ILLINOIS INSTITUTE OF TECHNOLOGY

Advancing ipro 316 Robotics Experience

FINAL REPORT
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Table of Contents **page #**

INTRODUCTION

The introduction of the robotics IPRO program in its few years has already served the IIT community some rather practical and innovative concepts of robotics. Through an impressive and beneficial advancement, the program has successfully carried on to the spring 2005 semester. The goals of the program remain simply a quest to advance the art of robotics in the IIT community. The stage has been aptly set by previous IPROS for higher and more substantial progression on this cause. The goals of the IPRO Spring 2005 team will be to create four prototypes of not merely user friendly robots but a sophisticated utilitarian bunch that would gain enough attention in support of the ultimate cause of the introduction of a robotics course. The Peppy, Roomba, Darpa and the Pyro are the four prototypes set for construction this semester.

The Roomba sub-group worked to create a cheap mobile platform to which multiple functionalities could be added. The group planned to use the Roomba robot, a home appliance being mass produced by iRobot, and modify it to suit their purpose. The modifications required were both electrical, meaning circuitry, and programming. The overall goal of the sub-group is to have multiple mobile platforms operating in a swarm.

One of the main purposes for the Peppy group was to create a modified & repaired form of Peppy™ robot having a particular function of which a providing convenient module and general prototype for a couple of fields. Peppy™ is supposed to feature voice recognition technologies for people to interact with. Peppy™ is designed to be a kind of smart pet for the disabled. Ideally, Peppy™ will be on command for a person to do tasks like picking up things on the floor, monitor the security of a person's home, and just generally be helpful to people. This deliverable would hopefully make students at IIT more aware of what their peers were up to and spark interest as well.

The PYRO group would learn how to design PYRO interfaces between the higher level language (Python) whereby all robots simulated in PYRO are controlled via a single higher level language but also have an interface specific to each computer in its system so that the PYRO program that controls each robot in the simulation can also be used to actually control the specific actual robot. The group will then go on from there to expand PYRO's repertoire of Robots and to design an interface for the modified Roomba and a second interface for Peppy. Of particular interest will be to enable simulation of SWARM activity and to actually test a model with a real SWARM.

BACKGROUND

Currently IPRO 316s05 is the fifth consecutive version of a sequence that was introduced in Spring/2003 (316s03). The stated purpose was to create an interdisciplinary robotics education initiative at IIT. The intent was to tap into the fact that commercial robots have become an integral part of global manufacturing with a parallel track in the arena of "hobby robotics." That new industry – offering robot kits-- continues to grow in the year 2005. Radio Shack has just announced their VEX Kit designed to be the basis of a USA-wide competition for secondary education (high school level) to be conducted in conjunction with the FIRST robotics national competition. Thus high school aged students are learning about robots by not only studying them, but also having hands on experience building and engaging with other institutions that have the same activities... Expectations are high upon entering a private institution like IIT that they will have resources and support to continue their education and interest in Robotics.

IPRO 316s03 team members conducted a literature search and learned there were several universities that had developed undergraduate programs on robotics and are fully functional places (including Princeton, Stanford, CMU and UIUC) They mapped the course descriptions found in the undergraduate curriculum and found clear evidence that existing courses at IIT in electrical, mechanical engineering, and computer science could support three separate tracks leading to a concentration in robotics.

Indeed, the leader of IPRO 316s04 created a spin off – the well-populated IIT Robotics FIRST Club thus reflecting an ongoing interest in robotics at IIT.

The fact that the four subsequent robotics IPROs were filled to capacity clearly demonstrates interest in robotics. What is essential to this initiative is to set in place a set of complementary robotic experiences and a convergence of the three track foundation sequences that would be accessible to IIT undergraduates. These components would span the important areas of robot design, construction and application as well as innovation and creative thinking.

The four robot focuses to be described at the 29 April 05 IPRO Day, all worked on by members of this IPRO, illustrate four such areas.

They are:

Peppy**,** a multifunction robot designed to show application in the most rapidly growing area of robotics – helping to deliver health care.

Roomba, a sophisticated home appliance (a product of iROBOT) that has sold a million units, has evolved over three distinct models in as many years, and because they are mass produced offers an cost effective opportunity to use many of them adapted as mobile robot platforms to which a variety of functionalities can be added.

