PHILIP GOULD

FROM THE DUCK BLIND TO THE DESERT

BY SARAH SPELL

DR. ARUN LAKHOTIA IS AN ASSOCIATE PROFESSOR in the Center for Advanced Computer Studies who specializes in computer security, developing methods for detecting computer viruses. Last August, Lakhotia was settling in for what seemed a typical fall semester. Then one of his students, Muralidar "Murali" Chakravarthi, came by his office to discuss his research plans.

"I asked him what he would really like to work on," Lakhotia recalled months later.

"Robotics," Chakravarthi had answered.

Lakhotia showed him a web site. The Defense Advanced Research Projects Agency, the central research and development agency for the U.S. Department of Defense, had announced a Grand Challenge: build an autonomous ground vehicle, capable of navigating on its own, to race from Barstow, Calif., near Los Angeles, to Primm, Nev., near the outskirts of Las Vegas. The first vehicle to reach the finish line in less than 10 hours would earn its team a $1 million prize.

CACS/PATRICK LANDRY

Would Chakravarthi like to be part of a team to take the Grand Challenge?

"You're kidding," Chakravarthi said. "Besides, you're not in robotics."

"I'll find someone who is," Lakhotia responded.

That someone was Dr. Charles Cavanaugh, also of CACS. Cavanaugh studies computer hardware and systems. "I asked Charles if he thought we could do this," Lakhotia said. "We decided to give it a try."

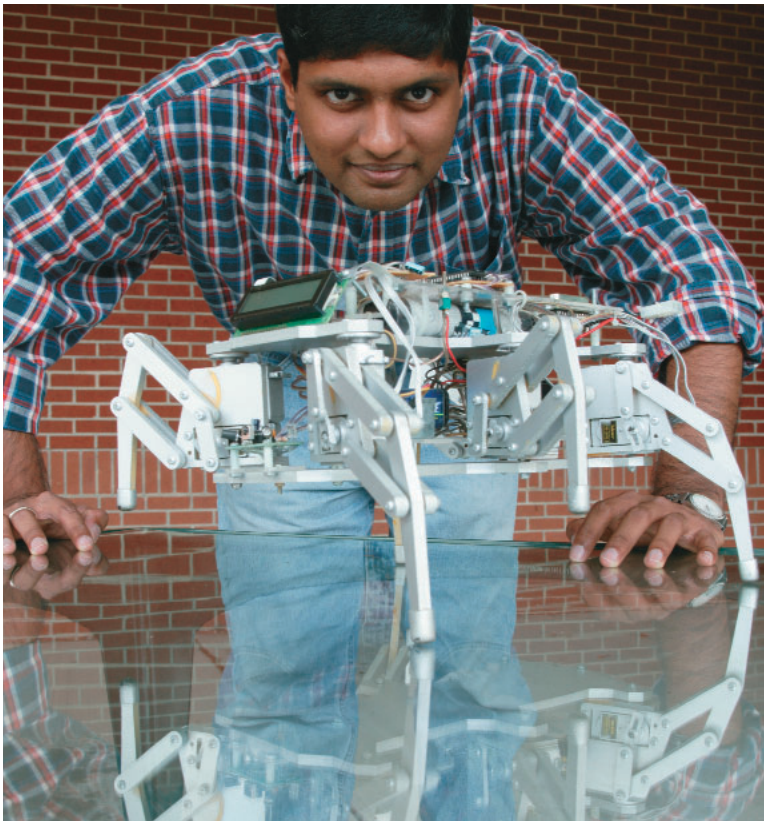
Two hundred days later, the idea was a reality, a vehicle named CajunBot, that could think for itself and move on its own, competing in an elite, million-dollar race in the West Mojave Desert.

CAJUNBOT'S INCREDIBLE JOURNEY

TWO HUNDRED DAYS LATER, THE IDEA WAS A REALITY ITSELF AND MOVE ON ITS OWN, COMPETING IN AN ELITE

THE COMPETITION WAS STIFF — AND had a serious head start. DARPA had introduced the contest in July 2002. By Fall 2003, dozens of teams had formed. Private companies were created for the sole purpose of entering the Grand Challenge. The California Institute of Technology was working on its modified 1996 Chevy Tahoe, the University of Florida on its 1993 Izuzu Trooper. And Carnegie Mellon University was readying its military-surplus Hummer for the desert race.

