StandStation Post Mortem Report

Project Team:

Wayne Chen
Gavin Wu
Kyuho Cha
Edward Chan

Contact:

wyc3@sfu.ca

Submitted To:

Patrick Leung
Steve Whitmore
School of Engineering Science
Simon Fraser University

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1. Introduction

StandStation is an add-on to electric wheelchairs that assists user to stand up. Users will not only benefit from the standing application, but also the medical improvements from using StandStation. Better blood flow, healthier muscle tissue, and reduce in joint calcification is just a few great benefits that StandStation offers. In this document, StandStation's future developments, financial standings and further improvements will be explained. Moreover each team member's experiences through the project will also be briefly covered.

1.1. Intended Audience

This document is intended as an overview of our past and present progress as well as how substitute methods may have been used to further improve our product and overall system. The intended audience is for the professors and instructors as an evaluation of our project execution but will also be used within the New Step Innovations group for use in future development.

2. Current System State

StandStation is currently fully functional and meets all the prototype functional requirements we set out in the functional specification. The system is controlled by a controller composed of tactile buttons mounted on the arm rest of the wheelchair. The controller has four buttons, up, stop, down, and memory.

2.1. Up Control

Automatically raises user to a standing position, StandStation will only top in 3 cases; maximum height reached, memorized height reached, and lastly if the stop button has been pressed by user.

2.2. Down Control

Automatically lowers user to the sitting position, StandStation will only stop if the user presses stop button.

2.3. Stop Control

Pauses the system anytime during an operation. The stop button has the highest priority out of all the buttons.

2.4. Memory Control

Can only be used when the system is not moving (stop button has been pressed). This button memorizes the current height and therefore the next time the up button is pressed, the height will be stopped at the memorized height. Pressing up after the system stopped at the memorized position could raise the height further acting as a temporary override function.

Rising of the height of the seat exercises the user's leg joints, preventing calcification of the joints. When the user is standing upward, extra pressure on the leg bones help bone density from decaying at a faster speed.

3. Future Developments

Our company is highly interested in further development of our product to be able to compete in the actual market. During development process, we were able to find areas in our design that could be altered to achieve a smoother result. Given the follow changes are made to our product, we believe StandStation will have competitive edge over our competitors.

3.1. Actuator Control

- Control both actuator and the same time to allow for a smoother transition between sitting to standing position.
- Add an additional sensor to detect interference of the actuator motion, thus increasing the safety of the user.

3.2. Enhance Safety, Comfort and Appeal

- Attach higher quality safety harness to improve comfort and safety.
- Improve visual appeal of frame and design buy making custom cushions and covers

3.2. Enhance User Interface

- Apply a sip-n-puff method of control for quadriplegic people.

3.3. Improve Customizability

- Customize frame to fit the needs of various body type.
- Use different size actuators to control the trajectory of the frame

3.4. Mechanical Structure

- Enhance the mechanical coupling between the frame and the actuators to allow for a smoother trajectory

4. Problems Encountered

During the course of the project we ran into few snags and drawbacks which we overcame to successfully complete our project. The problems we encountered will be broken down into mechanical and electronic problems.

4.1. Mechanical Problems

During the course of this project, we faced many mechanical problems. Two major problems we encountered were design changes and in the actual fabrication process. During the planning stages we decided to change the design of Standstation multiple times, with improvements made in every change. Although the end result was positive, we spent a lot of time redrawing Solidworks model and was left with unused parts that added to the cost. During the actual fabrication process we had to make sure that the machinist understood what we wanted to achieve with the product. Since it was our first time dealing with an outsourced machine shop, we were very careful to let them know exactly what we wanted to do. To ensure they knew our expectations, we had to make accurate technical drawings as well as watch over the fabrication process. Furthermore, to reduce costs we had to prepare some of the parts to be welded.

4.2. Electronic Problems

We ran into several problems when testing and integrating the components. Aside from the bad soldering and human errors, many problems arose from the components themselves.

