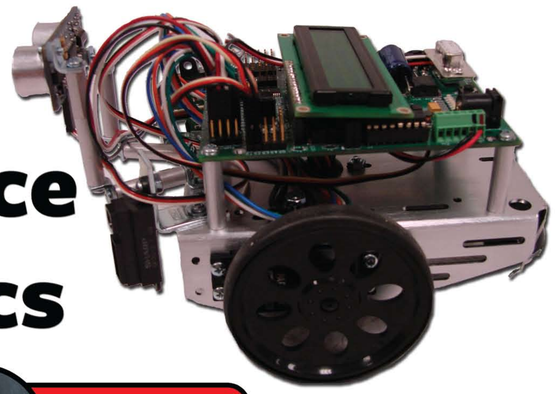
Exploring Computer Science Through Robotics



Abstract

The field of Computer Science is growing rapidly, yet high school students often remain uninformed about the details of the field. Overall, introducing students to the field of Computer Science through the use of robotics applications not only proves efficient and useful, but also provides insight into the discipline and can attract them to the field. This work presents a method for introducing high school students to the field of Computer Science through the use of Intellibrain Java programmable robots. The material is structured into a five day course in which students become associated with basic Object Oriented programming styles, utilize the Java programming language, and discover practical applications of computer programming. Additionally, concepts concerning Intellibrain interactions with IR range sensors, IR photo reflectors, and sonar sensors are explored. An outline for the course, a description of the concepts and teaching methodology and sample materials are presented.

Autonomous Robotics

Students are transformed from having very little knowledge of Computer Science concepts to having a firm understanding of fundamentals via autonomous robotics. By the end of Session Five, students can program a robot to autonomously solve any maze.

"My favorite part of the camp was learning about Java."

"I like programming the robots."

"This is great, you definitely need to do this."

Goals

- **Explain Computer Science -** computer science, a field of great diversity within itself, often goes unnoticed and unexplained to students making decisions regarding career paths. This material strives to explain to the unfamiliar high school student the fundamental ideas of computer science.

- **Interest Students -** computer scientist are in great demand, and that demand only grows larger each day. Through this course students are encouraged to make practical and fun application of computer science concepts. Students are shown over and over that the simple concepts of computer science apply broadly throughout a number of systems and products in existence today.

- **Teach Students -** this course aims to expose as many high and low level computer science concepts to high school students as possible. Students are given a primer in object oriented design, basic control structures, and even behavior based programming. At the finish of each session students have made great strides in their understanding and abilities. Additionally, by the final session, students have progressed on from a level of zero programming ability to one of successful problem solving.

- **Retain Students** - by showing students the diversity of computer science related tasks, this course aspires to retain students in the computer science field. Expressing basic programming through robotics is fun and exciting, if students can experience joy early on in their accomplishments they will aspire to continue and grow more confident in the field.

Methodology

Relying on intrigue and curiosity as its driving force, the Intro to Autonomous Robotics material introduces fundamental computer science concepts while peeking the student's interest in exciting robotics applications. Core concepts include:

- ***Teach With Purpose* -** the material attempts to connect even the most basic Java Programming concept to some real world application or robot function. Students stay interested, as the concepts are instantly being put to work in their robotics projects.

- **Promote Problem Solving -** great computer scientists are great problem solvers. The teaching material works to establish strong patterns of logical thinking. Students are encouraged in each session to answer though provoking questions which will affect their real-world robotics programs.

- **Code Building -** students are shown early on that the code they write will be built upon over the course. As the course continues, students being to build up a code base of functionality they have written. This code is reused and built upon in each session.

- **Inspire Zeal -** passion alone can carry a student miles on their journey through the Intro to Autonomous Robotics material. The material provided is only a guide, and encourages students to become creative masters of design. Students are given ample time to form their own creations, put their ideas into play and accomplish something they find exciting.

Session One

Students are introduced to the ideas of computer programming, robotics and the fusing of the two.

Object Oriented Programming, along with the basic concepts of Java are introduced in the day one material. Students are encouraged to think about programming the computer to complete some task, rather than using already developed software. Additionally, students are introduced to the Intellibrain robot and its primary development environment. After only one session, students will have their robots displaying, moving and signing.

Exercises:

Hello World - Display a message on the robot's screen.

Drive Around - Basic introduction to moving the robot by setting power levels of servo motors directly.

Beeper - utilize the robot's built in speaker to create sound at various frequencies and durations; play a song with the robot.

Session Two

Computer Scientist are always striving to make their lives easier, on day two students become familiar with methods, loops and conditions.

Students love day two simply because it allows greater control of their robot's movement coupled with easier programming style. After developing motion methods for their robot, students can then use these methods anytime they need to move their robot. Students also experience the power of loops and conditions, allowing their robots to perform more complex tasks. Students are asked to think critically about how to create methods for turning both left and right. Finally, students are introduced to the idea of calibration and error correction of their robot. Issues such as surface, battery life, and sensitivity are explored in a hands on approach.

Exercises:

Turns - Students create their base motion methods, with emphasis on the turn left and turn right methods. Servos must be given specific power values for certain durations in order to perform a correct and accurate turn.

