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VEX EDUCATIONAL ROBOTICS EDR

Grassroots Robotics

by Tom Atwood

Carnegie Mellon Launches a Mega Million Dollar Robotics Education Initiative

Powerful web and technology tools to inspire STEM majors

In this column we like to highlight successful growing robotics programs, competitions, initiatives and the robots used in them—and this issue, we have a mega-story that in a compelling sense encompasses practically all of our past columns. Robots are inherently interesting and they attract the curiosity of students and hobbyists alike in a way that makes learning computer science, science, technology, engineering and math (CS-STEM) engaging and fun. For this reason, robotics competitions and programs, both in-class and extracurricular, have been growing like wildfire domestically and worldwide—the attraction of robots make them natural teaching and learning tools.

Hundreds of thousands of students in the U.S. alone are involved in competitions and robotics programs each year, in and outside the classroom, and that number has doubled in recent years as educators and students have come to understand the magic of robotics.

A new $8+ million dollar initiative launched by the Carnegie Mellon Robotics Academy in concert with the School of Computer Science, the Robotics Institute, and others is likely to accelerate this growth profoundly. Announced July 13, the program, Fostering Innovation through Robotics Exploration (FIRE), is a carefully integrated mix of multiple tiers of web and technology teaching and assessment tools that will be systematically deployed by world experts at Carnegie Mellon and made available to educators and students nationally. The combined effect of these intertwined programs will be to expose unprecedented numbers of students to robotics and computer science lessons that, in turn, will lead to the development of the next generation of innovators.

Team Trinity Robotics campaigned this VEX robot at the 2009 VEX World Championship in Dallas, Texas. This bot showed a lot of design creativity—a spiral, curved bay stored blue cubes that were placed in goals in that year's game, Elevation.

The scope of the programs offered under FIRE is itself remarkable, from game-like virtual worlds where students can test their robot programs to intelligent tutors that adapt the learning process to the needs of individual students and then report on student progress. One phase of FIRE develops the technology and training materials that will allow students to learn to program teams of cooperative robots (swarm bots), a forward looking initiative that recognizes the importance of collaborative robotics in our future. Another part of the project takes the highly successful Alice project and integrates an Alice Animation competition into informal education programs across the United States.

A FIRST Robotics Competition (FRC) Arena at the 2010 FIRST World Championship in Atlanta, Georgia is temporarily occupied by three FIRST LEGO League (FLL) playing fields. Photo by Ken Berry.

The scale of the problem that America faces is immense according to DARPA, the initial funders of the project. DARPA project requirements noted "While computers and Internet connectivity have become daily fixtures in the lives of Americans, we are steadily loosing the engineering talent to program and maintain these systems. According to the Computer Research Association there were 43% fewer graduates and 45% fewer CS degree enrollments in 2006/2007 than there were in 2003/2004."

FIRE is a formidable program in its depth, partnerships, and complexity. FIRE's mission is extremely important—to inspire more students to pursue CS-STEM majors so that we have enough computer scientists and engineers to program the computerized tools, appliances, medical devices, electronic equipment, transportation systems, green technologies, business platforms, military and infrastructure systems, etc. that are proliferating all around us.

A Botball team prepares a robot for competition. Photo courtesy of www.botball.org.

The FIRE project lead is Robin Shoop, director of the Carnegie Mellon Robotics Academy, an international leader in the development of K-12 robotics education curriculum. "The idea is that these programs must be rigorous, but fun — what we call 'hard fun,'" said Shoop, director of FIRE. "Robots provide a great teaching tool. Kids like robots and are innately curious about how they work and how they make decisions. Finding answers to their questions is fun, but technically challenging, and that makes robotics uniquely suited to teaching students computer science, engineering and mathematics."

Since 2000, the Robotics Academy, part of Carnegie Mellon's Robotics Institute, has developed techniques and tools to help K-12 teachers use robots to teach science and mathematics and has trained thousands of teachers on how to incorporate robotics into their lessons. The academy will play a central role in FIRE, but the project also will draw on expertise from across Carnegie Mellon's renowned School of Computer Science, the University of Pittsburgh's Learning Research and Development Center, and from the FIRE team's impressive list of informal and formal education partners.

