microSense metrics

School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC, Canada V5A 1S6

25 January 2005

Mr. Lakshman One
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Re: ENSC 440 Project Proposal for a Posture Measurement and Data Logging System

Dear Mr. One:

We propose to build a data logging device which acts as an inclinometer designed to measure the posture of an individual. The device will require tilt measurement, signal analysis, and data storage and transmission. Enclosed please find a copy of our project proposal which details the scope, finances, and schedule of the project as well as a proposed design solution.

The device will be created primarily for research use by Dr. Steven Robinovitch of the School of Kinesiology at Simon Fraser University and Dr. David Rempel of the University of California Ergonomics Program.

Our team is comprised of three dynamic engineering students: Brandon Ngai, Lawrence Wong, and Josephine Wong. If you have any further comments or concerns, please contact us by e-mail at ensc440-u-sense@sfu.ca or by phone at (604) 724-8864. Thank you for your time.

Sincerely,

Josephine Wong

Josephine Wong
President and Chief Executive Officer
microSense metrics

Enclosure: *Project Proposal for a Posture Measurement and Data Logging System*

cc: Mike Sjoerdsma
Scott Logie
Amir Niroumand
Tony Ottaviani
Steve Whitmore

Project Proposal
for a

Posture Measurement and Data Logging System

Team Personnel: Josephine Wong
Lawrence Wong
Brandon Ngai

Contact Email: ensc440-u-sense@sfu.ca

Submitted To: Mr. Lakshman One – ENSC 440
Mr. Mike Sjoerdsma – ENSC 305
School of Engineering Science
Simon Fraser University

Issue Date: 25 January 2005
Revision: 1.0

microSense metrics

School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
Canada V5A 1S6

http://usense.cjb.net

Executive Summary

Hip fractures in the elderly and carpal tunnel syndrome in construction workers are two commonly encountered injuries. Such injuries have lasting or even fatal effects on the patients, and also impose significant medical costs on society. These rising costs have motivated much research in the area of injury prevention in recent years. Unfortunately, researchers still lack the tools to adequately track and capture natural human movement. We therefore propose to design an angle-sensing posture measurement system that meets the research needs of two leading injury prevention experts.

Our proposed system will incorporate commercially-available micro-electromechanical system (MEMS) inclination sensors with data storage and transmission capabilities. The system will comprise of a number of independent sensor units, each capable of measuring the angle of inclination of one part of the subject's body as it moves through a dynamic range of motion. The data logger records the data in memory until the data can be transmitted to a computer terminal for further analysis. In the first iteration of the design, a direct USB link will be used to transfer the recorded data onto the computer. However, the goal is to move to a wireless or satellite data transmission scheme, whereby the data can be collected and analyzed in a near real-time situation.

Combining the expertise of one sixth-year and two fifth-year engineering students, microSense metrics will strive to be the leader in medical sensing systems. Our proposed project will cover research, design, and prototyping within a complete engineering development cycle extending over a thirteen-week period, from 10 January 2005 to 7 April 2005, with an operational prototype for presentation at the end. The entire budget of our system calls for $530 in the first design iteration, and $640 in the second.

Table of Contents

List of Figures

1. Introduction

The prevention of injury and disability is a growing field of research. New techniques and novel approaches to prevent, diagnose, and rehabilitate injuries will ultimately save billions of dollars in medical costs and countless lives and livelihoods. We are concerned with two particular injuries: hip fractures in the elderly due to falls and musculoskeletal disorders, such as carpal tunnel syndrome (CTS), in construction workers.

Each year in Canada, approximately 23,000 cases of hip fractures are reported, over ninety-percent of which are caused by falls (Robinovitch *et al.*, 2003). For the elderly population, hip fractures can be especially devastating, leading to a decline in mobility or even to loss of life. Evidence has been gathered that correlates hip fracture with the nature of the fall and impact on the body. Dr. Stephen Robinovitch, an associate professor of kinesiology at Simon Fraser University, has been studying how the elderly lose their balance and how hip fractures are caused by certain falls.