On Sept. 2, Cavanaugh visited the toy aisle of Wal-Mart to begin work on the CajunBot prototype, GPS Bot. He modified a remote-control car, adding GPS sensing and a computer algorithm — a set of instructions for the bot to carry out. It worked — almost too well. "This thing is really fast. I tried it on campus and let it loose on the sidewalk — it went so fast I couldn't keep up with it on foot. I had to reprogram it to slow it down," he said.



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This was not exactly new territory for Cavanaugh. In his office in the UL Lafayette Conference Center, a red plastic Ferrari and its modified remote control share a shelf with academic research materials. "I made it when I was 15," he said. He pointed to a computer port installed on the remote. "I modified it so that I could control the car with a computer." The Ferrari was controlled by a then-powerful Commodore 64. Cavanaugh could not have guessed that in another 15 years, he'd become the technical leader for Team CajunBot.

"The GPS Bot was important, because with it, we could show people what we were working on," said Cavanaugh. "When they saw that this was do-able, they began to get excited about the project." Faculty and students encountered the GPS Bot, and the CajunBot team grew.

As the leader of the project, Lakhotia was a cheerleader, encouraging his students, his peers and community members of the team. But he also kept everything on track. "I would tell them, 'We are aiming for success in the next step.' That is all: 'Success in the next step.' Because if you look too far ahead, you will lose focus.

"The first step was to write a technical paper that would be accepted by DARPA," he said. The paper was due on Oct. 14. On Oct. 31, the team was notified that the paper had been accepted. But there was no time to celebrate. "We just kept working," said Cavanaugh. "All along, we were going on faith, believing that this would really happen."

Then the team encountered an unexpected challenge. "When the technical paper was accepted, we thought we were in. Later we learned that our acceptance into the Grand Challenge would hinge on a site visit. But that still didn't guarantee

DOUG DUGAS

LEFT: Muralidar Chakravarthi had already built his own six-legged, walking robot when his professor encouraged him to take the Grand Challenge. Chakravarthi helped develop electronics hardware for CajunBot. ABOVE: Firaz Bouz of the Center for Advanced Computer Studies conducts field testing of CajunBot.

A VEHICLE NAMED CAJUNBOT, THAT COULD THINK FOR MILLION-DOLLAR RACE IN THE WEST MOJAVE DESERT.

that we'd get to race. If they liked what we were doing, then we could go to California for the QID — Qualification, Inspection and Demonstration. If we made it through QID, then we'd get to actually compete in the race."

DARPA officials would be on campus Dec. 11 to evaluate Team CajunBot's progress. By mid-November, the team still lacked a full-scale vehicle. "We were desperate for a vehicle," Cavanaugh said.

That's when fate took a hand. "We knew what kind of vehicle we wanted," Cavanaugh said. He took an amphibious all-terrain vehicle for a test drive, hoping the dealer would donate one. Instead, the dealer told him to call Brother Ray Majors, who donated his own Max ATV for the project.

"It was muddy. It was caked with leaves. It was a real amphibious Louisiana vehicle. Who'd have guessed that CajunBot would have started out as an ATV owned by a preacher from Melville?" Cavanaugh said. "He'd drop by and see how things were going. He seemed glad that it was working out for us, but sort of sad that he would never get to take her duck hunting again."

Majors proved to be an important connection. His son, Mark Majors, is the owner of MedExpress, an Alexandria, La., ambulance company that became a CajunBot sponsor. His son, Danny Majors, headed up the CajunBot Chase Team, giving non-technical, yet crucial, support to the team. Other community connections formed. Firefly Digital created a web site for the team. Diamond Data Systems contributed financially. Pixus Printing created adhesive labels for the bot. And, Begneaud Manufacturing created a bright red, larger-than-life-size crawfish to ride atop the bot. "Everyone loved the crawfish — especially the media," said Lakhotia, with a laugh. "They asked more questions about the crawfish than about CajunBot!"

