School of Engineering Science • Burnaby, BC • V5A 1S6
http://www.xotro.com • xotro-440@sfu.ca

April 15, 2010

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

Re: ENSC 440 Post Mortem for Rolada, Rollator with Controlled Braking System

Dear Dr. Rawicz:

The attached document describes the Post Mortem of *Rolada, Rollator with Controlled Braking System*. Our goal is to design and implement a rollator which produces automatically controlled variable braking resistance while going down a steep slope to provide the user with a stable support, and reduce stress on the knees. Issues such as difficulty opening doors and accidentally kicking the seat while walking will be mitigated by a new ergonomic frame construction which incorporates a seat that is clearly out of the path of the user's legs when folded. Safety features such as obstacle notification and nighttime LED lighting are also added.

This post mortem report details the current status of the proof-of-concept device, variations from the original design, and suggestions for future developments. It also entails the outline of the actual budget and the time constraints faced in comparison to the estimated timeline and budget in the project proposal document. Lastly, individual team members will reflect on their experience of group dynamic and technical knowledge gained while working on the project.

Xotro is composed of three Systems and two Electronics Engineering students from SFU: Henry Kam, Jeff Ip, Chuck Lee, Nathaniel Seung and Benjamin Chen. Please feel free to contact me at (778) 865-8859 or by email at xotro-440@sfu.ca, if you have any questions or concerns.

Sincerely,

Henry Kam
President and CEO
Xotro

Enclosure: *Post Mortem for Rolada, Rollator with Controlled Braking System*

POST MORTEM FOR A ROLLATOR WITH CONTROLLED BRAKING SYSTEM

Project Team: Henry Kam
Jeff Ip
Nathaniel Seung
Chuck Lee
Benjamin Chen

Contact Person: Henry Kam
xotro-440@sfu.ca

Submitted to: Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

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Glossary

GUI	Graphical User Interface
FSR	Force Sensing Resistor
ABS	Automatic Braking System
LED	Light-Emitting Diode
LCD	Liquid Crystal Display
CAD	Computer-aided design

1. Introduction

Rolada, Rollator with Controlled Braking System is an innovative wheeled walker which provides automatically controlled resistance to the wheels according to the slope or velocity of the walker. Using acceleration and velocity sensors, Rolada detects the slope angle or speed and will adjust the braking force on the wheels accordingly to provide safe and comfortable walking support for the user. Rolada also features an obstacle detection system which uses sensors to spot curbs or other barriers before the front wheels. Once an obstacle is detected, the user is warned by audible feedback through a beeper. The frame of Rolada is ergonomic because it offers more legroom than most conventional models while maintaining easier access to doorknobs by allowing the user to move closer to the front. To provide easier passage through doorways, the walker will have a door-wheel mechanism which allows the user to push through a door without damaging it. Finally Rolada provide LED lighting when ambient light is low thus increasing its night time visibility to other road users.

2. Current System State

Currently Rolada is fully functional and meets all the prototype requirements listed in the functional specifications. The system has four major components that are controller either manually or automatically. The four major components are ABS, sonar, door wheel and lighting system.

2.1. ABS

Automatically apply the brakes when it is over the user defined speed during only downhill application or past the user defined speed limit. The user can define three speed limit options by using a four position turn switch. The brakes will release when the speed is below the user defined speed limit.

2.2. Sonar

Automatically detects any object that is within a meter of the rollator and alert the user by the sound of a beeper. As the distance between the object and object decreases, the interval between each sound of the beeper becomes shorter causing it to sound repeatedly. The other feature of the sonar is to detect dips in the sidewalk. There is a toggle switch option to disable the Sonar detection.

2.3. Door Wheels

The door wheels are used to help assist the user to hold door closers when the user and the rollator pass through. There are four door wheels in total with two door wheels attached to each side of the rollator and are angled outwards. Therefore by adding it on two sides, it does not matter what way the door closes.

2.4. Lighting System

Automatically turns on four LED lights and adjust the brightness with respect to how dark the surroundings. The LED emits white brightness to add more awareness for nearby pedestrians and illuminates the floor.

3. Future Developments

Xotro is interested in further research and development of the product in order to compete in the actual market. During the development process, Xotro was able to find alternative methods to help improve the product. The following modification will help Rolada be more of an attractive product and give Xotro a competitive edge over competitors.

3.1. Overall System

- More tidy Product.
  In order to make the product cleaner and attractive to customers, the wires will be routed through the interior frame of the rollator as the metal tubes are hollow. Lighter material for the ABS mechanism frame and casing for the electronic components will help the product to be lighter and hence improve the portability.

