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April 5, 2004

Lakshman One
School of Engineering Science
Simon Fraser University
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RE: Ensc 440 Project Post-Mortem for the BEAM Pedometer

Dear Mr. One,

Attached is the BEAM Pedometer Post-Mortem for Ensc 440: Capstone Engineering Project. The included document summarizes the current state of the device, deviations from the proposal and problems encountered. This report outlines the changes we would have made to our budget, schedule, and overall approach with the knowledge we possess now. Finally, the report outlines future improvement plans and a personal retrospective on the semester from each team member.

The BEAM team includes four dedicated senior engineering students: Eliot Aharon, Manpreet Johal, Aaron Payment, and Biljana Pecelj. If you have any questions or comments please feel free to contact me via email at eaharon@sfu.ca or the team at ensc440-beam@sfu.ca.

Sincerely,

Eliot Aharon
CEO
BEAM Inc.

Enclosure: *Post-Mortem Version 1.0 for the BEAM Pedometer*

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Pedometer
Post-Mortem Report

Project Team: Eliot Aharon
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Submitted to: Lucky One
Mike Sjoerdsma
Nakul Verma
School of Engineering
Simon Fraser University

Date: April 5, 2004
Revision: 1.0

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Executive Summary

Over the years, various studies have shown the connection between obesity, diabetes, heart disease, and stroke. The devastating diseases associated with obesity can be avoided through regular exercise and a healthy diet. New studies indicate that walking 6,000 steps a day is sufficient for good health and 10,000 steps a day can result in weight-loss [1]. Such studies have encouraged walking and step counting, making pedometers a very popular fitness item. The team is in the process of designing and implementing the BEAM Pedometer, an accurate and low cost device.

The project development will occur as a two-step process. The first phase of the project is the development of the prototype. The prototype will have the following features:

1. Accurate step counting algorithm
2. Distance traveled measured in km
3. Easy to use user interface
4. RF module connecting ankle and display units

The second phase of the development will include:

1. Display unit redesigned into a wrist attachable module
2. Protective casing for the ankle and wrist module
3. Watch feature
4. Size comparable to already existing pedometer units

The first development phase will end by the first week of April 2004.

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1. Introduction

Over the course of this semester, the Beam Pedometer has evolved from an idea to reality. The Beam Pedometer prototype was conceptualized, designed and implemented using the talents of the four members of the Beam team. This document reviews the process involved in taking the project from the starting stages to the final prototype. Finally, each group member wrote a personal review of the semester and the Beam experience.

2. Current State of the Device

The Beam Pedometer is a distance-measuring device used by walkers to determine how far they have traveled. A system overview is shown in the figure below.