FIRE PROGRAMS

We have space here only for a sampling of FIRE programs, goals and timelines. To get the latest details on FIRE, which is evolving on a weekly basis, please visit www.fire.cs.cmu.edu. It should be noted that the tiers summarized below are not new concepts but are already years in development, with many millions of dollars invested. Carnegie Mellon is bringing mature technologies to the table, making the promise of FIRE of enormous significance.

ROBOT LESSONS & INTELLIGENT TUTORING

FIRE is developing lessons for teaching computer science, engineering design and math that require students to use math and computer science rather than simply guessing and checking how a bot performs. In the first year, the project will focus on Robots in Motion, a set of training tools designed to teach the mathematics behind robot path planning. FIRE will also offer training and support for students learning to program Arduino, LEGO, and VEX robot platforms and to students participating in robotics activities.

Over the next three years FIRE will integrate Intelligent Tutor-enabled technologies designed to significantly improve a student's ability to learn STEM into a plethora of robotics curriculum. Intelligent tutors are already used by hundreds of thousands of students; these tutors teach things that are algorithmic like mathematics and computer science, two pillars of future innovation. By analyzing the steps a student takes in solving a problem, these tutors track a student's progress and provide feedback or additional practice as necessary. Classroom-enhanced versions

An NXT LEGO MINDSTORMS robot stands with suitcase in hand; LEGO robots are at the core of both the FIRST LEGO League (FLL) and the FIRST Tech Challenge (FTC) competitions.

of the tutors produce student reports for teachers, enabling targeted remediation on top of the differentiated learning experience that the tutor's adaptive nature inherently provides. Ken Koedinger, Albert Corbett and their colleagues in the Human-Computer Interaction Institute (HCII) will develop these systems in collaboration with the Robotics Academy.

ALICE ANIMATION

Alice, www.alice.org, is a programming environment that enables novice programmers to create 3D virtual worlds, including animations and games. 3D models of objects, vehicles, people and animals populate a virtual world and students use drag-and-drop editing to create code that drives

Balls are thrown into the opponent's field in Clean Sweep, the 2010 official VEX game. Over 400 teams battled it out at the 2010 World VEX Robotics Championship in Dallas, Texas.

the motion of these objects. Wanda Dann and her colleagues in HCII's Alice Project will work with FIRE to create an Alice animation competition designed to increase the number of girls involved in computer science. Animation contests like this typically appeal to both sexes and teach programming effectively to beginners.

A VEX driver concentrates playing Elevation in 2009.

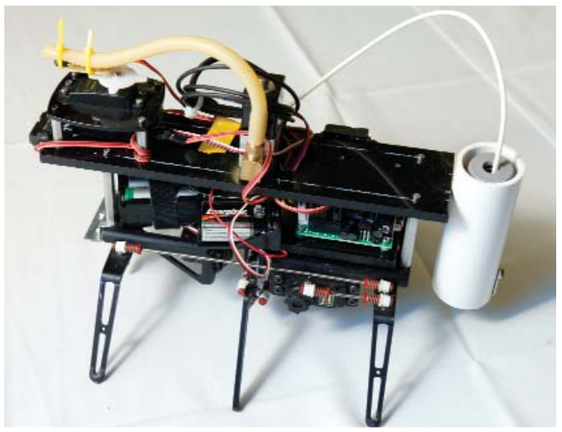
ROBOT VIRTUAL WORLDS

Perhaps the most exciting and fun part of the project is the development of robot virtual worlds where students can program their virtual robots using the same programming language that they use for their physical robots. "The team begins with ROBOTC but plans to add other programming languages as the project evolves," Shoop said. This project will eliminate one bottleneck to teaching how to program robots by providing a virtual robot for every student on the team! Another exciting part of the project is that the robot virtual world is being designed in ways that will allow students to build their own worlds to program in. There will be much more on the project in a future issue of *Robot*; the team is seeking collaborators for this part of the project (if you are interested, leave a message with Robin at the "contact" link at www.fire.cs.cmu.edu).

SWARM BOTS!

