While military planners push for teams of robotic scouts that can be deployed in an urban area to reconnoiter a situation and even neutralize danger, VaCAS researchers have developed first-of-its kind technology to help make such teams possible.

The research effort, led by Tomonari Furukawa, an associate professor of mechanical engineering (ME), was selected as one of the 10 semifinalists in the Multi Autonomous Ground-robotic International Challenge (MAGIC 2010). MAGIC is jointly sponsored by Australia’s Defence Science & Technology Organisation (DTSO) and the U.S. Research Development & Engineering Command (RDECOM), the core U.S. agency for developing ground robotics.

MAGIC challenged teams to develop a cooperative of unmanned ground vehicles that can coordinate their activities to explore and map an urban area – inside and out-of-doors. The robots would combine information for mapping and identifying potential objects of interest and relay it to ground control. One of the robot team members would be disabled during the mission, forcing the team to alter its communications and control pattern.

The competition is not about sensor development or vehicle mobility, according to the published rules, but about coordination and teamwork to complete a mission.

“While remote-controlled robots are being deployed in operational areas, we need smart, intelligent and fully autonomous systems that can take over from humans in conducting intelligence, surveillance and reconnaissance missions,” said Greg Combet, Australia’s Minister for Defence Personnel, Materiel and Science, when announcing the competition.

The Virginia Tech team was one of five semifinalists to be granted $100,000 in funding by the competition. While the team did not make it to the finals, the testbed and cooperative technology systems that were developed for the competition will give Virginia Tech researchers and students a strong base for ongoing efforts in cooperative robotics.

In addition to building a permanent indoor testing environment, the team developed a control center, which serves double duty as a virtual environment to test different autonomous cooperation and communication schemes. The system uses laptop computers — each representing an individual robot. The laptops can operate virtually, within a simulated environment, or can ride on the robots and process real-time data from the on-board sensors.

The simulation system is a “huge asset,” according to Furukawa. “We can handle eight simulated robots and test complex organizational schemes,” he says. The testbed was an idea he had wanted...
to implement for some time, but until the MAGIC competition didn’t have the right scenario.

Because of this system, they discovered a communications flaw in the processors: the current hardware system can’t handle the communication load. The team designed a cooperative group composed of six sensor robots (one of which is the leader), and two disruptors (robots whose job is to neutralize a dangerous element).

“With our mesh network and two-way operation, we decided a leader system would be most efficient and most robust,” Furukawa explains. Decision-making is centralized to the leader, for vehicle allocation during mapping and vehicle allocation after detecting an object of interest. If the leader dies, another root in the team is assigned the role.

The cooperative control strategy the team developed uses a recursive Bayesian approach, making it more accurate and more efficient for tasks of coordination because the information is more reliable, according to Furukawa.

Another unique feature is the VaCAS team’s use of a belief maintenance system in the search and mapping actions. “The problem with search and tracking is you have to create a search space,” explains Furukawa.

“This is expensive computationally.” Belief maintenance, which is a technical approach using negative information (null data is good data), also allows for better accuracy and efficiency. “If an object of interest is in our field of view, our smooth Gaussian process is enough,” explains Furukawa. “Gaussian processes say, ‘if I don’t see it, I don’t update.’ But using negative information, we are confident that the target does not exist in the field of view. That is still information,” he says.

Finally, the Virginia Tech approach is set apart by use of a graphics processing unit.

“We’re the only ones using a graphics processing unit (GPU),” explains Furukawa, who describes this approach as “the way it should be.” GPUs were initially developed to enable fast graphics for video games. Team VaCAS, however, uses a GPU for mapping calculations. Using a Bayesian approach with each unit of area mapped to a pixel, a GPU allows for faster calculations, he says.

Furukawa’s team continues to work on the search and tracking efforts. “Our work on MAGIC helped us improve our capabilities, but there are still big problems to be solved,” he says. He expects the indoor robotics testbed, and the simulation testbed to serve many future projects.

Furukawa is stationed at Virginia Tech’s Institute for Advanced Learning and Research in Danville, Va. The researchers in Danville worked with three ME VaCAS faculty members from the Blacksburg campus, including: Dennis Hong, director of RoMeLa, Andrew Kurdila and Alexander Leonessa.