PYRO, a simulation package, developed at Bryn Mawr, that brings out clearly that a robot specification requires three components: 1) hardware (the physical robot with all its sensors and actuators), 2) software (the brain), and 3) its world (that is the environment in which it is expected to function).

The ***DARPA Grand Challenge*** where by a 2 million dollar prize is offered for the autonomous vehicle (using GPS) that successfully completes a rugged 200-mile course in California. After three attempts, nine miles is the farthest a contestant has gone. We have conceived of a Mini challenge competition to be conducted on a much smaller scale on a much smaller course laid out on the IIT campus and possibly using retired FIRST robots appropriately enhanced.

Finally, we have drawn on metro Chicago talent to give campus-wide lectures at IIT by way of informing us on both expertise in robotics, significant robotics applications, and trends in this area.

To that end, we can advise with confidence that we have a meaningful IPRO-like capstone course that can be fed into and sustained by at least three distinct academic tracks thus comprising a robust Robotics experience that is scaleable and adaptable over time. Every indicator suggests that truly interdisciplinary robotics will continue to grow buoyed by the current growth in other emerging technologies such as nanotechnology, biotechnology, and information technology.

RESEARCH METHODOLOGY

To attack the tasks presented by the IPRO, the entire team met once a week whilst the sub-groups broke off to perform their various activities at their convenience. The team would use the allocated meeting time every once in a while when the need arose. The methods of the subgroups were as follows.

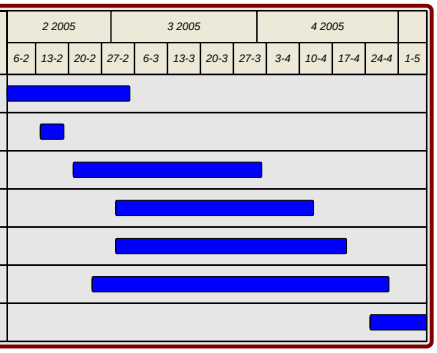
The Roomba sub-group consisted of four undergraduate students; a fourth year ECE major, third year CPE major, third year CPE/ECE major, and a second year ECE major. The biggest obstacle was a lack of knowledge on projects of this scale and complexity. The group used multiple sources to obtain the information they needed:

- The internet from which the group obtained the Roomba patent that helped them understand how the Roomba was put together and how they may modify it. They also used the internet to search for additional Roombas and to gather information on chips or parts they needed and used, such as the microcontroller.
- The ECE department from which the group got permission to use labs that gave the group access to equipment they needed and did not have. They also sought the aid of professors for particular parts of the project.
- Professionals whom they invited on campus to give lectures on topics related to their project.

The first goal of Peppy subgroup was to repair the Peppy™ from the previous IPRO. The obvious approach was to find which parts had been broken. After the repair procedure, PEPPY will then be modified and renewed. To fix the ugly appearance of Peppy™, the plan was design a new chassis form. In terms of marketing, a plan exists to work with ENPRO, which is Entrepreneurial Project to make Peppy™ a marketable product; the plan was to discuss the issue of the chassis design with them. The appearance of Peppy™ was to be modified into a smaller and friendlier platform to people. The investigation of the possibility for a successful merchandising is another main purpose of this PEPPY group. For further approach to this project Peppy™ , we planned to make as many documentations as possible. Video clips, manuals, instruction and charts would be very helpful to the next Peppy subgroup members.

The following Gantt-chart describe the PEPPY proposed plan of action at the beginning of the semester.

ID	Tasks	Start	End	Required time
1	Approach	2005-02-07	2005-03-04	4w
2	Purchase modules	2005-02-14	2005-02-18	1w
3	Repair Peppy	2005-02-21	2005-04-01	6w
4	Update software	2005-03-02	2005-04-12	6w
5	Chassis design	2005-03-02	2005-04-19	7w
6	Documentation	2005-02-25	2005-04-28	9w
7	Design presentation	2005-04-25	2005-05-06	2w



ASSIGNMENTS

Group Leader: Daniel Bong Gun Shin

Daniel saw to it that the affairs of the team ran smoothly. He drew out accurately project deadlines and task appointment to fellow team members to ensure the efficacy of the team's efforts in producing required deliverables.

