Illinois Institute of Technology

IPRO 316 – SPRING 2004

Faculty Advisor: Prof. Peter Lykos

CREATING AN INTERDISICIPLINARY ROBOTICS INITIATIVE AT IIT

Sponsor: IIT Collaboratory for Interprofessional Studies

ABSTRACT

IPRO 316 is in the business of innovation. Divided into multiple subgroups, each working on a unique, robotics oriented endeavor, the goal of the IPRO is to explore and develop robotics while gaining an understanding of robotic systems and functionality and exposing the IIT community to the extensive capabilities of such robots and the necessity of understanding them.

One of the divisions, the Rhino Robotic Arm group, has set their sights on automating a common task; bartending. Throughout the semester, this subgroup learned how robotic arms, a widespread robotics application in industrial processes today, function and accomplish various tasks. The objective of this project was not only to automate the work of bartending, but to discover and invent methods to apply robotic arm technology to the educational process. The use of this arm could prove to be a great teaching aid for robotics in the future, and would expose undergraduates to common, modern-day technology in the working world.

Another subgroup of IPRO 316 is constructing a mobile platform based on the Roomba floor vacuum. The group disassembled the Roomba, learning how it works in its entirety and installed a new, more powerful main-board. Through this reverse engineering of the existing platform, the group has created a robot that will serve as an educational tool and a platform for future robotic experimentation.

Developing a robot that interacts with its environment to perform user specified tasks, the Peppy Project is the third initiative of IPRO 316. The group built a chassis, designed transmissions, developed an object identifying sonar array, integrated robot control systems and programmed voice recognition to produce a robot that will serve as a platform for future IPRO and IIT activities, as well as the foundation for a possible Entrepreneurial Project.

Along with its other initiatives, IPRO 316 is laying the groundwork for a robotics competition on the IIT campus. Following guidelines similar to those of the DARPA challenge earlier this spring, the competition would challenge interested college students and professors to build a completely autonomous robot designed to complete a time trial style obstacle course. The competition would serve as a monumental learning activity in the undergraduate college experience as well as attracting national interest to IIT and demonstrating the Illinois Institute of Technology’s dedication to producing engineers of the future.

The main objective of IPRO 316 is to pave the way for a robotics curriculum here at IIT. Guest speakers have been invited to campus from places like MIT and FANUC Robotics to promote student and administrative interest in robotics. It is the group’s intent that, with our activity and demonstrated outside interest, it is evident that a robotics program at IIT is unquestionably necessary. With the exploration of electrical and mechanical systems, development of programs and evolution of robots, IPRO 316 is working to maintain the Illinois Institute of Technology’s place in the future.

T E A M   O R G A N I Z A T I O N

TEAM NAME		
PARTICIPANT	MAJOR	ROLE IN TEAM
Christopher Jones	Aerospace & Materials	IPRO Group Leader
Speech Recognition		
Daniel Krol	Computer Engineering	Programmer Website Developer
Eugenia De Marco	Aerospace & Mechanical	Mechanical Team Leader
Paul Stachowicz	Computer and Electrical	ENPRO Planning Electrical System
Jonathan Hovde	Aerospace & Mechanical	Sonar Design and Construction
Automated Bartender		
Nicholas Burika	Electrical Engineering	Project Manager Programmer
Robotic Mobile Platform		
Gabriela Monis	Electrical Engineering	Project Manager Hardware Design
Henry Oyuela	Computer Engineering	Web Developer Operating System

INTRODUCTION

Robotics is a growing industry, and it is growing rapidly. The commercial need for speed and efficiency has caused many companies to extend their resources to encompass robots. As a technological institution educating future engineers, the Illinois Institute of Technology (IIT) should promote the awareness of robotics both in the undergraduate and graduate levels. This IPRO 316 Subgroup's project was designed to be a demonstration of robotic experimentation preformed at IIT, and our product deliverable was devised in order to facilitate the use of a robot as an educative tool and platform for future robotic experimentation

The purpose of this subgroup's project was to transform a Roomba into a robotic mobile platform such that it could to be used as a base for robotic experiments and analysis. To accomplish this task, we chose a different microcontroller and programmed it to have the same functionalities of the Roomba motor wheels and sensors. We then integrated it into a Roomba, already in possession. The new microcontroller would allow for implementation of additional functionalities in future IPROs.

BACKGROUND

The Roomba is a robotic vacuum cleaner created by iRobot Corporation. It was originally designed to clean floors; however, it has also become a platform for experimentation with robotics. As the patent for the Roomba covers only the microcontroller, it is within rights to use the structure of the Roomba so long as a different microcontroller is employed.

Several independent groups have already begun this venture. For example, the Zoomba is essentially a Roomba with a different microprocessor. The Zoomba is connected over a serial interface which provides simple commands to control all of the motors on the Zoomba and reads the state of each sensor. The Zoomba can then be programmed to perform tasks other than cleaning.

This sub-section of IPRO 316 is in the process of programming a new microcontroller using the Parallax Javelin Stamp Board. The Parallax Javelin Stamp is a single board computer that was designed to function as an easily programmable "brain" for electronic products. The Javelin is programmed using Parallax software and a subset of Sun Microsystems Java Programming Language. Once a code has been downloaded onto the Javelin, it can run the program independently of any computer.

P R O J E C T M E T H O D S[1]

In order to understand fully the platform for our experiment, we planned to reverse engineer one of the Roombas. We spent some time researching the Roomba on the internet and read the Roomba patent. Upon entering the lab, we found both Roomba A and Roomba B to be non-operational; however, we succeeded in repairing both robots. Upon researching the Roomba and the MC68HC11 chip, we found several other options that could support our own application. We chose the Parallax Javelin Stamp rather than an MC68HC11 (mounted on a Handy Board) because it possessed more i/o pins, built in D/A and A/D conversion, and provides power width modulation (PWM).

Upon receipt of the Javelin Stamp, we attempted to program it with a simple algorithm to control the motor wheels of the Roomba. We began to test one of the wheel motors with this program; however, the motor would not function for any of the programmed conditions (forward, reverse, and stop). The motor did run when connected directly to the power supply. After further testing, we realized that the motor was not drawing enough current when connected through the processor. At that point, we began to research ways to implement robotic motors and found that low output current from processors was a common problem in programming motors.

In researching methods to increase current, we found many basic circuits used in robotics for this same problem. Most of these circuits, mainly H-bridges, did not seem very complex, four to eight transistors and a few resistors. However, after simulating these H-circuits using OrCad PSpice Simulation Software, we found that none of the simpler circuits produced the voltage and current levels that the Roomba motor wheels required to function. We then turned our attention to the Handy Board in order to examine how one drove motors via this board. We found that the Handy Board contained two motor driving chips: Texas Instruments, Quadruple Half H Bridge SN 754410NE and decided to use those chips rather than creating our own motor driving circuit.

Once the wheel motors were successfully programmed, we focused our attention to the infrared (IR) sensors located in the front bumper. In normal state the IR detector does not "see" any infrared light, and outputs a logic high. When the IR detector sees infrared light sent by the emitter diode, the output will drop from logic high to logic low. If the infrared light does not reflect off an object, the IR detector output will stays high. In the case of the Roomba, the emitter sends off infrared light. That light reflects back off the bottom of the bumper and is perceived by the detector, thus causing a logic low to the sensor input. When the Roomba collides into a wall or object, the bumper moves closer into the Roomba, and covers the sensors. The detector does not see any of the infrared light emanating from the emitter because all that light is blocked off. The IR detector then shits to its normal output state: a logic high. That high is sent to a sensor input pin; where the program is then set up create an interrupt in the main program.

[1] Documentation of additional circuitry can be found in the team binder.

Because each sensor outputs an analog signal, the sensor output must be converted to a digital signal before it can be used a meaningful input to the Javelin. The analog to digital converter is shown below. The complete circuitry for all five IR sensors and the interconnecting circuitry through the Javelin are appended.

The Roomba also contains three push button sensors: one in the front and one for each wheel. These sensors ensure that the Roomba is in the upright position and moving on level ground. The Roomba stops and turns around if any of those three sensors detects a signal. The circuit schematic used to test the push buttons are shown below. As indicated by the figure, the push button acts as a switch; when pushed, it allows current to flow from one end to the other. The test program was created such that the LED would turn on if the button was pushed. The program was designed such that the Roomba would stop and move in the reverse direction if any sensor was activated.

