School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6
ensc440-beam@sfu.ca

January 20, 2004

Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6

RE: Ensc 440 Project Proposal for Beam's Pedometer

Dear Mr. One,

The enclosed document outlines our project proposal for the capstone engineering project. Our project goal is to design a pedometer that will aid health and fitness conscious people in obtaining accurate information regarding their walking or running workouts.

The purpose of the attached proposal is to give an overview of our product. The document includes information about design requirements and possible design solutions. The financial summary for the project is given in our budget, along with a schedule which includes project milestones.

Beam Inc. was founded by four engineering science students including Manpreet Johal, Aaron Payment, Biljana Pecelj and myself. If you have any questions please feel free to contact me via email at eaharon@sfu.ca or the group at ensc440-beam@sfu.ca.

Sincerely,

Eliot Aharon
CEO
Beam Inc.

Enclosure: Proposal for Beam's Pedometer Version 1.0

Proposal for a Pedometer

Project Team: Eliot Aharon
Manpreet Johal
Aaron Payment
Biljana Pecelj

Contact Person: Eliot Aharon
ensc440-beam@sfu.ca

Submitted to: Lucky One
Mike Sjoerdsma
School of Engineering
Simon Fraser University

Date: January 20, 2004

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Burnaby, BC V5A 1S6
ensc440-beam@sfu.ca

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Executive Summary

While masses strive to achieve a narrower waistline, the premise that improving personal fitness and health is critical to leading a longer and better life, has motivated people to improve their personal fitness level. Research has shown small adjustments in activities performed on a daily basis can prevent disease and forms of premature death. Just taking a daily walk has proved to be an effective way to offset disease and weight gain. In a technology savvy society consumers are searching for ways to use technology to enhance or monitor their workouts.

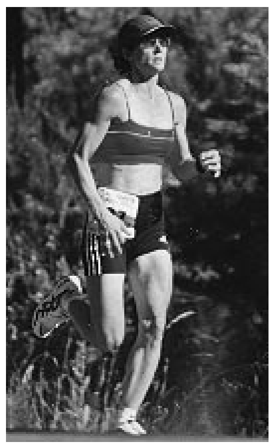

Figure 1: Modern day runner

Many people like to use devices such as pedometers as motivational tools or to track their progress. Pedometers are used to keep track of the distance a person walked or ran. A typical pedometer senses the movement of the body and counts the number of steps traveled. Based on user input, a simple calculation is performed and the overall distance traveled is calculated.

Current pedometers experience accuracy problems because of their dependence on user input and estimation of personal stride length. It is unrealistic to expect that each stride a person takes is exactly the same length. The more accurate models are very inefficient and costly. This document is a proposal for a pedometer that is more accurate, more power efficient and cheaper than the ones currently available on the market. Our goal is to design and develop a pedometer for which the stride length will be calculated rather than input by user, improving the overall performance of the distance sensing devices.

Introduction

Over the last fifteen years there has been an increasing trend of obesity noticed in the North American population. This trend has resulted in a severe increase in deaths due to adult onset diseases such as type 2 diabetes, hypertension, and arterial sclerosis. A rough estimate suggests that nearly 30% of the North American population is obese.

The startling increase in the percentage of overweight children and young adults in North America has brought the issues of healthy living to the forefront of problems facing western civilization. There are several important ideas associated with healthy living. The most talked about are maintaining a balanced diet and a continuous fitness regime. Unfortunately neither is easy without proper support and motivation.

Often an effective motivational tool for exercise is a strong sense of accomplishment, which can be achieved through striving to meet physically challenging goals. There are several ways to keep up to a goal, some methods include keeping a diary or athletic schedule, others involve gadgets that estimate the distance and time a person has traveled.

The objective of our project is to develop a personalized motivational device known as the 'BEAM Pedometer'. This product will allow a user to accurately determine the distance and time they have traveled. This motivational tool will be more accurate and therefore more useful than other conventional pedometers on the market.

In comparison with other similar products in the market, the 'BEAM Pedometer' will be independent of user input for physical attributes such as stride length, bounce and other variables which can change by +/- 40% over the duration of exercise.

This document is a proposal describing the overall system, functional design considerations, sources of information, access to funding, and project scheduling. Estimated financial needs and external support are provided as are other possible scheduling models.

