IPRO 334:

Robotics Applications for Elderly Living Environments

Fall 2008

Background

This problem was researched by members of IIT's Institute of Design and presented to our group by Professor Sato. As the baby boomer generation reaches retirement age and beyond, the shortage of caregivers and nurses makes this a foreseeable problem in the future. This demographic has certain physical, emotional, and social needs that set them apart from other robotics applications. Companionship, family engagement, community, learning, memory, physical, and mobility support, as well as healthcare and monitoring are core issues that should be addressed in this solution.

Robotics can supplement and offer more widespread support for seniors than assisted care communities can alone. Individuals can maintain their independence and encourage them to direct attention to physical and mental activities. With the ability to serve as a channel of communication, family and friends can stay connected. The robot can filter and simply present any emails, photos, or other internet communiqués to someone with limited comfort using technology. Simplicity in design should maintain the user's dignity and sense of control, providing appropriate responses even if the input data is not exact. Personalized, customizable behaviors and appearances can maintain individuality, and the robot can learn certain preferences over time.

Patient care in hospitals can be improved greatly by reducing the staff work load on tasks that are not critical and can be automated. Coordination between staff members can be improved with robotics systems, and a patient's desire for information and support can be met. Different robots can accomplish different roles. Automated medication delivery will reduce the burden of staff to gather and track these resources. The medicine will be delivered in a regular and timely fashion, and prescriptions and dispensing errors can be avoided. Supply delivery can restock basic necessities in a patient's room, medical and surgical equipment in a operating room, and ensure that all these materials are available to the patients, doctors, and nurses that need them. The transfer and transport of patients and equipment can become more efficient and quick with the aid of robots. Through assisted walking, seated, or patients lying down, every patient can be accommodated to their own needs. While transportation is the focus of the robot, a nurse can accompany the patient by their side and focus on the interaction and comfort aspect of hospital care.

The different roles of these robots share common components of sensors, manipulators, task specific functionality, processing, power, and mobility. A product architecture that is modular in design would be most beneficial in meeting these needs. A wider range of product grades will become available with different modules. A successful and cited example is the coffee maker. Originally, it was one low price product consisting of a brewing unit, water tank, and heater. Its new modular design extends the water tank to a filter and filter holder, and adds a removable carafe for easy maintenance and serving. Business opportunities lie in the parts, supplies, and alternative choices available. This same concept can be extended to the creation of a robot. By designing each of the functionalities and being able to choose the inclusion of modules, the result will be fully customizable, reusable, and expandable.

Ethical issues or ethical dilemmas that could be faced during the course of this project are discussed here. Four main categories of ethical dilemmas are emphasized here.

SAFETY:
The main idea of the project is the application of robotics to the elderly environment. As the title suggests, the project would be dealing in working with the health care. So, care should be taken such that the expected standards are fulfilled. Since the project deals with working of the robot in the health care centers, it should be taken care that the robot moves in a correct manner. It should be designed in such a way that it can move around freely and avoid obstacles. It shouldn't be crashing into people or choking them. There shouldn't be any error in decision making; the right patient should be getting the right treatment. To summarize, it can be said that the robot should be reliable in terms of safety, thus minimizing the risk of harming someone's safety.

EFFICIENCY:
It should be made sure that the robot must be used efficiently. Efficient use of the available resources must be made. For example, the battery power should be more but at the same time the robot shouldn't get heated, the motors and the sensors should be used effectively so that they last long. The equipment should be handled with care in order to avoid any wear and tear. It should be able to be recycled or reused again. Just because a robot is available it shouldn't be used for performing every small task. To summarize, it can be said that the robot should be sustainable, effective and it performs more work than required.

JOB OPPORTUNITY:
This project should be helpful in the field of employment. The robot that is designed should not be like a competitor for the workers; instead, it should be useful to them. Robot should be used in order to reduce the work of the worker but it should not be a cause for terminating a worker from the job. That is, a robot working in a health care center doesn't mean that the nurses should be fired from their job. Also, the robot should increase the opportunities for employment, that is, people should be hired to program the robot, extend its features, etc. In short, the robot should redistribute the work, not terminate the workers.

BUSINESS:
With the improvement in the business sector and development of new technologies, there are also few unpredictable problems that arise. Problems like privacy, security arise. It is necessary to make sure that these issues are properly dealt with. For examples, the code or the prototype should be copyrighted and licensed. Business tactics must be implemented to with stand economically. That means the robot must be designed in such a way that it is cost effective and it raises the economy (or improves the business) of the organization which uses it.

