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April 29, 1999

Dr. Andrew Rawicz
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Simon Fraser University
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Re: ENSC 370 Project - Physiological Signal Data Logger Process Report

Dear Dr. Rawicz,

The attached document, *Physiological Signal Data Logger Process Report*, outlines the process that our team went through during design and implementation of our 16-channel data logger for physiological system that is to be used by the Living Lab, a joint venture between SFU and BCIT. This project is to provide researchers at the Living Lab a lightweight portable data logger that is capable of monitoring and recording 16 different inputs physiological signals captured by already available biomedical sensors and electrodes.

The current state of the device, deviations from our original plans and our future plans for the device are explained in this document. In addition, some of the difficulties and time constraints we encountered and the inter-personal and technical experience gained from working on the project are outlined.

Versatile Innovations consists of four innovative and enthusiastic third-year engineering students - Fiona Chan, Karen Chan, Andy Jien, and Sean Shieh. If you have any questions or concerns, please feel free to contact me at 420-0782 or yien@sfu.ca.

Sincerely,

Andy Jien, Chairperson
Versatile Innovations

Enclosure: *ENSC 370 Physiological Signal Data Logger Process Report*

VERSATILE INNOVATIONS

Process Report

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Introduction

Since the beginning of January 1999, Versatile Innovations has put in tremendous effort to bring the Physiological Signal Data Logger System towards realization. This document re-examines the work that was done for the past 15 weeks and outlines the future plans of this project.

Current State of the Device

The first prototype with functions in configuration, logging, and upload was constructed by the end of April. This device is capable of storing 65,000 readings from two channels. Moreover, the system includes minimal support for configuring and uploading. To configure the logger, users will use a simple graphical user interface to set the options. For uploading, the logger will transfer the content of the collected sample to the PC.

The prototype system is a “cousin” to our final product. In areas such as field programmability, data acquisition, storage, and data transportation to a PC, the prototype system fulfills some of the requirements in all areas but none completely.

The data acquisition component allows 2-channel sampling at a fixed sampling rate of about 15 kHz. After the necessary conditioning, data is directly transferred to a memory chip for storage. The storage memory is capable of storing 65,000 samples. After the collection is done, the device has the option of delivering the result to an oscilloscope or transferring the result to an IBM PC computer with a serial port.

Deviation of the Device

In our design specification, we lay down the design for our project. However, after evaluating more options, we will have the following deviations from our specification

1. Data transportation means:
   PC's serial port (RS-232C) was defined to be the means of communicating between the PC and the Logger. After evaluating the performance of the standard. We have discussed with the Living Laboratory about using a more powerful communication method. It is designated to be using the parallel port of the PC to perform data uploading. However, the possibility of using universal serial bus port (USB) is being investigated.

2. Data storage
   Two hundred megabyte of data stored in memory is both expensive and power consuming. Removable massive storage media will be one of the candidate in our next iteration of our design. Storage devices such as back-up tape drive , zip drive offers both portability and big storage capacity. However, the moving parts needed for these devices might hard to maintain and/or protect.

3. The DSP
   The requirement for the processing unit is changing with respect to our storage method. If a massive storage media is used, less compression will be needed and thus less processing power is needed.

4. Modular Signal Input
   Input analog channels will be separated into modules with individual programmable gain unit. This will help increasing the flexibility of the device. Upon product assembly, each module will be plugged into the design slot into the device. Dedicated input will have dedicated modules. This will aid significantly when programmable gain/pre-amplification unit needs upgrade or replacement.

Future Plans

Versatile Innovations is determined to further design and develop the Physiological Signal Data Logger System. As the project will help the human factors research at the Living Laboratory, it also proves to be useful for studies such as people's interaction with devices, environmental features, and assistive technology. Three of the team members: Fiona Chan, Andy Jien and Sean Shieh will be working full time along with Karen Chan working part-time on the project for the next four months in hoping to have the proposed device finished by the end of August.

We are planning to achieve the proposed specifications of the followings:

Configuration Mode

In Configuration Mode, users are allowed to program the signal data logger through a personal computer. The signal data logger will be connected to the computer via a parallel interface. Parameters such as variable gain, user selectable sampling frequency to the input signals will be set through a graphical user interface.

Logging Mode

Also, users are allowed to turn on/off the logger, pause/resume sampling session and reset the current sampling session. These will be implemented through membrane switches on the signal data logger.

Upload Mode

In the Upload Mode, users are allowed to transfer the stored data in the logger onto a personal computer. Computer software providing a graphical user interface will be available to the users. This software interface will provide progress indication such as number of channels loaded, estimated time to completion and percentage completed. In case of error, proper error messages and suggestions for trouble shooting will be displayed.