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Possible Design Solutions

In the course of our research, and meetings we determined that there are mainly two types of pedometers; hip mounted and foot mounted. Designs for each were considered, below is information on the different designs.

Using accelerometers

Using a two dimensional accelerometer array we can determine horizontal distance traveled by the wearer's foot and hence the total distance traveled. One accelerometer measures when a step has been taken, the other determines what the acceleration of the wearers foot is. Determining the horizontal acceleration between steps allows us to determine how much distance was traveled by the person in a given period of time. The unit would be attached to the users shoelaces, and have a display on it that would display information on it.

Stride length

Using stride length, the length of one step and the physical motion of their leg while taking a step, distance traveled can be determined. Using the physical properties of walking, and running, as well as the user inputted stride length, the distance between steps is determined using geometry. The problem with this design is that is very static, and relies on the user not taking very different types of strides when they walk. The design lends itself to a great deal of error, as much as 40% per stride. Another variant of this method is to determine the number of steps taken and multiply by the stride length to determine distance. Another disadvantage is that it requires user input, where we would like the design to be automatic and adjust to different strides automatically. The advantage of this design is that it is easy to implement.

Using Sensors

We considered having the wearer attach a set of sensors onto their shoelaces on one shoe, and a receiver on the other shoe, in order to determine how far they have traveled by measuring how far apart they have their feet. Using these sensors the diagonal and horizontal distance is determined based on the geometrical positions of the sensors. Several different sensor configurations were considered including, using a pair of narrow beam sonar transmitters on one shoe, and a sonar receiver on the other. Another sensor design that was considered is using infrared transmitters, and a receiver. Several sensor configurations were also considered. One such configuration is to have two sensors, and 2 receivers. One of the sensors would measure the horizontal distance of the wearers feet as one foot passed the other, and the other would measure the diagonal distance. The two aforementioned distance measurements would be used to determine the distance, traveled. In any case everything will be timed by an accelerometer that determines when the person has taken a step, and retrieve the data to be processed. A design based on sensors would give a very accurate account of how far the person wearing the device, has gone, and is very accurate. However, the problem with a foot mounted sensor design is that it is very obtrusive for the person running or walking to have on.

System Overview

The BEAM pedometer will provide walkers and runners with their real time exercise data in a user friendly way. The pedometer is capable of displaying to the individuals total time, total distance, total number of steps, average velocity, and number of calories burned during their current exercise session. The pedometer is comprised of two modules: the sensing module and the display/interaction module. User input is used to change the display mode, change the units of the current display mode (where applicable), and reset the currently logged data. Figure 2 is a simple block diagram illustrating the interaction between the two modules and the users input.