An additional component, similar the push button, was the user control interface. The original purpose of the user control interface was to allow the user to chose what size room he/she wanted the Roomba to clean: small, medium, or large. Only after one of those buttons was pressed would the Roomba begin to clean. As we no longer included the vacuum cleaning aspects into our design, we did not feel the need to program these components. We did, however, use the "S" button to initialize our program. A user must press the "S" button on the control interface in order for the Roomba to begin moving. The wiring is shown above in Figure 1, as all buttons on the user control interface are similar in function to push buttons.

Upon successful completion of the test and program stage of each individual component necessary for a robotic motor platform, we devised an operating system for the entire Roomba. The program is designed to check the correct operating mode for each component. If a component has been disrupted and has sent a signal to the main program, the Roomba will respond accordingly.

PROJECT TIMELINE

Our original focus of this subgroup's project was to program a different microcontroller to have the same functionalities of the Roomba, and then integrate it into the Roomba. At midterm, however, there arose a need for a mobile platform for use this semester. In accordance, we shifted our project goal in that we no longer attempted to recreate the functionalities of the Roomba; we instead disregarded the vacuum cleaning aspects in order to have the structure of the robot ready for use as a mobile platform this semester.

Although we did deviate from our initial goal, we did not completely digress from the main focus; rather, we simply disregarded certain components of the Roomba that are not vital to a robotic mobile platform. Before midterm, we decided that it would be more beneficial to test and program each individual object, i.e. motor wheels, brush motor, and additional sensors, rather than creating an entire algorithm and perform testing after the integration onto the Roomba. Thus, this shifting of focus did not invalidate any of our previous work.

The following chart compares our initial project proposal's timeline with the actual work we accomplished during this semester.

Week	Dates	Projected (January 30, 2004)	Final (April 30, 2004)
1	1/18-1/24	IPRO Introduction	IPRO Introduction
2	1/25-1/31	Project Proposal	Project Proposal, Set up Work Area
3	2/1-2/7	Reverse Engineer the Roomba, Understand the Roomba Algorithms, Acquire the MC68HC11 chip, Understanding the MC68HC11 chip	Reverse Engineered Roomba A, Tested & Repaired Roomba A, Researched Options for the "Brain"
4	2/8-2/14		Tested & Repair Roomba B, purchase of Javelin Stamp ("Brain")
5	2/15-2/21		Began testing Stamp with basic programs, attempted to program the motor wheels
6	2/22-2/28		Simulated Circuits to Attempt to Drive Motor Wheels, Midterm Report
7	2/29-3/6		Successfully Repaired Roomba B, use of PSpice to Simulate Potential H-Bridge Circuits
8	3/7-3/13		Successfully Programmed and Tested Wheel Motors
9	3/14-3/20	Programming the MC68HC11 chip	Successfully Programmed and Tested front IR Sensors
10	3/21-3/27		Successfully Programmed Wheel Sensors; Successfully integrated all components into one Program
11	3/28-4/3		
12	4/4-4/10	Integrate the Programmed Microcontroller and the Roomba	Funding Proposal for additional components for Roomba B; Constructed Report Template for Entire IPRO Group; Began Documentation (Manual)
13	4/11 - 4/17		Successfully powered Javelin Stamp using the Roomba battery; completed all circuitry for Roomba B; Completed Introduction for Group Website
14	4/18-4/24	Preparation for IPRO Week	Final Report Written; Documentation for Next IPRO completed; Presentation Prepared

15	4/25 - 4/30	IPRO Week	Presentation at IPRO Week

BUDGET

The following chart contains information on our purchases for this semester.

Quantity	Item	Amount
2	Parallax Javelin Starter Kits	$478.00
2	Power Supply	$20.00
	Shipping and Handling for the Javelin	$47.07
2	Protoboards (including tax)	$29.36
4	Quadruple Half H Bridge SN 754410NE (including shipping and handling)	$10.35
Total		$584.78

CONLUSION

This report details the midterm progress of our IPRO 316 sub-group project, the Mobile Platform. As stated, the purpose of this project was to create a mobile platform using the Roomba as a base. In creating this platform, we hoped to facilitate the use of this robot as an educative tool and platform for future robotic experimentation at IIT. A more detailed document for each individual component can be found on our website: www.iit.edu/~ipro316s04

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www.focus.ti.com/docs/prod/folders/prints/SN754410.html
http://plan.cs.drexel.edu/project/legorobots/hardware/sensors/ir.html
http://plan.cs.drexel.edu/project/legorobots/hardware/sensors/proximity.html

AUTOMATED BARTENDER

(RHINO ARM)

INTRODUCTION

In the field of robotics, the most widely used device is a robotic arm. IIT recently purchased a Rhino Robotics XR-4 Arm and a Mark IV Controller for its showcase lab located in E1. The use of this arm could be a great teaching aid for robotics so I decided that my one-man team would use this arm to further robotics ideas and skills here at IIT.

OBJECTIVE

The purpose of my subgroup was to be familiar with the Rhino robotic arm and to then pass on the knowledge to the next robotics IPRO. In order to reach this goal I thought of two objectives:

1. To have the arm do a project involving automation.
2. To make a mini-manual from the 5 manuals provided by Rhino.

PROJECT SCHEDULE

PROGRESS IN TABLE FORMAT LIKE THE FOLLOWING

WEEK	MILESTONE
Feb1 – 7	-idea to work with Rhino Robotic Arm
Feb 8 – 14	-brainstorm to automate a process with arm, came up with a Bartender
Feb 15 – 21	-learned how a robotic arm worked with Teach Pendent which was independent of a computer
Feb 22 – 28	- set-up and plotted points to demonstrate a simple program
Feb 29 – Mar 6	-built elevated platform and plotted where drinks would go on a posterboard
Mar 7 – 13	- discovered how each drink would take a serious of points to pick-up, pour, and return
Mar 14 – 20	- spent Spring Break researching simple drinks to be made with the arm
Mar 21 – 27	- programmed the arm to pick up and pour 6 bottles
Mar 28 – Apr 3	- tried to develop a user interface, but since neither the student helping me or myself are CS majors it went nowhere. I decided to add more functionality to the program.
Apr 4 – 10	- got all the drinks plotted and programmed

Apr 11 – 17	- tried to figure out stirring command, problem with loops; decided to spin wrist motor instead
Apr 18 – 24	- final programming done

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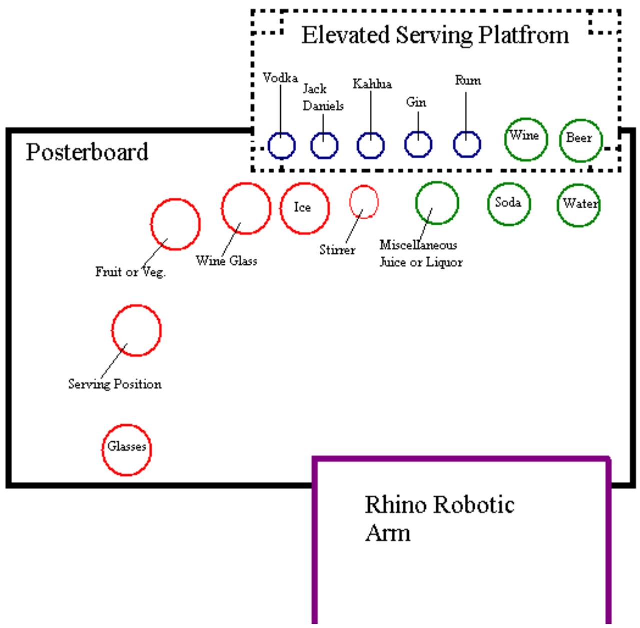
DIAGRAMS



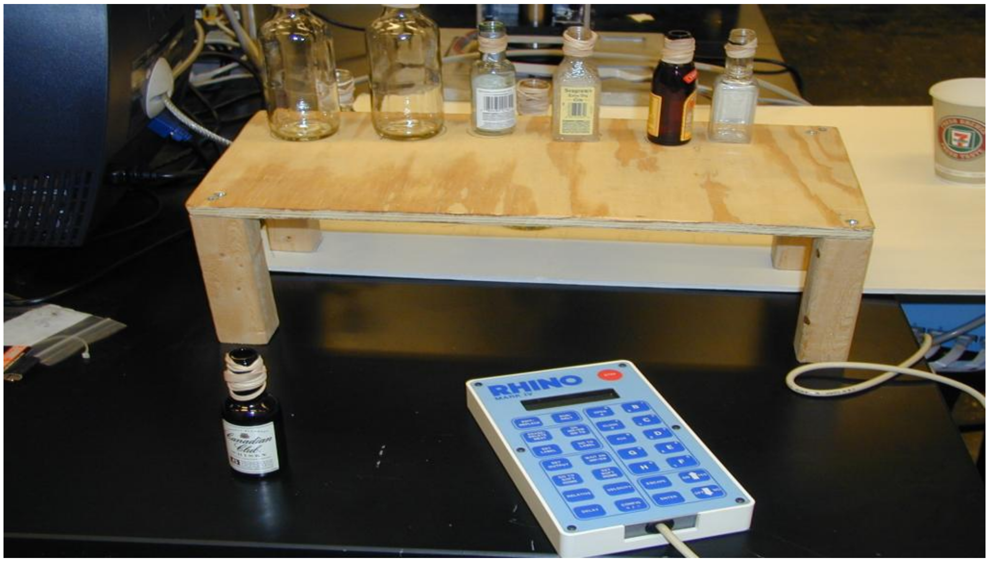
This is a diagram of the work area I created for my bartending program.

