A Top-Down Education Approach In Robotics and Mechatronics Courses

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Abstract

In a *top-down* approach to education, students are introduced first to the applications and systems concept, which then leads to the teaching of fundamentals. Experiments, labs, and projects can be used to motivate technical discussions and concepts. Utilizing this top-down education style provides perspective and motivation to students, and attracts students to the field.

This innovative approach incorporates the following pedagogical topics:

- Project-based Learning
- Active Learning
- Self-directed learning
- Learning with Technology

Introduction and Objectives

The goal is to develop top-down course curriculum for Robotics and Mechatronics courses in which students are introduced first to the applications and systems concepts which then leads to the teaching of fundamental concepts . The curriculum should combine theory with hands-on technical experience in cutting edge technologies to dynamically engage students with the intent of sparking an enduring interest in engineering and technology.

Courses/Programs where the approach has been applied:

- Summer Academy on Applied Science & Technology – Robotics (high school)
- Introduction to Robotics (undergrad/grad)
- Microprocessor Applications in Mechanical Engineering (undergrad/grad)

Developmental History of Innovation

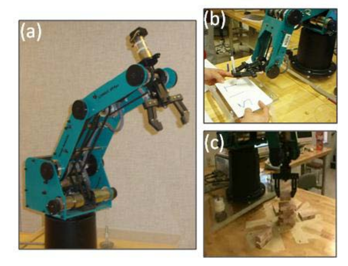
- Approach implemented initially in Summer of 2005 at the University of Pennsylvania Summer Academy in Applied Science and Technology (SAAST) Robotics course. It has evolved every year since then.
- Implemented at Stevens Institute of Technology courses: Introduction to Robotics (S09, S10, S11) ; Microprocessor Applications in Mechanical Engineering (F09, F10)

Learning Activities and Materials

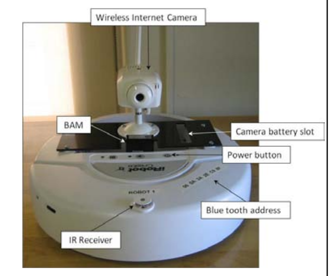
Introduction to Robotics

- Robot Video of the Day
- Class youtube site
- Robot Manipulator Labs
  - Kinematics & Path Planning
  - Palletizing Task
- Mobile Robot Labs (MRL)
  - Locomotion & Sensors
  - Vision-Based Navigation
  - Localization
- Midterm Project

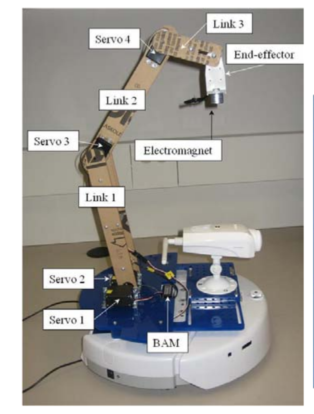
Mobile Robot Manipulator Design & Implementation

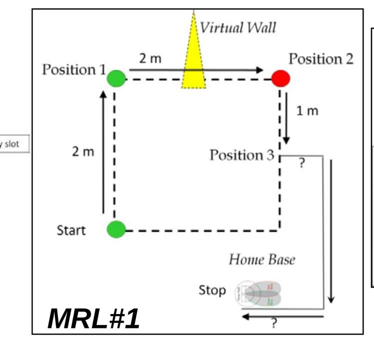


Manipulator Labs: (a) Intelitek SCOREBOT Manipulator; (b) Lab 1 - Kinematics and Path Planning; (c) Lab 2 - Palletizing Task