Approximately eight million people are employed in the construction industry in the United States, accounting for 6.4% of the workforce (Rosecrance *et al.*, 2002). Work-related injury rates are higher in construction than any other industry except manufacturing. Factors leading to CTS, such as large forces on the hand, repetitive motions, and awkward positions, are highly present in construction tasks, making CTS one of the leading causes of injury and one of the most expensive in terms of missed workdays. As part of the research carried out by the University of California Ergonomics Laboratory, Dr. David Rempel studies ways of preventing musculoskeletal disorders in construction workers.

In order to study ways of preventing the two aforementioned injuries, a portable posture measurement system is required to determine body position during the injury-causing event. The objective of our project is to develop such a system that measures angles of inclination of limbs relative to gravity.

We will be working closely with both Dr. Robinovitch and Dr. Rempel to incorporate our device into their research.

2. System Overview

The need for a portable angle-sensing posture measurement system has emerged from the injury prevention research undertaken by Dr. Rempel and Dr. Robinovitch. The desired system integrates two primary functional components: sensors which measure the angle of inclination of a segment of the body with respect to gravity, and a data logging system which records and parses the vast amounts of data that will be generated.

Figure 1 is a graphical depiction of our proposed posture measurement system. The sensor units will be mounted onto the subject's body for extended periods of time, and must be comfortable and unobtrusive enough to enable the subject to engage in their usual daily routines. Weight and size are therefore important design considerations, particularly when the system is used to constantly monitor elderly subjects over a multi-week period.

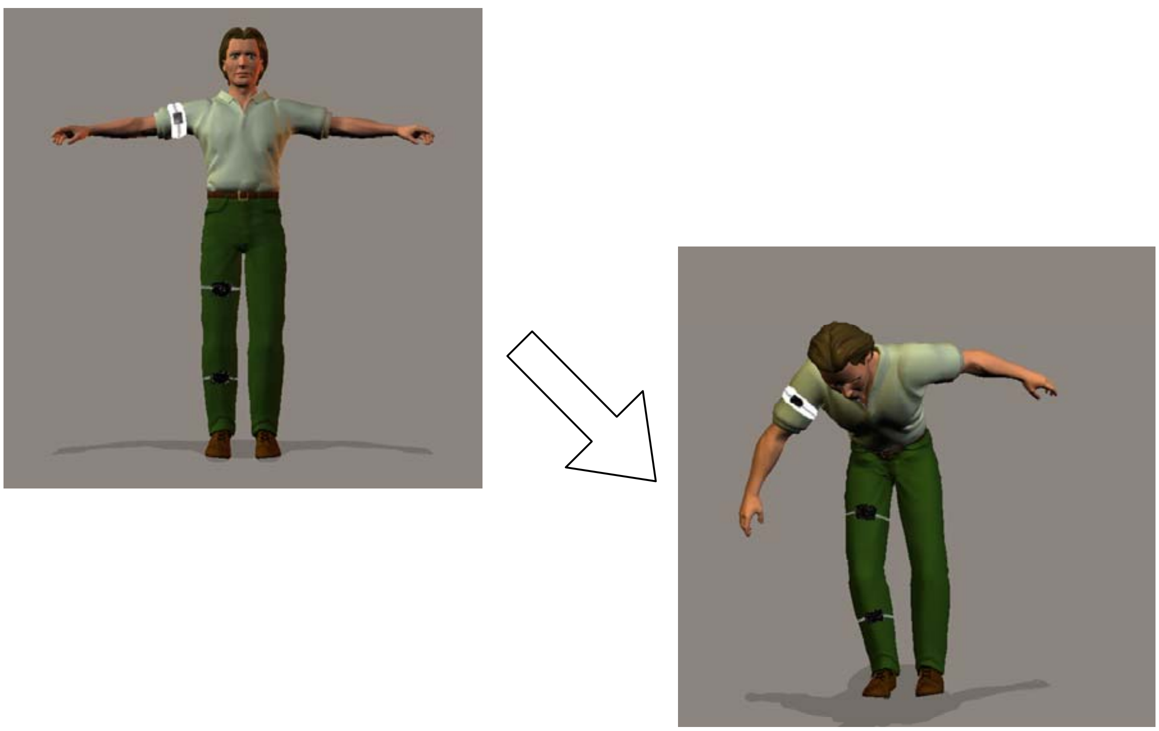

Figure 1: Scenario Involving System Use

Each inclination sensor will provide a steady stream of data which must be stored and transmitted to a computer terminal for further analysis. In his intended application for the project, Dr. Robinovich envisions that up to fourteen sensors will be used simultaneously on a subject, which provides a lower bound for the data processing capabilities of the data logging system.

