Jan 18th, 2010

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal of Automated Item Retrieval System for Disabled People

Dear Dr. Rawicz,

The attached document, *Proposal of Automated Item Retrieval System for Disabled People*, outlines our ENSC 440/305 capstone project. Our goal is to design an automated system that can help disabled people to retrieve item at home. People with restricted mobility or agility usually rely on their families or friends on daily life. Our system will make those people live more independently.

This proposal will have an overview of our proposed product, accompanied with the explanation of the need of the product. We will also describe the technical aspect of problems we have during the product development. Possible solution will be discussed. Also, we will list information such as detailed tentative budget, sources of funding and projected schedule. At the end, we will provide an executive profile of our team members.

Freedom Innovation Research (FIR) consists of five motivated and innovative people: Steven Choi, John Ogawa, Jason Tsai, Kenta Yuan, and Richard Zhang. We are all fifth-year engineering students with at least one year of industrial work experience. If you have any question or concern about our proposal please feel free to contact us at ensc-440-2010sp-fir@sfu.ca.

Sincerely,

John Ogawa
CEO
Freedom Innovation Research

Enclosure: *Proposal of an Automated Item Retrieval System*

Proposal of Automated Item Retrieval System for Disabled People

Project Team:

- Steven Choi
- John Ogawa
- Jason Tsai
- Kenta Yuan
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Submitted to:

- Dr. Andrew Rawicz – ENSC440
- Steve Whitmore - ENSC 305
- School of Engineering Science ,School of Applied Science
  Simon Fraser University

Issued Date:

- January 18, 2010

EXECUTIVE SUMMARY

In Canada roughly 14.3% of the population has some form of disability that limits their daily activities [1]. About half of all reported disabilities are restrictions in mobility (walking, climbing stairs) and agility (reaching, lifting, and bending) [2]. For these people, there could be a lot of difficulty to take a book from a distant table or to grab a pop can from the floor.

This document proposes to develop an automated robot that could retrieve objects for disabled people. The robot will be able to move itself freely in the room and it will be navigated by markers on the floor, self generated map, or remote control. It will have robotic arms for item retrieval and it should be able to raise itself to reach an item on a table. A combination of camera and other sensors will be used for item identification. The robot will feature a computer graphical user interface. We are going to spend extra effort on interface design to make sure it can be easily used by disabled people.

Freedom Innovation Research (FIR) is a start-up company that dedicates to apply the latest technology to help people with disabilities. We are a team of five talented and motivated individuals with a collection of skills in mechanics, digital and analog circuit design, embedded system, telecommunication and signal processing. All FIR members are 5th year engineering students with at least a year of industrial work experience in various fields, which makes us a particular strong and competitive team.

We propose a 12-weeks engineering cycle for this project which spans from Jan 10, 2010 to April 10, 2010. The outcome of our project will be a fully functional prototype that will be demonstrated by mid-April. The estimated cost of the projects is $1693 and it will be funded from a variety of sources including ESSS and Wighton Engineering Project Fund.

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INTRODUCTION

Try to imagine the time you become old and the simplest tasks seem like difficult challenges everyday because your body does not function as well. For people who have disability, they have to rely on family or friends for their daily life, such as getting a fruit from the kitchen. This simple movement is not simple at all for them if they are having a difficulty on moving. Disabled or elderly people may feel embarrassed to constantly asking someone to get this and that. What's worse, these people may not be able to afford such caring cost. Our goal is to design a product that provides freedom to such people. Besides helping disabled or elderly people, our product can be used for other purposes. It can give a lot of convenience by retrieving household items for people working hard at desks or by retrieving store items for workers or customers.

Our product, the Automatic Item Retrieval System, is designed to improve daily life of people who are having difficulty walking. This product will provide a safe, automatic and reliable service by replacing human service at home. This robot should be very easy to control for disabled or elderly people. With our automated technology, users will only need to input simple command and the robot will figure out the details of the tasks.

This proposal is going to give an overview of our product, included approached design solution, budget and funding information. We also include an estimated schedule for our project development. Unlike the automation technology for industry purposes, our product is specifically for home usage. We believe that our product is so innovative that it will provide great contributions to those who need it. Figure 1 illustrates the conceptual overview of the Automatic Item Retrieval System.