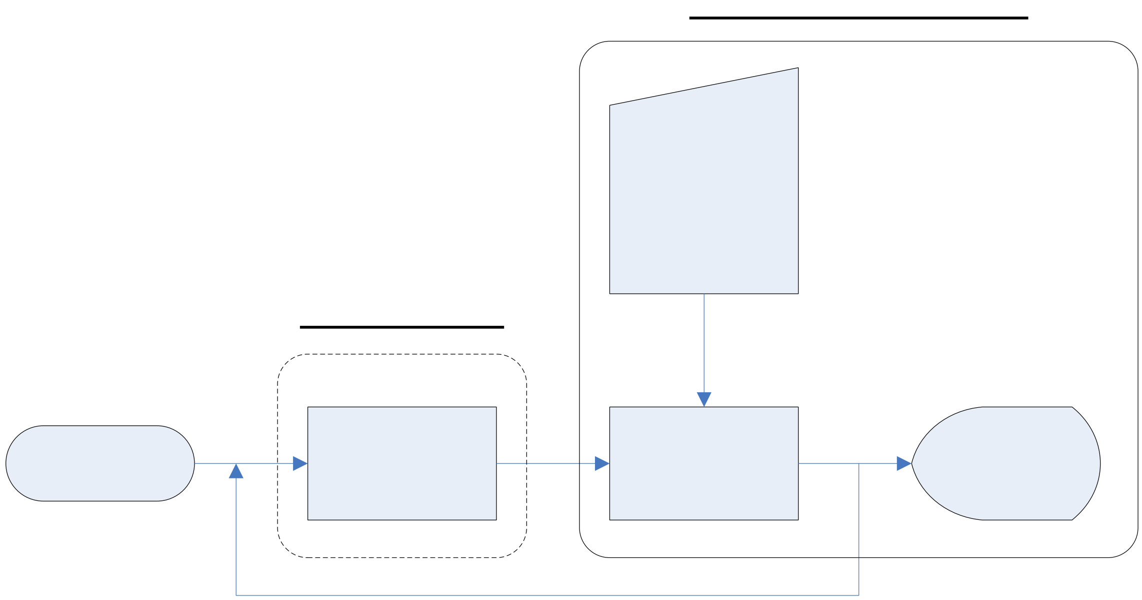

Figure 2 – Simple Block Diagram of System Overview

The sensing module and the display/interaction module are independent entities in order to allow the user to view and interact with the system without varying the way the system acquires the data.

Proposed Design Solution

After considering the possible design solutions, we decided to base the design on one that minimized the effort required by the user to attach the device, and the one that provides an easy to use interface, and provides results of high accuracy. The resulting design solution is to implement the sensing module as a self contained set of accelerometers used to measure horizontal and vertical displacement. The module will be attached to one of the user's shoes via the shoelaces, to minimize the setup complexity. The display/interaction module will be implemented as an attachable hip unit that the user can freely remove and view and/or reset their currently accumulated exercise statistics.

The display/interaction module of the system is the main component and it contains a microcontroller, display LCD, and push buttons. The microcontroller is responsible for acquiring the data from the sensors and performing the necessary algorithms to determine the total time, the total distance, the total number of steps, average speed, or the total number of calories burned, based on the users input. The necessary algorithms are implemented as a result of analyzing the human gait pattern and determining which components are required in order to calculate and display the various modes of the system. After our preliminary analysis of the human gait, we found that an individual's stride length, and the instance when they plant their feet on the ground are the components that will allow us to calculate the various exercise statistics.

Within the sensing module the sensor of choice is an accelerometer. An accelerometer outputs the instantaneous acceleration of the sensor and interpretation of the data can result in the relative distance traveled by the sensor and any sudden impacts made by the sensor. Therefore, an accelerometer can be used to determine an individual's stride length by monitoring the relative distance traveled in the horizontal direction of the sensor. Similarly, the instance an individual plants their foot can be determined from an accelerometer configured to operate along the vertical axis of motion and interpreted to sense sudden impacts.

Referring back to Figure 2, the simple overview of the system, the feedback loop between the sensing module and the display/interaction module implies that the microcontroller will be continuously polling the sensor in order to provide real time output of an individuals exercise statistics. As a result, a means of connection between the sensing module and the display/interaction module needs to be addressed. For the scope of the project we have decided to implement the connection as a cable connection between the two devices. However, future improvements, if time permits, include implementing a wireless connection between the two modules. For actual production purposes such a step would be more logical and practical implementation for the user's maximum comfort.

The overall system will be battery powered and housed in water-proof casing to provide the user with a portable device capable of use in all weather conditions. The design is also such that it dynamically determines an individual's unique walking/running pattern. This implementation provides a highly accurate system without the knowledge of an individual's unique anthropometry which would otherwise need to be obtained and input manually or hard coded into the system based on experimental norms.

Sources of Information

For development purposes of the project we will need to access a variety of sources to obtain information about sensors, electronic components, kinesiology and software development.

Aaron and Biljana plan to contact their teaching assistant, a kinesiology graduate, for purposes of learning more about the human gait patterns and the physics needed to determine stride length. For help with sensors we plan to contact Ensc 440 TA, Nakul, because he is quite knowledgeable in this field. Any other problems or questions will be dealt with by contacting additional sources including professors and classmates.

EUSS is going to be our resource for funding. We plan to apply for an ESSEF project grant which the EUSS administers, plus some of the EUSS member may give us tips on where else we could look for funding or assistance.

Funding

We plan to fund the project through a variety of methods. First we plan to apply for an ESSEF project grant. In addition each group member is willing to invest approximately $100 towards the project. Between these two sources we should have enough money to fund the project basics which are outlined in the budget section. The extra money raised will be used for the contingency fund or in case we decide to add extra features (ex. wireless) to our pedometer if time permits us to.