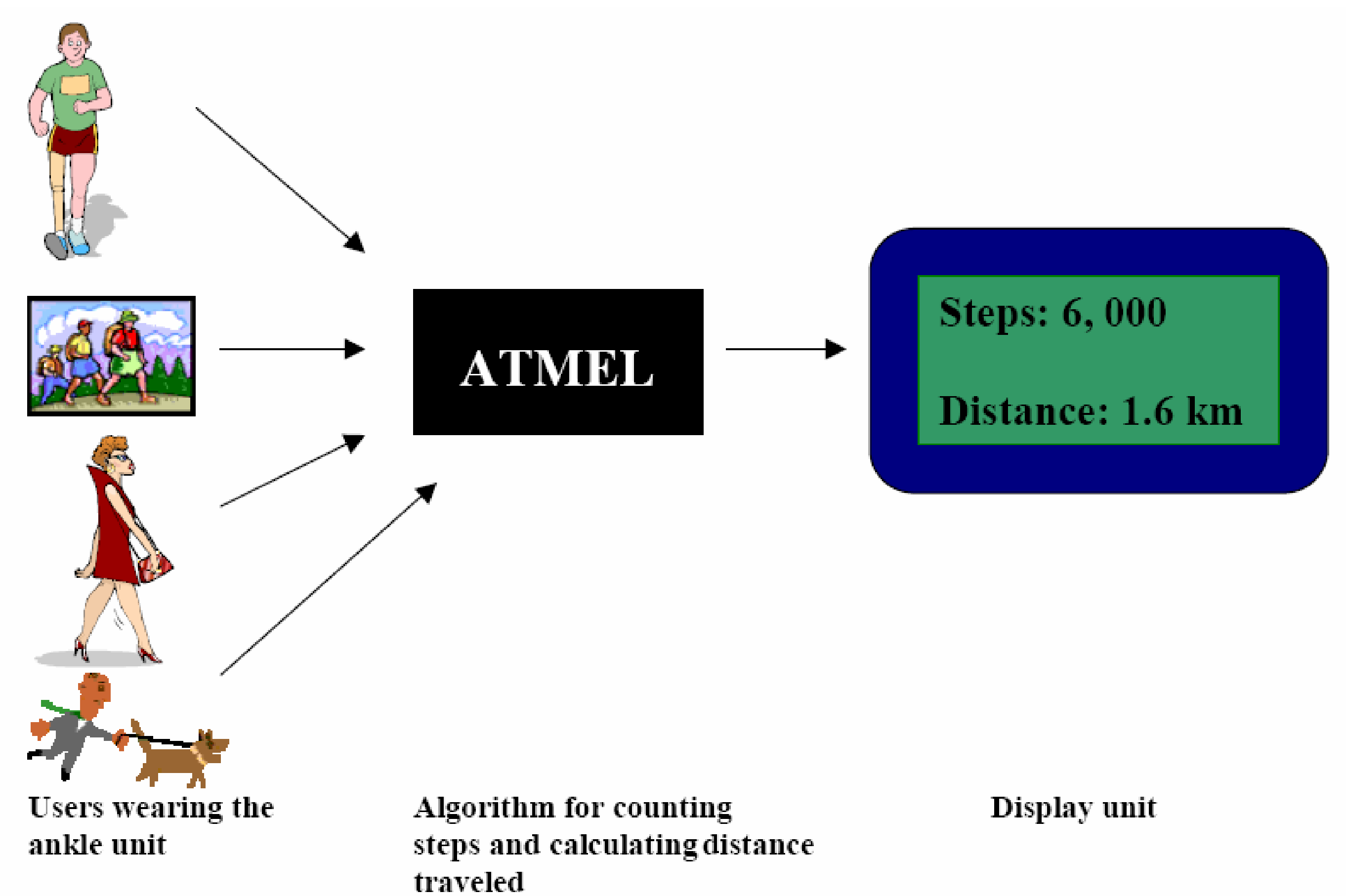

Figure 1-System Overview

The system consists of several sub-units: ankle unit, algorithm and display unit. The current state of the system will be discussed by discussing the state of each sub-unit.

2.1. Ankle Unit

The ankle unit consists of an ADXL202 accelerometer, an RF module, and a battery. All the components are mounted on a single board, which is connected to a Velcro strap using an adjustable metal swivel. The Velcro strap allows a walker to safely secure the unit to the ankle. While the ankle unit meets the requirements stated in the proposal, the unit is larger than we originally anticipated because the RF module used is large and its addition to the ankle unit was not planned in the proposal.

After analyzing the accelerometer data, we realized that to develop a truly accurate distance algorithm we require more information; hence, a single accelerometer is not sufficient.

2.2. Algorithm

The algorithm is the most crucial part of the Beam Pedometer. After the accelerometer data is transferred to the Atmel chip via the RF module, the data is analyzed and evaluated by our algorithm. The algorithm was based on basic physics principles. The algorithm did not meet the 5 percent error margin we predicted in our proposal. The error margin varied from 15 to 40 percent depending on the distance traveled and testing terrain.

Our tests allowed us to conclude that the algorithm is capable of producing very accurate results but only when used on a flat surface without any tilting. As already mentioned an additional accelerometer would improve the algorithm's performance by gathering extra data that could be used to for proper tilt compensation.

2.3. Display Unit/User Interface

The display unit consists of an Atmel chip, LCD, buttons and a battery. The display unit did not pose any unexpected problems. Our user interface slightly deviated from the proposal since the distance was displayed in centimeters instead of kilometers.

2.4. Additional Problems Encountered

One unusual problem we encountered involved power. In the last week of testing, we noticed that the RF module frequently failed when batteries were used. When we used a wall socket as the power supply no problems were noticed; the RF module worked as expected. While batteries were used the RF module experienced problems. The module would only work if the ankle and display units were approximately half a meter apart. Once they were moved beyond that range the transmission ceased. This problem would warrant further investigation because currently we do not have enough information to draw any valuable conclusions.

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3. Budget

Table 1 contains the estimated budget stated in the Beam Proposal and the actual project budget.

Table 1: Actual cost versus estimated cost

Components	Actual Cost	Estimated Cost
Microcontroller	$ 83.00	$100.00
Sensors	$ 0.00	$100.00
LCD	$ 0.00	$ 20.00
RF Unit	$ 15.00	$ 0.00
Batteries	$ 10.00	$ 10.00
Misc. Components	$ 50.00	$ 10.00
Contingency Fund	-	$250.00
Budget Total	**$158.00**	**$490.00**

As can be seen in Table 1, the estimated cost was three times bigger than the actual cost. We cut costs by using all possible sources to obtain free parts. The sensors were obtained for free from the Analog Devices website. We borrowed the LCD from Lucky One, therefore, we did not to spend the money allotted for its purchase. The two items that were more expensive than originally anticipated were the miscellaneous components and the RF unit. The RF unit was not part of our original design so its purchase was not planned in the original budget. However, the RF unit was low cost because we chose to use the RF unit from an inexpensive remote control car instead of purchasing a more expensive RF module.