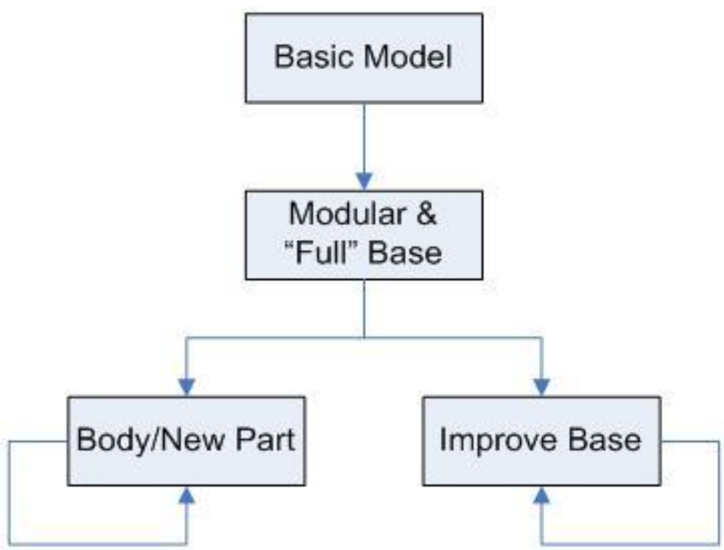
Apart from these four issues, few other common issues must be taken care of. The robot should be user friendly and easy to implement or work with. It should also be environment friendly. That is, it should maintain cleanliness, the working environment must be healthy, and the battery or the microcontroller used should be programmed with care because any short circuit may lead to environmental hazards. The robot should be designed such that it can work under common environmental conditions, it shouldn't be too big or too small, the size should be ideal. Thus, these kinds of ethical dilemmas or issues should be taken care of for the smooth functioning and implementation of the project.

Objectives

As a group, we brainstormed and decided upon several objectives for the semester. Since this was our first semester as an IPRO, we decided to keep our objectives modest. We strived to create a working prototype of a robot that is modular in design, as well as create a functioning module to demonstrate the usefulness of such a modular design. In addition to modularity, another major focus of our prototype would be mobility. We wanted the robot to be able to deliver a message from one point to another. Ideally, the sample module would facilitate the delivery of messages. To that end, we decided to make a drawer-style compartment for securely storing items within the robot for our first module.

Methodology

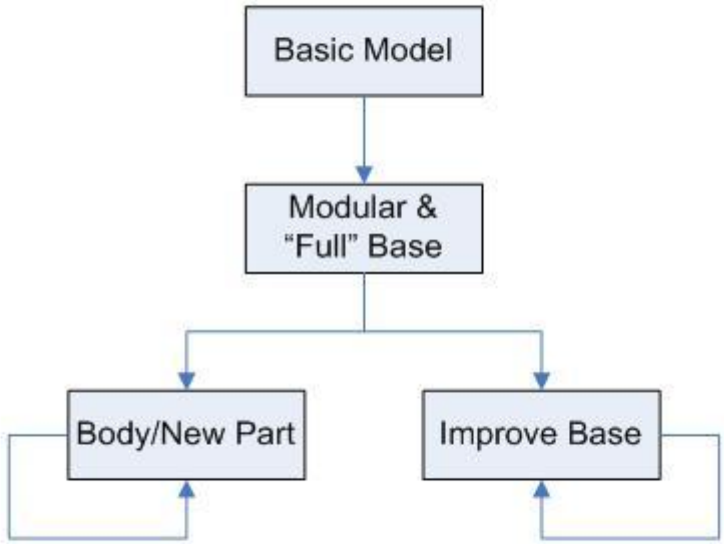
The tasks of the software team as of the midterm project plan are effectively shown in the flow charts below.



Software Team Tasks

The team first learned the particularities of the code used. They then developed code for the line following sensors, the limiter switch sensors, the bumper sensors and the ultrasonic sensors. The movement algorithms were developed within the process of developing the code for the line following sensors, as the basic movement for the robot is to follow a line. The bumper sensors are the integration of the other behaviors, since they are used to change the function of the robot from one mode to another. Code for additional modules involved programming a servo to open a drawer module when a bumper sensor is pressed. The tasks of the software team did not change from the midterm project plan. What did change were the ideas for how to implement the tasks.