- Minimize Power Consumption.
  To reduce power consumption, the code will be optimized to enable sleep mode condition when the components are not being used.

- Develop GUI Interface.
  By developing a GUI interface, it will replace the current switches the prototype product will have. The user will be able to control the GUI interface by using a LCD touch screen. The GUI interface will allow the user to check the status of each component along with all the functions the switches provide. It will also display the distance between the obstacle and the rollator.

3.2. ABS

- Mechanical Structure.
  Augment the mechanical coupling between the motor screw and the metal plate, which allows easier transition motion. A new position of the brakes to reduce the time it takes to make contact with the wheel and release back to initial position. The brakes are re-designed to protect the FSR sensor from being damage. The structure can be implemented on other application design, such as wheel chairs.

3.3. Sonar

- Accuracy, Mapping and linking to ABS.
  Incorporate a mapping system implementation to view the size and distance of the obstacle. Link the sonar and ABS system together to brake when a collision is imminent. Other additional add on will be increase detection distance and accuracy in detecting pits or negative obstacles.

3.4. Lighting System

- Further increase visibility by including yellow or red LEDs on the side or back or rollator.

4. Problems Encountered

Throughout the course of the project there was some setbacks and complication that was overcome to finish the project. The problems experience can be divided into two categories, mechanical and electronics issues.

4.1. Mechanical Issues

Two major mechanical problems that were encountered during this project were the design changes for both the door wheels and the ABS. During the planning stages, both the design of door wheel mechanism and ABS was going to be fabricated by an outsourced machine shop. Constant Solidworks design and technical drawings were used and changed multiple times until it satisfies each group member. But with limited funding, the outsourcing idea was scrapped as we thought of alternative ideas. We decided for the door wheels design using screws, eye bolt, washer, nut and paint roller attached to the rollator was strong enough to hold the door while passing through it. The only difficult part was to drilling holes on the rollator at an angle to attach the door wheel. For the ABS, we needed to hold still the motor so the screw only moves. In order to do so, we design a clamp out of aluminum to hold the motor. Once the motor is still, the screw will be attached to one side of the metal plate. The other side will have the brake pad. Fabricating this design proves to be difficult as aluminum was cut using hacksaw that lacks precision for small pieces. We ended up remaking parts of the ABS until it was correct.

4.2. Electronics Issues

During this project there was some minor and serious problem with the electronic components. The most notable problem was the FSR used for the ABS. We used the FSR as a feedback control to release the brakes when the rollator speed is past the user define speed limit. During the testing phase, the durability of the FSR was in questioned as two FSR malfunction. This was caused by the motor sheer pressured applied to the FSR causing hysteresis problem. To protect the FSR from malfunctioning, we put a layer of foam on both side of it to reduce the pressure. Also relocation of the FSR helped avoid the possibility of being damage by physical contact.

5. Budgetary and Time Constraints

5.1. Budget

Table 1 below contains the estimated cost of the project up to April 15th, 2010.

Table 1: Estimated Cost vs. Actual Cost

Required Material	Estimated Cost	Actual Cost
Sensors (Sonar, FSR, IR, Accelerometer)	$150	$82.61
Microprocessor	$200	$111.24
Motor	$150	Salvaged
Motor Driver Boards	$20	$34.13
Power Supplies	$35	Borrowed
Prototype boards(s)	$25	$5.80
Rollator	$200	$125
Mechanical fabrication	$200	$80.84
Discrete Component	$25	$19.80
Miscellaneous	$100	$101.51
Total	$1105	$560.93

Comparing the total cost, the estimated cost is almost two times more than the actual cost of the project. To justify the discrepancy between the two costs, the actual cost listed in the table does not reflect on the total cost of the project. The actual cost did not take into account the shipping fee required to deliver the material and the material salvage from past ENSC 440 project. Also new methods used for the mechanical fabrications allowed group members to do the mechanical work themselves, avoiding labor cost. Other cost reduction moves were the accessibility of power supply from group members. The miscellaneous cost is high because of the spare electronic component orders to compensate in an event that an electronic component is malfunctioning. Miscellaneous cost includes electronic parts that were proposed to be used initially but not incorporated into the final project.

5.2. Time

The Gantt chart below illustrates the comparison of the timeline between proposed schedule and actual project schedule. The proposed schedule time of completion is indicated in orange and the actual project schedule is indicated in purple. For most of the tasks, we were able to complete within the proposed schedule. The only difficult tasks that needed more time are the Electronic Design and Research and Programming Microcontroller. The difficulty experienced with the Electronic Design and Research is finding the right components to use within the limited budget received. Programming the microcontroller was delayed due to waiting for the shipment to arrive and complexity of the ABS synchronization on both wheels. By laying out the foundations of tasks completion time and relatively following it; we are able to avoid the pressure of trying to finish the project in the last week.

