Q515: Learning with LEGO Robots

Background

This course was co-taught by Tom Keating and Matt Jadud during the second intensive summer session at IUB. It provided 10 teachers from all over Indiana the opportunity to play with and develop curricula utilizing the LEGO Mindstorms Robotics Invention System.

What's it about?

Teachers, being discriminating creatures, had to be lured in with hype normally only associated with the release of major motion pictures. In particular, they were led to believe that they would

- Design, build, and program LEGO robots for use in the K-16 physical, life, and mathematical sciences.
- Develop curricular units for your classroom.
- Publish curricular materials to the World Wide Web.
- Write proposals to obtain funding for the purchase of LEGO Mindstorms Robotics kits for your own classroom.
- Read and discuss literature relevant to constructivist theories of learning and instruction.
- (If you didn't catch it between the lines, HAVE FUN!)

Our overriding goal in presenting Q515 was to make it useful for the teachers, and focus on supporting them in developing curricula and proposals for funding that might make using the Mindstorms kit in their classrooms a reality. Because of the individual nature of the course, curricular ideas for students grades two through the university level were developed and discussed as a group, and the ideas and interaction between the instructors was greatly appreciated by all.

Examples of Students' Work

A brief summary of some of the teachers' work is presented here; more is available at the URL listed below.

Jodi Huebert, Bethany Christain High School

Jodi currently teaches computer science, economics, and algebra at the high school level. The Mindstorms kit looked, to her, like an excellent vehicle for engaging her students early in her computer sciences courses, giving them a reason for wanting to learn to think and solve problems like a computer programmer.

Christi Rockwell, M.A. in Mathematics

Christi's son is mildly autistic, and the Mindstorms kit presented an opportunity to combine several things he enjoyed (computers, LEGOs) in one. She wrote up a series of documents detailing her approach to using the kit with her son, and found it did a very good job of holding his attention, providing him an environment to focus and structure his thinking.

LEGOScheme

LEGOScheme is a compiler capable of converting a limited subset of the Scheme programming language into Spirit OCX code capable of controlling LEGO Mindstorms robots. Written as a proof of concept, LEGOScheme's primary goals were to show that a well-designed, high-level language could be used to control LEGO robots and thus could be used for educational purposes in an introductory computer science course.

Our compiler understands a large subset of introductory Scheme, including variable introduction via 'let' and 'letrec', conditional statements, first-class functions, statement sequences, procedure applications and quoted constants. Recursion is handled, although only in tail-recursive contexts (contexts where a potentially infinite number of calls requires only a finite amount of saved state).

The current implementation of LEGOScheme was designed purely as a proof of concept, yet we were able to design a robot which could intelligently navigate a hallway using two sensors with only 57 lines of Scheme code.

It is hoped that LEGOScheme could be used in introductory computer science courses to enrich the teaching of functional languages. Scheme itself has been proven effective as a teaching language and is currently used in introductory courses at Indiana University, Rice and M.I.T. LEGOScheme could enrich such courses by showing a practical application for this functional language.

LEGOScheme was written by Adam Wick '00, Kasey Klipsch '00, and Mitch Wagoner '00, three exceptional undergraduates in the CS department at Indiana University, Bloomington.

http://www.indiana.edu/~legobots/legoscheme/index.html

What does LEGOScheme look like?

Presented here is the code for the first Schemebot built at IUB, a rather reckless bump-and-wander bot. Below, his portrait.

```
(define try_again_left
  (lambda ()
    (set-engine-on/off "02" 'off)
    (set-engine-direction "02" 'backward)
    (set-engine-speed "0" 5)
    (set-engine-speed "2" 1)
    (set-engine-on/off "02" 'on)
    (wait 100)
    (set-engine-on/off "02" 'off)
    (set-engine-speed "02" 5)
    (set-engine-direction "02" 'forward)
    (set-engine-on/off "02" 'on)))


(define try_again_right
  (lambda ()
    (set-engine-on/off "02" 'off)
    (set-engine-direction "02" 'backward)
    (set-engine-speed "0" 1)
    (set-engine-speed "2" 5)
    (set-engine-on/off "02" 'on)
    (wait 100)
    (set-engine-on/off "02" 'off)
    (set-engine-speed "02" 5)
    (set-engine-direction "02" 'forward)
    (set-engine-on/off "02" 'on)))

(define setup
  (lambda ()
    (setup-sensor 2 'switch 'boolean)
    (setup-sensor 0 'switch 'boolean)
    (set-engine-direction "02" 'forward)
    (set-engine-speed "02" 5)
    (set-engine-on/off "02" 'on)))

(define task_one
  (lambda () ;; main loop
    (let* ((x (and (read-from-sensor 0) (read-from-sensor 2)))
           (y (or (read-from-sensor 0) x)))
      (if (= y #t)
          (begin
            (try_again_left)
            (task_one))
          (if (= (read-from-sensor 2) #t)
              (begin
                (try_again_right)
                (task_one))
              (task_one))))))

(define task_zero
  (lambda ()
    (setup)
    (task_one)))
```

Teachers at Work and Play

Q515 provided graduate students in the School of Education the opportunity to interact and collaborate with practicing teachers, discussing and implementing new, innovative ways of approaching topics in biology, life science, computer science, physics, and even (yes!) 2nd grade life lessons in sharing and community. We believe that this kind of interaction helps provide fresh ideas for creating better learning environments for students, and just as importantly, support and tools for teachers to use when they enter the classroom.

Left: Mike and Jodi represented the remote contingent in Q515, coordinating with their classmates through the use of teleconferencing and web conferencing tools.

Right, Top: Gene and Sufen making their best attempt to sort and verify the contents of their kits.

Right, Bottom: Tom Keating lending a helping hand to Carol, our 2nd grade teacher who found ways to distill down anything we dealt with into a form she could use with her students back home.

http://www.indiana.edu/~legobots/q515/index.html

WebWorms

The WebWorms project is a continuation of work with the Mindstorms kit for both JT and Matt (pictured at right). Having taken part in the A110 TecTrac during the Spring 1999 semester, they wanted to continue developing their programming and building skills. In collaboration with Prof. Jonathan Mills and Matt Jadud, an independent study designed to introduce Matt and JT to research at the university level was put together.

Matt and JT are picking up the work done previously by Ph.D. students in the Adaptive Systems Lab, attempting to build a colony of robots that interact and communicate with each-other. In particular, they are attempting to model the behaviors of the common tent caterpillar, which when threatened by a predator, twitches about in synchrony with its neighbors as a cohesive group, attempting to scare off their assailant (or, perhaps, prevent the predator from landing on them easily).

The Mindstorms kit has proven to be an effective vehicle for these two as they attempt to come up with some plausible explanation for how and why the tent caterpillar (or, as we affectionately say, 'webworm') do their funny dance the way they do.

From the WebWorm Wranglers' Mouths...

The WebWorms project to date is going very well. Project milestones met so far include learning Not Quite C and prototyping robots to be used in the final modeling of the worms' behavior. We have moved away from thinking about the robots and the programming, and are now thinking about what possible biological systems may be at work causing the "twitch" behavior. Many possible theories have been proposed; now we only need to weed out the less likely candidates in favor of more strongly supported theories.

Matt is a Junior Fine Arts major at IUB, and JT is as of yet undecided, just beginning his second year at here.

Right: Matt and JT have both taken active roles in designing, building, and programming their robotic 'web worms.'

http://www.indiana.edu/~legobots/webworms/index.html

Kudos and Thanks

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