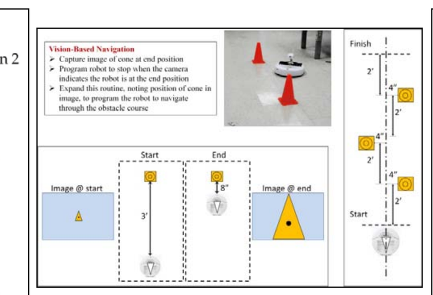


Modified iRobot Create Mobile Robot Platform

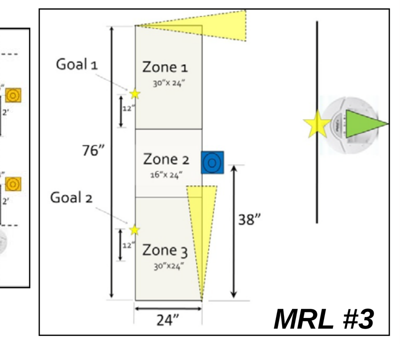




MRL #1

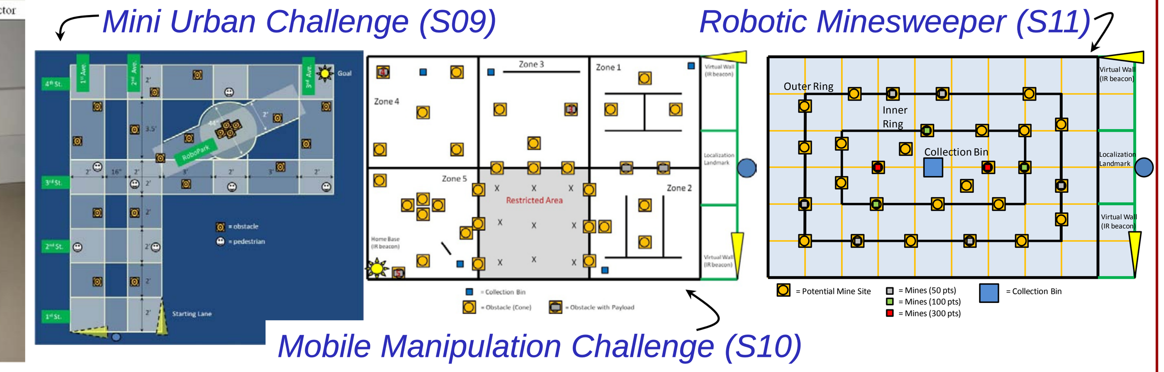


MRL #2



MRL #3

- Final Project Competition



Mini Urban Challenge (S09) *Robotic Minesweeper (S11)* *Mobile Manipulation Challenge (S10)*

Learning Activities and Materials

SAAST: Robotics

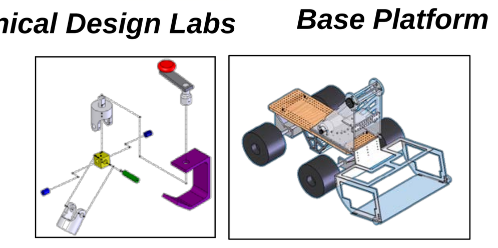
- Design Game
- Worlds Strongest Truck Competition
- Electronics Labs
- Mechanical Design Labs
- SolidWorks (CAD) Labs
- Final Project Competition
- Class presentations

Design Game

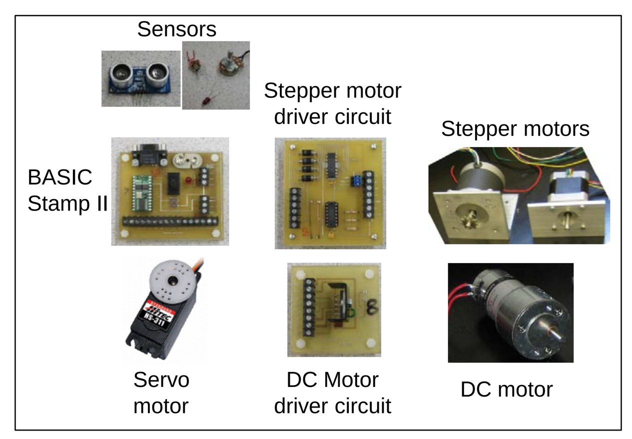
World Strongest Truck Competition

Mechanical Design Labs

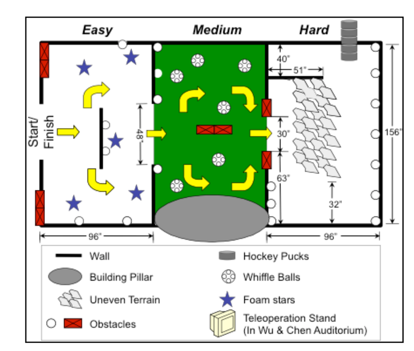
Base Platform



SolidWorks Labs



Electronics Labs



Final Project Competition Course

Gallery of Final Project Designs

Student Presentations

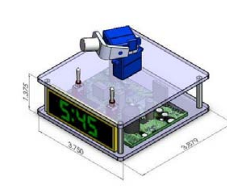
Learning Activities and Materials

Microprocessor Applications in Mechanical Engineering

- Electronics Labs
- Microprocessor Interfacing Labs
- System Simulation Labs (NI MultiSiim)
- Open-ended Final Design Project
- Competition-based Final Design Project