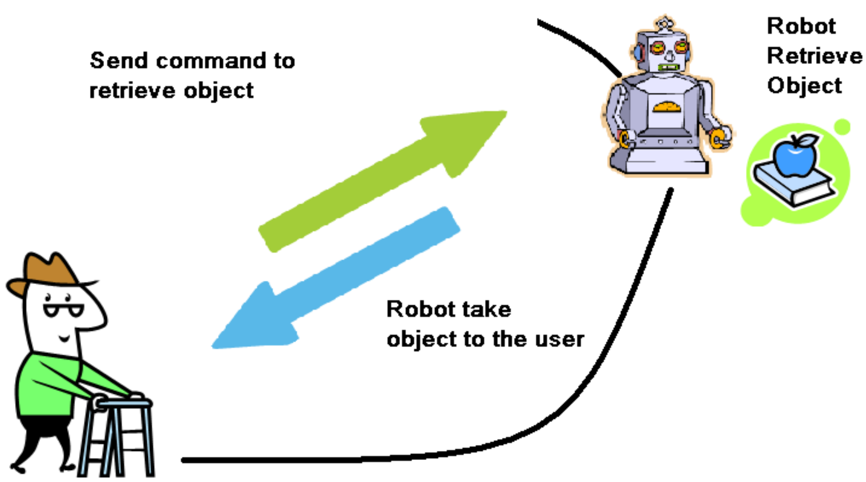

Figure 1: Conceptual Overview of the Automatic Item Retrieval System

SYSTEM OVERVIEW

Our robot system will contain two major components which are very crucial for proper functionality. One is a PC tower or laptop, running Microsoft Windows OS as our computer platform to run the robot control program and GUI. The GUI will provide the primary interaction with the end user. With the proposed voice recognition interface, the user can navigate between the options easily without hand control. Our main GUI will provide categories of items stored in the database, the system overview such as the location and health of the robot, and advance user pages listing more in depth system tweaking options. Underneath the program, each item will have its location stored so that the system can issue the location to the robot; main routing calculation will be handled in the computer program to leave more computing power on the robot.

The other main component will be the robot itself, which is responsible to retrieve the item as per requested. The robot will operate wirelessly through 802.11g/n wireless network to perform bi-directional communication with the main program. The power source will be sealed Lead-acid batteries which can provide up to 24 hours runtime between charges. The design will be modularized to provide future upgrade flexibility such as the elevator platform and robotic arms upgrade, microprocessor upgrade and power circuit upgrade. Mobility and performance is our main focus. The estimated length-width-height dimension is 50cm x 40cm x 25cm with the platform collapsed. This size gives the robot a good mobility inside a medium sized household with a stable platform to prevent tripping and flipping over. The robot will be built with stainless steel frames to provide rigid framework and support heavy components, then ABS plastic or metal sheets will be used for the body. This design will provide a light weighted but rigid structure. Where funding is available, a higher strength metal will be used in making the elevator platform and robotic arm to lift up heavier items.

The electronic component in the robot will contain the following items: robot orientated CPU/microcontroller with GPIO/PWM/ADC/I^2C interfaces, 802.11g/n wireless adaptor, webcam, high power H-bridge motor driving circuit, geared motors, servo motors, stepper motors, ultrasonic sensors, RFID reader, IR sensors, 3-axis accelerometer, digital compass, motor encoders and power regulating and monitoring system. Here is a brief explanation of the use of the main components. The microprocessor will receive all sensor signals and calculate/send to computer, and then it will send control signals to motor driving circuit to control the motion of robot. The wireless adaptor will create the communication channel to the host computer. Sensors will provide necessary information of the surrounding and the reference location. Power regulating and monitoring system will provide different voltage to different components and monitor the power consumptions with battery charging function.

Mechanically, the robot will have a metal frame base with 4WD system so it can overcome slippery inclined hardwood floor surface with heavy load as well as high friction carpeted surface. Power, driving and computing components are separated to different chambers to ensure easy debug and faulty component replacement. An elevating platform will be built on top of the robot to place the item retrieved, a two degree of freedom robotic arm will grab the targeted item from the shelves and tables as the platform will be raised to the pre set height.

We will be looking forward to use C as the main programming solution due to its strength to control hardware communication ports easily and its relatively stable and efficient platform. We have provided the conceptual Operation Flow Chart in Figure 2.

