## The Smart Rollator Project:

A Collaborative Student Project Benefiting From a Multidepartmental Approach
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## Introduction

The Smart Rollator Project is a case study of a university joint project between the Industrial Design and the Systems and Computer Engineering (SCE) programs. The project includes several industry collaborators: a health-care products manufacturer, a geriatric hospital, and physiotherapists. Rollators are wheeled walkers that help seniors enjoy a more independent, healthier, and mobile lifestyle. The primary objective of the project is to investigate how sensors can play a part in defining new product experiences for the elderly in the context of mobility aids such as a rolling walker.


Figure 1. Smart Rollator prototype by id student and test model by engineering student.
The idea of adding sensors was initiated by Professor Chan in the Department of Systems and Computer Engineering in response to new, smaller and more mobile sensor technologies. Professor Chan approached Professor Hallgrimsson in the School of Industrial Design (SID), who had extensive experience working on rollators for Dana Douglas, a major manufacturer of these types of assistive devices. The project was also of direct interest to Professor Budd, the fourth-year industrial design studio professor, who has recently started the new Sensor Lab at SID. Since the project presented a good balance between the assessment of user needs and the application of new technology, it was decided that it would be suitable as a final thesis project for fourth-year students from both engineering and design.

## The Challenge

For the purposes of this paper, the interpretation of multidisciplinary project refers to students from different departments working on a project theme together, while focusing on their own core competencies and deliverables. The students in our multidisciplinary project are registered in their respective fourth-year major project courses. The thesis course represents the final capstone project for students in both of these professional programs and represents the culmination of the knowledge learned in the respective fields. The course requirements for engineering and design students are expectantly different. This approach, in our opinion, would differ from an interdisciplinary project, where students from different disciplines would be working together on the same project in the same course. The latter scenario typically involves additional administrative complexities including the requirement to create a new course with new pedagogical requirements.

Whereas there are interesting opportunities across the university for collaborative work, the curriculum issue is obviously a common problem, especially for an undergraduate thesis. New programs have been formed that transcend these boundaries by establishing new objectives and interdisciplinary pedagogies. A true interdisciplinary project at the fourth-year level, between engineering and design students, would, as an example, have to take professional accreditation requirements into consideration. At Carleton, the ID program is recognized by the standards of the Association of Chartered Industrial Designers of Ontario. The Canadian Engineering Accreditation Board accredits the engineering degree programs and places very specific requirements on the curriculum content. Similarly, the ID emphasis on user research versus the engineering focus on technology creates very different schedules. In the context of this situation, the most feasible option was to have students from the two fields work in parallel on a similar problem, with some levels of overlap. This paper, therefore, examines the lessons learned from this first multidisciplinary step, which is seen as a path towards more interdisciplinary work on the Smart Rollator project in the future. The interdisciplinary work will commence with graduate students from both of the departments working towards the same deliverable, namely a fully developed functional platform; that work is expected to start in the fall of 2008 and last for 3 years.

Beyond successful student thesis projects, the following research questions were identified for dissemination:

1. Do sensors really benefit the usefulness of Rollators?
2. Will students realize the implicit benefits of working with students from another discipline in the absence of formalized interdisciplinary deliverables?
3. Would there be noticeable differences in both the engineering and design projects, from typical projects in previous years?
4. Would the experience assist the 2 departments in terms of understanding and planning a more interdisciplinary Smart Rollator project at the graduate level?

## The Structure

Whereas no tangible collaborative deliverables existed, multidisciplinary interactions were scheduled during the course of the project as shown in the following timeline:


Figure 2. Timeline of recorded interactions between ID and engineering students.

1. An initial meeting was scheduled with students from each discipline to explain that both ID and SCE were participating in the joint collaborative Smart Rollator project.
2. Students toured each other's departments and were introduced.
3. Engineering faculty attended ID presentations.
4. The ID research report was made available to engineering students.
5. ID was invited to participate in the engineering Wiki Web site.
6. At the end of the project, students were debriefed about their experiences and these sessions were recorded for later analysis.

Students were encouraged to seek out help from the other department in terms of complementary input to their projects. This was addressed through an informal collegial open-door policy.

## Validating the Need for Sensors

Little work had been done in terms of validating the need for sensors on Rollators. The need to investigate this in more detail was of the highest importance to the future of a commercially viable Smart Rollator. The ID students spent most of the fall term (September to December), researching the user needs and creating specification briefs for products that would more effectively address the combined performance and lifestyle considerations for the elderly. This work included:

- Literature reviews:
- governmental statistics and societal cost of aging
- effects of aging and compounding of medical issues
- existing Smart Rollator research
- sensor technologies
- Competitive market products analysis of Rollators
- User observational analysis, including visits to nursing homes and hospitals in the Ottawa area.
- Surveys and interviews with health-care professionals including physiotherapists, a Rollator manufacturer, and a rehabilitation center
- Scenario and persona development

This research forms the basis for future planned research. The students exposed some of the complicated issues, relating to compounding of health issues. Whereas obstacle avoidance had been previously addressed, it was now better understood in the context of specific scenarios for people with vision impairments. Additionally, the students classified and studied the effect of various typical vision impairments such as macular degeneration and isolated the most typical kind of obstacle avoidance problems, so that a better system could be designed. This contrasts with the engineering projects where these needs are presumed and students work immediately towards implementing technological solutions.