4. Schedule

Figure 2 shows a Gantt chart for our project. The chart includes the planned schedule as stated in the project proposal and actual schedule.

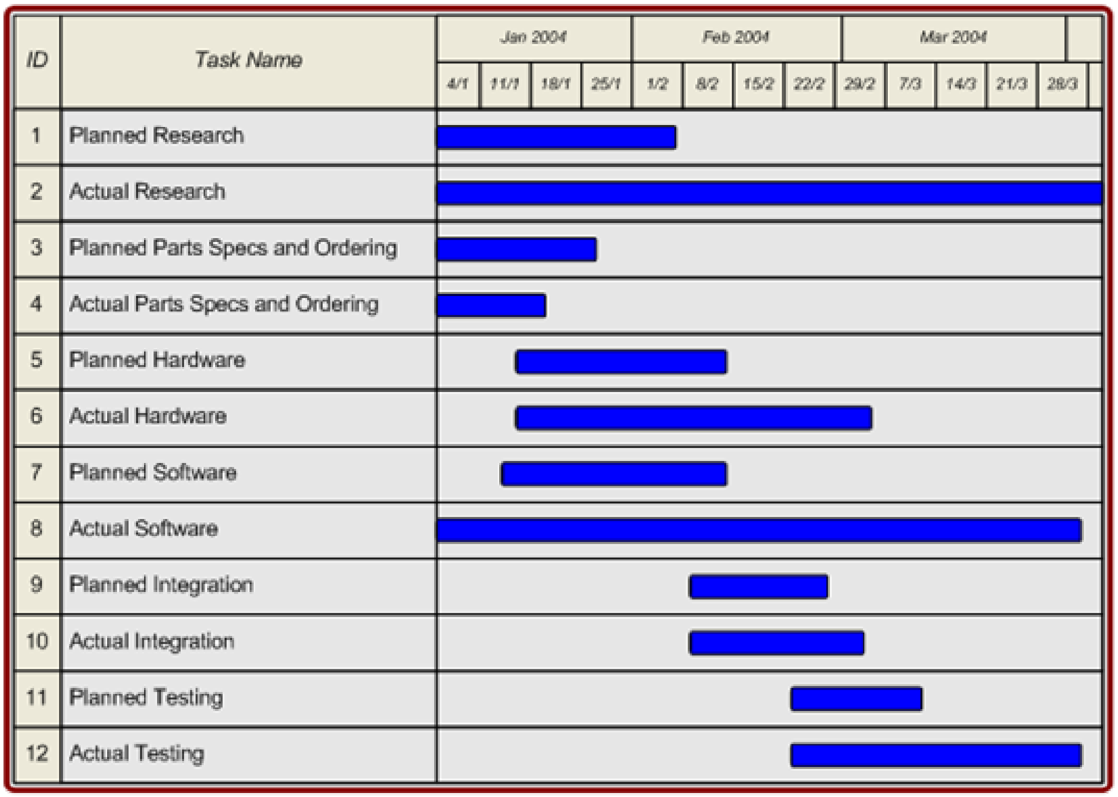

Figure 2: Gantt chart schedule comparison

From the Gantt chart it is obvious that for most tasks we underestimated the amount of time the tasks would take. It should be noted that the actual schedule for most tasks was roughly twice the predicted time frame.

The predicted schedule was particularly inaccurate for the software development section. This section took much longer than anticipated because algorithm development was more complicated and complex than expected. Hardware development also took longer than anticipated but this delay was due to last minute decision to include RF. Initially, we had a wire connecting the ankle and display units. Hence, the additional time spent on hardware can be attributed to the work on the RF module.

While we felt that we could have followed our initial schedule more tightly, we learned that in future scheduling we must account for last minute changes and unanticipated problems. Setting realistic schedule goals is key.

5. Future Plans

The Beam Pedometer has great market potential once improvements and development of the commercial version are completed. We have the following suggestions for our product's further development.

5.1. Overall System

- *Packing the device*

  Enclose the device into plastic casing that is water and weather proof.

- *Compact size*

  The device should ideally be compact and easy to carry. A more compact size implies a smaller LCD and a small RF module. The RF module could possibly be removed altogether if the whole device is packaged as a single unit.