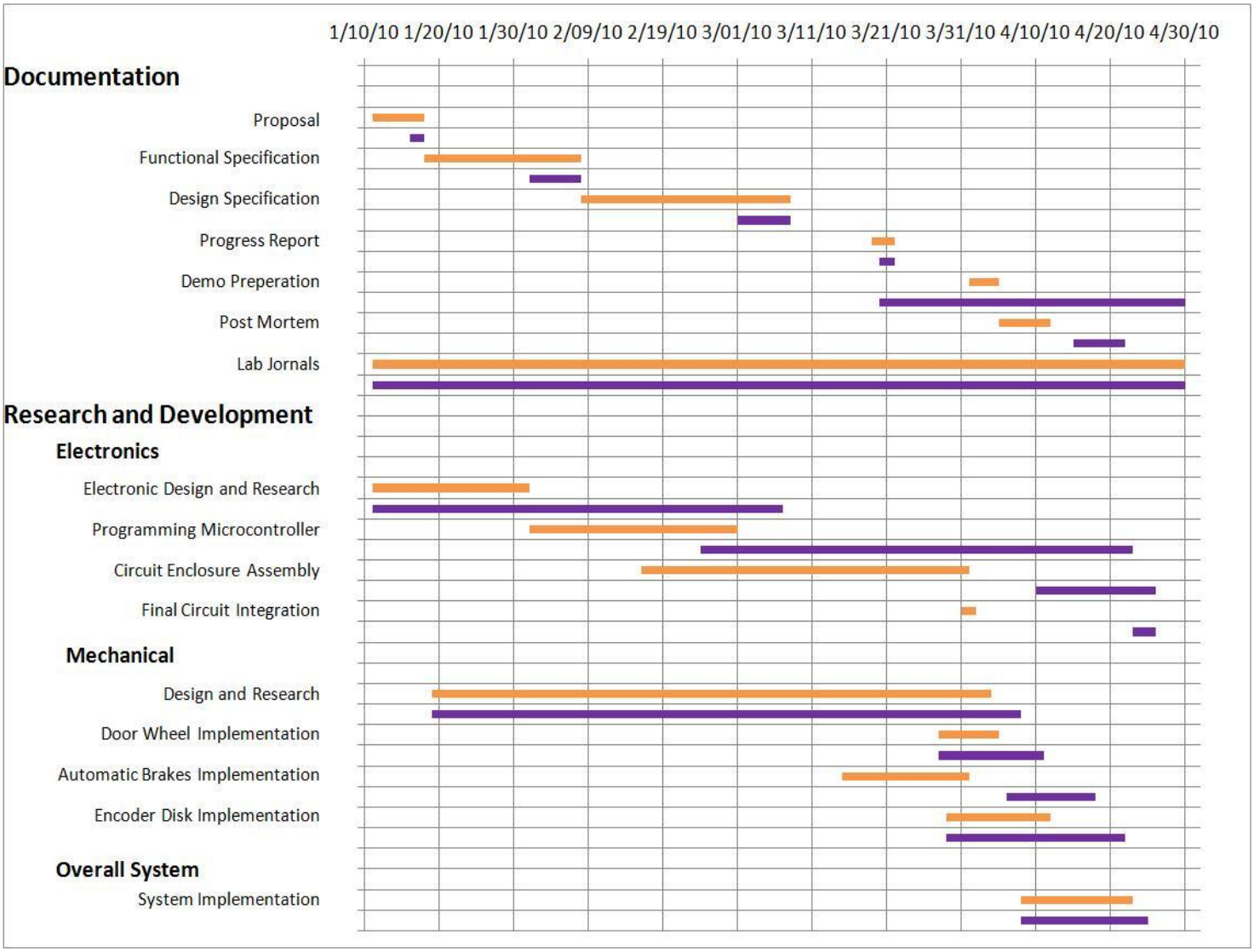

Figure 1: Proposed Schedule Time (orange) vs. Actual Time (purple).

6. Individual Experiences

6.1. Henry Kam

Throughout the project, I have realized that when putting theory into practice, many unforeseen difficulties can and will arise. Detailed planning and resourcefulness will help solve such problems in the long run.

I have become more familiar with real-time systems programming using microcontrollers as well as the use of various electronic components. I have learned to electronically connect and communicate the microcontroller to the motor driver boards and various transducers. This is fascinating to me because many simple household electronics today use microcontrollers. Now I can, in theory, use this knowledge in combination with various components to fabricate or at least simulate the logic to many such electronic devices. This will definitely be helpful for any projects I carry out in the future. This knowledge would not have been gained as quickly without the hands-on work done in ENSC 440.