Repeat -Students are exposed to the most common use of loops and conditions, while performing critical thinking in order to tweak their robot's motion.

Custom Drive - Creativity runs wild during this exercise. Students are encouraged to create the most useful, entertaining or interesting project they can using the basic motion techniques they already posses. This exercise inspires students to see the need for input concerning their environment.

Session Three

What if our robot could make decisions based on its environment? Session Three introduces students to the power of sensors.

If our robot can understand the world around it, we can program it to make decisions based these factors. Session Three focuses around inspecting the world around the robot. Students are given the opportunity to use sonar sensors, infrared range sensors and photo-reflector light sensors in order to discover what is around them. Combining sensor readings with motion methods, loops and conditions allows for a seemingly intelligent robot which can perform task while making decisions. Students must work to make correct logical programming choices which will affect the outcome of their robot's behavior. Special attention is given the distance of surrounding objects, as well as color change below the robot. Students are also given a chance to learn about the accuracy of various sensors and the conditions which can cause them to behave in both predictable and unpredictable manners.

Exercises:

Sonar Sensor - Students combine motion methods, loops, conditions and sensor readings in order to have their robot's avoid hitting objects which may obstruct the robot's path. Students are encouraged to experiment with different thresholds of sensitivity as well as the reaction the robot should have to an obstruction.

Door Finder - Combining all previously learned techniques with the infrared range sensor, students work to find an opening within a straight wall (a door). The robot should progress along a wall, beeping when it detects an opening within the wall. Students are required to use two sensors, in order to validate their readings. This exercise exposes the world of redundancy within systems and checks which need to be performed to assure accuracy of measurements.

Stop - The Stop program uses the photo-reflector light sensors under the robot to detect a color change. Students are tasked with telling their robots to perform until driving over a dark colored area, at which time the robot should stop operation.

Session Four

Can a robot appear intelligent? Session Four teaches how behavior based programming can make the Intellibrain function autonomously while appearing intelligent.

Behavior-Based control of a robot makes complex tasks easier. In order to form a behavior-based program, students must first determine which behaviors a robot will need for a given task. Students spend significant amounts of time during Session Four working to understand flow of control when behavior arbiters are involved in controlling the program execution. Session Four proves to be a steep learning curve, but not out of reach for those who are determined.

Exercises:

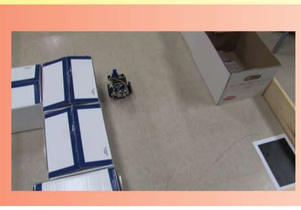
Object Circle - Students use behavior-based programming to have their robots circle around an object. This exercise combines infrared range sensors and motion methods into a behavior-based system which can then successfully circle around an object, without touching it.

Avoid - Students re-implement an earlier program, this time using a behavior-based approach. Avoid is a behavior-based version of Sonar Sensor from Session Three. Students are encouraged to compare results from the two programs.

Session Five

Robots ready, Maze Solve!

Session Five combines every concept learned over the previous four sessions in order for students to solve any maze autonomously using their robots. Using sensors, motion methods, loops, conditions and behavior-based technique, students compete to see which robot can successfully navigate a maze with the most accuracy.



Materials

Custom materials were developed over the Summer of 2007. These materials work to uphold the chosen methodology and goals. These materials were relied upon by session instructors during the one week academy which piloted Intro to Autonomous Robotics. The materials were last updated in Summer of 2008, after completing a full cycle of use.

Leader Guide -

- **Keynote Outlines -** detailed notes covering each keynote presentation are include. These notes explain each topic in depth to both the instructor and student.
- **Examples, Teaching Ideas -** the guide includes several ideas for furthering activities or varying the specifics.
- **Line By Line Solutions -** every piece of solution code is documented,line by line. You'll never be without an explanation.

Resource Disc -

- **Program Solutions -** a copy of a solution to each exercises is included. Solutions contain detailed comments.
- **Keynote Presentations -** multiple formats of the daily keynote presentation are provided for any viewing situation.
- **Maze Building Plans -** to scale plans for the final project are included.
- **Web Server Pack -** a folder which you can copy to a web server for easy access by students.
- **Student Pack -** complete pack of files a student will need for all five of the sessions. Includes student template files for each exercise.

Outcomes

Our pilot group participated in Intro to Autonomous Robotics as part of a larger academy in the Summer of 2008 at Lamar University. Students were evaluated through pre/post test, self-reports and interviews. Our results indicate:

- **Significant Knowledge Gain -** in the robotics portion of the academy, students showed a significant level of performance increases. The combined pre/post test score for the academy over the five day period rose from pre test at 6.29 to post test scoring 24.36 on average.

- **Continued High Interest -** the pilot group of students indicated a high level of interest in computer science both before and after the academy. Interviews with students indicate continued curiosity and intrigue concerning the field of computer science.

- **Great Satisfaction -** everyone of the seven high school students participating in the academy indicated a great level of satisfaction with the robotics material. Students were enthusiastic about returning to another academy if given the chance.

Our Group

Researcher Information:
Zachary Henkel - zmhenkel@tamu.edu
INSPIRED Team -Lamar University
Summer 2007 & Summer 2008

http://cs.lamar.edu/inspire