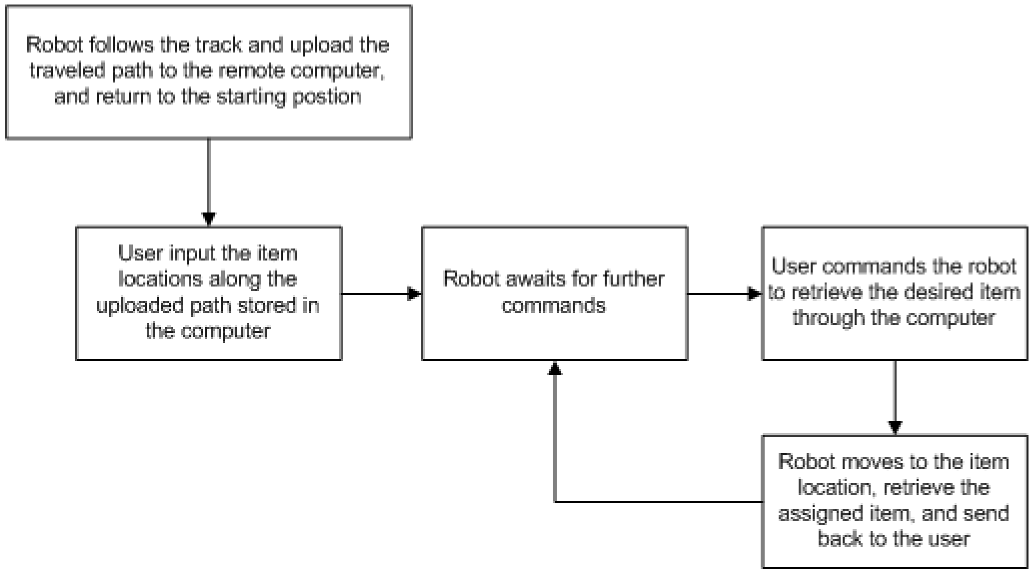

Figure 2: Conceptual Operation Flow Chart

TECHNICAL ASPECT OF PROBLEMS

Because AI is highly integrated (e.g. shortest route to grab the item, response to route is blocked by some unexpected object, and many other corner cases), we need to consider the control logic carefully under this short development timeframe. Upon the project progress, more or less corner case handling and AI algorithm will be put into the main control logic.

Which robotic platform to use is another problem. We looked into many robotic products but we could not find any that suits our needs, so that we decided to design and build our own platform. In addition, we considered having tank tracks or drive wheel in order to provide best terrain adaption, durability, cost, complexity, noise and efficiency. How heavy and how high the robot can retrieve will be slightly restricted as this will be the first prototype to represent the idea. However, we are still looking for possible full design specification that can lift a 10KG max item and item location from 50cm to 200cm height.

Navigating precisely within 2cm error is another huge challenge; many inexpensive methods that determine the current location would not work indoor with many obstacles or have an accurate measurement (such as GPS, Wi-Fi RSSI, RFID, RF beacon). Due to budget consideration, we might develop some low tech navigation system which will work well for our purposes and will be explained in the proposed design solution.

Mobility and Power consumption is very important for a robot as we do not want it to get stuck or flipped over and require the disabled personal to recover it. We want it able to operate the whole day so that the robot can be readily available when needed. Due to the trend of green environment, our robot will be also built with saving power in mind by having as few components as possible and high quality components to achieve high power efficiency and durability.

PROPOSED DESIGN SOLUTION

To fulfill the system overview and overcome the technical design problems, we have proposed a target design solution for our robot and we will explain them in small sections.

For CPU/microcontroller, we decided to use a micro x86 compatible CPU with plenty of PWM, GPIO and I^2C bus. Based on many previous projects' resources, a simple AVR, ATMEGA and PIC controller will be too slow to do fast computing with massive amount of information. Communicating between many smaller microcontrollers can be a difficult task and we have to program each chip individually. Select an x86 chip running Linux can provide us a usable interface to do real time embedded system programming in C, as well as many features readily be used (Network Interface, manufacture APIs and CPU intensive multithread programming).

As mentioned before, we will be building the robot body frame by ourselves to fulfill our own specification and size. After some detailed analysis, we decided to use driving wheel system instead of tank tracks. It is because there are not much tough terrain challenges in an indoor environment and the complexity of building driving wheel system with steering will not exceed tank track too much. Also, it is more energy efficient than using tank track due to less friction between the floor and the wheel.

