IRIS: A Student-Driven Mobile Robotics Project

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Abstract

This paper introduces the IRIS mobile robot project. IRIS is a largely student designed and implemented mobile robot platform created to provide a mechanism for classroom explorations of topics in artificial intelligence, cognitive science, and robotics. It has been designed to be used by students from middle school through college.

Teaching About Intelligence

Anyone who has taught artificial intelligence or cognitive science knows that there is always one question that hovers over every other topic that gets addressed: What does it mean to say that a given entity is "intelligent?"

It is a simple enough matter to discuss this topic in the abstract, referencing the Turing Test and Searle's Chinese Room, among other topics. Frequently, we can also discuss programs from the past, such as PARRY, ELIZA, or SHRDLU (see Copeland 1993 for descriptions).

However, not every instructor has available to them a modern, working system that can be used to concretely address the question of what is intelligent behavior. This is particularly true at smaller colleges and at the middle school or high school level. Whether due to lack of time, money, or expertise, few institutions have the means to construct a system that embodies the basic parameters of an intelligent agent.

The Mind Project

The Mind Project is an interdisciplinary, learning community that brings world-class researchers together with students and teachers from grade 6 to 16 with the goal of doing research and creating curriculum modules in the cognitive and learning sciences. During the past decade, the Project has produced three dozen interactive online curriculum modules and the website serves as a repository for high quality curriculum produced by other authors. Modules exist for teaching concepts such as Turing machines, the Turing test, neural networks, and machine learning. The Mind Project also sponsors international student research projects. The IRIS Robot Project is our most ambitious student research project.

The IRIS robot

The IRIS robot[1] is an attempt to create a relatively simple and inexpensive, but robust, mobile robot that can be used in conjunction with the ProtoThinker cognitive engine (described in more detail below). It consists of:

- A simple wooden base roughly 20" square in footprint and 30" tall. The bottom of the base is attached to two drive wheels powered by high-torque servo motors and an unpowered caster wheel for stability.
- A Robix gripper arm driven by six small servo motors attached to a Robix circuit board.
- A USB web cam to provide video input
- A laptop running the IRIS, Robix, and ProtoThinker software.

Each of these components and their capabilities will be explored in more detail below. They were each chosen to provide maximum ability and flexibility for the minimum cost. Thus, each component can be acquired off the shelf, except for the base, which may need to be constructed by cutting some plywood. Figure 1 contains a picture of the most recent version of IRIS.

[1]http://www.mind.ilstu.edu/research/robots/

Figure 1: The IRIS Robot

While there already exist several small mobile robotics platforms (e.g., LEGO Mindstorms NXT and the Parallax BASIC Stamp), these systems tend to be geared towards the exploration of relatively basic, low-level robotics. The LEGO system, for example, does not provide any support for a visual sensor. They also tend to be very limited in their computational power, which limits the range of cognitive tasks they are capable of performing. While these systems serve a useful purpose introducing students to how simple it can be for an artificial system to exhibit some forms of intelligence, they lack the power to perform more complex tasks such as planning, problem solving, and decision making. The IRIS project is an attempt to create a robotic system as intuitive to use as these other systems, but that still provides a platform powerful enough to directly address questions about intelligence.

IRIS Components

Sensors

Currently, the only sensing capability IRIS has is a web cam that interfaces with visual processing software. Currently, this software only enables IRIS to play tic-tac-toe with its gripper arm holding a pen. One of our next goals is to improve the visual processing to allow IRIS to recognize simple objects, such as colored geometric shapes. We also intend to add other sensors, such as bump sensors, as IRIS becomes more mobile.

ProtoThinker

ProtoThinker[2] (Barker 2002) is the software that serves as the "brain" for IRIS. It provides a relatively simple model of cognition that none the less is able to problem solve and perform natural language processing through either typed commands or through a speech-to-text module. It models cognition with sentential logic, some features of predicate logic, and a range of heuristics that restrict it to processing syntactically simple sentences, though some work has been done attempting to extend PT's capabilities to analogy and metaphor.

Action

IRIS currently has two sets of actions it can engage in. One set involves the use of the drive wheels, to maneuver around a room, for example. Currently, none of the physical IRIS simulations take advantage of this.

The second set of actions that IRIS can perform involves a servo operated gripper arm driven by a Robix circuit board. The arm consists of five servos reflecting the six degrees of freedom that the human arm and wrist have, and one more for a pincher at the end to grip objects with.

[2] http://www.mind.ilstu.edu/research/pt/

IRIS Simulations

There are currently three IRIS simulations. Two use the physical robot itself while the third is a software simulation of a virtual IRIS intended to model the behavior of a fully capable IRIS robot.

Tic-Tac-Toe. IRIS is also capable, through the web cam interface and ProtoThinker, of playing Tic-Tac-Toe on a piece of paper in front of it using a modified version of the gripper arm that holds a pen.