Physical and Power Requirement

As the physiological signal data logger is a portable device, the whole system is to be enclosed in a water and impact proof case and powered by batteries, which will have a standby time of at least 24 hours and operation time of 1.5 hours.

Budgetary and Time Constraints

Budget

Table 1 contains the estimated cost and the cost of the project up to April 30th, 1999.

Table 1 Estimated Cost vs. Actual Cost

Required Components	Estimated Cost ($)	Actual Cost ($)
Microcontroller(s)	150	200
Prototype Board(s)	100	65
Memory Storage Device	200	15
Casing	140	20
Power Supply	120	25
LCD Display	100	N/A
A/D Converter(s)	250	40
Data Acquisition Card (changed to D/A Converter)	900	90
Miscellaneous	250	400
Total Cost	2210	855

Since the development of the project is still under going, the cost listed above does not reflect the total cost of the project.

Time

Other than the project course ENSC 370, we were also taking other courses. Most of these courses involved laboratory works, projects and midterms. When we planned for the timeline for our project, we failed to take the deadlines of these projects and lab write-ups and dates for midterms into consideration. This caused the ENSC 370 projects defer somewhat.

We all felt that we should have put those deadline dates and midterm dates into consideration so that we could follow our project schedule closely.

Please refer to the Gantt chart in the Appendix.

Team Dynamics

Planning

A successful project can always be traced back to a good schedule. For our team, we failed to come out with a well-thought out project schedule and this contributed to the fact that our project is behind schedule. The project was behind schedule due to a number of reasons.

First, we had underestimated the complexity of the entire system. Since the beginning of the semester, we have invested quite a lot of time doing researches on physiological signals and finding the right components that is suitable for the project. During the semester, one of the major problems we had encountered was that the Living Lab requires a portable device that is capable of storing 200 Mbytes of data. Due to the size of the memory required, we ran into memory addressing problems. After considering different memory management schemes and numerous DSP's, we decided to use a high end DSP as well as a device architecture that enables us to manage large memory storage. Complex problem such as the one just mentioned is only one of the many.

Second, due to our inexperience in designing embedded system and the architecture of such a complex system, we lacked the confidence in making design decision and thus decision process was rather long.

Communication

Regular meetings were held within the team and with the Living Laboratory. Meetings with the Living Laboratory allowed us to communicate with the Living Lab about the requirements of the system. Meetings within the group allowed communication between team members regarding the progress of each member. Problems were also discussed and resolved during these meetings. However, we all felt that communications between team members were not efficient and enough.

When problems arose, we resolved the problems together during meetings. However, we felt that it is not necessary to have the entire group involve in resolving all of the problems. Unless necessary, some members should be held responsible for a subset of the problem. This way, team members could comment on the solution came up by the other group members without any biased views. Also, this can also reduced the time duration of meetings.

Project progress review was not frequent enough. Plus we failed to set specific deadlines, and this caused delay in our project progress. We all felt that progress review of the entire project should be held every other regular meeting, and we should have set clear deadlines.

Shifted Focus

Due to the large amount of research needed to be done and the complexity of the project, the development work required to finish the project is beyond 4-month work. Although we have expected and agreed to put more than normal efforts into the project, other affairs such as immediate due dates of projects, assignments and lab reports shifted our focus from the physiological data logger project. Again, if clear and specific deadlines for the project were set, we would have been able to focus more on the project.

Inter-Personal Technical Experiences

Fiona Chan

For the past 15 weeks, I felt that I had gone through some intensive and all-rounded training. All-rounded because ENSC 370 has taught me from electronic circuits and design, soldering skills to organizational skills, communication skills and interpersonal skills. Considering the cost of this course, ENSC 370 is certainly "a good deal" from an economic point of view (ignoring the cost of components though)☺.

In terms of technical skills, as I was responsible for Signal Acquisition and Signal Conditioning, I have learned much about analog circuitry design, power consideration, sensors and filter design. I have also learned about a number of different types of physiological signals. Due to unfamiliarity of physiological signals and biomedical electrodes, I had the opportunity to talk with biomedical engineers and technicians from various educational institutes and hospitals. I am convinced that the effectiveness of a good assistive device design as a result of human factors research in elevating the degree of convenience of those who have disability.