3. Proposed Design Solution

Our proposed solution is to design an angle-measuring module that integrates commercially-available micro-electromechanical system (MEMS) inclination sensors with data capture and transmission capabilities. Each module would operate independently of the other units in the system, giving researchers the freedom to choose the number of sensors needed for their application. Providing each unit with its own data processing capabilities also eliminates the need to connect the network of sensors with physical wiring, since any wiring is likely to impede the movement of the test subject.

Each sensor module will be installed with built-in flash memory. The size of the flash memory will dictate the amount of data that can be stored between data transmissions. In the first iteration of our design, we propose that each sensor will interface directly with a computer terminal via a USB port, as illustrated in Figure 2. Data can be easily downloaded onto the computer using existing data transmission protocols. Once collected, the data can be analyzed or transmitted via the Internet to a remote server.

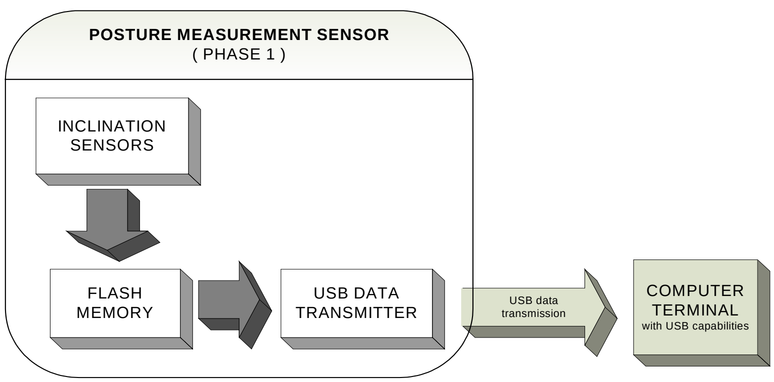

Figure 2: Phase 1 Block Diagram

One limitation of the USB design is the inability of the researcher to obtain real-time data. The data could potentially be stored for up to two weeks before it is collected and analyzed. We hope to address this during the second iteration of our design, where we will replace the USB interface with a wireless or satellite transmission module. This design change is illustrated in Figure 3. With this added functionality, we will be able to transmit data close to real-time, a design feature that may be highly desirable for future applications.

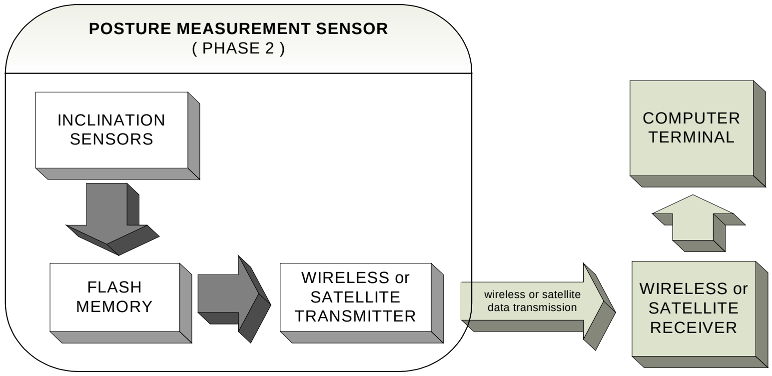

Figure 3: Phase 2 Block Diagram

4. Existing Commercially-Available Solutions

Two existing commercially-available solutions and their merits are discussed as follows.

MicroStrain Virtual Corset™

MicroStrain Inc. manufactures sensors for diverse applications, including the biomedical field. Their Virtual Corset™ device allows for the measure of inclination angles of the trunk of the body. The measurements can then be saved by a data logging system for future analysis. Also, the device may be pre-programmed with inclination angle limits so that the wearer is alerted by an on-board silent vibrating alarm if those limits are exceeded.