All the sponsors' contributions were appreciated, Lakhotia said, but perhaps none so keenly as that of C & C Technologies, a Lafayette-based company that specializes in underwater navigation and surveying. "We could not have done this without the expertise provided by C & C," said Lakhotia. And this connection seemed fated, as well.

PHILIP GOULD

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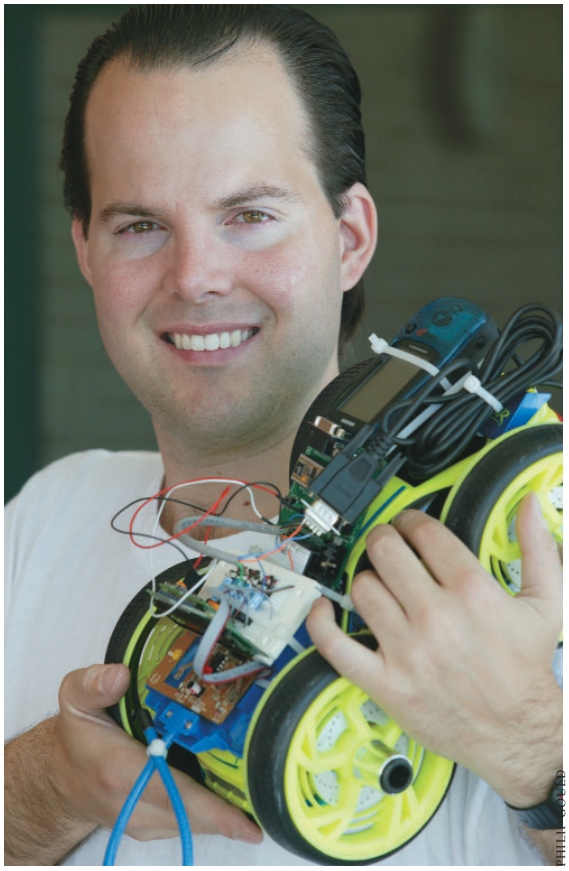
LEFT: Dr. Arun Lakhotia, Team CajunBot's project leader, organized a creative, high-tech team. ABOVE: Unlike some of its competitors, CajunBot is equipped with a remote control — a modified video-game joystick.

Lakhotia was having lunch at Bisbano's Pizza Parlor, a restaurant near campus, when he ran into a former student, Pablo Mejia. Mejia works for C & C Technologies, writing computer software that enables autonomous robotic submarines to navigate using Global Positioning System technology. "He brought exactly the skills and expertise that we needed and he was

"YOU HAD TO DESIGN SOMETHING THE SAME DAY YOU WERE



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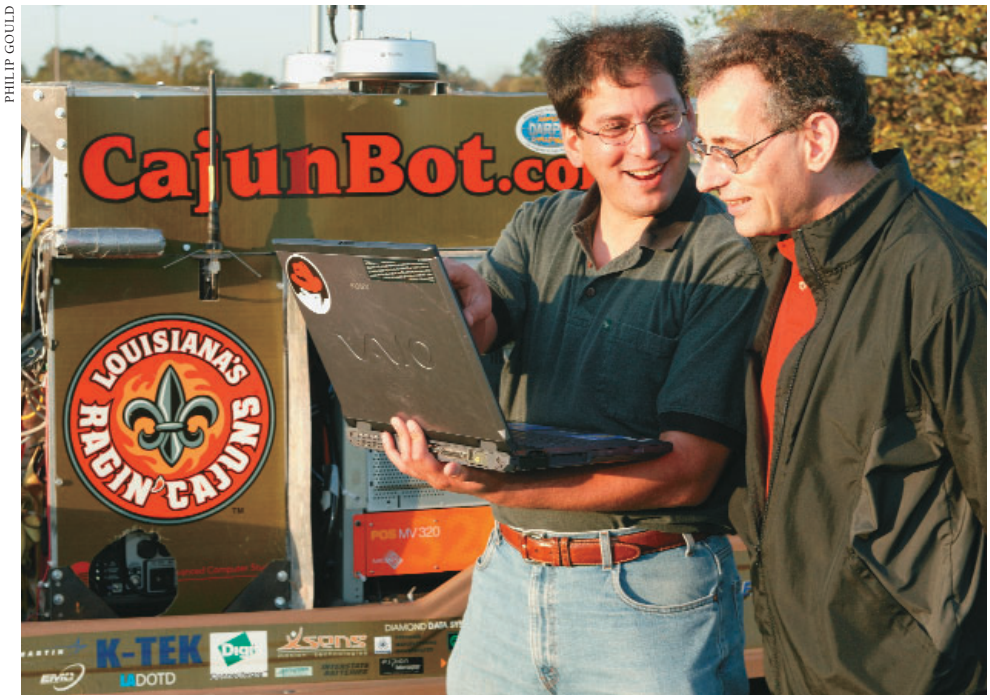