The next flowchart describes the tasks for the Mechanical Team as of the midterm project plan.



Mechanical Team Tasks

The base was constructed and improved until it was functional and could perform the tasks required of it. The modules that make up the body were also designed and created. New parts in the form of sensors were also placed on the body of the robot in positions that would allow them to operate efficiently. In addition to the tasks outlined in the midterm project plan, a functional module was created. This module was given the function of opening a drawer when a button is pressed. It was decided to create this module in order to better demonstrate the prototype's eventual application.

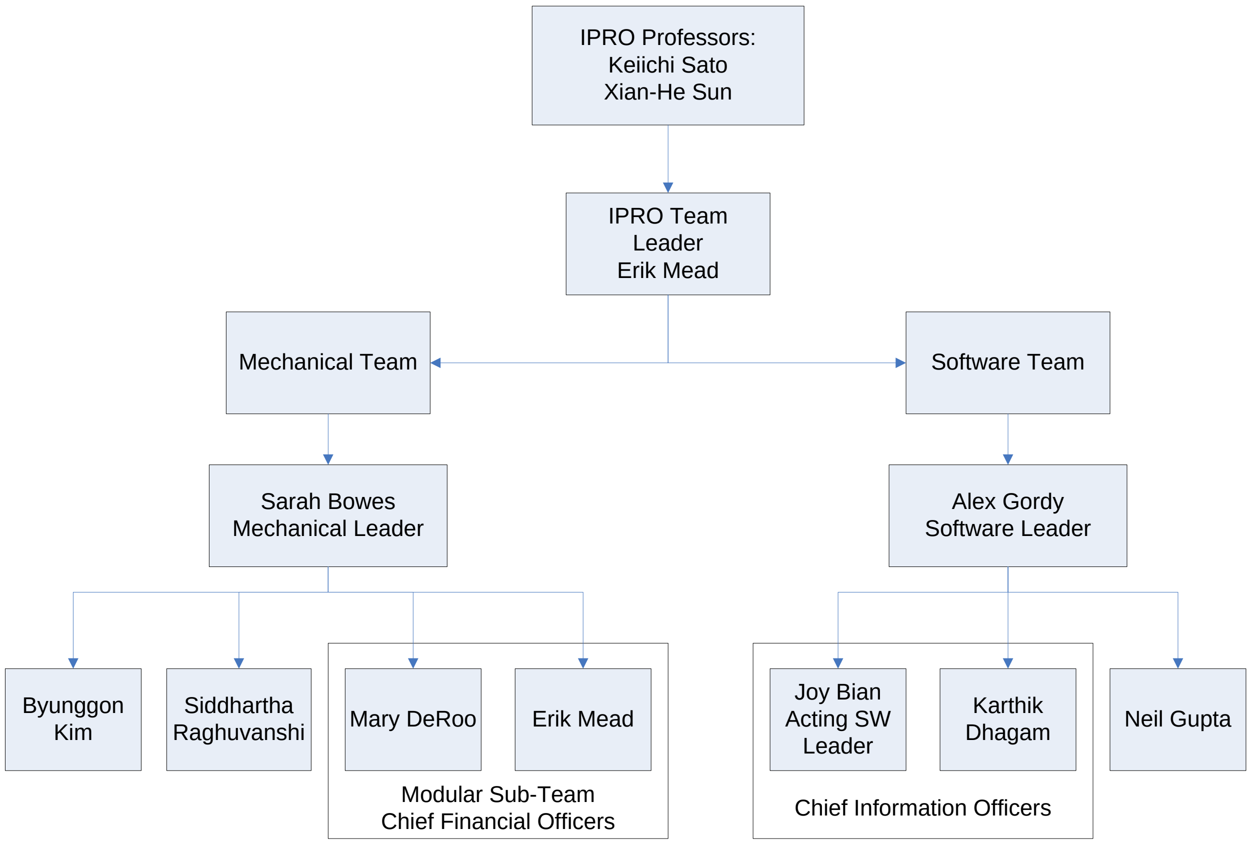
On the previous page, a Gantt Chart with the weekly breakdown of each task illustrates the methodology of the IPRO 334 team. Included in the chart are the tasks of the mechanical and software teams, along with the general tasks of the IPRO, including the midterm project plan and ethic's statement.

