Robot Intelligence Kernel: Invention improves human-robot collaboration

Inventors at Idaho National Laboratory have produced a breakthrough that offers a giant step toward the far more capable, intelligent robots as depicted throughout film and literature.

"The INL Robot Intelligence Kernel enables robots to act on their own, when needed," said INL engineer David Bruemmer. "It fundamentally changes how humans and robots work together. We have created a new, collaborative relationship between man and machine employing our software on simple embedded processors similar to those you find in handheld computing devices."

This invention can adapt to use a wide variety of sensors in a variety of combinations. The system recognizes the payloads available and adapts the robot's behavior accordingly. Sensor data are manipulated by algorithms to combine sensor inputs into meaningful, actionable perceptions to avoid obstacles, plan paths, visually track, identify changes and much more.

INL's generic, object-oriented software architecture serves as a sort of MS DOS for robots. The intelligence kernel has four levels including:

- The generic architecture layer which interfaces the robot hardware and sensors;
- The perceptual layer that filters and fuses sensor data into abstract perceptions;
- The behavioral layer that uses these abstract perceptions to do things like virtual tracking and obstacle avoidance; and
- The cognitive glue layer, which orchestrates multiple behaviors and provides high-level decision making.

It's easy to define new robots within the architecture. Once a robot has been defined, the whole suite of behaviors unfolds with no further source code changes. The INL Intelligence Kernel is currently operating on a variety of robotic systems, all with different low-level proprietary controllers. This means it can be used with many commercially available robots today.

INL's invention is designed to use low-bandwidth, long-distance communication devices like cell phone modems to allow for operations in shielded and difficult environments at greater distances than conventional wireless networks. The data transmitted from the robot creates a virtual representation of the robot's surroundings on a unique Operator Control Unit.

It uses a computer-game-style interface to digitally create the robot's environment, permitting a 3D map on-the-fly capability and avoiding previous operational limitations and failures.

In addition to vastly improved communications and autonomous navigation, INL's Intelligence Kernel enables novice operators to learn robot management in minutes, operate multiple robots simultaneously, and increase their abilities to respond to other important tasks – all of which exceeds the known competition.

The intelligence kernel has been ported to a wide variety of robots for use by the U.S. departments of Defense, Energy and Homeland Security, along with the National Institute of Standards Technology and many others.

The INL team is proud to note that the robot intelligence kernel has been the brains behind winning the American Association for Artificial Intelligence's urban search and rescue competition in 2003. The U.S. Army now plans to use the intelligence kernel on its next generation of robots.

When applied to demining, robots with the intelligence kernel found and accurately marked, with no human intervention, 130 out of 135 buried land mines. The results show that the robot finds more mines than a trained soldier doing the same task and takes less than one-tenth of the time.

The intelligence kernel has been extended to include mobile manipulation capabilities. This offers a compelling opportunity to meld human-like dexterity with intelligent mobility. The robot is no longer just a taxi cab for sensors. It can now meaningfully affect its environment by opening doors, turning on lights, pressing elevator buttons and picking up objects.

"We're very excited about taking the intelligence kernel and applying it across a variety of critical applications," said Bruemmer. "One example is search and rescue. We've taken this robot all over the world and shown how it can find people in collapsed building structures. Another example is security applications where we can build up a map and then track wherever people move inside of the environment. Urban reconnaissance, sending robots into Iraq to actually be able to find people in caves, build up maps of underground bunkers. We've been working some time on landmine detection, taking robots like this and developing the behaviors that can actually find landmines in orders of magnitude faster than a human with a handheld mine detection device. Lastly, looking at space applications. Taking this robot and putting NASA's humanoid on it and being able to do things dexterously that robots have never been able to do before."