The tilt sensors we have are very sensitive and accurate, but we were unaware of the problem for using an accelerometer to detect the angle of a moving object until the very end when we are doing our final testing. We were relieved to find a work around to eliminate this problem for our prototype. We also had problems with the output range of our accelerometer; instead of generating voltage from 0V up, it had a 1.65V offset 0 degree voltage output. This problem could have been easily resolved using a subtractor built from op-amp, but we were unable to get it working with only one power source, until we found ourselves with a single supply op-amp.

The relays were pretty easy to work with. The only problem we encountered while implementing and testing replays was the lack of current from lab's power generators, so the relays were jumping like crazy making noises. However, successful tests were possible after using separate power sources to power the butterfly and relays (Thanks to Patrick).

In general we did not encounter many serious problems that aren't human made (Bad soldering, wrong connections and etc).

5. Timeline

Throughout the semester, we followed our proposed timeline very closely with the exception of two categories which were the Solidworks design and the building of our mechanical structure. Since were not able to receive our wheelchair until February, we weren't able to fully make concise and accurate Solidworks models. Moreover, design changes as mentioned on our Mechanical Problems section made an extended design period. Constant mechanical structure revisions were made along the whole course of this project to allow a safe, secure and functional system prototype. Although these were usually smaller mechanical structure revisions, this made an extended structure implementation period.

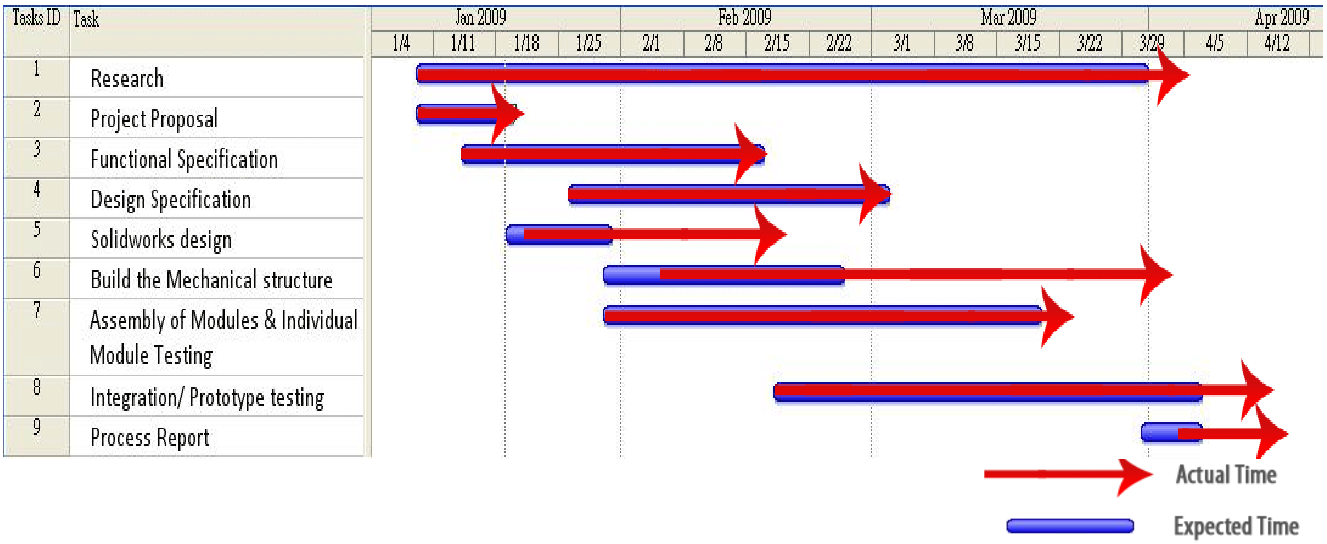

Figure 5.1: Actual and Proposed Timeline

6. Budget & Funding

In Table 6.1, the development costs of our project can be seen. The total sums up to be $2547.50. The prototype funding is mainly coming from the Wighton Engineering Development Fund which will cover all of the development costs as outlined.

