

# Robotics in the Classroom: Providing Robotics Equipment to Support Intelligent Systems Curricula\*

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## Abstract

The authors present how the Institute for Research in Intelligent Systems (IRIS) at California State University, Chico (CSUC) provides access to robotics equipment to support courses in intelligent systems. The supported courses range from core courses in computer science, general education courses, and senior project courses in computer science and in engineering.

## Introduction

In the Fall 2003 semester, the authors were awarded a National Science Foundation (NSF) Major Research Instrumentation (MRI)/Research in Undergraduate Institutions (RUI) grant. The primary focus of the grant was to acquire robotics equipment for use in intelligent systems curriculum development, research, and outreach activities. The authors formed the Institute for Research in Intelligent Systems, or IRIS (IRIS 2006), to oversee the Intelligent Systems Laboratory, or ISL (ISL 2006). The ISL facilitates development of inter-disciplinary intelligent systems courses and provide exciting collaborative research possibilities for students and faculty.

## IRIS Facilities

For basic/beginning robotics, IRIS has thirty (30) *LEGO Mindstorms* kits. Each kit includes one (1) light sensor, one (1) rotation sensor, three (3) Technic 9-v Mini-Motors, and two (2) touch sensor bricks.

For intermediate robotics, IRIS has six (6) *Lynxmotion Carpet Rovers* with dual Hitec HS-422 servo drive systems and a *Parallax BASIC Stamp 2* (BS2) module. Additionally, each robot has a *Lynxmotion Lynx 5 Arm and Gripper*. IRIS also has six (6) *Lynxmotion Extreme Hexapod 1* with *Savage Innovations OOPic-R* robot controller boards.

For advanced robotics, IRIS has three (3) *Sony AIBO ERS-220A* and ten (10) *Sony AIBO ERS-7M2* quadruped robots. The ERS-7M2s are only used by IRIS's Robocup

Team. IRIS also has six (6) *K-Team Khepera II* mini robots. Recently, IRIS acquired ten (10) *LEGO Mindstorms NXT* kits.

IRIS also has a number of *Parallax Boe-Bots*, and some older model *iRobot Roombas*. Available equipment include microcontrollers such as *Parallax BS2* modules and *Net-media BX24* modules, as well as a variety of sensors such as IRPD modules, ultrasonic range finders, *CMU-cams*, and others. IRIS also has are five (5) *Crossbow MicroNav MNAV100CA* sensor suite modules (with accelerometers, angular rate sensors, magnetometers, static and dynamic pressure sensors, and a GPS sensor). A number of desktop and laptop computers are available to support intelligent systems research, instruction, and outreach activities.

## Supported Courses

**CSCI 313H: Mind in the Machine** is "an Honors seminar that explores the psychological, philosophical, social, biological, and technical aspects of machine *minds*" (CSU, Chico 2005). This course is an approved General Education course. Robotics demonstrations involving IRIS's Lynxmotion hexapods and Parallax Boe-Bots have been used to successfully discuss sensory input, dynamic environments, and sensor fusion. In Spring 2006, a Sony AIBO ERS-7M2 was used to videotape and compare student interactions with quadruped robots and with a real dog.

**CSCI 330: Software Engineering** engages students with special problems in the development of large software systems. A group project is required in this writing proficiency course. In Fall 2006, students were involved in either developing an IRIS equipment inventory database or work with IRIS ERS-220A robots. The database project facilitates inventorying of all the robotics equipment managed by IRIS. The initial database design was accomplished by another group of students in another course (see CSCI 470). The group working on the ERS-220As were given a simple robotics task the group had to solve using the quadrupeds.

**CSCI 380: Machines, Brains, Minds** is "an examination of the emergence of artificial mind in machines, with special attention to related issues in the philosophy of mind and cognitive science" (CSU, Chico 2005). This course is also an approved General Education, upper division theme course.