IPRO 334 Weekly Task Breakdown

Tasks	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
General Tasks															
Assign Team Positions															
Structure Semester Goals															
Project Plan															
Ethics Discussion															
IPRO Day Preparation															
Mechanical Team Tasks															
Design Basic Structure															
Create Module Frames															
Create Functional Module															
Cut Metal Pieces															
Modify Structure as															

Needed	
Software Team Tasks	
Line Tracking Code	
Limiter Switch Bumper Code	
Bumper Sensor Code	
Ultrasonic Code	
LED Funtionality Code	
Test Code	

Team structure



The team structure changed in the final weeks. The software team leader, Alex Gordy, had to leave the IPRO. Joy Bian stepped up and took over the team's lead role at the end.

Erik Mead - Overall Team leader; overseeing the project as a whole; communicating with our professor and IPRO office, in charge of finances, budget, and ordering; mechanical team member; performed research and investigated possible modules; aided construction and testing as well as provided temporary space to work before an office was obtained; presented in the midterm and final presentations

Sarah Bowes - Mechanical Team leader; oversaw, provided vision for, and implemented the construction of the base, mobility system's gears and wheels, as well as positioning of sensors, battery, and microcontroller and modules; valuable prior experience in robotics with materials and tools that streamlined ; provided solutions for mechanical problems along the way

Byunggon Kim - Mechanical team member, responsible for documenting the progress of construction, rendering models of the robot as well as future envisioning of appearance; provided access to metal shop space and cut metal pieces for robot construction; authored final report

Siddhartha Raghuvanshi - Mechanical team member, aided in the construction and testing of the robot; authored final report

Mary DeRoo - Mechanical team member; assisted in financial matters, aided in the construction and testing of the robot; as well as solving many of the wheel and gears problems seen in construction; performed research in modules and investigated antimicrobial silver ion coating of metal; authored project plan, midterm report, final presentation, and final report, as well as presented in both presentations

Joy Bian - Software team member, took over role of leader in last weeks; responsible for taking notes and disseminating information from meetings; assigned specific software tasks to team members; main code project was to work with and test the ultrasound sensor and author and test the main driver function that would be loaded and demonstrated on IPRO Day; assisted mechanical team with their testing; authored project plan, midterm report, final presentation, and final report, as well as presented in both

Karthik Dhagram - Software team member; assisted in communication and information tasks; responsible for line following code and testing to provide a demonstration of its capabilities for IPRO Day; authored final report and presented in the final presentation

Neil Gupta - Software team member; responsible for touch sensor obstacle avoidance code and testing to provide a demonstration of its capabilities for IPRO Day; authored final report

Budget

Approximate Date	Product Description	Approximate Amount spent
9/11/2008	VEX Starter Kit	$300
9/11/2008	EasyC CD	$100
9/11/2008	VEX Metal Parts Kit	$80
10/4/2008	VEX Power Pack	$50
10/4/2008	VEX Line Following Kit	$40
	VEX Bumper Switch Kit	$13
	VEX Ultrasonic Range Finder	$30
	VEX Gear Kit	$13
	VEX Motor Kit	$20
	VEX 2 Wheel Pack	$10

	Total Spent by IPRO Team	$656

Professor Sato also purchased a couple laptop computers to be used by the group for testing.
The money for this purchase came from a separate budget.

Results

During the process of achieving the goals set, the IPRO 334 Team accomplished a design for a modular robot geared toward work in the healthcare industry. Through brainstorming and trial and error, the structure of the robot was created using VEX Robotics parts. The configuration of the robot is that of a tower on a sturdy base. The tower is rectangular and contains slots for modules. These modules will represent different functions for the robot. Sensors were also placed on the base of the robot to give it added functionality. These include bumper sensors, limiter switch sensors, and an ultrasonic sensor. This prototype was tested, modified, and redesigned in order to create a model for the future semesters of IPRO to work on.

In addition to providing a physical model for the future, some basic functions were given to the prototype. The robot, aside from having basic movement, was meant to follow a black-on-white line. Though the code had been written for this function, the sensors were found to be faulty towards the end of the semester when there was no time to acquire new ones. The robot does have some avoidance capabilities. The limiter switches allow it to turn away from an object that it hits, and the ultrasonic sensor allows it to avoid objects directly in its path without hitting them. The bumper sensors are an interface for the user to instruct the robot. By pressing a bumper sensor, the user causes the robot to perform different tasks. The code and testing of these functions will provide a valuable start to the future IPRO teams.