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ABOVE: Dr. Charles Cavanaugh, the technical leader of the team, holds the GPS Bot, the CajunBot prototype. RIGHT: Pablo Mejia, left, and Dr. Anthony Maida developed software that allows CajunBot to navigate using GPS signals and to avoid obstacles in its path. BOTTOM: Software that simulated how CajunBot would perform in the real world helped the team succeed. Here, the virtual CajunBot finds its way around an obstacle.

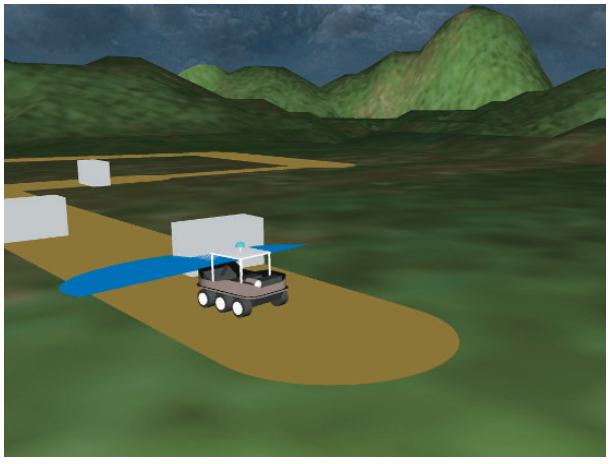
also great in the field, calling the shots. Pablo turned out to be our MVP."

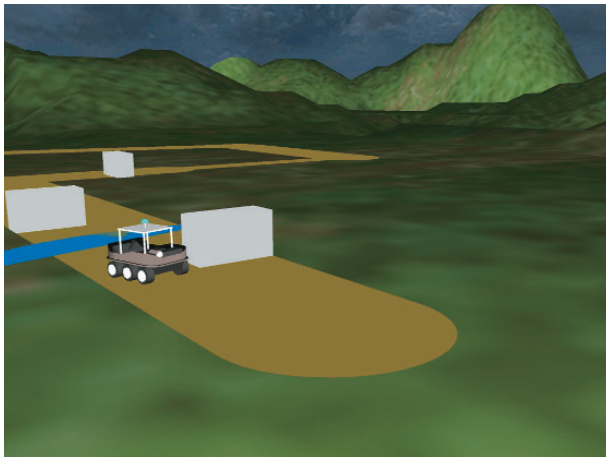
Lakhotia turned to UL Lafayette's Mechanical Engineering Department to modify the ATV and to build a shock-proof metal structure to house computer components and other key equipment. The task fell to four undergraduates: Patrick Harris, Christopher Meaux, Jonathan Raush and Ryan T. Rucker; their work on the bot comprised their senior project.

"It was a lot of work and it was frustrating at times," Harris said. "Things changed every day, so you couldn't plan. You had to design something the same day you were going to build it. The goal was minimum down time."

