Department of Defense, the race promotes the development of technology for autonomously controlled ground-based vehicles.

In 2001, Congress set a goal that by the year 2015 one-third of all military combat ground vehicles would be able to drive themselves. The first Grand Challenge was run on March 13, 2004, when none of the 15 vehicles that entered completed more than 5 percent of the course. The failures of the first race and a doubling of the amount of the prize has brought a number of new players to the race this year. One team, formed by Jim Crittenden and several colleagues, may have a special edge. The members of Team Mojavaton are experienced in various aspects of custom machine building, design, vision systems, control systems, electronics, programming, and project management. Crittenden is also the Automation and Manufacturing Manager at CoorsTek.

All the teams this year could benefit from the lessons of the previous race. They just had to glean those lessons from the technical reports prepared by last year's final 25 teams and from the instrumentation data they submitted. "One of the things we noticed by reading the technical reports and by watching the videos is that many of the teams had auxiliary generators," Crittenden says. "A couple of teams actually had gasoline-powered generators hanging off the backs of their vehicles."

One of the first things that the team did was to make a list of the loads and their power requirements for the sensors, the programmable logic controllers, and the computer—everything that it would add to the vehicle. Through careful attention to power use in its design, the vehicle consumes only 25A at 14V for all its navigation and automation systems. This is well within the capability of the 90A alternator on the vehicle and still allows the air-conditioner to cool the passenger compartment.

"The system really comes down to only two things that you need to know," Crittenden says. "Going down the road, I need to know where to turn the steering wheel and I need to know what to do with the throttle and the brake." With this information in hand, it becomes a matter of how quickly and precisely the system can react to it.

The autonomous brake uses a pneumatic cylinder that applies pressure rather than the controlled displacement through servos of the steering wheel and throttle. For the servo motors, the team selected units with the highest RPMs at the lowest voltage level to consume the least amount of power.

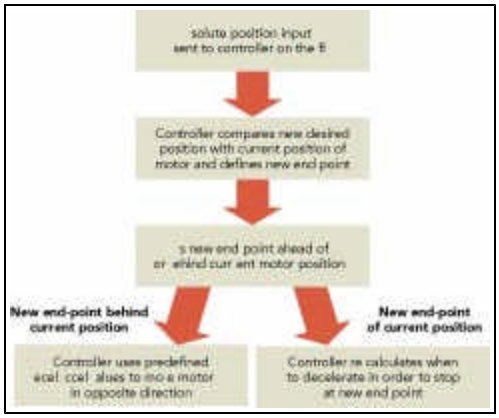
For controlling the steering and throttle, the team selected Galil's DMC-1416 single-axis controller and drive combination. Lisa Wade, vice president of sales and marketing at Galil Motion Control, notes, "One of the things that they use in our controllers is the Position-Tracking Mode." This allows the system to send new points on the fly. It does not have to

get to the previously commanded position if new sensing data indicates an alternate position. The controller responds in real time. This is important because the vehicle has to make about 10 decisions per second to determine the correct direction and velocity.

Galil initially added the Position-Tracking Mode to controllers for a similar application where instant adjustments were required. Since that first application, the need for this capability occurred enough that it became a standard feature on two products. Without the Position-Tracking Mode, the typical motion control system has to reach the target destination before it accepts new commands.

Team Mojavaton's vehicle, a Nissan Xterra equipped with GPS navigation and other sensors, drives autonomously in the desert based on motion control inputs to the throttle, steering, and braking systems.

In many respects, the autonomous vehicle is similar to an advanced automation system, except it must face a number of undetermined obstacles. According to John Wade, a senior application engineer at Galil, the motor control portion of the vehicle is rather straightforward: "They have an encoder on the motor, so we take in the encoder signal, and close the loop around it. We are able to take in the position from their device that is providing the position information and drive the motor to that location as fast as possible."



Position tracking uses the input from the absolute position encoder, compares the new desired position to the existing position, makes a decision, and moves the motor to the appropriate position without completing the previous command.

Motion control is obviously just a portion of the overall control system. Each car in the race has a GPS receiver. Two hours before the start of the race each team receives a CD with a text file of the coordinates that must be loaded into the vehicle's computer. Crittenden expects it will take about 5 min to load their system.

On the course, the vehicle drives from one waypoint to another. Along the route, however, there are ditches and at least one DARPA-planted tank trap. The vehicle has to "see" the road ahead and avoid these show-stopping hazards. "We have a variety of sensors in our car, all of which see the world in a slightly different manner," Crittenden says.

With the technical work behind them, the activities on the race day should be straightforward once the team gets its GPS file. Crittenden says, "You load it in, drive your car up to the starting line, switch it into autonomous mode, get out, close the door, and watch it drive off. You hope to see it 10 hrs later, 150 miles away."

A decision was made on June 6 that Team Mojavaton is among the 40 teams chosen to move onto the next level of the 2006 challenge.

Web Resources

For more information on Team Mojavaton
http://rbi.ims.ca/4412-531

For more information on Galil Motion Control DMC-1416
http://rbi.ims.ca/4412-532