Precision Lifestyle Technologies

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The Heart of Medical Advances.

December 17, 2007
Dr Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440/305 Post Mortem Document for a Wireless Heart Attack Detector

Dear Dr Rawicz,

The enclosed document, *Post Mortem report for a Wireless Heart Attack Detector*, summarizes the activities and accomplishments of our group while designing and implementing a Wireless Heart Attack Detector called Pulze™. Our group had faced and overcame different challenges in the past four months but the outcome is a prototype of Pulze™ which was successfully designed and presented. We are planning to continue the hard work to take this device to the market.

The accompanying document encloses the current state of the project, the deviations from the original plan, the possible future work for the project and its marketing aspects, and the problems we encountered. In addition, each group member provides descriptions of individual contributions to the project and the experiences learned.

PLT's dedicated, talented and motivated team of senior engineering students is comprised of Piraj Fozoonmayeh, Mojtaba Gharehbaghi, and Sara Moghaddamjoo. For further information or any concern you may have please do not hesitate to contact me by phone at (778) 883-2424 or by email at sma22@sfu.ca.

Sincerely,

Sara Moghaddamjoo
President and CEO
Precision Lifestyle Technologies Inc

Post Mortem for:

Wireless Heart Attack Detector

Project Team:

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Sara Moghaddamjoo

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1 Introduction

Telemedicine is a new advancement in delivery of clinical care through information technology and communication devices. This technology could be used immensely for disease detection and therapeutic purposes. It has been proven that early detection of a disease at its preliminary stages could profoundly reduce the risks and complications that may arise with time.

In the year 2004 United States statistical data recognizes coronary heart disease as the leading cause of death among American citizens. Each year 1,200,000 cardiac attacks are reported, from which 38 percent of these cases result in death. This amounts to one in every three incidences of heart attack amounting to death. Considering the world population of more than six billion people, there are millions of people who are susceptible to death by heart attack. To reduce these horrific numbers we should concentrate our resources and technologies on improving early detection devices to further assist physicians to communicate with their patients on a daily basis since some heart complications may arise without prior warning.

Electrocardiogram (ECG) shown in Figure 1, measures the heart beat electrical activity which generates a wave or impulse through the heart muscles. This electrical impulse would constrict the cardiac muscles which in turn causes blood to be pumped out of the heart into arteries. With patients with cardiac issues, an ECG allows the physician to know the length of time required for an electrical wave to travel through the heart. This information determines whether the electrical activity is normal, too fast,/slow or irregular. An ECG can also give information about the size and health-state of the heart based on the amount of electrical activity that passes through the heart muscle. Based on these types of information, an ECG can detect a heart attack.

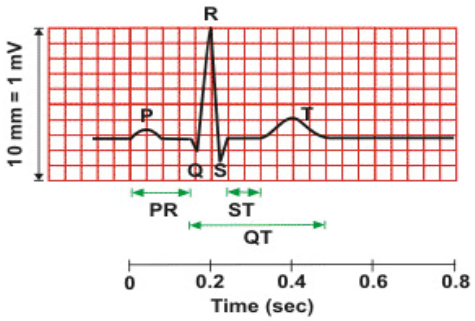


Figure 1: *Standard electrocardiogram (ECG)*

http://www.cvphysiology.com/Arrhythmias/ECG%20trace%20with%20grid.gif

The ECG technology has had an enormous impact for diagnostic purposes since its discovery, however, there are still shortcomings that may be improved to further enhance ECG. For instance, available ECG devices lack the advantage of being portal and hence they impose physical and spatial restrictions on the patient and the doctor. Moreover, an ECG device is able to detect a heart attack only after it has occurred, and by that time it may be too late to save the patient's life. To this date there has been only a little improvement on the ECG devices to enable faster and better communication between the patient and the doctor. Therefore, it is necessary to recognize the flaws that this technology is experiencing at this time and take actions to further improve its functionality to serve human lives more efficiently.

Our proposed system not only detects heart attacks for immediate assistance, but also could be used for various other applications:

1- The rate at which a heart beats plays an important role especially in catabolic exercises such as cardio exercises, so this device may also be used by athletes and people that would like to lose weight.

2- The design of the bio-sensors may be modified for other medicine applications such as using a respiratory sensor to detect respiratory problems.

2 Current State

We were able to deliver a fully functional device with the ability to detect a heart attack and send a Bluetooth signal to user's cell phone to attain assistance.

If the heart signal is normal, the LED on the device displays a text stating a normal heart signal. Moreover, it is able to display the heart beat of the user as well.

The microcontroller detects heart attack (ST elevation type) by evaluating the time it takes for the Q wave of the heart signal to reach to the base line. Next, the buzzer and vibrator on the device start beeping and vibrating, to notify the user of an abnormal heart signal.

After heart attack is detected, the MC and Bluetooth communicate together and the Bluetooth module was successfully programmed to send a wireless signal to user's cell phone to initiate a phone call to emergency personnel or any other given numbers to the program.