The Virtual Corset™ utilizes one of MicroStrain's top-of-the-line inclinometers, boasting high measurement accuracy at ±0.5 degrees, low power consumption at 3.6 volts and 900 microamps, and low weight at 2 ounces. However, the Virtual Corset™ was designed only to measure trunk inclination and would not be suitable for complete human posture measurement. As well, at 6 centimeters long and 5 centimeters wide, the device is too large for our purposes.

Motion Capture Systems

Computerized motion capture of human movement has been used extensively in areas such as video game and motion picture production. Reflective markers are placed on the body of an individual whose movements will be tracked. The location of the markers in space are recorded by a series of specially-designed video cameras. Sophisticated software then interprets the locations to construct a computerized model of the movements.

Although motion capture can be an accurate technique in tracking human posture, it can only be performed in a specific arena because of the complexities of the equipment requirements. Thus, our objective of monitoring posture can only be done in the laboratory, defeating the requirement of portability.

5. Budget and Funding

The budgets for the prototype systems from the two design iterations are outlined in Table 1. In our first prototype, the data will be transmitted by a USB adapter. Once this prototype is debugged and tested thoroughly, a second prototype, implemented with a radio-frequency (RF) transfer module, will be introduced. A 15% contingency has been added in the costs for most of the components to compensate for cost overruns.

Table 1: Proposed Budget

Materials	Estimated Cost	
	1st Prototype	2nd Prototype
Sensors (Inclinometers)	$100	$100
Microcontroller	$40	$40
Power Supply	$60	$60
Memory Storage	$120	$120
Data Transmission Module	$90 (USB)	$200 (RF)
Case	$20	$20
PCB	$100	$100
Total	$530	$640

Both Dr. Rempel and Dr. Robinovitch have generously committed financial support for this project. As well, we will be applying for design project funding from the Engineering Science Student Endowment Fund.

6. Timeline

Figure 4 demonstrates the time we expect to devote to key components of the project.

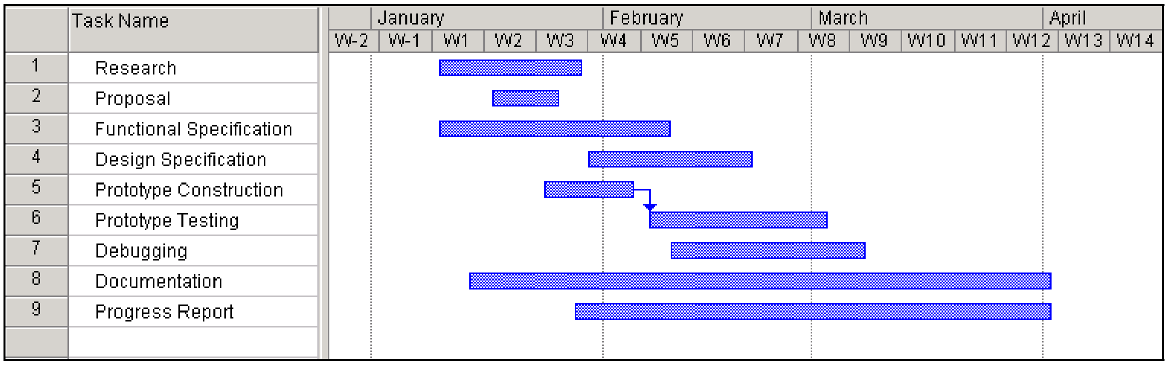

Figure 4: Gantt Chart

Figure 5 pinpoints the deadlines that we have set for each stage of the project. We intend to complete our project by 7 April 2005.