Being the internal relations of the team, I have learned that when deadline approaches, pressure and frustration builds up, and it is very difficult to do a good job on maintaining a conflict free environment. Yet, it is this time that conflicts must be prevented to ensure productivity. As an impatient person, this administrative task really helps me learn to be patient with others. Plus, I also learned to convey messages to other team members in a precise and yet considerable manner during conflict time so that what I say would not agitate them further.

I have learned that planning ahead is crucial in any project. In my opinion, clear and precise deadline should have been set to prevent project delay. Regular meetings within the group and with the Living Laboratory were held. During our team meeting, I felt that we often tended to attack a big problem together rather than assigning some members of the team to attack a sub-problem to increase productivity and effectiveness.

For the time being, we do not yet have a complete prototype of the system. However, we are determined to have the proposed device fully developed. Moreover, we were able to pinpoint team dynamics problems. This will no doubt help us to organize the team in the future.

Karen Chan

As a part of this project team, I really appreciate the cooperation among each of us. Due to the size of our project, we separate the project into four parts. However, when we have trouble with our own part, other members in the group are willing to provide help. In this way, we are able to understand the whole project, in addition to learning it from the specifications.

In addition to the long-term perspective to our project, we developed a scale down version for ENSC370. In this version of our project, I increased my knowledge of the usage of Motorola M68HC11 microcontroller and digital circuitry associated with it. I learned programming M68HC11 using assembly language and gained experience in interfacing digital circuitry with M68HC11. I learned about data bus sharing, latching register and the usage of static RAM in digital circuitry.

However, from this scale down version, I also learned the limitation of M68HC11. The M68HC11 has exposed its limitation on interfacing with external devices from its number of I/O ports. This experience encouraged us to think of the possibility of using a digital signal processor to interface with devices in addition to manipulate data (ie. digital filtering and data compression) in the system.

I found that sufficient research and communication within the group is crucial. Research can lead the group into the same direction and communication can assist the group in the same direction when research is not enough. Although the project is broken into four parts, the final system is linked together. If there is a change in one part of the design, informing the other members as soon as possible can reduce the time of re-implementing the other parts.

The weekly meeting for this group improves our communications. We take turns to be the chairman, and everybody is free to express his or her ideas and constructive criticisms. The chairman is responsible for the agenda in the meeting, so that we can focus during the meeting, without wasting time from everybody. I learn how to listen to others and communicate with them. The linear structure of our group encourages us to be self-motivated. However, encouragement and remainders from other group members are also important in finishing tasks. I enjoy working in this group.

Andy Jien

Ever since the beginning of this project, we have been holding regular meetings among our group as well as with the Living Laboratory. These meetings kept us well informed with the progress of each member of the group and major decisions about the project are also made during these meetings.

For the duration of the project, I have gained invaluable experience in the design process of a complex system. Every stage, from the proposal to the design to the prototyping of the system, is a new and worthwhile experience. I’ve also found out that sufficient research can help tremendously in the success of the project. The more information we gathered, the easier it is for us to put the device together.

Technically, I learned about the HC11 Assembly language, A/D converters, and D/A converters. I also gained some knowledge in filters and direct memory access from the works of my fellow group members. One of the major problems we encountered was the interfacing between different components and the handshaking required. We spent a lot of time trying to build interface between the components.

I feel that the most important aspect I learned regarding group dynamics is to be patient and understanding. We need to understand each other and incorporate our ideas together in order for the project to move forward. When disagreement arises, we need to be patient and try to think about each other's perspective on the matter. Another important issue is to ensure that everyone in the group is heard and that everyone's opinion is openly expressed. There might be some intelligent insights that one of us had that would greatly simplify our work but was never heard. Communication is vital to the success of the project.

If I would change anything, it would be that we should make a more detailed plan of short-tern and long-term goals. I felt that our short-term goal presented in our proposal is not reachable because we underestimated the complexity of the system and the amount of time we have to work on this project.

Sean Shieh

In the month of April, we "sealed" our design for a sixteen-channel signal data logging system. In the first week, we put together a device that can only perform the logging mode operation for a brief moment with 256 reading storage capacity.

Adjusting from roles as designers to technicians took us quite some time to adjust. The prototype employs components that are much simpler than our full-scaled solution, yet we spent a great time trying to put the simple components to work. In putting together a prototype system, I was mainly responsible for computer programming both on PC and on the HC11 microcontroller. On PC, I went through a short learning cycle and generated a very basic graphical user interface for our Configuration tool.

