News

(Details)

SeaBee II Swims for USC in This Week's International Underwater Robot Contest - 2007-07-16

SeaBee II – a 50-pound underwater robotic submarine with three camera eyes, two arms, a novel water-cooling system and enough smarts to find Pirate Dave's treasure at the bottom of the lagoon – is swimming for the championship in this week's 10th annual International Autonomous Underwater Vehicle competition in San Diego, CA.

The USC Southern California Competition Robotics (USCR) team has been participating in this international student competition for the past four years, but this year's contest is proving to be a nail-biter. Sponsored by the Association for Unmanned Vehicle Systems International (AUVSI) and the Office of Naval Research (ONR), the competition challenges students from 29 colleges and universities this year to design, build and deploy an autonomous underwater vehicle that can find the pirate's hidden loot. To qualify for the competition, all of the underwater robotic entries must be autonomous, able to sense their surroundings and respond accordingly, independent of any external control by an operator.

SeaBee II, USCR's treasurer hunter, is the team's most ambitious design to date. SeaBee II is a BeoWulf Class I underwater robot with a smaller and lighter hull than its predecessor. The core of the sub — a cylinder about 24 inches long and 7 inches in diameter, or the size of a boom box — also has completely redesigned mechanical and electrical subsystems to support not just an impressive array of sensors but two Core Duo processors.

"One of the most challenging aspects of this design was to minimize the size of the robot without sacrificing capability," said Christian Siagian, a computer science doctoral student on the USCR team, who is specializing in robotics and computer vision. "The mechanical design of SeaBee II is radically different from SeaBee I on many levels."

First and foremost, the sub has a single hull rather than the compartmentalized design of last year's entry said Randolph Voorhies, a first-year computer science master's degree student and USCR president. Internal racks were designed to hold all of the robot's components, including five thrusters, the spring-loaded arms, a six-battery array, three cameras, a sensor processing microcontroller and the sub's computer brains.

After consulting with the USC College Machine Shop, Voorhies said the team decided to make the hull out of machined aluminum eight-inch-diameter tubing. The idea, inspired by deep-sea pressure casings that are used in oceanographic studies, produced a mass reduction of nearly 60 percent over the previous year's design.

SeaBee II also uses five thrusters for propulsion and depth control. They are arranged in two groups, with three thrusters aligned vertically and one pair aligned horizontally. The arrangement allows for five degrees of freedom to control the sub's balance and orientation.

"Using the software control, we can keep the SeaBee II oriented in the proper direction regardless of any shift in the center of mass," explained Chris Roth, a fifth-year computer science/computer engineering undergraduate.

To meet this year's challenge of recovering the "treasure" at the end of the competition course, the team had to design a simple arm mechanism, which sits underneath SeaBee II. When SeaBee's vision system detects the X-shaped treasure and has centered itself above it, the sub is able to maneuver into position and lift it to the surface. Siagian said the manipulator consists of two outstretched arms which are attached to the external frame of the vehicle "in a specific location so that the aft-most camera can judge when the sub has situated itself in the correct position to lift the treasure."

SeaBee's many heat-producing elements, plus its Core Duo processors, created a heat problem, which the team had to solve before they could enter the competition.

"All of that computer power forced us to design a very efficient cooling system that would prevent thermal damage to the electronics," Voorhies said, "and that's one of our major innovations this year. We came up with a unique fluid cooling system that pumps liquid coolant over our high heat components, such as the main computers and the motor drivers inside the hull. The coolant is then run outside of the sub through custon-made copper tubes to exchange the heat with the surrounding water."

SeaBee II also has an impressive array of sensors to provide input to the main computers, including three mega-pixel, high-resolution, wide-angle USB cameras, both internal and external pressure sensors, and a digital compass with pitch and roll detection. The sub also carries a high-speed accelerometer, three internal temperature sensors, and will eventually have a passive sonar system to act as it ears.

The team beamed with pride as they showed spectators what SeaBee II can do.

"We are very proud of our design because it is a culmination of a full year of research and experimentation," Roth said. "The amount that we've learned over the course of this year is truly the prize we sought. Placing and getting a chance to compete in this competition only provides further validation of our efforts."

Despite its current sophistication, SeaBee II is just a hint of things to come. In future years, the team hopes to endow SeaBee's offspring with onboard battery recharging capabilities and new, high-resolution cameras and a host of other electronic upgrades.

One of the primary goals of this new hardware design will be to develop active sonar techniques for three-dimensional mapping, Roth said. On the software side, the team also wants to incorporate stereo vision for a more complete object recognition system.

"Our goal is full integration of all our sensor systems to create a highly accurate position and mapping system for this type of autonomous underwater vehicle," Voorhies said.

The team's emphasis on vision and complex processing power is also a key goal of future SeaBee generations, and has its roots in biology, added Laurent Itti, team faculty adviser and head of the USC iLab Neuroscience Institute.

"Brain-inspired machines are really the key to the next generation of technology," he said.

In addition to Siagian, Voorhies, Roth and Itti, this year's USCR team included Michael Montalbo, a junior in computer science/computer engineering; Andre Rosa, a USC graduate who has been with USCR for the past three years; Andrew Chambers, an electrical engineering undergraduate student; Kevin Roth, a junior in electrical engineering; and Neilsen Bernardo, a sophomore majoring in electrical engineering.

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