ITEM	Cost
Electronic Components	
Total	$475.04
Metals	
Total	$144.87
Bolts/Misc Components	
Total	$146.79
Fabrication	
Total	$1780.80
Sub Total	**$2547.50**

Table 6.1: Prototype Development Costs

The actual costs of our project were lower than the development costs since additional costs were incurred in sourcing extra parts for backup as well as custom fabrication. Fabrication costs were a major portion of our project budget. If mass production occurs, partnership can be made with a fabrication shop and we foresee a major reduction in the fabrication component of our budget. Moreover extra and additional parts were sourced in for quick replacement if parts are damaged along the testing phases. Therefore if we rid our budget of this component, we estimate our actual costs to be about $1247.50 as outlined in Figure 6.1.

Prodution Costs $2547.50 − **Estimated Unnecessary Costs** $1300 = **Actual Costs** $1247.50

Figure 6.1: Production and Actual Costs

7. Group Dynamics

Since each member of our group have distinct skill set, we have a system, electronic, computer, and biomedical engineer in the group, we decided to divide up the work to best use those skill sets. Initially we worked as a whole to come up with the design and discuss the project details. But once we got the basic design finished, we decided to work in groups of two. One group was in charge of the mechanical part of the project, while the other worked on the electronic components. Wayne and Gavin worked on the electronic components of the project, and Kyuho and Edward worked on the mechanical side.

Throughout the semester we met up regularly to discuss the progress of each of the group. Furthermore we would give suggestion to the other group if any bright idea came to mind. For the write-ups we would each take some parts to write and come together to edit each other's work. This worked out greatly since it provided a way for our document to be proof read by 3 other members in the group.

We took great care to maintain the mutual respect we have for each other and also made sure that no one felt left out. We put our trust in other members of the group, and did not mistreat or use hurtful words even when we had conflict of ideas. Overall we believe we worked fantastically as a group and we pulled together as a team.

8. What We Would Have Done Differently

Although all of our team members worked do diligently to complete the project on time, there are some parts of the project that could have been done differently which would have reduced stress and work load. The areas where we could have done differently are mechanical design and the sensor feedback for our system.

8.1. Better Sensor Feedback

We chose accelerometer as our sensors to monitor the status of our system. However, due to the limitation of the mechanical structure, the sensors do not give us a very large voltage swing. This made our system less accurate. Also, toward the final integration, we came to realize that the bottom seat does not have a fixed angular velocity due to the limitation of our mechanical structure; the output of the accelerometer was less linear than we expected. If we had more experiences working with the mechanics and the accelerometer, we could have avoided this problem by either changing the mechanical structure to support more linear angular displacement on our bottom seat, or by using another type of sensor (i.e using sensors to measure the increment of length).

8.2. Mechanical Design

As mentioned in the problems we faced, we had to undergo few design changes in the mechanical structure of the wheelchair. Every time we made such design change we would come up with new Solidworks drawing to see if it would work out to the way we designed. However, instead of drawing a new Solidworks drawing for all design, we could have drawn a rough sketch on paper. This will greatly reduce the work load and also allow more time to be spent on actual design itself.

9. Individual Descriptions

9.1. Wayne Chen

My main contributions to the project include designing and integrating the main software and the electronics components. After finalizing all of our major components of the project, we split into groups of two. Gavin and I worked on the electronics while Brian and Edward worked on the mechanical aspect of the project. My first task was to get some simple functions of butterfly working. After we have the capability of reprogramming the butterfly, I took in charge of designing the main flow of our system. We then exam the software closely to determine the hardware components on the butterfly we could make use for our project. I was in charge of input/output ports, LCD, external interrupt, and the analog to digital converter. Each module was tested individually to verify the functionality before we moved on to the next set of tasks. Our next challenge was to design all the circuitry. I was in charge of designing the relay circuitry, the user interface circuitry and the circuitry on the main board. Implementation was done with Gavin's assistance. After all the circuitry were finished and tested, Gavin and I worked on the final integration of all the software and hardware components together.