PICTURES

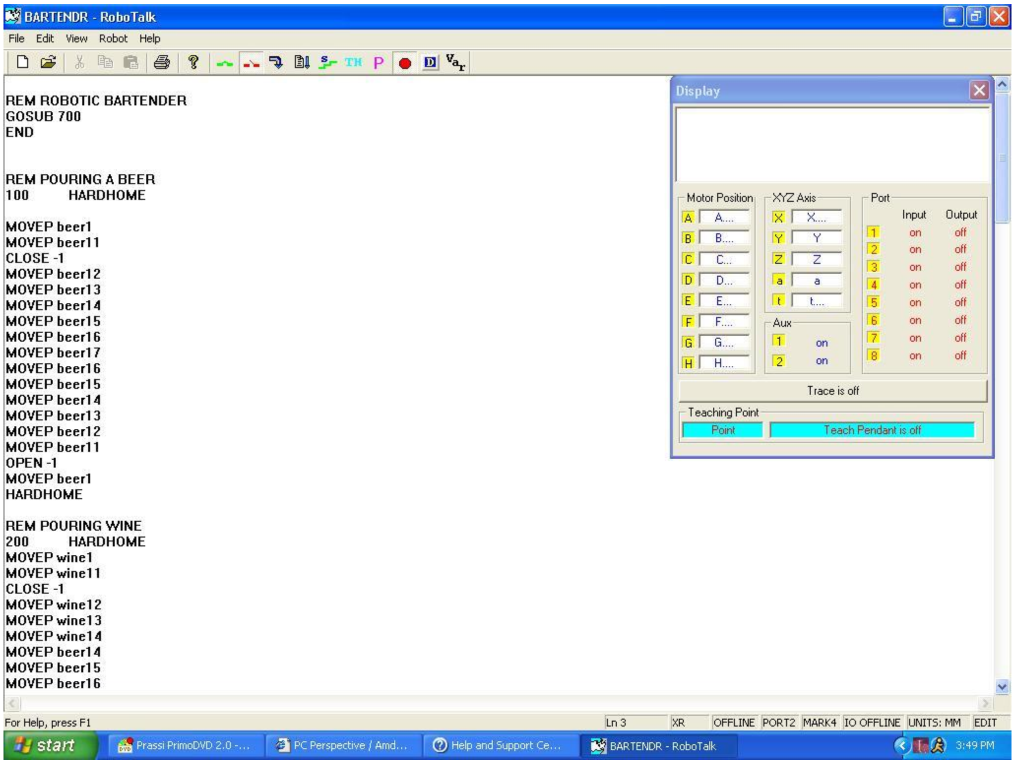
Rhino Arm picking up a “beer” bottle

View of platform and poster board with drinks

Arm pouring Rum into a glass.



Rear view of platform with teach pendent in display



Screen capture from RhinoTalk program

BUDGET

Since my project used a robotic arm provided by the school and the materials I needed, mini-bottles of liquor, wood, and poster board, were all things I had around my house my budget was zero dollars.

SUMMARY AND CONCLUSION

The Rhino XR-4 Robotic Arm located in the Showcase lab in E1 is a great asset to IIT and to the furthering of a robotics curriculum or minor here at IIT. Since there is an obvious interest in robotics at the IIT community and if someone wanted to continue there robotics education in the work field, this arm would do wonder. Most of the work with robotics in industry is in the field of automation and even more work in the field is done with robotic arms; from car factories to high-tech medical operations, the arm is used in all facets of industry. Not only would an education in programming and automation with a robotic arm pay-off for students but it could very well be the difference in getting a job in many industries since automation is the wave of the future.

The work I did, programming a simple automation process and compiling of a mini-manual, will serve as a asset to an upcoming robotics IPRO or class. As I said earlier automation is the future and the work I did could be the groundwork for how to set-up and automate different puzzles or problems with this arm. The mini-manual complied could be used a simpler form of research for the arm since the student no longer will have to plow thru the 5 included manuals that came with the arm and the controller. So both parts of my project, the automation and assembling of a manual are a great help to myself, the upcoming IPRO, and to the school at large.

REFERENCES

Rhino Robotics, maker of the Rhino XR-4 Robotic Arm and Mark IV Controller
http://www.rhinorobotics.com/

S P E E C H   R E C O N I G T I O N
(AKA PEPPY PROJECT™)

INTRODUCTION

Exploring and developing robots, Project Peppy™ has learned a great deal and has been successful in developing the Peppy™ Robot. The project has entailed extensive electrical systems development, mechanical design and development, system communication, project and time management, research and programming and has demanded a high level of hard work and dedication from its members.

OBJECTIVE

An ambitious objective was set early in the semester; Project Peppy is that objective. The goal of the project is to develop a small, fully autonomous robot that will respond to verbal commands to perform various tasks. The robot, "Peppy," must be able to interact with its environment to identify objects and move from one location to another. In order to interact with its environment, the project involves the development of three-dimensional sonar pattern recognition and may, in the future, include video pattern recognition. To receive verbal commands, the project includes the development of speech recognition software that will serve as a translator, interpreting a user's commands into signals the robots other components can understand. The sonar array and speech recognition chip work in combination with the Lynx robotic arm, the aluminum chassis, and the main controller to produce a robot that will perform user defined tasks.

PROJECT SCHEDULE

Progress for the Peppy Project depended greatly on the acquisition of its components. Only so much could be accomplished without the parts, and it took more time than expected to acquire them. Our objectives however, have been met with little problem.

Predicted Progress Report:

Week	Dates	Updated (February 26, 2004)
1	1/18-1/24	IPRO Introduction
2	1/25-1/31	Project Proposal, Set up Work Area
3	2/1-2/28	
4	2/8-1/24	
5	2/15-2/21	Research and acquisition of components, program development
6	2/22-2/28	
7	2/29-3/6	
8	3/7-3/13	
9	3/14-3/20	
10	3/21-3/27	
11	3/28-4/3	Completion of Chassis, Integration of Components
12	4/4-4/10	
13	4/11-4/17	
14	4/18-4/24	*Preparation for IPRO Week, Assemble Final Documentation for Future IPRO 316*
15	4/25-4/30	*IPRO Week*

Actual Progress Report:

WEEK	MILESTONE
1	IPRO Introduction
2	Discussion of IPRO goals, division into groups
3	Development of project objective Submission of prospectus Beginning of conceptual work
4	Concept development and exploration Research into possible robot components.
5	Decide on robotic helper idea Consider Scorpion chassis, handiboard and lynx arm

	Decide to develop our own chassis Look into acquisition of a FIRST kit of parts and controllers
6	Research into speech recognition hardware and other components Sensory Voice Extreme Kit ordered and acquired New chassis design pursued and completed. Consider developing a stronger arm
7	Chassis parts in the ordering process, fabrication will begin this weekend Still waiting for a response on the availability of a FIRST kit of parts Progress on VE halted due to an unusable AC adapter.
8	Recieved parts for building chassis from the ThunderChickens. Waiting for machinery/tools and looking for a building location. Searching for components for the transmission Acquired AC adapter, VE is running
9	Begin work on Voice Extreme Look into using two handiboards instead of waiting for a FIRST controller Mid-term presentation
10	Looking for a high current capacity 12V battery The FIRST controller has been sent out, though still not the kit Conflict with number of storable words in VE resolved.
11	Decide to enter the "Peppy Project" into the EnPro office for their competition, Working on entry form and business plan Finished rough draft of VE program Innovation First controller delivered.
12	Transmissions completed by ThunderChickens mentor Bill Badke and future IIT student Karina Powell. Set up the main controller and was able to run a program that outputted debug text to the computer. Decided to use the frame from last year's "Scorpion" robot. The transmissions have been mounted.
13	Backup battery for FIRST controller made 12V motorcycle battery acquired FRC and OI communicating, programming FRC ensues Lynx arm responds to commands Burnt the VE programming board with a seemingly inappropriate AC adapter
14	We completed the structure in code which facilitates coding arm animation Made a rough draft of main controller program. Working on code to communicate between the FRC and the VE Spoke with Sensory about the VE and resolved the issue by bypassing the voltage regulator on the Programming board. Arm, battery, VE, sonar and controller mounted to chassis. FRC and VE communicating, programming serial input
15	Presentation week: Final draft of report, final preparations for presentation, finish binder

METHODS

The Peppy Project™ spent the semester developing the robot, Peppy™. The project has entailed extensive electrical systems development, mechanical design and development, system communication, project and time management, research and programming and has demanded a high level of hard work and dedication from its members.