Roomba Group Leader: Ryan Daniels

As Team Leader Ryan's responsibility was to organize sub-group meetings and to make sure the sub-group was making progress. On top of these tasks, he was partially responsible for the removal of the brush system and testing of the sensor circuit.

The task assembly is represented in a table below

	Kwaku	Ryan	Edgar	Brian
Find & purchase microcontroller	✓			✓
Design Sensor Circuit	✓			
Build Sensor Circuit	✓			✓
Contact Experts	✓		✓	
Testing Roombas		✓		✓
Remove Brush & Build Floor		✓		✓
Naming Roombas	✓	✓		✓
Soldering and Parts Pick up	✓			✓

PYRO subgroup Leader: Megha Yanamadula

As the PYRo subgroup leader Megha was responsible for the following tasks:

1. Learn to use the PYRO program.
2. Teach the other team members how to use it.
3. Consider a swarm simulation.
4. Dissect one of the robot interfaces in PYRO and use as a model for the modified Roomba.

DARPA subgroup Leader: Edgar Becerril

As DARPA leader, Edgar was faced with the task of designing a mini version of the DARPA grand challenge to be built on IIT campus.

Website Designer: Robert Meyer

OBSTACLES

Various obstacles surfaced through the course of the semester that affected the project timeline of the subgroups.

There were a great number of obstacles that faced the Roomba sub-group this semester. First, for most of the group this was their first IPRO so they were not use to having to go out and finding the stuff or information that they needed. This was something they were not use to so it took time for them to find what they needed. Over time the group got the hang of it and was able to find what they needed much quicker than early in the semester. Along with this the group did not have anyone with the skill to write a program that could drive the modified Roomba.

Another problem was that the group was not entirely knowledgeable enough to take on some of the tasks required. The sensor circuit, for instance, required knowledge that only one member had and even then presented itself as an onerous task. After some research and meetings with the leader of the previous Roomba sub-group they were able to design, test, and construct a functional sensor circuit. Another area they had problems was with the communications system. The group attempted to get help from some of the ECE faculty but any knowledgeable faculty member was too busy to aid them.

The microcontroller that was ordered from the semester before was not the complete microcontroller but a component of it. The group attempted to find out how to complete the microcontroller and found it to be very complex and time consuming. Instead of spending what little time they had, the group did some research and found the complete microcontroller and ordered it.

The group came across a problem with obtaining a printed circuit board. The group found that there was a machine on campus that would print a board for them and decided to use it instead of sending the schematics to a company and a pay for the circuit boards. Upon further research they

found out that in order to be able to use it one must go through a course which would last a semester to learn to use it. By the time they learned of this they did not have the time to do that or get a company to print one for them. The group does have everything prepared for the next group to take either course they choose.

With the arrival of the new Roombas came a new problem. The new Roombas were later models that had added features which would have been lost if the modifications from the prototype were included in the new Roombas. To include these new features additional circuits would be needed as well as more programming. There was not enough time for the group to adapt the modifications to the new features.

The Peppy team faced lack of time to repair the model. At the beginning of the semester, the broken Peppy was acquired and every part had to be investigated. The time taken to attack this problem exceeded the estimated time as suggested by the Gantt chart. There was much time needed to activate all functions of Peppy. Anyhow the robot was repaired but for the sonar part. If granted more time this would have been possible. A major obstacle surfaced in the end as the Robot appeared to be burning the Voice Extreme circuit board. The reason could not be specified, but there's reason to belief that there is some disorder between VE and motors. When Peppy was commanded to move by voice recognition function, the VE was burned.

An obstacle the PYRO team faced in creating a PYRO interface for Roomba was that we do not have access to a functioning Roomba with support for communication with a computer. Because of this our sub team has created a virtual Roomba to be used in place of the actual hardware until a real Roomba is ready. The PYRO sub team has been doing what it can to help the Roomba sub team obtain the cable which Roomba requires for communicating with the computer.