Throughout the semester, I have gained more knowledge on writing firmware. Making our prototype circuit boards gave me more hands-on practice on soldering, designing, and implementing analog circuit. The painful debugging period also gave me valuable experience which will help me in my profession. Finally, working in a team environment for a large project also gave me many lessons on team dynamics. I am happy to see this project being completed on time, and I would like to thank all the team members for putting efforts into this project to make it possible.

9.2. Gavin Wu

My contributions to the team were primarily on the electronic side of the system. I started out working with Wayne on the building of the Solidworks model for the wheelchair to make the mechanical structure design easier. Next, I moved on to the software design of the butterfly with Wayne, mainly focused on the timer interrupt and a portion of the analog to digital converter for the arrival of our tilt sensors. I worked closely with Wayne in testing and implementing the electronic components needed for StandStation to function throughout the whole building process. While Wayne is holding responsibilities for the replays and button controls, I took charge in managing the tilt sensors from implementation to tests and finally the operation of the sensor in the final prototype.

I am relieved to see that the prototype is a success (Although we did smoked our board during demo), thanks to all the team members who put in their time and effort to make this possible. Overall the semester was enjoyable…until mid February, where we started working our butts off trying to debug each components, which took forever.

9.3. Kyuho Cha

This project gave me a lot of experience working in a team to achieve a common goal. We all pulled our own weight and worked as efficiently as we could by dividing the work load. Furthermore we shared the work load in such a way that it maximizes the skill set each member. I believe our team chemistry was great, and given the choice I would work with again.

My main contribution to the team was mechanical designer and modeling our wheelchair using Solidworks. Also along with Edward Chan we overlooked the fabrication process, and modified the wheelchair as needed. I had to come up with innovative mechanical design that was both cost effective to make and would perform to expectation. Furthermore I had to model everything as close to real life dimensions as possible to allow for a perfect fit when attaching the frame and actuator to the wheelchair. Lastly I had to make technical drawings that the machinists would use to recreate my design as closely as possible. This experience would help me greatly in the future if I choose to pursue a career in mechanical engineering.

Overall I believe our group had good group dynamic, good communication and mutual respect for everyone in the group. I believe the reason we did not have major factor of us getting along so well together is that we put our trust in everyone in the group, and everyone respected that trust. I believe our group did a great job in working together to achieve great results.

9.4. Edward Chan

I am very happy to have worked on this project as it gave me an opportunity to learn and experience many different expects of project design and development. During the past 4 months, I worked closely with Kyuho Cha in the mechanical aspects of our project. Initially I assisted in the design and modeling of our wheelchair. To lower fabrication costs, Kyuho and I made elaborate technical drawings which were very detailed and concise. Additionally, we scouted many different places for cheap metals and materials to be brought to the machine shop. During the entire fabrication process, we supervised and helped out at the machine shop to guarantee that any problems or questions with the mechanical design as well as smaller components of the fabrication process can be done by us to save time and money. After the frame and wheelchair components were fabricated, we completed our integrated additional components like the harness, knee pads and the track system which allowed a safer and functional system.

As the CFO of our project, I also took care of all the budget and funding aspects of our project. I contacted Dr. Andrew Rawicz and prepared different proposals and documents to successfully apply for the Wighton Engineering Development Fund. With generous Andrew's time and help, we were able to cover most of the costs in our prototype development.

Although there were times which different opinions sparked lively conversations, I believe our group worked well together and splitting into smaller subsets of teams allowed a more efficient use of our time and skills sets. Mutually, we came to a common focus in our design and was able to successfully complete our prototype in our scheduled deadline.

10. Conclusion

Through our dedication and hard work, we were able to create and complete our project into a functional prototype. With these working results, we are definitely able to prove the concept of our design and show an elaborate potential for this product on today's market. Further development and room for improvement can definitely be achieved on our system and design. We believe that the StandStation has a vast potential in improving the quality of life for many different disabled and elderly people.