The robotic arm/elevating platform is chosen for the ability to handle heavy items intuitively. The draft idea of operation are listed as follows: when in motion, the elevating platform will be lowered to its minimum height to lower the center mass of gravity; after the arrival of the targeted object, the platform will rise up to the same height as the target object; the robotic arms will reach out and grab the item then return back in a horizontal motion to the platform; after the object is retrieved, the platform will be lowered to the minimum height to ensure a safe delivery; robot will return to its home base(beside the end-user) and rise the platform to the end-user height for them to obtain or use the item being retrieved. The elevating platform will have a similar design to a car jack which needs only a small torque to rotate the screw but can raise a heavy object. The robotic arm will only retrieve the tray which contains the target item due to the lack of time and difficulty of designing a robot arm (which can well be another ENSC440 project).

Our proposed robot design will support up to 3 navigational methods. The 1st method uses colored markers on the floor as navigational references. We got the idea and the details from David Cook's projects [3]. We can use special markers for corners and junctions so the robot will know where to make the turn as seen in Figure 3. The 2nd method is remote control which allows the user to take direct control of the robot and use the on-board camera to see what the robot is facing. This method of navigation can be used both indoor and outdoor and it doesn't require any extra setup except WIFI wireless connectivity. The 3rd method of navigation involves the generation of the room map using the onboard sensors such as the motor encoder which evaluates the distance travelled. When first used, the robot will map the room following a surveillance algorithm and store the information about the boundaries and obstacles of the room to its database. For all the subsequent uses, the robot can use the room map for navigation and positioning. Due to the complexity of this method, we will tentatively mark it as an optional feature and will only attempt to implement it if we have time. In addition, the robot should implement a collision avoidance algorithm and it should have the ability to come around small obstacles.

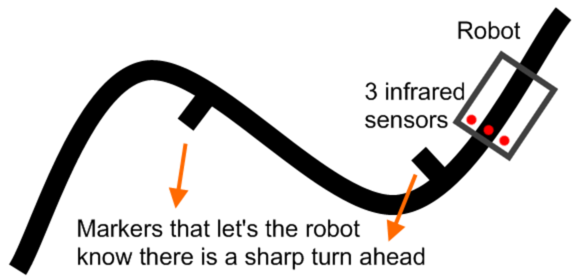

Figure 3: Line following navigation using infrared sensors and markers

BUDGET & FUNDING

Budget

Table 1 shows a tentative cost of our robot at the early stage. Since our system is the combination of electronic and mechanical components, the total cost will be a bit higher. The major cost is from the microcontroller development broad, robotic arm, lifting platform and battery. There is other trivial cost that we did not highlight here, such as wheels, gears, etc.

Table 1: Estimated Component Cost

Component	**Estimated Cost**
Drive Motor w/ Optical Encoder	$115.45
H Bridge Motor Driving Circuits	$131.20
SRV-1 Blackfin Camera + WiFi (Robot Controller)	$367.50
Ultrasonic Range Sensor	$62.95
Reflectance Sensor Array	$16.25
Customize robotic arm and elevation platform	$300
Robotic base and drivetrain	$200
Power system(12V lead-acid battery and charging station)	$200
Phidgets RFID Quick Start Kit	$100
Other building materials and electronic components	$200
Total Cost (Before tax)	**$1693.35**

Funding

We expect the cost of the robot to be inexpensive once it reaches the stage of mass production. However, it’s costly now because it is the first prototype. It’s necessary that we get funding at its development stage in order to come with a fully functioned prototype.

As we have applied for Engineering Science Endowment Fund, once approved, it will become one of our funding resources. Moreover, since our project is related to biomedical application, we will also try to apply for Wighton Engineering Development Fund. If we are still not able to rise enough funding in the end, each of our team members will contribute the rest of the cost.

SCHEDULE

The following figures represent a Gantt chart and millstone chart showing the estimated timeframe for each task. It also gives the approximate start and end date. Although these timelines are only estimated, our team will try to complete the product as soon as possible to allow us to have more time for future improvements.