RESULTS

The results achieved according to the different sub groups were:

PEPPY

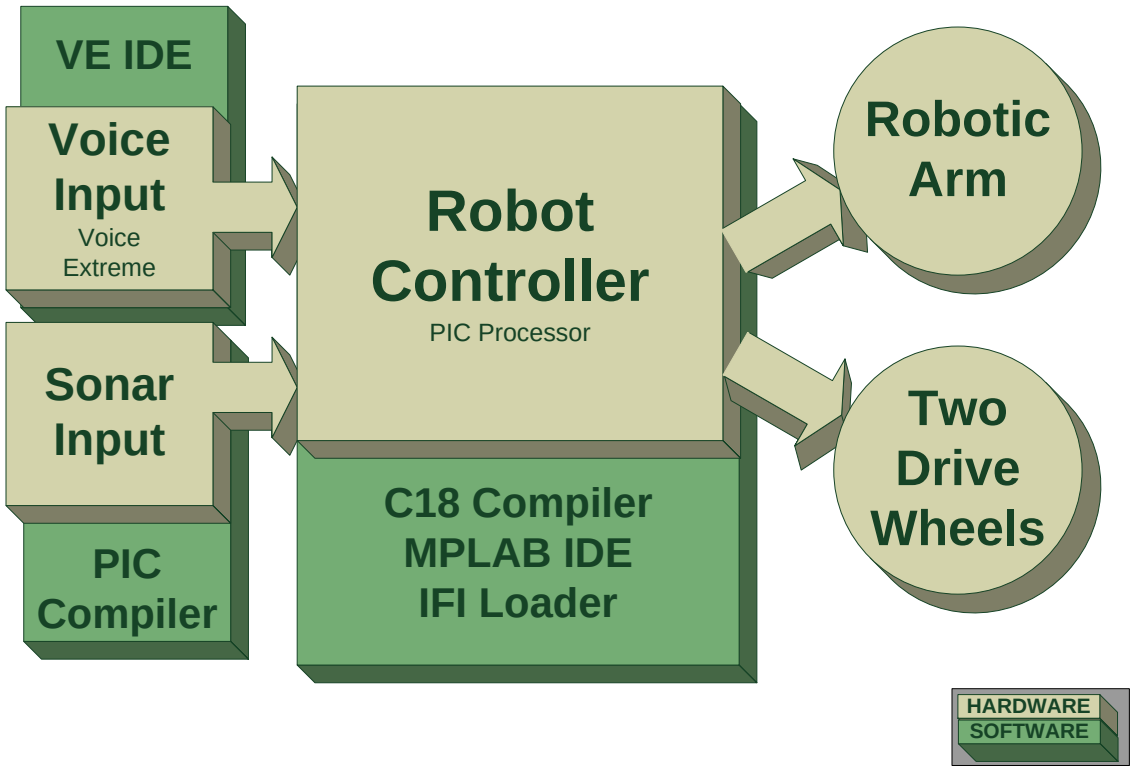
Repaired Peppy

The broken voice module is replaced with new one. All program bugs are patched. We programmed Peppy to show issuing voice commands to Peppy. But we could not repair sonar parts because of lack of time.