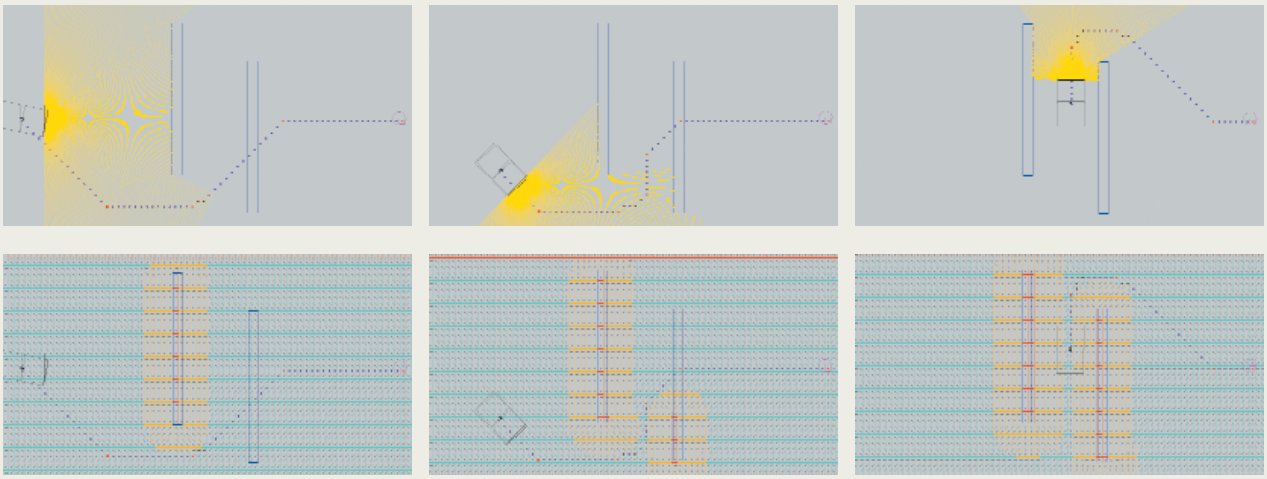
Lakhotia applied a divide-and-conquer strategy. "We had a fantastic team — people who were able to focus on their own area of expertise, without worrying about what someone else was doing. We were working hard, but we were also working smart."

The project leader relied on his colleagues' expertise. "Until you have a project like this, one that truly requires a





GOING TO BUILD IT. THE GOAL WAS MINIMUM DOWN TIME."



Software developed by Dr. Anthony Maida shows how CajunBot sees the world (top row) and how the robot gets around obstacles. The yellow areas represent information collected by CajunBot's laser system, as the laser makes a horizontal sweep of 180 degrees. The second row of images tells what's on CajunBot's mind. The bot creates a two-dimensional, mental map of the outside world; the arrows show the path CajunBot wants to take in every grid square.

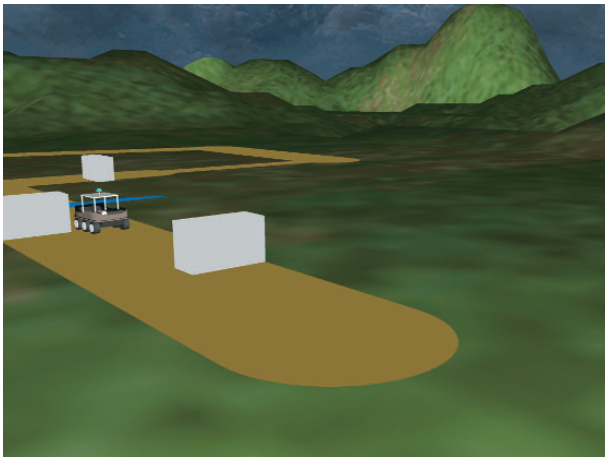
multidisciplinary approach, you may not know what someone right down the hall is working on." Dr. Christoph Borst conducts a variety of research, including technology for computer games. CajunBot benefited when the team developed a simulator — much like a computer game — to test and perfect the robot's software.

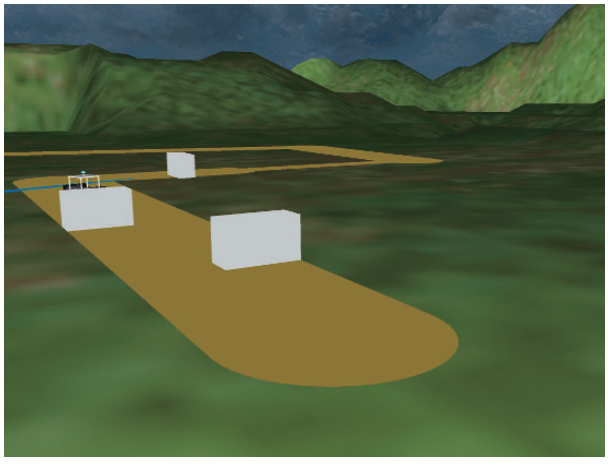
"The simulator really gave us an advantage," Lakhotia said. "Given the time constraint, we couldn't have done it any other way. The software was designed to be independent, so that it could be run on the simulator — or on CajunBot itself. So instead of having to take the bot out every time we wanted to run some software, we were able to do everything on the simulator. We could make corrections to the software as we went along."