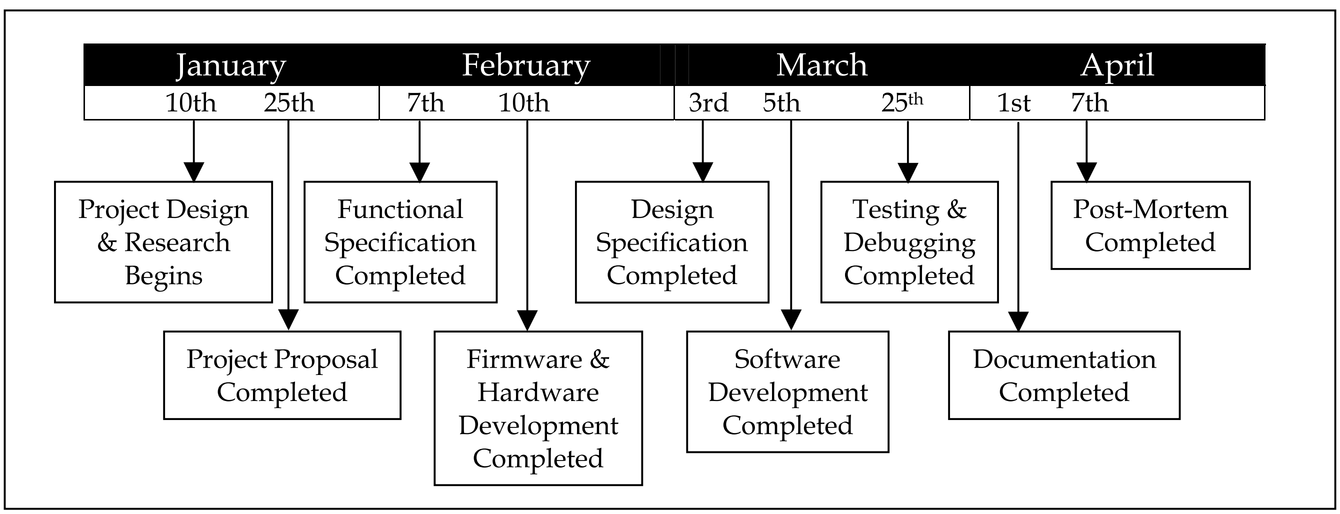

Figure 5: Milestone Chart

7. Team Profile

Our team recognizes the importance of synergy and will work to meet our objectives through our commonwealth of individual experience, knowledge, and dedication. Since our team is relatively small, we have elected to maintain a horizontal structure. While each member will have a leadership role in a specific area of expertise, all will participate fully in the activities of the team. We feel that this "united we stand, divided we fall" approach will make our team successful.

As President and Chief Executive Officer, Josephine Wong will facilitate the progress of the project and the vision of the team. Her experience as a dedicated member of the student society at Simon Fraser University makes her apt for this role. Lawrence Wong will serve as the Chief Financial Officer of microSense. A minor in business administration, Lawrence will oversee all financial aspects of the project and guide the team in a fiscally sound manner. Brandon Ngai, Vice-President Research and Development, will coordinate the technical work of the team and ensure that the finished product meets design criteria. His experience in managing extensive projects for school, work, and extracurricular activities will come in handy for this role.

Our team is bolstered by the strong support and technical expertise of our faculty advisory panel. The research needs of Dr. Rempel and Dr. Robinovich form the driving force behind the project. Together, they offer great insight into how our posture measurement system can help prevent injuries in construction workers and the elderly. Similarly, Dr. Bozena Kaminska's experience with biosensors and wireless technologies will undoubtedly prove invaluable, particularly as we move towards the second design stage of our project.

More detailed biographies for team members and the advisory panel are available in the following section.

One of the keys to success will be the ability of our team to work closely and collaboratively with everyone involved in the project. In addition to weekly meetings, our team has created an online web journal to maintain communication between ourselves and our stakeholders, and to track our progress as we push forward towards achieving our goals.

8. Personnel Profiles

Josephine Wong – *President and Chief Executive Officer*

Josephine is a sixth-year engineering undergraduate at Simon Fraser University. Having worked in very diverse settings at PMC-Sierra and Redback Networks, she brings a mix of hardware and software skills to the project. She is particularly familiar with circuit design and PCB layout, and is well-versed in a range of programming languages such as Java, C++, assembly language, and VHDL. Josephine also brings a keen interest in ergonomics, which has arisen out of the introductory coursework she undertook in the School of Kinesiology. Beyond her academic commitments, Josephine devotes much time to representing student interests at the Simon Fraser Student Society and the Simon Fraser University Senate.