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Budget

The following table outlines a tentative budget for the “BEAM Pedometer” based on sensors and other physical components we expect to require as suggested by the possible proposed design solutions. Component prices have been inflated by at least 30% based on the digi-key catalogue quotes.

Table 1: Tentative budget for proposed project

System Module	Proposed Price	Source
Distance Sensor • Ultrasonic (A.R.G) • Infrared • Hall Effect	$50	Estimation based on digi-key catalogue
Accelerometer • 1axis • 2axis	$50	Estimation based on digi-key catalogue
Microcontroller Development Kit • Atmel • HC11/12 (School) • HC08	$100	Estimation based on digi-key catalogue
Power (Batteries) • AAA • Pancake • 9V	$10	Estimation based on digi-key catalogue
LCD (if not in dev kit) • Ti83 Display • 2x4 • 2x8	$20	Estimation based on digi-key catalogue
Misc Passive Components • Resistors • Capacitors • Buttons	$10	Estimation based on digi-key catalogue
Total	**$240**	

**Reserve fund of $250 if above insufficient

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Schedule

Figure 3 shows the Gantt chart which demonstrates how long we expect major components of the project to last until reaching completion. The milestone chart shown in Figure 4 shows the completion dates corresponding to the tasks outlined in Figure 3.

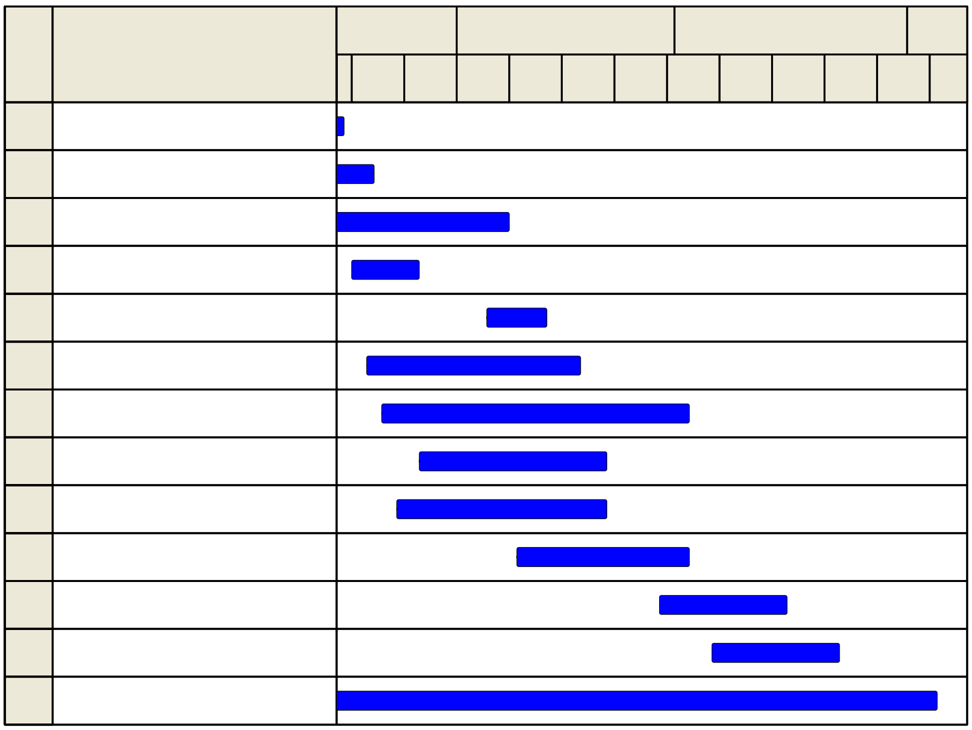

Figure 3-Gantt Chart

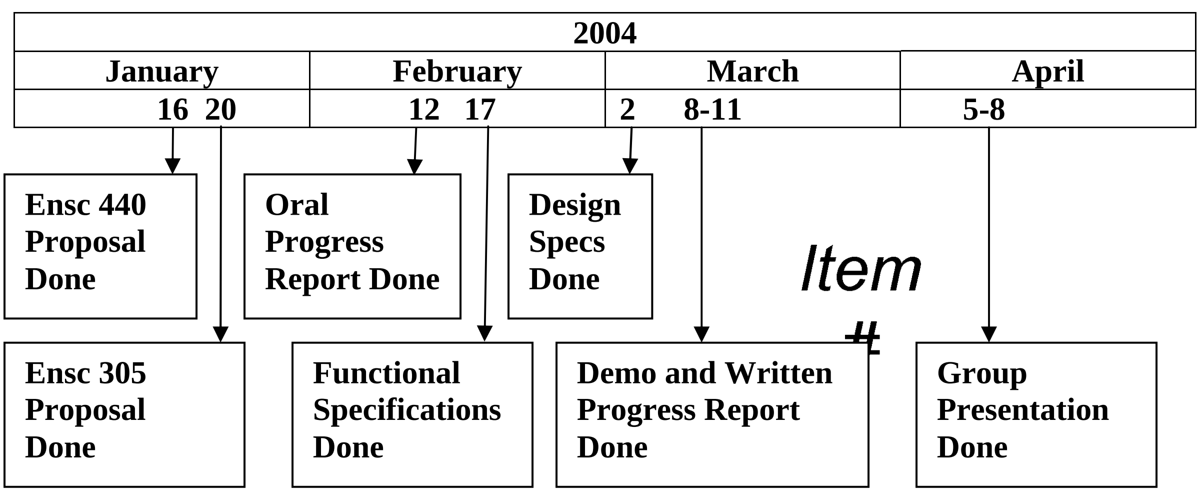

Figure 4-Milestone Chart

Item # *Task Na*

1 Ensc 440 Propo

2 Ensc 305 Propo

Team Organization

Beam Inc. was founded by four engineering students at Simon Fraser University. All four members have a unique area of expertise they plan to contribute to the group. The group includes systems, electronics and computer engineering students.

Eliot Aharon, Beam's CEO, will work as the group coordinator. He'll make sure that group members meet the necessary deadlines. Biljana Pecelj will serve as the Chief Operation Officer. She'll be in charge of developing testing procedures. In addition, Biljana will be in charge of documentation and funding for the project. Manpreet Johal is the Chief Technical Officer. His primary duty will be dealing with software for the project. Aaron Payment is VP Engineering Operations. His role is to work on hardware development and finally integration of all the modules.