Mejia created a software program that enabled CajunBot to interpret GPS data. The Global Positioning System is a worldwide radio navigation system made up of 24 satellites and their ground stations. The satellites are used as reference points to calculate positions on the Earth's surface, giving every square meter of the planet a unique address.

Working in tandem with Mejia was Dr. Anthony Maida of CACS and the Institute of Cognitive Science, who developed a simulator to help CajunBot plan its path and avoid obstacles. Maida explained the difference between "objective" and "subjective" coordinates. The GPS coordinates are the objective coordinates, which form a sort of general road map. A road map will tell you how to drive from New Orleans to Houston — but it won't indicate lanes closed for construction. Those kinds of details are revealed in subjective coordinates.

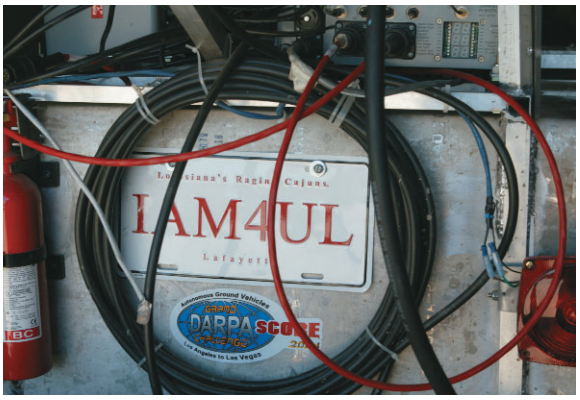
CajunBot's visual system is a laser —





BY RACE DAY, MARCH 13, THE FIELD HAD NARROWED

exactly like the one that scans items in the supermarket checkout lane. The laser sweeps ahead of the bot, in an arc with a range of about 100 feet. The bot makes a mental map from information collected by the laser — this map is made up of subjective coordinates. As Maida explains, "The robot lives in the grid world in its own mind."



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A license plate on the rear of CajunBot.

When CajunBot encounters an obstacle, it makes a decision. Taking into account its distance from the object and its own size and width, it maneuvers around the obstacle. CajunBot is able to do this in the real world because Maida and the Simulator Team (graduate students Suresh Golconda, Nitin Jyoti and Arun Pratap Indugula) worked it out in the virtual world. And in the real world, Mejia's software interfaces with Maida's, so that the GPS points, or way points, make sense to CajunBot.

"We're able to pick up on subtle mistakes that show up in the software that you'd never be able to see in the physical world," Maida explained. "That makes CajunBot more reliable — but it's more reliable because somebody stayed up all night working on the simulation."

Meanwhile, Cavanaugh was working on "embedded systems and electromechanical controls." He employed actuators — motorized devices that are similar to those that pop open a trunk or hatchback window, and move the flaps on airplane wings — to automatically control CajunBot.

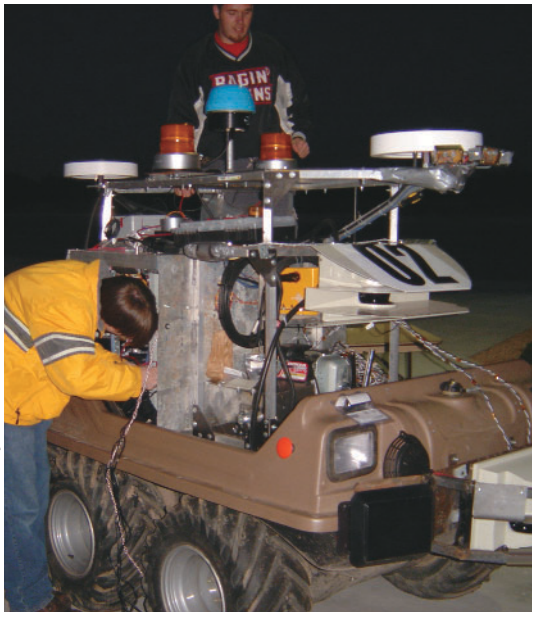
CajunBot uses skid steering, via a series of levers, to change direction. And although the bot is unable to move backward, its relatively tight turning radius, combined with its computerized know-how, make it a nimble competitor. Its throttle control is similar to an automobile's cruise control system.