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In Fall 2004, IRIS loaned a student group an AIBO ERS-220A and some Boe-Bot line followers so the students can demonstrate and open up philosophical discussions on how robots sense their environment.

**CSCI 470: Database Management** has a project component that “entails requirements definition, design, and implementation of a database application.” In Spring 2006, students were involved with the design and implementation of an IRIS equipment inventory database. The project was continued by another group of students in another course (see CSCI 330).

**Senior Capstone Project** in computer science is CSCI 490, Directed Programming Experience, a 1 to 3 unit “special topic programming experience” (CSU, Chico 2005) course. In Spring 2006, the authors mentored a group of three students to work on the IRIS ERS-7M2 robots by attempting to install and run the GermanTeam Robocup 2005 code (GermanTeam 2005). IRIS has also supported groups of engineering students working on their senior projects, including a “simple vision”-based autonomous robot and an autonomous electric wheelchair-based robot guided by an IRIS Crossbow MNAV100CA multisensor module.

**CSCI 567, GUI Implementation** In Spring 2005, one of IRIS’s K-Team Khepera II mini robots was used to provide students the opportunity to work on a project that required the implementation of a GUI that remotely controlled the Khepera II robot (Challinger 2005). GUIs were implemented using the Java Swing API.

**CSCI 583, Expert Systems and Applications** introduces students to “the basic concepts and techniques of expert systems” (CSU, Chico 2005). In Spring 2005, XS Lisp (Yuasa 2006) was used successfully with IRIS LEGO Mindstorms to introduce students to a fun project in Lisp.

**CSCI 585, Robotics and Machine Intelligence** “introduces students to the field of robotics by emphasizing the task of endowing machines with intelligence” (CSU, Chico 2005). IRIS LEGO Mindstorms kits are typically used in the first half of this course where students design, build, and program robots for specific tasks. The course is structured so that on the second half of the course, students use their own Parallax Boe-Bots. Details of this course are presented in (Juliano & Renner 2007).

**CSCI 681, Theory of Artificial Intelligence** is “an in-depth study of current techniques, applications, and issues in artificial intelligence” (CSU, Chico 2005). In Spring 2005, IRIS Lynxmotion Carpet Rovers with CMU-cams were used to supplement the topics covered in the course. The Carpet Rovers’ BS2 modules were replaced with BasicX-24 (BX24) modules programmed with a BX24 port developed by IRIS.

### Assessment

There are many challenges to introducing robots into the curriculum (Murphy 2000). To assess the impact of providing robots to support intelligent systems curricula, the au-

thors used a standard evaluation metric called the *Student Evaluation of Teaching*, or SET, which is based on a 5-point scale.

Of the courses listed in the previous section, three courses, in particular, illustrate improvements in SET scores apparently as a result of using IRIS robotics equipment to facilitate instruction of intelligent systems related concepts. Two of these courses are General Education (GE) courses taken by non-majors (neither Engineering or Computer Science). One of them is CSCI 313H, which had an SET score improvement of 4.81% from 4.16 in Spring 2005 to 4.36 in Spring 2006 when robots were used to facilitate discussions on theories of artificial intelligence and classic themes in human cognition and philosophy. The other GE course is CSCI 380, which had an SET score improvement of 31.42% from 2.96 in Spring 2004 to 3.89 in Fall 2004 when robots were used by student groups to open up class discussion on philosophical issues regarding how robots sense their environment. The third class is CSCI 583, a majors (in Computer Science) class, which had an SET score improvement of 13.92% from 3.52 in Spring 2004 to 4.01 in Spring 2005 when LEGO Mindstorms were used to introduce students to Lisp. The authors realize that these improvements in SET scores could just be coincidental, even though the only significant adjustments made between the indicated semesters was the introduction of robots into the curriculum.

Another advantage to having various robotics platforms and equipment available through IRIS is that these can also be used for research and outreach activities (Renner & Juliano 2007).

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