- *Optimize power consumption*

  After performing extensive testing to determine the power consumption optimize it and select appropriate battery type.

5.2. Sensors

- *Additional accelerometer*

  Add an additional accelerometer to be used for tilt correction.

5.3. Algorithm

- *Improve tilt compensation*

  After adding a new accelerometer modify algorithm to use the additional tilt data. The extra data should be analyzed to compensate for the tilt and more accurate results should be produced.

6. Personal Reflection

Eliot Aharon

Over the course of the last semester, I encountered several challenging problems, and discovered some very creative solutions. I discovered that working in a group, though tedious at times allows for an increase in the overall creativity of a project.

Each member of our team held a very important role in this project, though I was predominantly responsible for hardware, my group members made it possible for me to fully understand all the software and theoretical concepts and implementations within this project.

As a group, we encountered such problems as scheduling, performance errors, and overly high expectations. We were able to discuss and solve most of our problems by consulting one another and arriving at a consensus.

This project also introduced me to some new concepts and technologies such as the ADXL202 and the Atmel family. Overall, this project has felt like a success and a good experience, which I hope to be able to build on in the future.

Manpreet Johal

During this class I learned that even the most basic operations, have a ten-fold increase in complexity when implemented on an 8-bit microcontroller. After using high-level software programming languages, such as C++, and Java it was quite a challenge to implement multiplication, an operation I took for granted while using the higher-level languages, using assembly. I also developed more of an appreciation for assembly programming language and the power, and flexibility I have with it.

Another aspect of software design I came to appreciate a great deal is having good comments in your code. After writing a chunk of code at the beginning of software development and looking at it in the end, it was extremely helpful to have good comments. They allowed me to know what was going on, when something wasn't working or when I hadn't looked at the code in a while.

The last thing I learned is that it is difficult to gauge how much time a certain aspect of the project was going to take until the said aspect had been started. This made it very difficult to maintain a good schedule. For example implementing, fixed point math algorithms took a great deal longer than first expected. Once we started working on them we realized that it was going to take longer then scheduled to complete the entire portion of the project that fixed point was tied to, since we misjudged how long it would take to do the fixed point.

Aaron Payment

Throughout the past semester, I have experienced the whole design process from beginning to end and what it takes to create a prototype of a design. This group project has once again shown me that time is valuable and that scheduling is a very important aspect of a project. Although, initial deadlines and milestones were set out, I have concluded that sleepless nights will result, regardless of the scheduling.

My contribution to the project was mainly with the software aspects, and real-time algorithms. The decision to use the ATMega8, a member of the Atmel family of microcontrollers allowed me to gain an in depth experience with the chip and a refresher in assembly programming. The project also allowed further exposure to hardware and software interfacing and the problems that are likely to arise in the process, and the testing procedures that help to identify the problems. Working on a group project of this level requires multiple viewpoints to overcome the problems at hand. Where one person may be stuck on a problem a second opinion to help organize the ideas is usually a good solution.

Overall, this course was not what I expected it to be back in first year. I was expecting an overly elaborate project, yet after this semester I realize that in order to fully take a design from beginning to end and do complete testing and revising a scaled down project is the smarter way to go.

Biljana Pecelj

The key thing I learned from this unique 13-week experience is that planning ahead is vital. Proper scheduling is necessary to avoid unnecessary delays. Being realistic is crucial to staying on schedule. In our case, we found that delays occurred in software development and subsequently integration of the entire system. The software delay occurred because we did not take into account the complexity of implementing basic concepts from physics on the Atmel chip.

Documentation has proven to be very useful in the overall scope of our project. Writing the proposal allowed us to set clear objectives for the project. In retrospect, I learned that scheduling is crucial and that realistic goals must be set. The functional specifications gave us an opportunity to examine in detail what we should to do achieve our original objectives. The design specifications report proved extremely useful since it outlined every step in the design process. Finally, this document has been a useful review and a chance to reflect on the past 13 weeks.

Lastly, once again I was reminded about the importance of group work and communication. While working independently has its benefits, teamwork is a great way to obtain fresh ideas and new perspectives. This is particularly useful when you are stuck in the pigeonhole mentality and a certain problem is driving you mad.

7. Conclusion

During the course of the semester, the Beam team faced many challenges in designing and implementing the Beam Pedometer. After months of intensive research and work, we produced a working prototype by the final demonstration date. While our prototype did not meet all the specifications we outlined in our proposal, it did answer many questions and most importantly show that this product would have great potential upon further improvements. We are confident that the Beam Pedometer would be a feasible choice for consumers once the commercial phase of the development was completed.