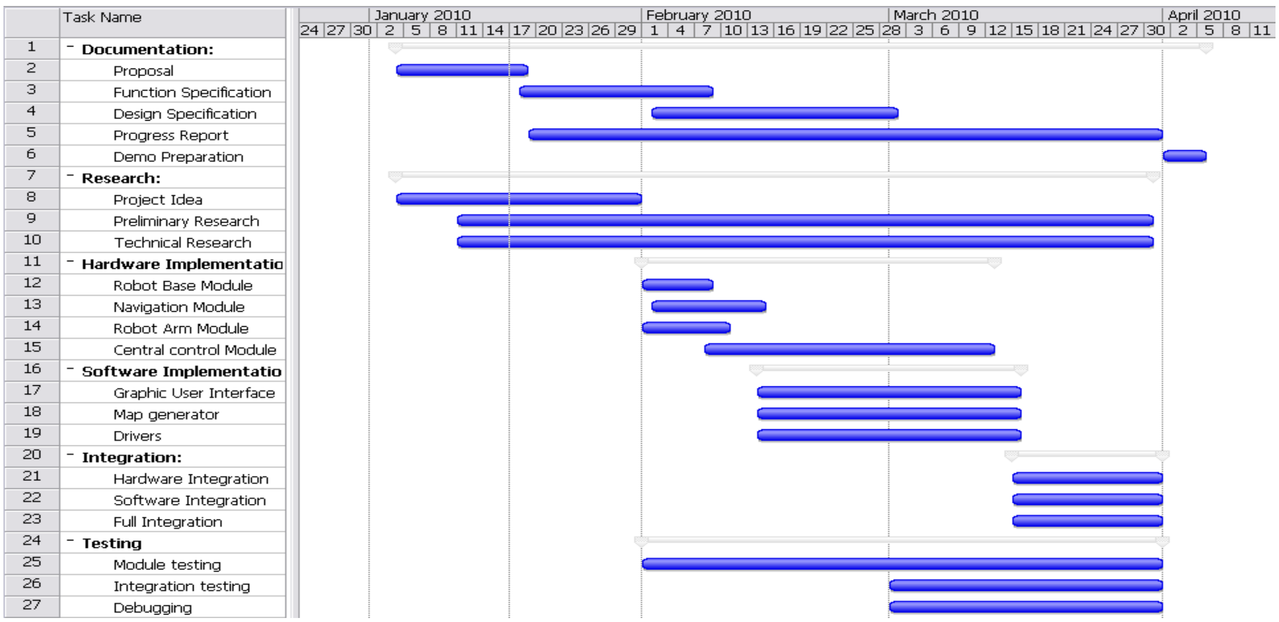

Figure 4: Gantt chart

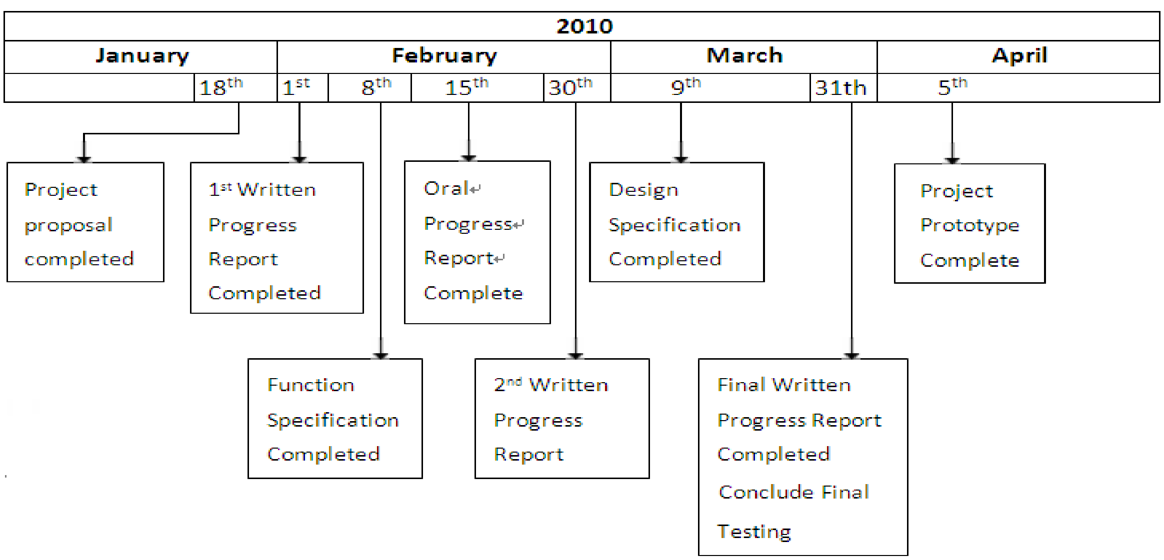

Figure 5: Milestone chart

TEAM ORGANIZATION

Freedom Innovation Research (FIR) consists of five talented and motivated engineering students: Steven Choi, John Ogawa, Jason Tsai, Kenta Yuan and Richard Zhang. All of us are in fifth year and we all have at least one year of co-op experience. The skills of each member are highlighted in the Company Profile section.