As noted on the FIRE website: "In the future, all systems will be networked and will communicate. It is imperative for future global competitiveness that students begin to learn multi-agent control and communications. There are autonomous multi-robot competitions for school age children in China, Europe, and Australia, but none in the US. There are competitions that have multiple robots on the field at the same time, but only the college level International RoboCup competition promotes autonomous multi-robot communication and collaboration."

The FIRST Tech Challenge (FTC) is based on the LEGO NXT MINDSTORMS platform and comes with a range of additional metal, plastic and other parts. This platform, part of high school level extracurricular competition, is being incorporated into classes as a teaching tool on a growing basis. Photo courtesy of Mike Beattie, FIRST Tech Challenge.



This Trinity Fire Fighting Home Robot Contest entry is a clever design that mounts a gas jet extinguisher on a hexapod platform.

Left: robot competitions thrill participants, teachers, mentors, parents, even whole communities. Botball team members root for their robot. Photo courtesy of www.botball.org. Right: FIRST LEGO League (FLL) robot is programmed.

Manuela Veloso, professor of computer science and president-elect of the Association for the Advancement of Artificial Intelligence, and Howie Choset associate professor of robotics, will develop new teaching tools and a new competition for teams of robots working cooperatively. "In the future, robots will work in teams, not as single robots," Veloso said. "If we want to drive future innovation, then we need to begin to challenge students to solve multi-robot problems today."

COMPUTATIONAL AND ALGORITHMIC THINKING

To further expand the potential pool of CS-STEM students, Eugene Fink, associate research professor in the Language Technologies Institute and his colleagues are working with FIRE to increase participation in activities like the North American Computational Linguistics Olympiad (NACLO), www.naclo.cs.cmu.edu. The International Linguistics Olympiad is very popular in Europe; FIRE's goal is to make it accessible to thousands of students across the U.S.

A VEX team from China at the 2010 Dallas, Texas VEX World Championship. Many foreign countries have growing robotics education programs. The FIRE program funded by DARPA and others will help the U.S. become more competitive on the world technology stage.

OUTREACH TO NONACADEMIC GROUPS

In addition to creating new competitions, FIRE will reach out to national organizations such as the Girl and Boy Scouts, 4H, YMCA, YWCA and the Boys and Girls Clubs of America to engage more students in activities that prepare them to be future innovators.

"Tens of thousands of students nationwide participate in robotic activities every year, but these activities do not always translate into increases in academic preparation or sustained engagement with CS-STEM," Shoop said. "FIRE will provide the infrastructure, the tools, and the resources to significantly engage students for the long term."

Christian Schunn and his colleagues at the University of Pittsburgh's Learning Research and Development Center will provide a key component for the project, evaluating the educational effectiveness of FIRE's tools and methods and monitoring outreach efforts to communities across the country.

CONLUSION

Competitions are envisioned in FIRE that will entice participants to create virtual robot platforms that can become part of the permanent landscape in the virtual worlds provided by Carnegie Mellon for programming and running robots. Visionaries like Woodie Flowers, emeritus professor of mechanical engineering at the Massachusetts Institute of Technology and senior advisor to FIRST, has long advocated the creation of learning multi-media that will engage students with all the bells and whistles of a hit science fiction movie. It appears to us, at *Robot*, that the initial steps are now underway to do just that, using robotics and intelligent virtual media to revolutionize the educational process. We applaud the FIRE program and the hard work of the many people at Carnegie Mellon that made its inception possible.

Teachers and students interested in exploring opportunities to partner with and utilize FIRE resources should visit www.fire.cs.cmu.edu and the web mail link on the contact page. There you can email FIRE staff and leave a personal message. *Robot* will continue to offer the latest on FIRE.

RoboParade is the only autonomous robot parade competition in the world; it is an offshute of the annual Robofest contest for middle and high school students.

Links

Alice, http://www.alice.org

Carnegie Mellon Robotics Academy, www.education.rec.ri.cmu.edu, (412) 681-7160

FIRE ("Hard Fun!!!" homepage), www.fire.cs.cmu.edu.

Learning Research & Development Center, www.lrdc.pitt.edu

North American Computational Linguistics Olympiad (NACLO), www.naclo.cs.cmu.edu

For more information, please see our source guide on page 89.