I have learned to use many tools that I have not used before, such as the dremel tool and circular saw. It was difficult to fabricate the custom parts we needed to mount on various components for the project. However, my father had given me many pointers in using workshop tools, and with help from some of the other team members, we were able to fabricate some of the critical parts ourselves.

In doing research for this project, we have interviewed several users of rollator in Century House to ask about the problems or improvements they would like to see acknowledged. Doug and Ian from GF Strong have also kindly provided us with their helpful opinions on our project. It is encouraging to see that many people are willing to offer their time to help us for our project.

I have realized that being a leader is an extremely difficult task, especially in a large group. It requires excellent time management and organization skills, communication skills as well as technical expertise. I have learned that a leader needs to compromise to others' opinion as well as be assertive at times in order to maintain progress. In retrospect, the efficiency of the group was somewhat hindered in part by miscommunication and differing opinions. I have learned that, in order to complete the project, everyone in the group should offer their time and effort regularly, even with a busy schedule.

6.2. Chuck Lee

As a member of Xotro, my contributions to this project include designing and assembling of the mechanical features, recording the team's logs on an almost day-to-day basis, managing the group meetings, distributing the tasks, and high-level designing of the ABS. Because I had recently taken a course about sensors, actuators and feedback control systems, I have been assigned to assist in selecting necessary and cost friendly sensors and actuators for the project.

In the process of working on this project, I have learned how to use Solidworks as another CAD program. Honestly, the last time I used a CAD program was for an introductory drafting class in high school which was four years ago. During the early research and design stage of the ABS's mechanical system, I was given the chance to learn about the many different types of existing braking mechanisms. Having the

chance to use the laser cutting system over in the Surrey campus and combined with my interest in the visual arts had once again raised my attention in rapid prototyping and the field of Architecture. Overall, I have found the mechanical aspect of the project to be quite interesting despite that I rarely have the opportunity to touch on any tasks beyond the electrical and mathematical fields of engineering throughout my university career. In fact, although unrelated, the concept of using gears in a mechanical design had fascinated me in the intricacy of clockworks. Regardless of interests, mechanical design and assembly are definitely challenging to accomplish, especially in the physical sense when assembling pieces of various sizes.

I definitely had a lot of fun working with each and every one of my teammates throughout this project. I especially enjoyed those pressuring moments when everyone available would sit together and finish up the assigned tasks that were due in a matter of hours. Although sometimes I do have to wait for hours until a teammate shows up for an arranged meeting, I personally do not mind them being late. Despite the pleasure of working together with my teammates, there were certainly moments of disagreements and signs of discontents. For instance, I did realize that one of my teammates tend to lack respect towards the other members which eventually lead to distrust among them. I have often tried to help bridge their trust towards each other back together, but this particular teammate still lack respect and good work ethics in general. Therefore, it is safe to say that I have realized the importance of respect and work ethics in a collaborative environment based from this semester's experience. Without respect or a good work ethic, one cannot gain much trust towards another member easily, and consequently, the team would collapse. Nevertheless, this project alone had been an excellent learning experience and a refreshing reminder of designing ethics in the practical world.

6.3. Jeff Ip

I was originally assigned the role as the main software developer for this project. Initially, being in the hospital majority of the time, it was rather difficult to communicate with the group members. Also due to my illness, I was not able to contribute too much into the early hardware aspects of the project. However, as my health improved and my treatment consumed less time, I was able to start contributing my skills to the group. With extensive back ground knowledge in web development, I set up a forum/server/ftp service for the ease of communication between group members. It helped resolved the lack of communication within the group. The forum proved to be vital in organization of ideas and tasks between group members. Since the usage of the new ftp/forum infrastructures, the group was able to efficiently divide tasks and communicate ideas.

Throughout the project I was also able to learn how to work with micro controllers. I have learned a lot in dealing with Arduino and the real time coding styles. With extensive knowledge in coding, it wasn't a difficult transition to learn Arduino coding, but it has proven to me that experience in develop of embedded system is vital. I have gain invaluable experience in hardware, and have gain the confidence to build any hardware application through the use of micro controllers. Ultimately, as the project progressed I had shifted from software design to hardware and software developer.

