ROBOTICS

'RoboCup' Soccer Match Is a Challenge for Silicon Rookies

NAGOYA, JAPAN—Soccer coaches and fans wouldn't ordinarily tolerate players who can't kick, wander the field as if blind, and shove the ball into their own goal as often as into their opponents'. But this was the norm at a recent soccer tournament here. And yet the coaches were proud of their teams, and the fans actually cheered. All bumbling was forgiven because the players were robots.

It was the first World Cup Robot Soccer competition,* RoboCup for short. The brainchild of Hiroaki Kitano, an artificial-intelligence (AI) researcher at Sony Corp., RoboCup attracted 38 teams, mostly from universities in Europe, North America, Japan, and Australia. "The fields of artificial intelligence and robotics need a grand challenge to move them forward," Kitano says. The ultimate goal is a robots-vs.-humans match, something Kitano admits is decades, maybe centuries, away. In the meantime, the challenge is meant to spur advances in robot vision, sensors, and mechanics; and in the programming needed for multiple autonomous robots to solve problems in real time, learn from experience, and work as a team.

PHOTOS BY D. NORMILE

A league of their own. A "midsize" robot match and one set of finalists, from the University of Southern California.

For now, RoboCup simply pits robots against robots in small and midsize categories. Robot teams were limited to five or fewer "players." The small robots, with a maximum dimension of 15 centimeters, used a golf ball on a pingpong table–sized field. The midsize robots, with a maximum dimension of 50 centimeters, used a small soccer ball on a field the size of nine pingpong tables.

The players were a motley crowd. Some had onboard controllers; others were controlled by remote computers via radio signals. Most of the small robots "saw" the field through a single overhead camera, while many of the midsize robots had onboard cameras. For the robot bodies, several teams simply modified remote-controlled model cars right off toy-store shelves. But others tried to design the ultimate soccer player. The team from the Royal Melbourne Institute of Technology (RMIT) in Australia, for example, inspired by the computer mouse, propelled its robots with two 10-centimeter spheres, each driven by two rollers set 90 degrees apart inside the robot. This enabled the robots to move with equal agility in any direction. "It's a very simple idea, but it was very hard to produce," says Andrew Price, one of RMIT's robot builders.

The software approaches also varied. Many of the small-robot teams tried to implement team strategies. The group from Carnegie Mellon University in Pittsburgh, whose CM United team won the small-robot league championship, defined specific behavior for five positions—goalie, defender, midfielder, and left and right forward. The midfielder would try to nudge the ball—it couldn't really kick it—toward one of the forwards. The forward would either pass it to the other forward or shoot after evaluating its position and the positions of its teammate and opponents.

Other designers didn't try to get their "players" to work as a team. Instead, each robot was designed simply to get behind the ball and head toward the goal. But one contingent of robots, from Ullanta Performance Robotics in Massachusetts, had a more stylish approach. The oblong robots were programmed to "kick," by whirling to whack the ball with their back end.

In the midsize league, simplicity worked best. Both teams in the finals, Osaka University in Japan and the University of Southern California (USC) in Los Angeles, used toy-store cars as the bases of their robots, which simply tried to find the ball and push it toward the goal. The championship match ended in a 0–0 tie, even after two overtime periods. USC's robots couldn't take to the field for a third overtime because their batteries were dead.

Indeed, the competition suggested that human soccer players aren't likely to face a Garry Kasparov–like defeat at the hands of machines anytime soon. For many of the robots, playing away from their home laboratories proved disastrous. The soccer ball, for example, was painted orange to be easily recognized by the robotic vision systems. But the conference-hall lighting gave everything an unfamiliar hue, leaving many robots wandering back and forth in search of a familiar shade of orange. Others mistook opponents for the ball. Robots of both teams bunched up and got stuck in corners.

Because the engineering limitations of the real robots limited the kinds of programs they could execute, RoboCup also included a simulator league in which the players were simulated on workstations, one for each of 11 "players" on a team. A central server ran a soccer simulation program. Each workstation fed the moves of its "player" to the server, which processed the signals and returned information on the position of the ball and of the other players. Humboldt University Berlin beat a group from Nara Advanced Institute of Science and Technology in Japan to win this competition, 11 to 2.

Markus Hannebauer, an AI researcher at Humboldt, attributes their success to routines that anticipated and intercepted passes by analyzing the positions of opponents. His team also practiced a maneuver that opponents dubbed the "superkick." The soccer simulation program controlling the matches specified the velocity of the kicks, but Humboldt programmers discovered a loophole. They found that if they positioned a player correctly, it could kick the ball twice, doubling the speed.

Future matches may showcase some more sophisticated AI approaches, says Hannebauer. His group, for example, is planning to implement an AI technique called case-based reasoning, so the program can modify its behavior during a match. Their players will start off making conservative passes, keeping them well out of the reach of opponents. Then they will progressively cut the margin until a pass is intercepted, gradually learning how close they can safely cut their passes.

Teams are already planning the second RoboCup, to be held next year in France. And even now there's a rival league. A group based at the Korea Advanced Institute of Science and Technology also held a robot soccer competition earlier this year and is trying to set up future matches. Wei-Min Shen, senior researcher at USC's Information Science Institute, sums up the enthusiasm. "It made research more fun, and fun more scientific," he says.

–Dennis Normile

* RoboCup was held in conjunction with the Fifteenth International Joint Conference on Artificial Intelligence, Nagoya, Japan, 23 to 29 August.