FIR will have a collaborative type of organization. Each team member has agreed to contribute a reasonable amount of effort. Each of us will be responsible for a specific area of the project, but we expect most tasks to be shared among more than one team member. Tasks will be distributed according to our skills and interests.

The team members will meet weekly to discuss the progress of the project. The CEO will send out a meeting agenda before each status meeting and send the meeting minutes to our team email group: ensc-440-2010sp-fir@sfu.ca. During a meeting, each member will have chance to express his thoughts and the final decision will be made by the whole team.

The members of FIR have gone through many difficult projects in the past so we have already formed a close bond between us. We understand each other's strengths and weaknesses and have planned this project according to his working style. With everyone all working toward the same goal, we are confident that the project will be completed within the specified time period and will deliver a high standard functional prototype.

EXECUTIVE PROFILE

Steven Choi – Chief Technical Officer and Project Manager

Being a CTO and PM, Steven has a broad knowledge and hands-on experience in analog and digital electronic circuit design, mechanical component design/building/repairing and all computer related technologies as a 5th year SFU Electronics Engineering student. Steven's strongest strength is his expertise at all subjects: from analog engineering classes to digital engineering classes, from auto mechanic to IT support specialist and from SQA engineer to computer programmer. He will be assisting CFO in purchasing parts that can fit our project needs and team budget. He will be working with CSTO, CHTO on project evaluation and development to ensure the success of our product.

John Ogawa –Chief Executive Officer

Through the work on the advanced digital system design and various embedded system design/tests, John is an experienced 5th year SFU Electronics Engineering student who organizes large problems into simpler parts and tackles them with plans. With previous co-op placements at Intel and Kodak, he has programming skills in C++, C, Python, and understands how to combine individual work into a whole. His greatest strength is in planning work in sequence to increase productivity and evaluating the theories with math and diagrams. He will work closely with CTO to come up with plans and share technical challenges with the rest of the members.

Jason Tsai – Chief Hardware Technical Officer and SQA Manger

Jason is a 5th year SFU Electronics Engineering student with previous co-op placements at Redback Networks and Offshore Systems Ltd. Through the course work and co-op experiences, he has gained programming experiences in C and testing experience using TCL scripting language under UNIX environment. He has experience with advanced digital system design project with FGPA and has accumulated practical knowledge designing analog circuits through school courses.

Kenta Yuan – Chief Financial Officer and Marketing Manger

Kenta is a 5th year SFU Systems Engineering student with experience in both electronic and mechanical system design. He is also familiar with various programming languages such as C++, java, Assembly, VHDL, TCL, etc. Kenta has more than a year combined work experience at Broadcom Canada and Safeway Canada as a quality assurance. He can definitely help at prototyping, debugging and testing the product.

Richard Zhang – Chief Software Technical Officer and Customer Relationship Manger

Richard is a 5th year SFU Systems Engineering student with expertise in variety of fields. His extensive engineering knowledge includes real-time embedded programming, firmware and driver development and modern control theory. His recent work as a technical support engineer at Broadcom Canada allows him to develop an in-depth understanding of embedded systems designs. In addition, his excellent communication and management skills make him a valuable member to the team.

CONCLUSION

Freedom Innovation Research (FIR) is dedicated to apply the latest technology to help people with disabilities. The Automatic Item Retrieval System we proposed would provide an easy solution for mobility restricted people to retrieve items that are hard to reach or too heavy to lift.

In this document we have clearly stated the problem we are facing, its social implications and the approach that will be taken to address this problem. We have given a preview of our system design and have demonstrated its ability to improve the lives of mobility restricted people because of its highly automated design and easy to use user interface. We have outlined our estimated project schedule with the Gantt chart and the millstone chart. We have also demonstrated our ability to meet our budget requirement by listing our sources of fund.

We are a team of innovative and motivated engineering students with a wide collection of skills. We all agreed to put the best of our effort into this project. We are confident that by the scheduled completion date we will have a high quality and fully functional prototype, which would also serve as the foundation of our future research.

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[4] Society of Robot, "How to Build a Robot Tutorial," Society of Robot. [Online]. Available: http://www.societyofrobots.com/mechanics_dynamics.shtml. [Accessed: Jan. 18, 2010].