Lawrence Wong – *Chief Financial Officer*

Lawrence is a fifth-year systems engineering student at Simon Fraser University with experience in analog/digital circuit design and embedded system design. He is also completing a minor in business administration at SFU. In 2003, while working for Universal Instrument Ltd., Lawrence developed a temperature profiler to help analyse the tunnel temperature in a reflow oven used in the surface-mount (SMT) process. The experience working on such a project allowed him to explore different aspects of the commercial product development cycle and sharpened his skills in electronic system design. In his spare time, Lawrence volunteers as the President of the SFU *UVoice* student newspaper, which provides students with valuable experience in publishing and journalism. He also practices kendo with the SFU Kendo Club.

Brandon Ngai – *Vice-President Research and Development*

Brandon is a fifth-year systems engineering student at Simon Fraser University with strengths in FPGA design, assembly language programming, and circuit design with operational amplifiers. During his two work terms at BC Hydro, Brandon gained great insight into the dynamics of client care and interdepartmental teamwork. In his minimal spare time, Brandon volunteers with the Canadian Federation of Engineering Students, which lends to his strong leadership and organizational skills. Although his mind is balanced, Brandon is known to trip over his feet on many occasions, which explains his enthusiasm for this project.

9. Advisory Panel Profiles

Dr. Bozena Kaminska

Dr. Kaminska received the MSc and PhD from the Warsaw University of Technology. After many years in industry and successfully integrating wireless sensors in wildlife management, she recently joined the School of Engineering Science at Simon Fraser University and was nominated for a Tier 1 Canada Research Chair in wireless sensor networks. Her areas of research include micro-medical devices, biosensors, wearable electronics, and physiological, behavioural and environmental monitoring.

Dr. David Rempel

Dr. Rempel received the MD from the University of California, San Francisco, where he is professor of medicine, and the MPH in epidemiology from the University of California, Berkeley, where he is associate professor of bioengineering. As director of the UC Ergonomics Laboratory, Dr. Rempel's research interests are focused on preventing disorders such as carpal tunnel syndrome in occupational settings through the design of hand tools and workplace.

Dr. Stephen Robinovitch

Dr. Robinovitch received the BASc in mechanical engineering from the University of British Columbia, and both the MSc and PhD in medical engineering from the Massachusetts Institute of Technology. He is an associate professor of kinesiology and director of the Injury Prevention and Mobility Lab at Simon Fraser University, where he studies ways for preventing disability and injury after a loss of balance and falling in elderly individuals. Dr. Robinovitch was recently nominated for a Tier 2 Canada Research Chair in injury prevention and mobility biomechanics.

10. Conclusion

microSense metrics is committed to developing an affordable and functional posture measurement system that will aid researchers in preventing injuries in construction workers and the elderly. The system will be lightweight and relatively unobtrusive, so as to minimize the impact that it would have on the subject's daily routines.

Our system will track the angle of inclination of the subject's body as it moves through a range of motions. The system's data logging capabilities will enable us to capture this dynamic data and retrace the subject's movement for further analysis.

Although our system is designed with two specific test environments in mind, our team sees great potential for our project. We hope that it will one day evolve into a key tool in the study of human physiology.

11. References

Injury Prevention and Mobility Lab, Simon Fraser University. 23 January 2005 <http://www2.sfu.ca/ipml/>

MicroStrain Inc. 23 January 2005 <http://www.microstrain.com/>

National Institute of Neurological Disorders and Stroke. 2004. "Carpal tunnel syndrome fact sheet," 23 January 2005 <http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm>

Robinovitch, S.N. et al. July 2003. "Strategies for avoiding hip impact during sideways falls," *Journal of Bone and Mineral Research*. Vol. 18, 1267-1273.

Rosecrance, J.C. et al. August 2002. "Carpal tunnel syndrome among apprentice construction workers," *American Journal of Industrial Medicine*. Vol. 42, 107-116.

UC San Francisco/UC Berkeley Ergonomics Program. 23 January 2005 <http://www.me.berkeley.edu/ergo/>