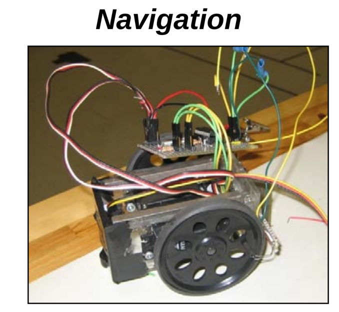
Final Project Required Functional Elements

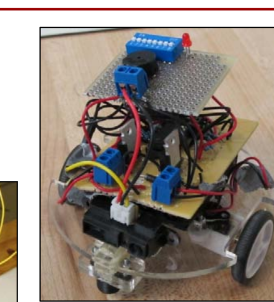
- ➢Output Display
- ➢Manual Data Input
- ➢Automatic Sensor Input
- ➢Actuators & Hardware Interfacing
- ➢Logic, Processing, & Control
- ➢Audio Output Device



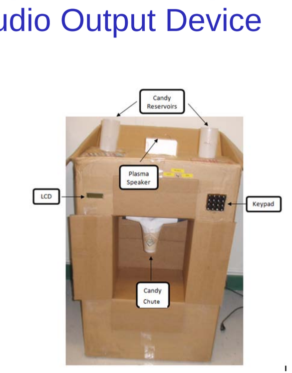
Body Heat Sensing Alarm Clock

Competition: Robot Design & Build for Autonomous Maze Navigation

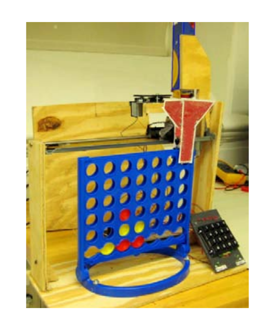




Robots must fit within 4x4x4 in^3 volume

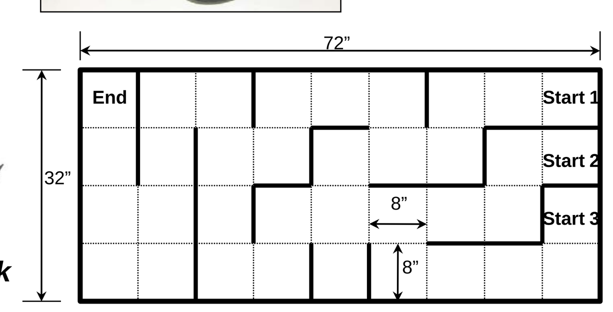


Pick & Choose Candy Dispenser



Automated Connect-4 Game

Mobile Snooze Button Alarm Clock



Final Project Competition Maze

Related Publications

- D.Cappelleri, J. Keller, T. Kientz, P. Szczesniak, and V. Kumar, "SAAST Robotics - An Intensive Three Week Robotics Program for High School Students", *Proceedings of the ASME International Design Engineering Technical Conference (IDETC)*, Las Vegas, 2007.
- J. Keller, D. Cappelleri, T. Kientz, N. Ayanian, P. White, and V. Kumar, "Capturing the Interest of Future Engineers: The Development of an Intensive Three-week Summer Academy in Robotics for High School Students", *Proceedings of the Fall 2008 ASEE Mid-Atlantic Section Conference*, Hoboken, NJ.
- D. Cappelleri, "A novel lab and project-based learning introductory robotics course". Special Issue on Novel Approaches to Robotics Education, Computers in Education Journal, Vol. 1, No. 3, July-Sept 2010.
- N. Ayanian, J. Keller, D. Cappelleri, V. Kumar, "Development of a Successful Open-ended Robotics Design Course at the High School Level", Special Issue on Novel Approaches to Robotics Education, Computers in Education Journal, Vol. 1, No. 3, July-Sept 2010.

Major Issues to Resolve

Class scheduling to ensure the highest probability of success of final projects

Examine trade-offs in creativity versus design constraints to manage project complexity

Students like hands-on, project-based courses but what is the best way to asses learning in these types of classes?

How to implement techniques with lower overhead and resources in this and other classes?

Lessons Learned

Robotics and mechatronics courses can be a highly motivational context with which to interest students in the STEM fields.

With labs and open-ended design projects based on current technology components (motors, processors, etc.), students recognize the assignments as rewarding and are willing to invest their best efforts.

Regularly scheduled design reviews must be conducted with cumulative but incremental objectives.

Student groups must demonstrate rather than describe their designs at each stage.

Expert mentoring of weak groups is essential to preserving balanced performance in the final competition.

The value of hardware testing must be constantly affirmed to ensure the final design will function as intended during the competitions.

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