The look of CajunBot evolved quickly. Originally, clear plastic storage boxes housed the computers, sensors and other electronics. Then the plastic boxes were replaced with a large wooden box. On Dec. 7, just days before DARPA's arrival, CajunBot was ready for its first test in the field. "Up until then, we'd been riding on top of the wooden box, steering the bot with a joy stick," Cavanaugh said. Now, they would see what CajunBot could do on its own.

COURTESY OF TEAM CAJUNBOT/CACS

The team brought the bot out to the site of the former McNaspy Stadium. "That vehicle took off and tried to steer," Cavanaugh said. The trial was a success. "We knew we had something." On Dec. 11, DARPA concurred, including CajunBot in a list of semi-finalists for the Grand Challenge.

Team CajunBot was playing a game of intense catch up — and succeeding. By December, other teams had entered the testing phase. "We didn't have time for testing." They were still building CajunBot, still writing computer programs. Work continued at a steady pace through the holidays and into the new year, with team members literally working day and night. CajunBot arrived in California March 2, a couple of days ahead of the team.



COURTESY OF TEAM CAJUNBOT/CACS

LEFT: Arun Pratap Indugula, a member of CajunBot's Sim Team, reviews the bot's simulation software. ABOVE: Joshua Bridevaux makes adjustments to CajunBot's electronic hardware while Adrian Aucoin Jr. looks on.

"We really looked at the QID as our biggest challenge," Lakhotia said. CajunBot and her team had made it to California — without knowing whether the software would work when transferred from the simulator to the real-life robot. But it did. Despite a slightly spotty performance, CajunBot survived the QID round, By race day, March 13, the field had narrowed from 106 entrants to just 15 participating bots.

Suresh Golconda, a grad student who worked on the simulation software, said he found the competition somewhat surprising. "We had modified a joy stick, from a computer game, to use as a remote control for CajunBot," he said. But several of the other teams apparently hadn't considered that feature a priority. "They had vehicles with GPS sensors, computers, everything,

FROM 106 ENTRANTS TO JUST 15 PARTICIPATING BOTS.

but they were having to push them around in the sand."

Lakhotia said his team's high-tech strategy, using a simulator to perfect software programming, was unique as well. "I don't think anyone else took that approach."

Two hours before the race, the teams were given GPS coordinates that defined the course. CajunBot seemed ready, but instead of moving smoothly out of the chute, as she'd done during the qualifying rounds, she veered to the right and bumped into a concrete barrier. The impact engaged the emergency stop button, and CajunBot was out of the running.

"This was a race that no one was expected to win," said Lakhotia. And indeed, none of the 15 finalists completed the course. Two competitors withdrew before the race. Other vehicles veered off course and became stuck in uneven terrain. One vehicle flipped over while trying to make a 90-degree turn. The Carnegie Mellon vehicle hummed along for almost seven and half miles — farther than any other team's — but was disabled when it became caught on a berm and its front

Some of the members of Team CajunBot. KNEELING LEFT TO RIGHT: **Nitin Jyoti, Arun Pratap Indugula, Christopher Meaux.** STANDING LEFT TO RIGHT: **Danny Majors, Patrick Harris (behind Nitin), Suresh Golconda, Muralidar Chakravarthi. Joshua Bridevaux, Adrian Aucoin Jr., Scott Wilson, Pablo Mejia, Prashant Pathak, Patrick Landry, Ryan T. Rucker, Dr. Arun Lakhotia, Firas Bouz.**

"I WOULD TELL THEM, 'WE ARE AIMING FOR SUCCESS I

wheels caught fire.

Although the race ended for CajunBot in a non-climactic way, Lakhotia recognized it as a blessing. "We had a lot of expensive equipment on board — much of it loaned. The bot did what it was supposed to do. It got into a bad situation and it shut itself off."