Much of the group's time was spent researching the required components to synthesize the robot. It was necessary to collect components that could be expanded and applied beyond the target robot, so as to provide for IPRO, lab and class development in the future. For the greatest flexibility, the FIRST Robotic Controller was desired as the main controller for the robot. The FRC has extraordinary input and output capabilities, well beyond the needs of Peppy™ but useful for development in the future. Research also led us purchase the Sensory Voice Extreme™ Toolkit for the speech interface of the robot. The VE provides the necessary digital i/o and programming flexibility that Peppy™ requires.

The Peppy Project™, in order to identify target objects, also developed a sonar array. The array of microphones picks up the sound signal emitted by the central speaker and, based on the time it takes for the wave to travel from the speaker to the microphones, the speed of sound is calculated. Next, the microphones pick up an echo of a waveform after it bounces off of surrounding objects. This echo waveform is translated into pulse width and height and, based on triangulation with the three microphones and their measured times, the FRC, or intermediary microprocessor, can determine the coordinates of the target object. Due to the magnitude of the task, the data analysis required for the implementation of the sonar was not within the scope of this semester, it was more pressing to develop a working speech interface and mobile platform.

In order to move the robot, we have developed two Fisher-Price driven transmissions. Manufactured by the ThunderChickens, the transmissions allow the robot to move at speeds up to 2m/s but do not give it more power than can be handled by the target audience. The motors are powered through Victor speed controllers, modulated by PWM output from the FRC. Detailed description of the workings of the transmissions can be found in the binder report.

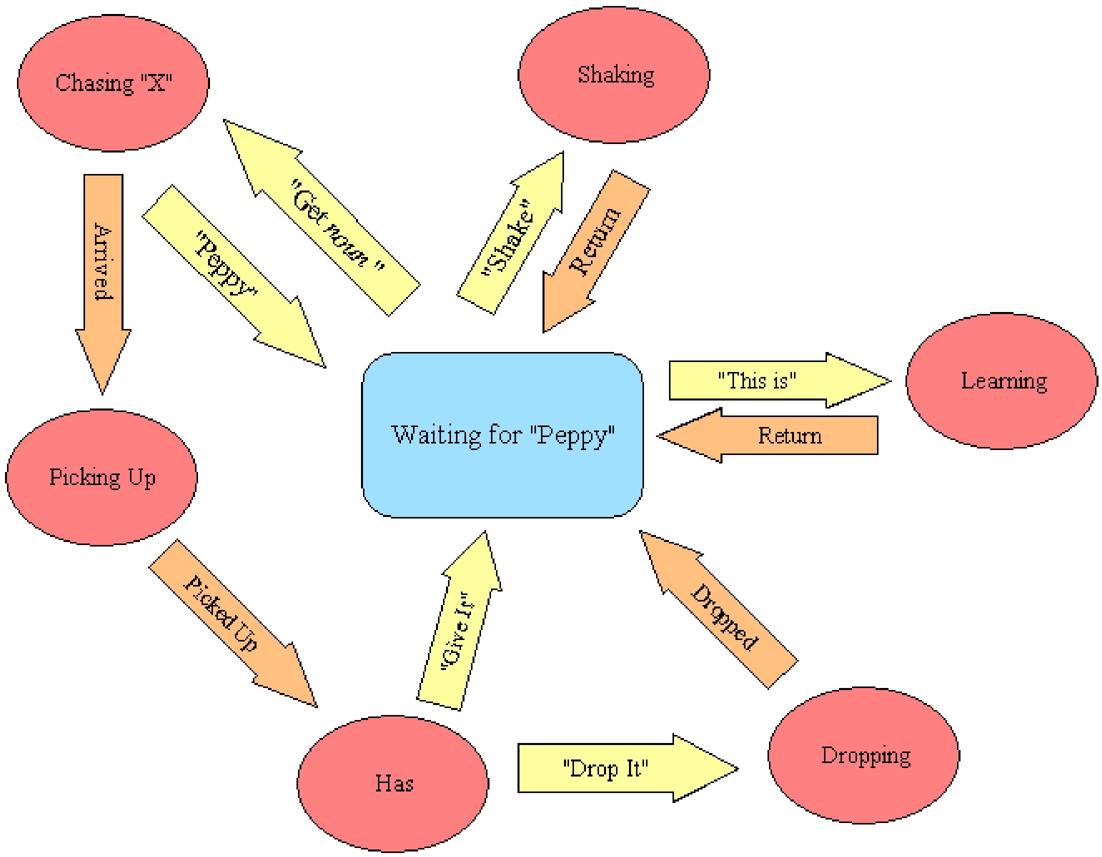
The Lynx arm, mounted to the front of the Scorpion chassis, is what Peppy™ uses to pick up objects. Used in previous semesters, the Lynx arm and Scorpion chassis were readily available for use by the Peppy Project™. The Lynx arm is driven directly by the FRC via PWM, drawing power from the FRC backup batteries. Powering the rest of the robot is a 12V motorcycle battery mounted in an upright position, between the FRC and the Lynx arm.

At the onset of the semester the group decided that we were going to develop a useful and practical robot that could be used by the elderly or disabled to ease day-to-day tasks. Since the declaration of that objective and with the development of Peppy™, we have realized the scope of what the robot can actually do. Applicable in garages, machine shops, labs and even the modern household, the potential of the robot reaches into day-to-day lives of people across the world. To achieve the full potential of the Peppy™ concept, the group has developed a business plan and submitted the concept for a future EnPRO.

The integration of components on Peppy™ proved a monumental task and learning experience for all members involved. After developing the VE program, driving the chassis and the arm based on user input, enabling the ability to teach the robot new 'nouns' and troubleshooting the controller interface and electrical systems, the Peppy Project™ has reached a plateau from which future semesters have the ability to build.

Note: A more detailed description of the methods can be found in the team binder.

DIAGRAMS



State: Blue Box- Main Loop State, Red Circle- Alternate State, Yellow Arrow- Transition via Verbal Command, Orange Arrow- Automatic Transition Via Code.

State:
Waiting:
During operation, it waits until it hears the word, "Peppy". Upon recognition of its name, Peppy will listen for a command, shown in the diagram as a yellow arrow with the command in double quotes.

Chasing "X":
Peppy has been given a "noun", X, and is in the process of locating and moving to the location of X. If Peppy hears its name while in this state, it will return to the initial Waiting state. If Peppy arrives within arms length of X, it shifts to the 'Picking Up' state, represented as an in-code transition with an orange arrow.