As for group dynamics, I am grateful my group understood my health condition and took long commutes to work at my house. The members I initially had planned to take this course with were well understanding of my situation and have done much to help me get supplies to work. I also learned to start saying no to ideas and opinions I do not agree upon. Through the project, I have learned that it is

not "okay" to allow wrong ideas slide. This is because work problems can easily be prevented by speaking out against ideas that are prone to failure. Overall, the group was working coherently as the deadline approached. However, it was evident that one group member was lacking professionalism in his software integration and electronics/soldering work. This has lead to delays in project development as most of the work was not integratable and not meeting requirements. Despite this issue, team Xotro was able to finish the project in a timely manner. Now I truly agree with the term "if you want things done right, you'll have to do it yourself".

6.4. Benjamin Chen

From the first lecture class of the 440 course, I was overwhelmed by the expectation of our professor and the required workload for this course. Before the start of the course, my group was already formed and we were brainstorming ideas for the project. We came up with some innovative ideas, but time constraint and funding forced us to consider other ideas. My group finally chooses a project during the first week of the semester. It was personally difficult for me in the beginning of the semester due to physical fatigue and time allocation for both working on the project and research coop for the school. As the semester went on I was able to adapt and it became a non-issue.

I was originally assigned to the ABS system for this project. The Arduino micro-processor we used was similar to C++ programming in which I have some experience working with it. My task was to find a way to implement a mechanical system for the ABS to release the brake when the FSR sensor exceeds a pressure value. By accomplishing this task, I have considerably increased my knowledge of using machine tools to fabricate parts as well as increase my knowledge of the Ardiuno coding style. I was also exposed to 3D design software programs such as SolidWorks when designing the mechanical system. Using the Solidworks program, I was able to design individual parts with the correct measurement dimensions and later assemble it all together.

For group dynamics, I am overall pleased with the group cohesiveness and work ethic displayed by my team members except for one member. It was personally difficult to work with him due to his attitude of superiority of always easily dismissing ideas and never finding any faults in his. I was also displeased by his lack of notification when missing schedule meeting that me wait for hours. The most problematic issue was again his lack of notification of his decision of extending the Design Specification document due date and not informing us about his decision of his personal grievance. I would like to work with this team again for future project except for one of the group member.

6.5. Nathaniel Seung

I started out by joining in this team with a sudden decision of taking this semester instead of staying in Japan or go to China to travel. So, this project course was the course that I took by giving up my fun.

This project was originated a year ago from an idea of my friend who graduated from Emily Carr as an industrial designer. From his marketing research, my friend and I saw a big opportunity, so we decided to plan further with it. However, it did not work out due to the finance issues. Now, after getting the project done with a new team, I became uncertain on the business stage of this project. The project took longer than the team estimated, and despite of the effort that my team put into this project, the project didn't go as far as I wanted it to be. However, this project gave me both the interpersonal and the technical experience.

On the technical side, I cannot say I learned a lot because most of the technical side of the project had similar concept to the work that I had done in the past as a form of a special project course and a co-op. However, I learned few new things such as using an encoder as a speedometer, and getting familiar with the development board called 'Arduino'. Learning about the encoder was very exciting to me. Speedometer was a new concept that I haven't used so far before this project course, so I gladly took part on the speedometer. It was not easy to make the encoder from the hardware along with the software. There were unexpected bugs as always, but it was lucky that I never got stuck on any bugs since those problems were solved as I was getting more familiar with Arduino.

On the interpersonal side, I realized that there are a lot of interpersonal skills that all members need to develop, especially the communication. All members were working hard towards their assigned tasks, and we all had our own style of pursuing the project as individuals. Depending on the personality, some members rather remain quite on their progress and some others preferred special forms of communication method such as using an Internet forum to keep track of each member’s progresses. I preferred the way of having a very short offline or online meeting almost every day as I did on my co-op, but these meetings took a lot longer than we planned, so we later reduced the frequency of the on/offline meeting. All these issues regarding to remaining silent on their progress, using a forum, and having an on/offline meeting, caused lack of communication. I regret that the team couldn’t communicate effectively. With the effort that the team made, and with better communication, the project could go further into the next level.

Lastly, I'd like to thank to professor Dr. Andrew Rawicz, Steve Whitmore, and TAs' (Ali Ostadfar and Sara Mogahddamjoo) for the opportunity and the support for us. Also, I would like to thank to my team members for their hard work on the project. It was a pleasure working with them even after some unavoidable conflicts that came in a way to get our jobs done.

7. Conclusion

For the entire project we have accomplish the requirements set for this project and for ourselves. Unfortunately for some tasks we did not follow the schedule as was planned. For the most part we were able to work together and communication was satisfactory. Most of the tasked that we propose on our proposal was accomplished. We would like to thank contributing people in no particular order, Professor Patrick Leung, GF Strong rehabilitation specialist and workers Ian and Doug for pointing us in the right direction for this project.