Our team realizes that organization and positive team approach is crucial to completing the project in a timely and organized fashion. To ensure that the project is progressing as planned we have schedule official weekly progress meetings which will take place each Sunday. On top of the formal weekly meeting, we'll have a few informal meetings throughout the week.

Company Profile

Eliot Aharon, Chief Executive Officer

Eliot Aharon is an electronics engineering student at SFU. He is in his fourth year of studies. Eliot's strengths include microcontroller programming and analog design. He is excited to be involved in the development of the BEAM pedometer, since he is an avid runner. On top of looking at our design from the technical aspect Eliot will be crucial to developing a product that meets the need of runners. When he's not running with his dog, Moose, in British Columbia wilderness, Eliot enjoys swing dancing.

Biljana Pecelj, Chief Operating Officer

Biljana Pecelj is in her fourth year at SFU. She is pursuing a degree in systems engineering. Despite the fact that she is an engineering student she tries to keep the "artsy" side of her brain alive by drawing and writing. In fact she is the creator of the BEAM company logo. On top of being artsy she is the group's news junkie. She gets her daily news fix by watching CTV news and reading BBC Online. Biljana spends her spare time by planning her escape to a far off exotic location.

Manpreet Johal, Chief Technical Officer

Manpreet Johal is a fourth year computing science student at SFU. He is the group's computer guru. Manpreet's large interest in computers means that he is well acquainted with the latest computer trends and gadgets. Currently he is keeping busy by customizing his laptop. When at home, Manpreet likes to catch up on sports action, by following the latest game or competition on TV. He also enjoys traveling; luckily he has a large extended family which leads him to weddings and family gatherings all over the world.

Aaron Payment, Vice President of Engineering Operations

Aaron Payment is a fourth year systems engineering student at Simon Fraser University. In his spare time Aaron enjoys playing with the latest high tech gadgets. While he claims that he doesn't like to exercise he does spend his spare time biking along SFU's trails. Recently Aaron joined a martial arts class and he enjoys practicing his skills by trying them on his group members. Aaron lives in North Burnaby with his three roommates and two very annoying birds.

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