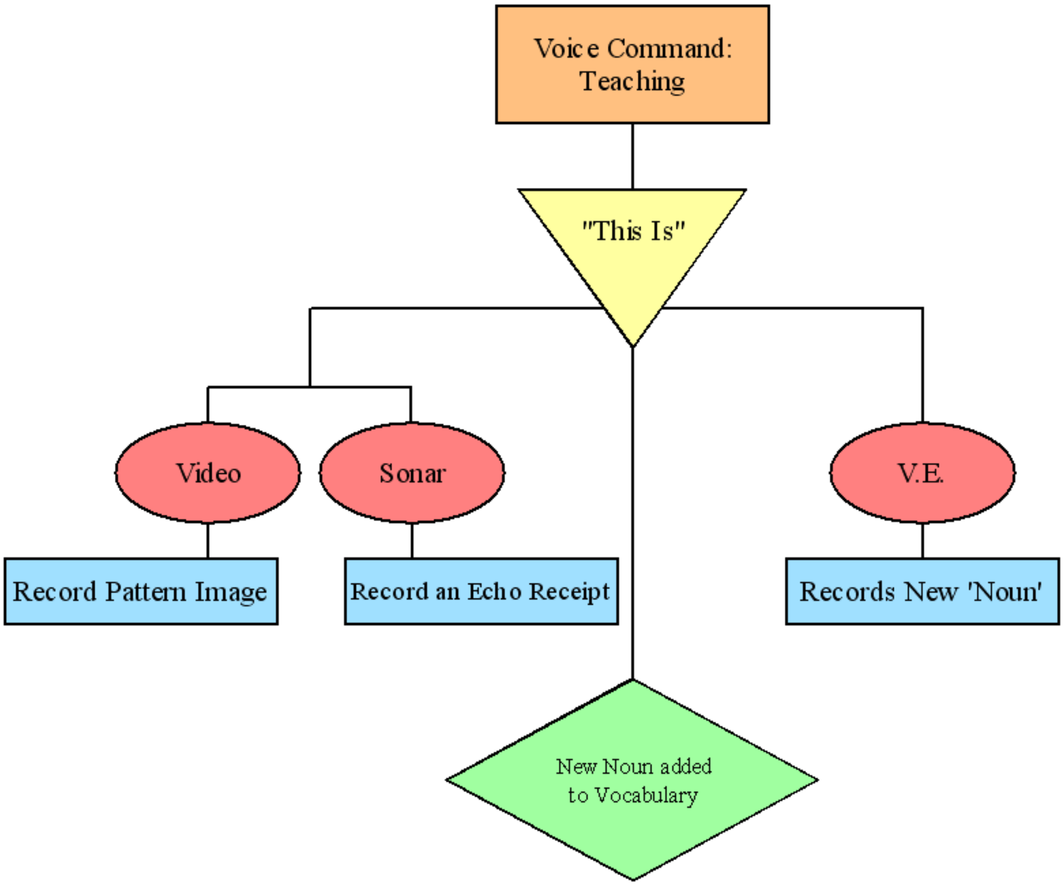
Picking Up:
Peppy is within arms length at the initiation of this state. Utilizing object location features, sonar and video technology, Peppy determines the location of the object relative to the arm and proceeds to move the grippers around the object and pick it up for the user to grab.

Has:
During this state, Peppy is holding the object. The robot waits for the user to instruct it as to what to do with the object. If it hears "Give It," then the grippers will open, making the assumption that the user is also holding the object. If it hears "Drop It," Then Peppy will revert to the 'Dropping' state.

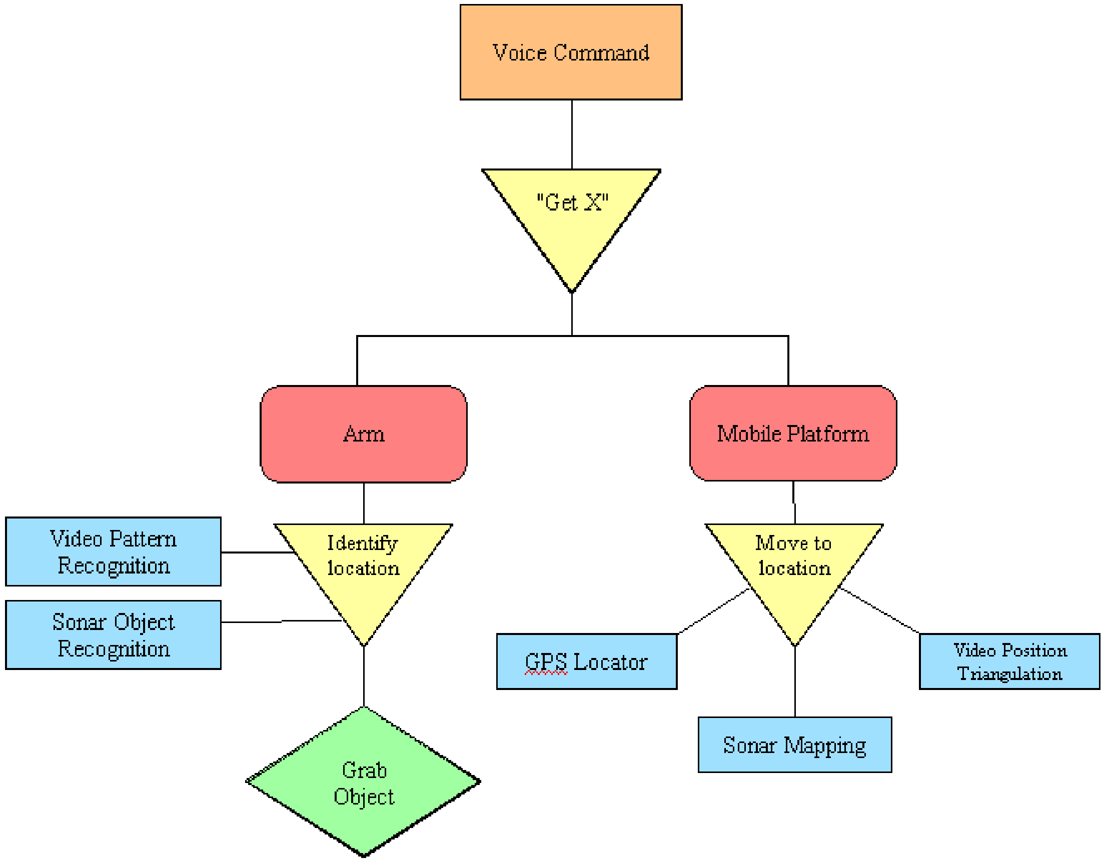
Dropping:
Upon hearing "Drop It," Peppy will proceed to place the object back in the position from which he acquired it.

Learning:
If Peppy hears "This is," it will record the next word, or word sequence, along with sonar and video picture of the object set in a special recording frame.

Shake:
If the user were to say, "Shake," then Peppy would extend its arm eagerly awaiting the user's and proceed to emphatically shake the users hand.

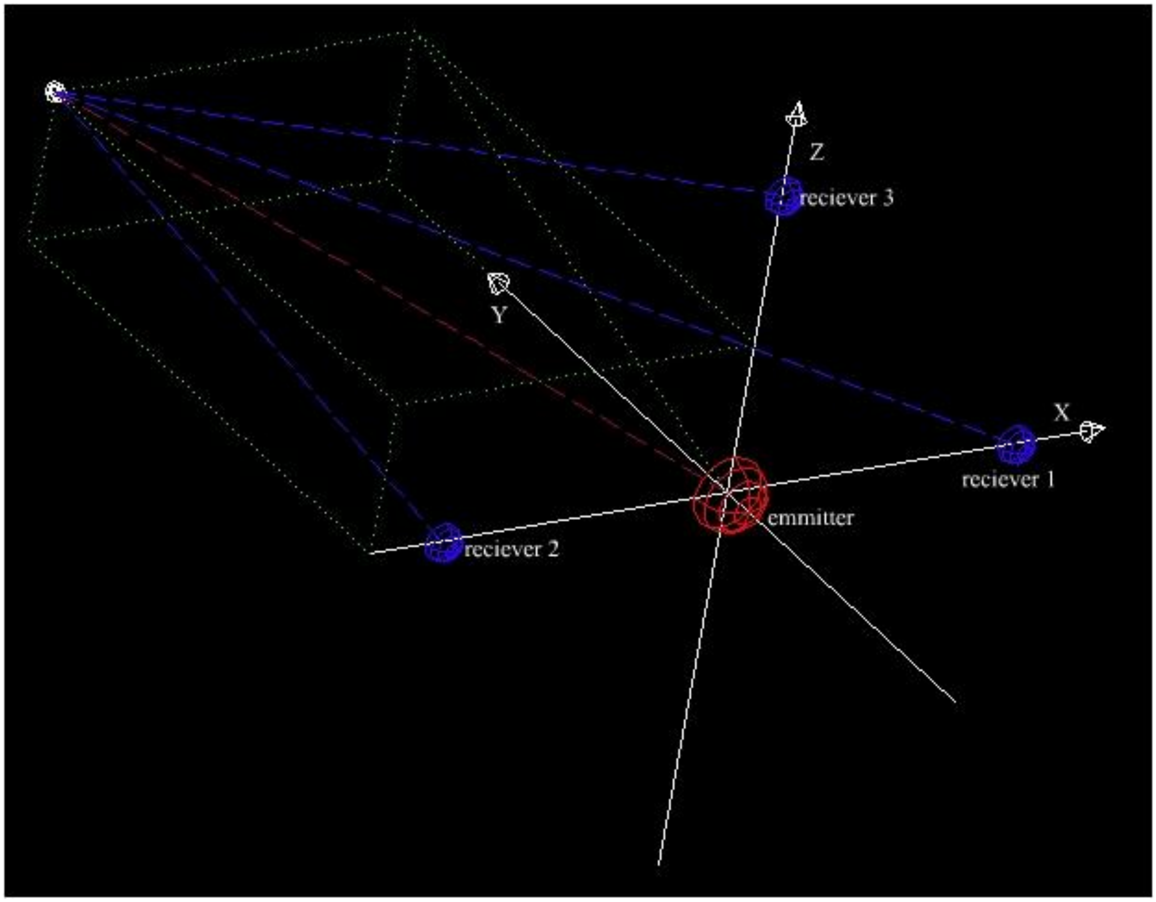


Teaching:
When Peppy hears "This Is," it is ready to record a new noun. Peppy will record the following word or phrase and associate it with a picture, taken by both the video and sonar, for future reference. At any time thereafter, the user can reference the new noun just like any of those previously stored.