Personally, I do not expect an outstanding evaluation result after the demonstration. However, I value the lessons gained by the many difficulties we encountered during the first four months of the project. Moreover, the hardship in the past two weeks to construct the miniature version of our design suggested us to reevaluate our design. Getting more off-the-shelf components into our design will be our priority to reduce the development time and cost. In my opinion, this project has a lot of potential in its practical value to the research community as well as the possible experience team members might learn from it. I am glad to hear my colleagues' interests in this project. Some of them have agreed to participate in this project after this semester. With the new members joining us, we can have enough resource to develop the product. I look forward to the second part of the project in the coming semester.

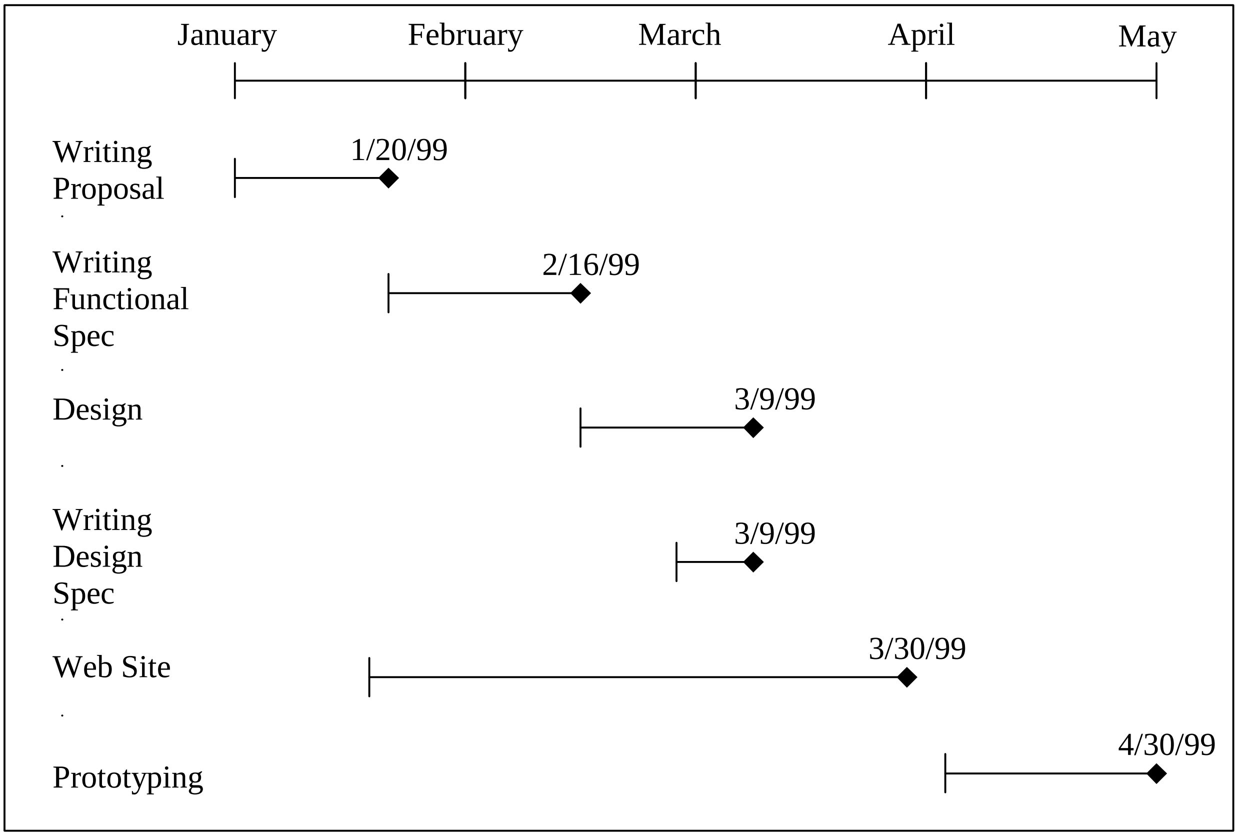
Conclusion

Like the saying, " No pain no gain". Even though we did not achieve what we wish we had, but we valued what we have learned from this project course dearly: from microcontrollers, analog and digital circuitry design, DSP to project organizational skills and interpersonal skills.
In the next 4 months or so, we will continue working on the project. We will no doubt work on our team dynamic and communication problems that we have learned from the past 15 weeks. We will increase the frequency of conversation updating any lead/lag of progress.

Afterall, ENSC 370 is a valuable course as it gives us a feel of the reality. It is great to find out our problems now rather than later when we are in the industry.

Appendix

Gantt Chart



The only major difference between our proposed Gantt chart in the proposal and the actual timeline is the time it took us to build the prototype. We started later than we originally planned and used more time than planned.