PATRICK LANDRY/CACS

Lakhotia remarked that DARPA's Grand Challenge is aptly named. "They are interested in really pushing the envelope, in encouraging out-of-the-box thinking about really complex problems. DARPA isn't interested in something than can be solved in a few months. They're looking down the road."

So is Team CajunBot. Because it qualified for the 2004 race, the team is prequalified for the next Grand Challenge, which is tentatively set for November 2005.

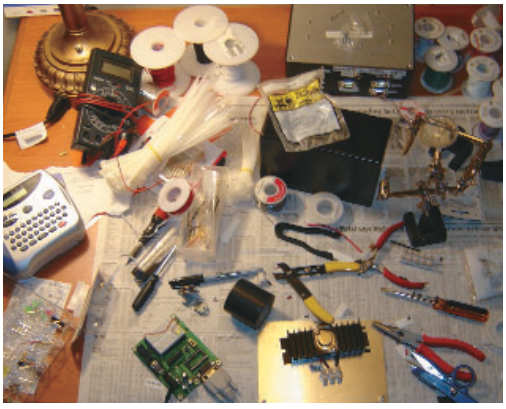
"The media attention has been great," Lakhotia said, "but I think the biggest advantage — what we really got out of this — has to do with our self-image. We see ourselves differently now and that automatically raises confidence and raises expectations. We've been on CNN. We've competed against the best.

"I think it's also been a very good experience across campus. It's broken down barriers and gotten people to work together. One of the reasons this worked is that no one saw themselves as better than someone else. There were no distinctions between graduate students and undergrads, between faculty and non-faculty. It was egoless. And that's what made it work."

That sense of interdisciplinary support extended beyond the computer science and engineering departments. Dr. Phil Auter's documentary production class followed CajunBot as a class project; one of his students accompanied the team to Barstow. "We had a high-profile, real-world client," Auter said. The class will create a DVD to be used for student recruitment and to solicit ongoing community support for the CajunBot project.

On March 22, a press conference was held in front of Edith Garland Dupré Library on campus — a welcome-home event for CajunBot and her team. University President Dr. Ray Authement summed up their accomplishments. "CajunBot has put this university in the big leagues academically."

Now Team CajunBot



COURTESY OF TEAM CAJUNBOT/CACS

PATRICK LANDRY/CACS

LEFT: Dr. Charles Cavanaugh tells an ABC News reporter about CajunBot's prospects in the race. TOP RIGHT: Team CajunBot turned a California hotel room into a real-world lab and workshop. ABOVE: Members of Team CajunBot conduct field testing in Barstow. Left to right: Ryan T. Rucker, Dr. Charles Cavanaugh, Scott Wilson, Muralidar Chakravarthi, Joshua Bridevaux, Pablo Mejia, Adrian Aucoin Jr. OPPOSITE PAGE: Pablo Mejia (foreground) and Firaz Bouz put CajunBot through her paces the day before the Grand Challenge.

THE NEXT STEP.' THAT IS ALL: 'SUCCESS IN THE NEXT

begins the task of analysis — figuring out what went wrong in the race. Cavanaugh has a hunch that it wasn't CajunBot's software. "It's pretty incredible when you think about it, but we relied a lot on hobby-grade electronics. They were available and relatively affordable, although the cost did add up." Some expensive equipment, including an inertial navigation system (which improves GPS navigation accuracy) and the bot's laser system, were loaned to the team. In all, Cavanaugh estimates CajunBot's equipment costs at around $200,000 — the INS alone would have cost about $120,000. "I think CMU spent about $3 million to go after $1 million."

Carnegie Mellon's sponsors included Boeing, Intel and BF Goodrich, which provided a pit crew to maintain its vehicle's tires. Team CajunBot relied on local expertise and an attitude of "irrational optimism," according to Lakhotia, integrating state-of-the art GPS technology with video-game components and hobby-grade electronics to create an improbable, yet successful robotic competitor.

"If we can upgrade to industrial-strength electronics, I think that will make a difference," said Cavanaugh. "We intend to compete in the next Grand Challenge." ▮