Voice Command:

When Peppy hears the command, "Get X," where X is a noun, Peppy will first look for the target object. If the object is outside of arms length, then the main controller will determine distance and move the robot to a position appropriate for picking up the object. Once within arms length, Peppy will proceed to identify exact object location and then utilize the arm to grapple and raise the object.



Above is a schematic diagram of how the sonar array triangulates the position of an object. Below are the equations used to generate x, y, z coordinates.

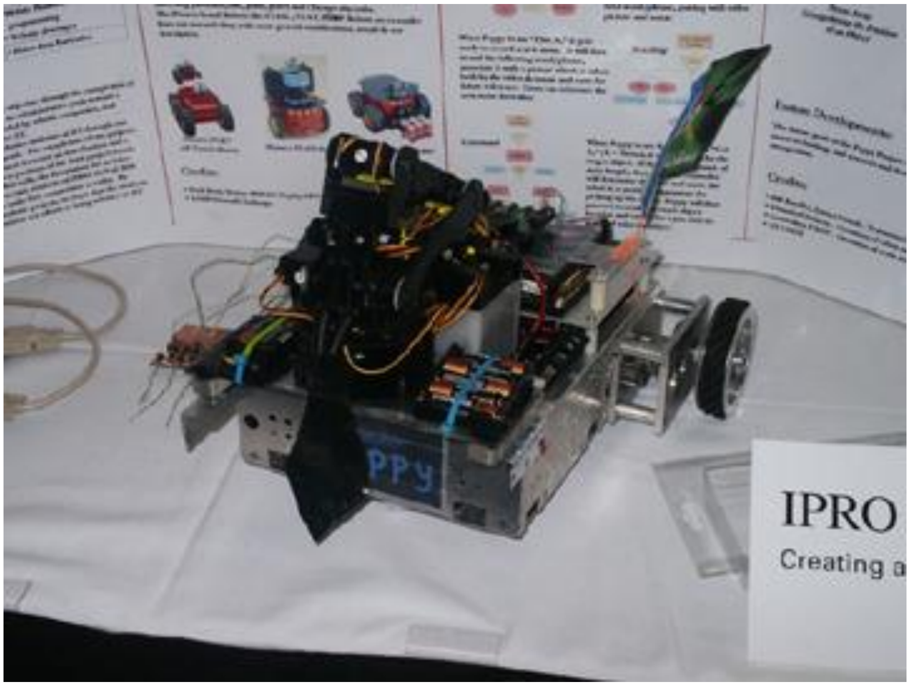
$$v = \frac{L_1}{t_{0,1}} = \frac{L_2}{t_{0,2}} = \frac{L_3}{t_{0,3}}$$

$$x = \frac{L_2^2 - L_1^2 - \frac{t_2^2}{v^2} + \frac{t_1^2}{v^2}}{2(L_1 + L_t)}$$

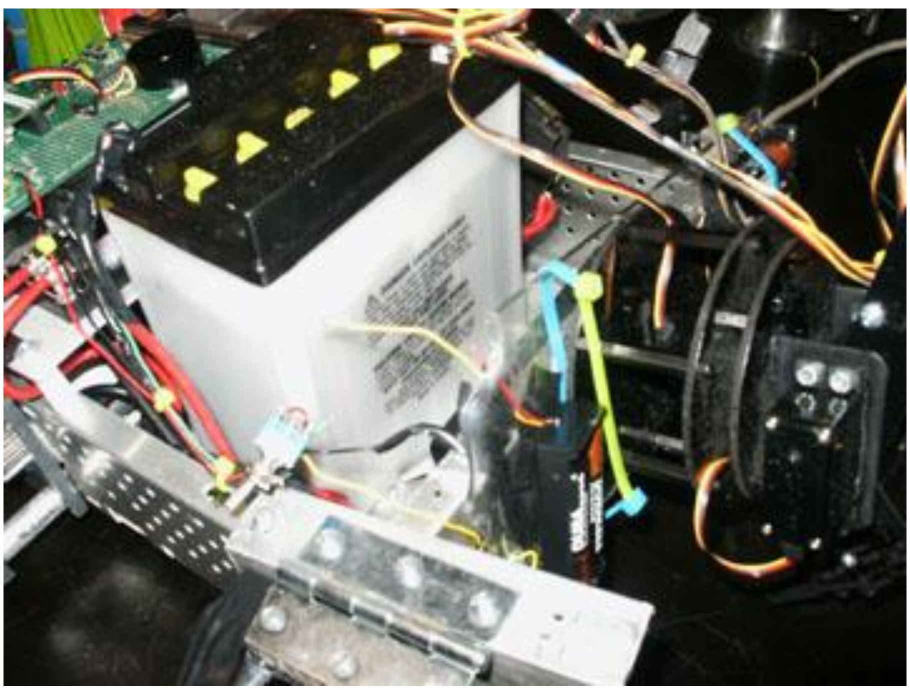
$$z = \frac{t_1^2 + 2xL_1 + \frac{t_3^2}{v^2}}{2L_3}$$

$$y = \frac{1}{2}\sqrt{2x^2 + 2z^2 + L_1^2 - 2xL_1 - \frac{t_1^2}{v^2}}$$

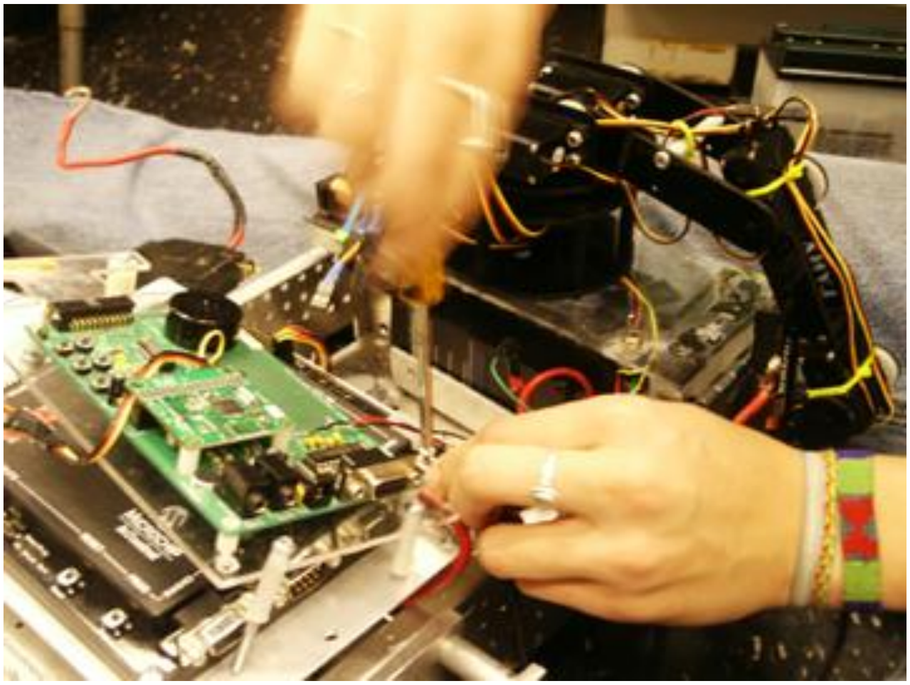
PICTURES:



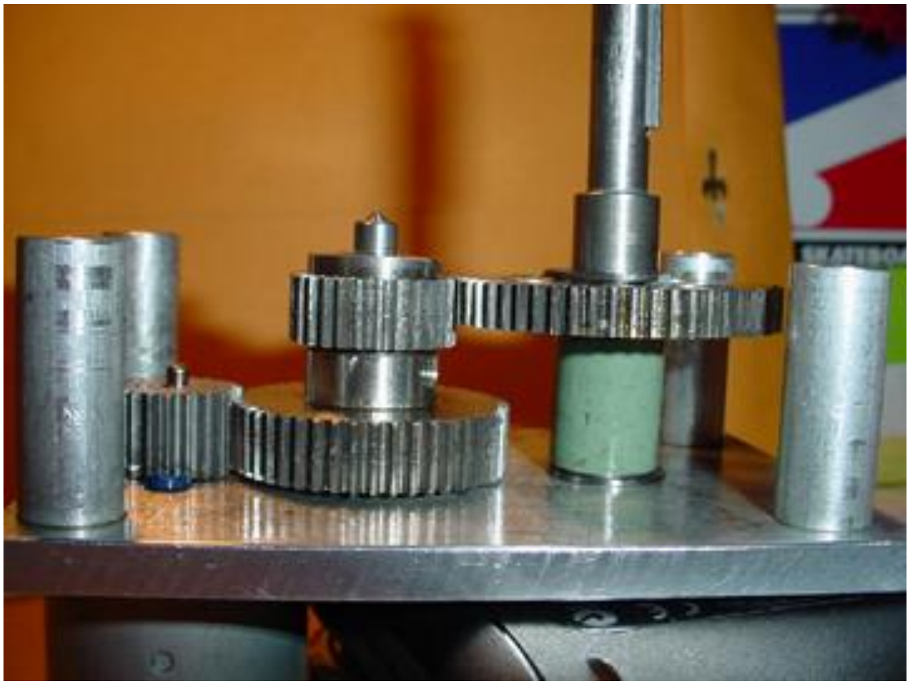
Peppy™ ready for IPRO Day

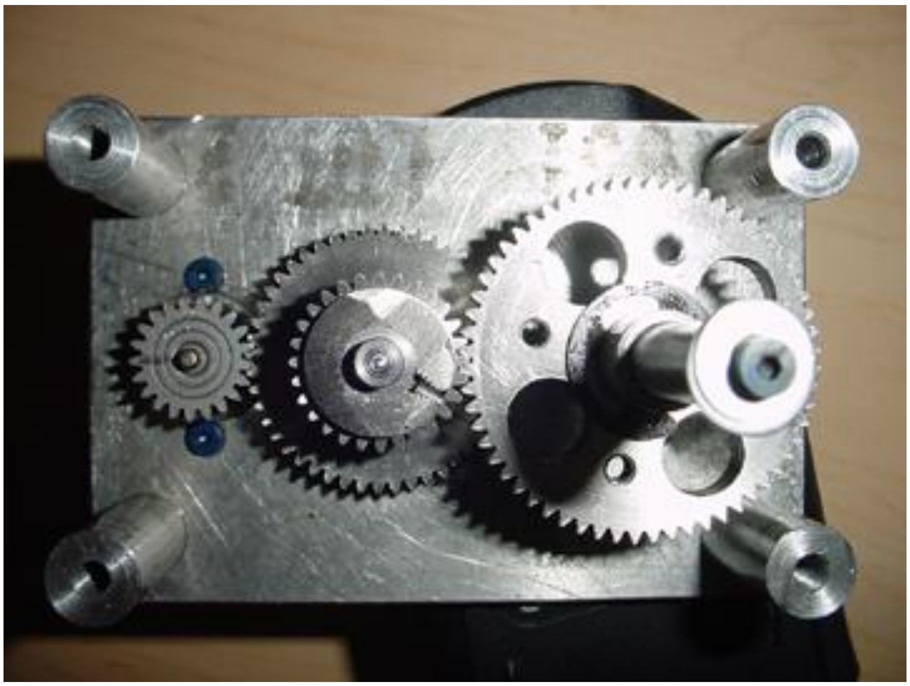


Repairing broken Plexiglas after Peppy™ decided to run into the wall.


Wiring Peppy™


Front view before acquisition of a new battery


Transmission- Side View. Fisher-Price motor is to the left, output on the right.


Transmission- Top View

BUDGET

The following chart contains information on our purchases for this semester.

Quantity	Item	Amount
1	Voice Extreme™ Kit	$250
1	Adapter	$20
1	Sonar components	$100
n/a	S&H and misc. parts	$150
Total		$520.00

The following chart contains information on parts donated for this semester.

Quantity	Item	Donator
1	Innovation FIRST 2004 RC	Innovation FIRST
1	Innovation FIRST 2004 OI	Innovation FIRST
2	Transmission Components	ThunderChickens, Team 217
1	Chassis Material	ThunderChickens, Team 217
2	Fisher Price Motor	ThunderChickens, Team 217

CONCLUSION

REFERENCES

http://www.generation5.org/content/2003/vekit.asp
http://www.gibsonteched.net/l5.html
http://www.thunderchickens.org
http://www.innovationfirst.com
http://www.usfirst.org

IIT ROBOTICS INITIATIVE

INTRODUCTION

The main objectives of IPRO 316 are to explore robotics and develop a Center for Robotics Education here at IIT. We have invited guest speakers to campus as well as laying the groundwork for a future IIT Robotics Competition in order to promote robotics at IIT. It is our goal to demonstrate that a robotics curriculum would be beneficial to IIT and attract many new intelligent undergraduate students as well as producing knowledgeable, innovative engineers of the future.

Introduction to FIRST Robotics

FIRST Robotics is a national robotics competition involving thousands of high school students and even more corporate sponsors. Every year, Innovation FIRST invents a new game for the student's robots to play that is drastically different from any previous year. Innovation FIRST supplies a multitude of components to every team to get them started building their robots. Students compete in regionals across the United States and several other countries and successful teams come together at the end of the season to compete in a national competition.

OBJECTIVE

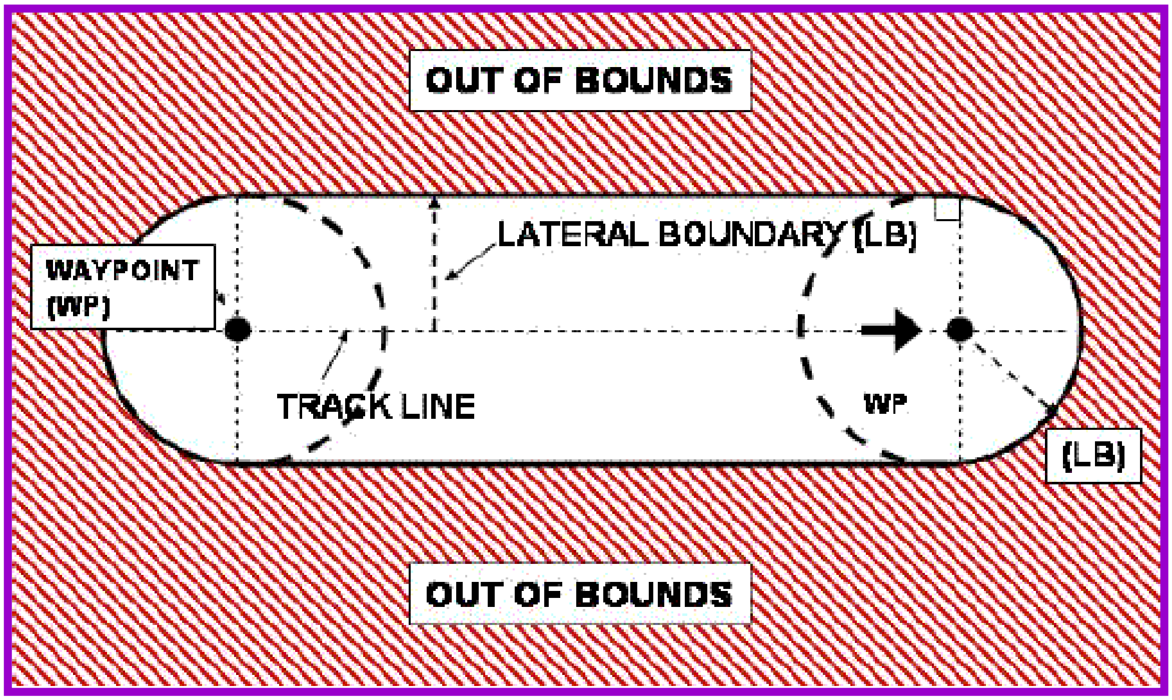
The objective of this initiative is to demonstrate the need for a robotics curriculum at IIT apparent and involve students and professors in the process. It is our goal to remove the distance between the workplace and the classroom for engineering students to better prepare them for future highly probable encounters with robotics.

PROJECT SCHEDULE

Week	Dates	Milestone
1	1/18-1/24	IPRO Introduction
2	1/25-1/31	Project Proposal, Discussion of objective
3-9	2/1-3/20	Explore Robotics, Discover interests, Research possible speakers, Investigate ulterior means of robotics promotion
10	3/21-3/27	Begin research into robotics competition here at IIT.