## Did Students Realize Implicit Benefit of Working with Each Other?

The value of user observation studies, by ID students, was clear to the engineering students who actually decided to change some of their own problem statements in response to design research. Persona creations for example (Figure 3), help students from other disciplines relate to the human aspect more easily. Industrial design students meanwhile became more familiar with technology driven projects, and the benefits of quantitative testing methods (for example, debugging techniques). During the debriefing sessions we asked students from both departments some questions, which dealt with the multidisciplinary experience.

Both the engineering and ID students expressed that they knew very little about the other field of study at the beginning of the term. The engineers for example said that they had heard and knew about ID, but that they had thought that it was only art based, or that it concerned itself mostly with the appearance of things. Similarly the ID students knew about engineering, but did not know what made computer and systems engineering different from computer science or electrical engineering.

The students expressed that they had new appreciation and respect for the other discipline. One engineering student said, "The ID students are really focused on the end user and seem to know a lot more about manufacturing aspects than we do." Another engineering student mentioned how ID made them think outside the box and consider things like the marketing of the product in terms of the cost of components. An ID student observed how engineering students think of a system and analyze the functional operation in terms of the different technological parts of the product: sensors, electronics, and software. ID can learn from this approach as well even when making simpler proof of concept electronic mockups. Another ID student also observed how he now sees that even within engineering, there are a lot of different areas of specialization to focus on (the engineering students were pooled from the Systems and Computer Engineering as well as Electronics departments).


Figure 3. Persona creation by ID students.

## Noticeable Differences in ID and Engineering Projects from Previous Years

The ID students have in the past developed mostly conceptual nonworking prototypes for their fourth-year major (capstone) project. This year, they were challenged to go further in terms of making working focused prototypes. This was also made possible by addition of the school's new Sensor Lab. The lab has been set up to introduce design students with little or no electronics and programming background to the basic knowledge required to conduct experiments and produce "proof of concept-type operational models" incorporating sensor technologies.


Figure 4. Use of Simple Lego Mindstorms System Opens Opportunity for Proof of Concept Testing for ID Students

In addition, the student interviews revealed that some of the ID students interfaced with the engineering students and learned about sensor testing as well as debugging approaches.

The engineering students have not been challenged in the past to give this amount of consideration to holistic engineering development. This affected the approach and criteria by which the engineering students selected the electronic components, to be much more real world oriented. Rather than a focus on what they could get away with in the lab, the engineering students looked at their Rollator systems in terms of what would be more user oriented.

The ID and engineering students did not collaborate in terms of their deliverables. In fact, the projects are distinct and different. That being said, there was evidence of students helping each other and collaborating in a real interdisciplinary sense. ID students showed engineering students how to do some user testing with their engineering test model through video methods, while the engineering students would help with explaining electronics and sensors to the same ID student.

The following is a brief list of the individual student projects:
ID 1 E-Nurse (Shayta Roy)
An electronic handle grip monitors heart rate and blood oxygen saturation levels. The user can transfer data to health-care providers online via Bluetooth and a secure server.

## ID 2 Conductor (Silvan Linn)

An obstacle-avoidance system for people with visual impairment. A compact sensor unit scans the area ahead of the Rollator for hazards (corners, curbs, stairs). The user is alerted through audio feedback via bone-conduction technology mounted on a glasses-like frame (freeing the ears to listen for other dangers).

## ID3 Rollator with Electronic Assist Braking (Justin Frappier)

This redesigned Rollator incorporates electronic-assisted braking. The design aims to eliminate human error associated with cognitive and motor skill impairments.

## ID4 Liberty (Chris Ledda)

This Rollator battery-charging system uses radio frequency (RF) technology. A transmitter that is plugged into a wall sends out a signal that is recognized by a Rollator-mounted receiver, which can charge the onboard battery while it is parked within 3 feet of the transmitter.

## Eng 1 Usage Monitoring System (Davide Agnello and Brian Earl)

The usage-monitoring system is a real-time distance- and speed-monitoring system to track daily usage and usage patterns of a Rollator. The system also includes wireless Bluetooth data communications and a software database with remote access.