Blocks. The first IRIS simulation is an implementation of a simulation from an earlier version of IRIS that only used the gripper arm. In this simulation, IRIS is able to pick up a block and place it in a cup. Currently, this simulation relies on pre-programmed movements. If the block or cup are in different places than IRIS expects, the simulation will fail.

Virtual Robotics Laboratory. The Virtual Robotics Laboratory[3] is an on-line simulation of the IRIS robot intended to walk students through the process of constructing a robot and programming it to perform a specific behavior (in this case, driving to the work bench, picking up the empty soda bottle, and dropping it in the recycling bin). Students utilize a virtual IRIS robot, ProtoThinker, and a virtual version of the IRIS scripting tool.

IRIS as an Educational Tool

IRIS can serve two primary functions as an educational tool: In the classroom for groups to explore issues in robotics, artificial intelligence, and cognitive science; and in the laboratory as students work on expanding IRIS's capabilities and designing better, smarter versions that can then be integrated back into the classroom.

In the Classroom

IRIS is designed to be used by students from middle school on, and we are currently preparing to do our first introductions into middle-school and high-school classrooms in 2010. Despite some of its current limitations, IRIS can still be used to explore a number of interesting issues. Some examples would be:

Robotics. We are currently completing a GUI interface that will allow students to create programs involving sequences of actions that IRIS can engage in. As a learning tool, this will allow instructors to use the Blocks simulation described above as a demonstration, and then challenge their students to use their own IRIS robot to replicate that simulation. Since all of the gripper arms are custom built, and no two servos work in precisely the same fashion, students will have to experiment with the proper combination of motions required to replicate the

[3] http://www.mind.ilstu.edu/curriculum/virtual_robotics_lab/index.php?modGUI=208&compGUI=1960&itemGUI=3428

simulation. This will introduce them to common issues that arise in engineering mechanical systems, even ones that are supposed to behave intelligently.

The scripting tool will also allow for the control of IRIS's drive wheels, adding another layer of complexity to the types of tasks that students can be asked to engineer, such as to pick up a block from a particular spot on one table and deliver it to a spot on another table.

Artificial Intelligence. As students are building their robots and writing their programs, this provides an opportunity to explore the question of whether their programs are intelligent or not. Issues that would be raised include classics such as what their robots are missing that makes them not intelligent, what would need to be added, and at what point do their robots become intelligent.

Students can also be asked to combine these two elements to try and replicate in the real world the sequence of events that occurs in the Virtual Robotics Laboratory.

In the Lab

The other educational purpose that IRIS serves is in the lab where students work on improving its capabilities. The IRIS project is, fundamentally, a student research project. Faculty serve primarily in an advisory capacity, setting the larger goals of the project and providing guidance and expertise as needed. The design and implementation of IRIS (with the exception of ProtoThinker) has been largely carried out by undergraduate students. This includes the physical design of the robot, most of the software, and the extensions such as the programming GUI that are currently being implemented. Thus, the IRIS project gives students at multiple institutions a chance to participate in the design and implementation of a comprehensive robotic platform, as well as the process of making such a platform accessible to students and programmers at all levels.

IRIS in schools

IRIS will make its first appearance in classrooms in the spring of 2010. As of this writing, there are two teachers in Detroit, three in Illinois, and one in Pennsylvania that are planning to use IRIS in their high school technology courses. There is also a college level team including three students from Illinois State University, a student and faculty member at the Technical Institute of Lisbon (Portugal), and a research fellow and faculty member at California State University, Monterey Bay.

Cost

IRIS is designed to be relatively inexpensive, while providing a robust platform for exploring issues of cognitive science and artificial intelligence. There are multiple configurations of IRIS depending on exactly how a teacher intends to use it and what resources are available. For high schools and middle schools, many of the components are provided by The Mind Project from a NIH grant. Not counting the laptop, a basic configuration with just the Robix arm and controller is less than $400. The full IRIS robot (again, not counting the laptop) is less than $800. YMCA International has donated some old laptops for use by schools adopting IRIS for use in the classroom.

Future Directions

There are numerous extensions to IRIS that we are planning to implement to make it an even more robust system. Primary among these is increasing the capability of the visual system to allow it to recognize a wider range of objects. We also intend to add other types of sensors, such as bump sensors, to increase the kinds of information IRIS can gather and respond to.

As each extension is implemented, the programming GUI is being extended to accommodate these new capabilities. Thus will IRIS become a robot that is more easily programmed to respond to its environment, making it a more useful tool in the classroom for providing a concrete exploration of many of the fundamental issues in artificial intelligence.

Acknowledgements

This work was funded with NIH grant R25RR020425, a Science Education Partnership Award (SEPA) five year, $1.3million grant supporting "The Mind Project's Cutting Edge Health Science Initiative."

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