11-13	3/28-4/17	Research potential involvement of other schools, develop a basic plan for a competition, Continue to research other means of promotion
14	4/18-4/25	*Preparation for IPRO Week, Assemble Final Documentation for Future IPRO 316*
15	4/26-4/30	*IPRO Week*

DIAGRAMS



Robots would follow a path determined by GPS waypoints identified as above. The lateral Boundary distance has yet to be determined and will vary with the resolution of the GPS used in competition. (Diagram taken from DARPA Challenge)

BUDGET

This initiative consumes none of the IPRO 316 budget.

SUMMARY AND CONCLUSION

Much of our time has been spent researching robotics in the world today. We gave researched competitions like DARPA's autonomous race across the desert and university held LEGO competitions, as well as products like Toyota's humanoid robot and Irobot's Roomba. We are also exploring curriculum and competitions involving robotics at other institutions. We have found projects like MIT's 6.270 and workshops like the University of Massachusetts Pilot Workshop, which expose undergraduates to innovative robotics technology. Programs like these illustrate the future of robotics in our society. Our goal is to transform IIT so that we remain forerunners in inventing the future.

This semester we are working to raise IIT awareness of robotics. We have invited two guest speakers to IIT who, due to outstanding circumstances, will not be able to speak until the fall term. The first of these speakers is a design engineer from FANUC Robotics, Paul Copioli. Mr. Copioli is heavily involved in FIRST Robotics mentoring Team 217, the ThunderChickens, a big sponsor of this IPRO, and is an energetic robotics enthusiast. We are also working with FANUC Robotics to set up a scholarship for an undergraduate interested in pursuing a degree in robotics at IIT. The second speaker is the director of MIT's Artificial Intelligence Laboratory and CEO of Irobot, Rodney A. Brooks. He will be speaking for Thought Leader, the FIRST Alum Club and IPRO 316.

It has been shown that there is a great deal of corporate as well as institutional interest in robotics around the world and IIT should posses the same interest. There are also a great number of robotics applications ranging from cutters, welders and painters, to the Roomba we have in our lab. These robotics are of the sort that every engineer will come across in their career and every engineer should have some knowledge base prior to workplace exposure; an IIT robotics education curriculum would be perfect for them.

The IIT Robot Challenge is a miniature version of the DARPA Grand Challenge hosted in the desert earlier this spring. The challenge is designed to raise the interest of IIT students and faculty in robotics and provide a high level of competition as well as exposing them to real world problems and promoting innovative thought and application of modern technology.

The Challenge will be held around the IIT campus on a closed course designated shortly before the start of the competition. The overall length of the competition will not exceed more than 1.5 miles and will include obstacles of any composition.

Robots will be required to be completely autonomous. Turned on at the starting line, robots, competing one at a time, will follow low-resolution GPS waypoints released close to the starting time of competition, until they reach the finish line. Throughout the course, robots will be required to stay within a certain range of the waypoint path as shown in the attached diagram.

Participating teams will be composed of interested college students and professors, funded on either an educational or corporate level. Robots entered in the challenge should be less than 200 lb, 36 inches square and 48 inches tall. The robots should be capable of traversing pavement, dirt, grass and Chicago city curbs.

The competition would demonstrate the capability of robotics as well as perk the interest of individuals who would otherwise have little exposure to the matter. Also, such a competition would demonstrate the vast untapped potential of robotics and the need for a robotics education at IIT. Further competition guidelines will be worked out in this semester and in a proposed IPRO for the fall term.

Along with perking corporate and institutional interest in IIT, a robotics education curriculum would attract many intelligent and enthusiastic undergraduates, primarily FIRST students, to our campus. These students gain some exposure to robotics in high school and there aren't many places for them to pursue their interest in the subject; an IIT robotics education curriculum would be perfect for them, not to mention an annual robotics event akin to the FIRST competition.

For the remainder of the semester we will continue our research along with our other initiatives, continue to search for other means of promotion and explore inter-institutional involvement in order to bring IIT into the future.

REFERENCES

http://www.innovationfirst.com
http://www.toyota.co.jp/en/special/robot/
http://www.sony.net/SonyInfo/QRIO/top.html
http://www.us.aibo.com/
http://fanucrobotics.com/
http://cs.smith.edu/~streinu/Teaching/robotLinks.html
http://web.mit.edu/6.270/www/home.html

FUTURE DEVELOPMENT

IPRO 316 has opened many doors for future development. Each project is ever evolving and possesses great un-tapped potential. It is up to future semesters to pursue these initiatives as they see fit, but an outline is suggested as follows.

Mobile Platform

IPRO 316 has opened many doors for future development. Each project is ever evolving and possesses great un-tapped potential. It is up to future semesters to pursue these initiatives as they see fit, but an outline is suggested as follows.

This semester, a Roomba Floor Sweeper was transformed into a Robotic Mobile Platform (RMP) so as to be used for robotic education and experimentation. The original microcontroller was replaced by a Parallax Javelin Stamp which can be controlled from a laptop or desktop PC using a RS232 Serial Cable.

The Robotic Mobile Platform developed provides a serial interface through the Javelin Basic Stamp. This feature allows a simple method of creating commands to control all of the motors on the Roomba and read the state of each of the sensors using Java Programming. In addition, one can write simple programs to control the motion of the Roomba, detect collisions and play sounds.

After programming the mobile platform, the Javelin contains an additional 7 i/o pins that allows for additional hardware interfacing. Some Possible Applications:

- Design your own vacuuming algorithms. Make the Roomba vacuum in a grid, discover the layout of the room, or add a microphone to make it voice activated.
- Play tag with both Roombas by having both programmed to find and chase each other.
- Make a Robot maze solver.
- Add a wireless webcamera and make a mobile security robot. Connect the Roomba and the camera to the Internet and monitor the security of your house while you are at work.

In successfully completing this task and providing detailed documentation of our project, we hope that the next IPRO will continue to learn about the Roomba and implement their own functionalities.

Peppy Project

One goal of the project was to develop and integrate a sonar object identifying array into the robot. The constructed Sonar array was assembled in an unworkable manner and requires rebuilding. After being rebuilt, the array can communicate either directly with the FRC or to a PIC that can communicate via TTL. Data can then be analyzed by the FRC microcontroller or that of the PIC and interpreted to determine coordinates of a target object.

Inclusion of the Sonar array raises several object identification problems. In order to identify an object, the robot will need to save a sonar or video for that matter, template and then associate that template with a “noun” or “noun-phrase” through the teaching program already on the Peppy™ Robot.

In order to further develop the robot, feedback will be required from the FRC to the VE. The FRC will need to be able to communicate errors to the VE if, for example, it recorded a bad template, so that the VE can delete the recorded voice template and be ready to try again.

One of the most advanced features we have dreamed up for the robot, is the ability to perform a “follow” command. Assuming Peppy™ can identify, save and access an object template, it may be possible to have the robot identify a human. This could be applied in several fashions, including returning objects to the original speaker, following a speaker and responding to a different set of voice commands based on an identified user.

In order to further Peppy’s™ applicability, it may also be necessary to develop a stronger, more durable arm. Regardless of the objective of the new arm, it will need to communicate position data, possibly through the use of potentiometers, to the FRC and the FRC will need to be programmed to respond to a different arm configuration. The current arm cannot lift more than a screwdriver and cannot reach the ground, a side effect of resorting to the Scorpion chassis. It has been proposed that a 3 part arm (one unit longer than the Lynx Arm) would be the most useful, and have the best functionality.

In order for Peppy™ to accurately track objects, it is necessary to know where the robot is in relation to its initial position. This can be achieved through the integration of encoders to the wheels. Similar to potentiometers in look, encoders count pulses as the shaft turns and sends that data to the controller. Based on the radius of the wheels and the number of pulses, the controller can determine the exact distance the robot has moved and even calculate the angle the robot is at relative to an initial position. From this, functions can be programmed that would tell Peppy™ to move a set distance at an angle, drastically simplifying robot motion as well as response to sonar derived coordinates.

CONCLUSION

IPRO 316 has worked to develop robotics and lay the foundation for a future Interdisciplinary Center for Robotics Education at IIT. The Mobile Platform subgroup has reverse engineered two Roomba floor vacuums to create an expandable mobile platform that has the potential to serve as an immense, hands-on educational tool in the future. The Bartender subgroup has demonstrated the applicability of robotics in everyday automation through the development of a robotic bartender. The group has also developed a comprehensive manual through the compilation of previous scattered manuals, to allow for easier use of the Rhino Robotic Arm. Project Peppy™ has also developed an immense educational tool through the development of a robotic structure and drive train, the evolution of its speech recognition interface and integration of object identification and manipulation. Along with the subgroup aspirations, IPRO 316 has invited multiple robotics guest speakers to IIT and set in motion the development of an IIT Robotics Challenge. IPRO 316 is working to help IIT continue to produce the capable and innovative engineers of the future.