Eng 2 Obstacle Detection System (Mohammed Aboul-Magd, Faysal Hassan, and Alex Sintu) This system was developed to monitor multiple objects and environments around the rollator; this included walls, drop-offs, inclines, and objects.

| Project | Project <br> Definition | Final Prototype | Usability and Technical <br> Testing | Sensors Electronics <br> and Software |
| :--- | :--- | :--- | :--- | :--- |
| ID1 | Created by <br> student | Appearance Model | Ergonomic testing and feedback <br> from physiotherapists users and <br> rollator manufacturer <br> Observed and used heart rate <br> and oxygen saturation sensors | Heart-rate and O2 <br> sensors. This electronics <br> portions was mainly <br> developed in last year's <br> project in SCE |
| ID2 | Created by <br> student | Fully integrated <br> working prototype <br> (technical and <br> appearance) | Ergonomic testing and feedback <br> from physiotherapists users and <br> rollator manufacturer <br> Lego Mindstorms mockups <br> Breadboards <br> Feedback mockups (haptic, eye, <br> audio) | Infrared and ultrasound <br> sensors. <br> Arduino embedded <br> system board. <br> Custom code <br> audio output. |
| ID3 | Created by <br> student | Appearance model <br> and separate <br> technical working <br> prototype | Ergonomic testing and feedback <br> from physiotherapists users and <br> rollator manufacturer <br> Electronically powered brake <br> mockup | Linear actuators |


| ID4 | Created by <br> student | Appearance model | Ergonomic testing and feedback <br> from physiotherapists users and <br> rollator manufacturer <br> No testing of technology | RF technology (not <br> tested) |
| :--- | :--- | :--- | :--- | :--- |
| Eng1 | Faculty | Engineering test <br> model | Sensor testing <br> Usability selection <br> Bluetooth testing <br> Client server testing <br> Usability testing with senior <br> using engineering test model | Listance sensor, seat <br> pressure sensor. <br> Handyboard embedded <br> system. <br> Wireless system and <br> custom software and GUI. |
| Eng2 | Faculty | Engineering test <br> model | Sensor testing <br> usability selection | Infrared and ultrasound <br> sensors. <br> Portable computer <br> system. |

Table 1. End project deliverables for the ID and engineering projects.

The table illustrates some of the main differences between the ID and engineering deliverables, for example:

- ID students spend a considerable amount of time doing user-oriented research and creating project definitions and concepts.
- The ID students always produce a final appearance model to show what the envisioned manufactured product would look like.
- ID projects tend to be more conceptual and engineering projects more safe in terms of feasibility.
- The engineering students build a technical prototype upon which they base their testing

The table also highlights some new project accomplishments in this year. ID students were able to use sensors and technology to build working proof of concept prototypes, which is atypical in their thesis project. The engineering students added usability selection criteria to the sensor and electronics selection; for example, larger LED screens and data collection that matched real user scenarios. They were also introduced to testing their engineering models with real subjects.

## Does This Project Help Plan a More Advanced Interdisciplinary Project at Graduate Level?

Both engineering and ID faculty feel that many valuable lessons have been learned from this project in terms of planning an interdisciplinary project at the graduate level. This has already been evidenced through a rewritten research plan, where additional focus has been placed on user-oriented research. This research needs to be done and explained in terms of context to the new engineering participants. The report done by the ID students in this year will help engineering students appreciate and understand this approach.

Another insight is a better understanding of how the ID projects differ at the technical level from the engineering projects. The ID sensor-based projects are typically focused on the proof of concept, whereas the engineering systems are more technically optimized to provide a more robust and reliable system. In the figure below, the ID student is thinking about how the sensor board can be mounted in a real product, the diagram next to it shows how the engineering students spend a lot of time analyzing the specific performance of a given sensor in a very detailed technical sense.


Figure 5. ID sensor project and engineering confidence interval analysis.

## Observations and Conclusions

1. It is clear from this experiment that the ID and engineering students approach the same or similar problems from very different perspectives with very different goals in mind.

- Design students are primarily interested in using sensors as a proof of concept to make sure that the technology is viable and that it is beneficial to the end user. Whereas the design students spend their time creating research-based, user-oriented design decisions, the engineering students spend a lot of time optimizing the electronics system reliability and efficiency. For example, making a wireless system work flawlessly is not easy; it is also important to evaluate its performance, including maximum distance between transmitter and receiver, data transfer rate, data transfer errors and recovery, and power consumption. It is important to make sure that the sensor readings are correct and test the sensors under all kinds of conditions to determine accuracy and confidence intervals.

2. It is also evident from the interaction among the students that each group recognizes the benefits of the differences in approach and can leverage certain aspects to help improve their own solutions.
3. Based on these findings it is relatively clear that there are significant educational gains to be made in developing more tightly aligned collaborative projects, through a multidisciplinary approach.

- These projects were not only good fourth-year projects, the experience gained by faculty has helped shape the future of the Smart Rollator project, which is expected to last at least an additional three years. The lessons learned will help frame some of the interdisciplinary work to be completed.


## References

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