Finally, a module was created that opens a drawer when a button is pressed. This will allow the robot to carry a message or medicine to a destination. This module is a good example of how the robot can be specialized for certain tasks by adding different modules.

Throughout the semester, the challenges that come with designing a robot for the healthcare industry were kept in mind. The avoidance capabilities of the robot were important in making a safe machine for helping the elderly. The drawer provides an ethical dilemma, as important, private documents are expected to be carried in it. This can be remedied with the eventual addition of a lock or fingerprint scanner. The cleanliness of the robot is also an important issue that may be remedied by using different materials that are easy to clean or antibacterial. Though these challenges were discussed and realized during the semester, the prototype has not addressed all of them as of yet and they will have to be considered next semester while finishing the design.

Our goals for this semester included creating a design for a modular robot that could follow a path in order to deliver a message or item. This was achieved by our mobile line following robot with its drawer module. Another goal set was to create a module that demonstrates the way a future module will be powered and easily attached to the robot. Unfortunately, this goal was not realized due to the time constraints of the semester. Frames for modules were designed and built, but they do not adequately show how they will be powered and controlled by the central processor. However, the success of creating a functional prototype should not be overshadowed by these setbacks.

Obstacles

A number of obstacles were encountered during our working on the robot. Here is a look as to what they basically were and how did we tackle them. They have been divided into two categories.

Software Problems:

Firstly, the code was divided amongst the team members and the time taken for the development; documentation and testing were dependent on the nature of the algorithm. This was solved with the help and co-operation if the members who were always ready to assist each other. Secondly there were problems due to the availability and functionality of the robot, as well as the workspace and the required equipments. Proper communication between everyone helped in tackling this problem. Flexibility also played a major role in ensuring that the workspace was available and the necessary equipments were present. Another obstacle that came in the way was that the problem solving was slowed down due to the lack of RobotC documentation. Due to this problem we searched online for RobotC forums to hasten the problem solving process. There were segments of code which were tested through trial and error. Lastly there was a problem that the semester was started learning Microsoft Robotics Studio but then had to switch to Vex Robotics kit, then to EasyC software and eventually to RobotC.

Mechanical Problems:

There were a number of design challenges on the mechanical front such as how to maximize the number of modules but keeping the robot stable at the same time, how to distribute the weight evenly and how to add modules without a lot of effort. The main problems that were faced were that the base had become heavy due to which the robot would fall behind. But this problem was solved by spreading the wheels further apart to bring more stability. Another problem was that while moving the robot would veer towards the right. So the alignments of the wheels on the base were readjusted to counter this problem. There were a couple of obstacles due to the gears as well. Since the gears were large, they were too close to the floor. Thus larger wheels were used to life the robot higher from the ground level. Another problem was due to the gear ratio which was not compatible with the needs of the robot. To deal with this problem the gear ratio was changed to slow the robot.

There are a few obstacles which might be faced in the future. Building a full scale model would be quite difficult. Then creating an interface between the user and the robot would also be a challenge. It would be required to make more advanced algorithms and modules in the future.

Recommendations

Since this was the first semester of IPRO 334, we agree that we had a slow start in the beginning. Starting from scratch was really tough. We believe that our prototype robot and our records of trial and error will help the future students who will participate in this IPRO. In the future IPRO, they should not be only working with the small prototypes, they should try to make a full scale model of the robot. This will also help to develop a "plug-and-play" modular bay; if the robot itself is small; the modules could only be smaller, which will be extremely hard to make. After the base and the completion of the module slots, designing more advanced robot algorithms, developing and determining the modules that would benefit the robot in its task of elderly care will be necessary; such as face recognition or arms and hands for handling medicine, creating interface between user and the robot.

References and Resources

Through the course of the semester, various works were referenced and employed to aid the progress of this inter-professional project. The Vex Robotics website, RobotC and Microsoft Robotics forums were valuable in answering questions about the construction and development. Also, the work and research done by the Institute of Design previously was used as inspiration and guidelines toward the tasks that we aimed to prototype in our design.

Acknowledgements

We would like to thank our professors, Sato and Sun, for their guidance and enthusiasm towards this project. We would also like to recognize the IPRO office for their communication, resources, and workspace provided for the construction and testing of our prototype.