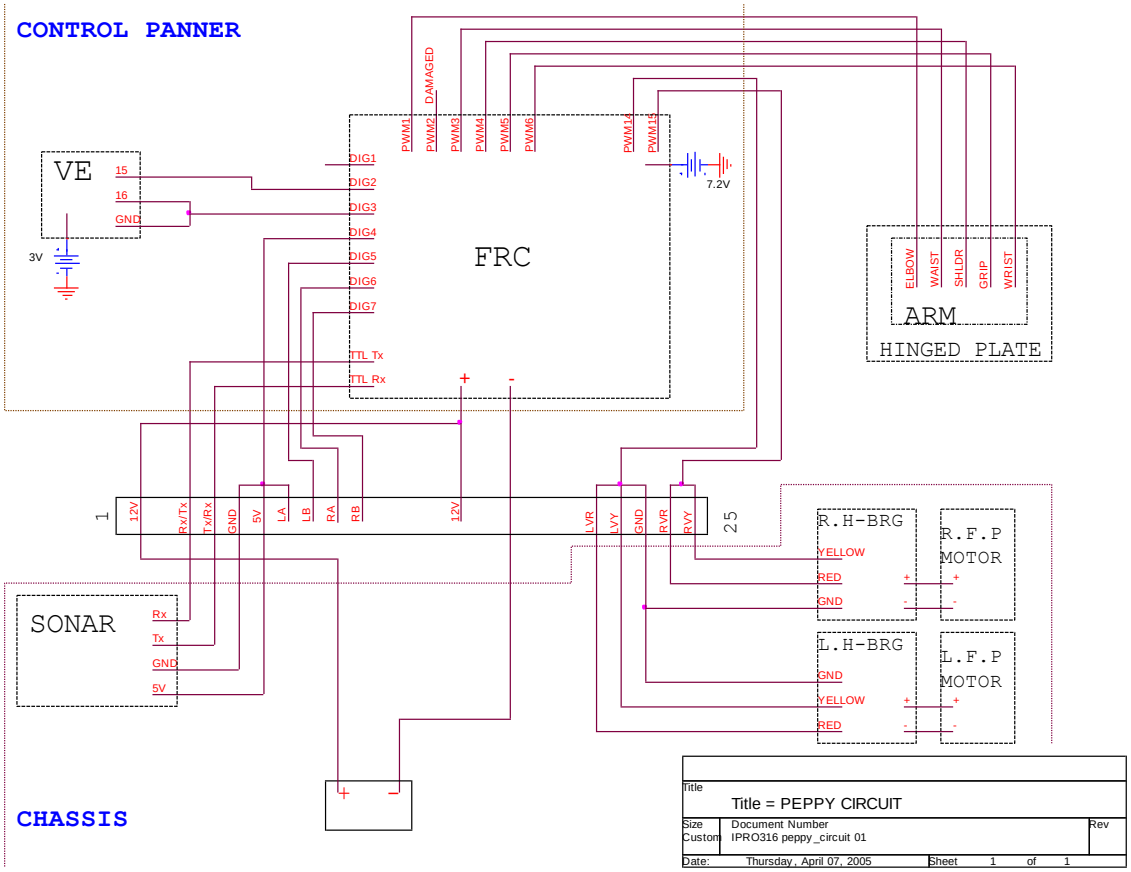
Documentation

We made video-clips and manuals. There are 2 block diagrams, functional and circuitry.

Functional Block Diagram



Circuitry Block Diagram



ROOMBA

The Roomba sub-group was successful in completing the original prototype. They created a functional sensor circuit and incorporated it into the modified circuits. They also inserted the new microcontroller. The group not only obtained a few new Roombas but got fifteen Discovery and

fifteen Red model Roombas, much more than they were expecting. These Roombas were donated to us by iRobot. These were Roombas that were sent back due to some malfunction. This added another task for the group of making as many of them as they could functional. Upon inspection most of them had problems with the brush system which was good because the brush system was being removed anyways. There was only one that had a charging problem that the group was not able to fix at the time. The group was able to successfully remove the brush systems from the new Roombas and has written up a documentation on process so future groups can easy do this with any they acquire.

The group was not able to make the prototype run due to the fact that it did not have a program to drive it. They could not accomplish this because there was no one in the group capable of such a feat. They also could not complete the communications and swarms programming due to a large amount of information they did not receive until later in the project. Although they did not complete all that they set out to do they have prepared everything so that the next group will have an easier time and may easily pick up where they left off.

PYRO

- Visited Bryn Mawr's website to obtain PYRO simulation design
- Learned how to use it
- Taught other team members how to use the software

- The data that has been gathered is presented in a Power Point format.
- No changes made to the schedule of tasks or events.
- Implemented a virtual Roomba to use for work on interfacing Roomba and PYRO
- Implemented a maze simulation

RECOMMENDATIONS

ROOMBA

From the work the Roomba sub-group did throughout the project they have made a large step in the understanding of what is necessary reach their ultimate goal. They found that their goal was more than what can be accomplished in one semester but have done all they could to make it easier for the next group to continue.

The next steps the group suggests any future group should take are as follows:

- Write a program that will drive prototype. This will require someone skilled in programming. They suggest using a C based language.
- Get multiple printed circuit boards. The group suggests getting them made by a company.
- Use the communications that is already in the Discovery models for their communications system.
- Write a swarm program that will include possibly up to fifteen or sixteen Roombas.

References

www.irobot.com

Documentation of the prototype

Acknowledgements

The Roomba sub-group would like to thank the following people for their help throughout the project:

Professor Lykos: Assisted the group with tips on how to find what they needed and how to meet the IPRO requirements.

Chris White: Assisted the group with the information of the machine for printing circuits and for providing them with some of the parts they needed.

Ty Sopko: Provided a great amount of information on the Roomba project and offering assistance when the group needed it.

Zhisong Zeng: Provided the various electric components needed to complete the design process