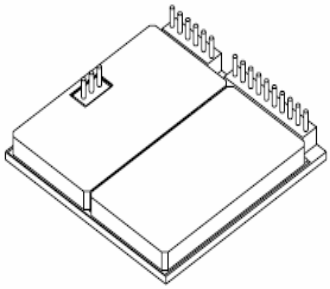
Moreover, during the project we successfully programmed 5 LabVIEW programs:

1. ECG signal display program via microphone jack, the signal can also be recorded for the physicians use.
2. ECG processing program to process the files sent by the previous program. (for physicians use)
3. Normal heart signal generator
4. Abnormal heart signal generator (ST elevated signal)
5. ECG signal manipulation program, using Matlab server and etc.

3 Future Work

3.1 GPS

We are planning to implement a GPS module to our microcontroller so the patient can be located if an abnormality is detected and immediate assistance is required. This is viable because we do not use the RX pin of the UART, and the following figure is the model of the module, we intend to buy.



Pin	Name	Pin	Name
1	GPIO [4]	11	DSUMUX
2	NC (MODE)	12	DSUEN
3	NMEA TX	13	DSUBRE
4	NMEA RX	14	DSUTX
5	WAKE UP	15	DSURX
6	Reset	16	DSUACT
7	VBAT	17	RF GND
8	GND	18	RF IN
9	VDD	19	RF GND
10	GPIO [0]		

Figure 2: GPS add-on to the MC

http://www.dynamics.co.nz/

This module will send the position of the person via the pin 3 (NMEA TX, National Marine Electronics Association). This data will then be buffered into the microcontroller registers and outputted whenever heart attack happens, so the emergency personnel can locate the patient.

3.2 Implementation of an Accelerometer

This functionality will alert the emergency personnel when the person slips and falls and no movements are detected after the incident. This functionality could specially be useful for elderly. The method of detection is based on acceleration of the person. The measurements will then be fed to the microcontroller which decides based on various conditions to call emergency personnel or not. We have chosen the ADXL321 for our application, the reason for this selection is beyond the scope of this paper.

3.3 Detection of Different Types of Heart Attack

In order to detect more types of heart attack, we have to upgrade the microcontroller we are using now. Speedy 33 (National Instrument) would be a great candidate. Figure 3 represents a Speedy 33 Microcontroller.

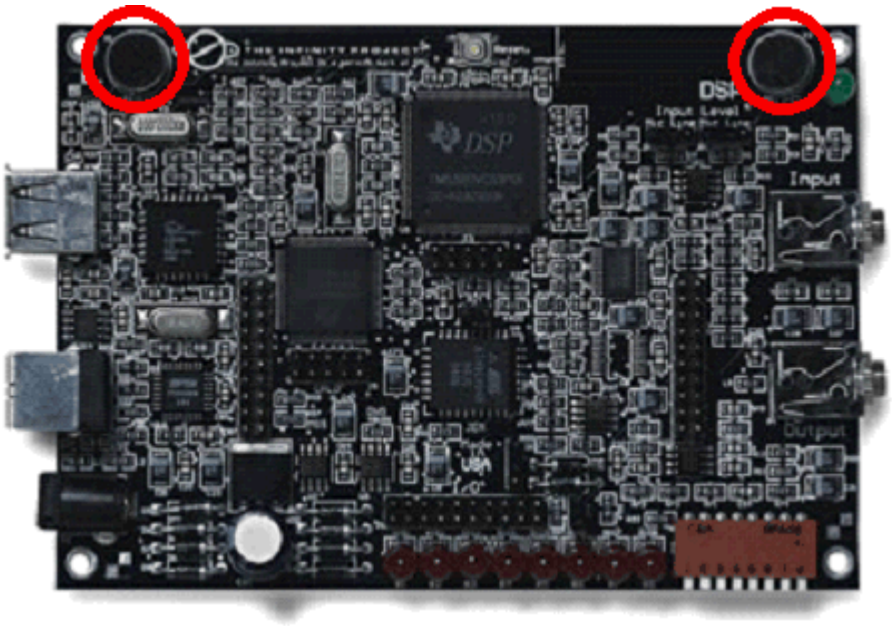


Figure 3: NI SPEEDY-33

http://zone.ni.com/devzone/cda/main

One of the main features of the Speedy 33 is its compatibility and programmability with LabView. And since LabView has a complete set of digital signal processing nodes, noise effects will considerably be lower. The figure 4 represents various available filters in standard version of LabVIEW.

Figure 4: Various available filters in standard version of LabVIEW

4 Experiences

Sara Moghaddamjoo

CEO

Our journey started unexpectedly about four months ago and led to a valuable experience. During the process of designing a prototype for Pulze™, I have learned not only engineering and technical lessons but also many life long lessons which I can apply to various problems in the future. I took the role of a team leader since I am planning to apply for MBA program in Biomedical Engineering and Law and pursue my career in business and management environment after receiving my undergraduate degree in Biomedical Engineering.

The experiences I learned in the past four months gave me a constructive point of view on what challenges I will face as a team leader and what will be the consequence of different approaches to solving the problems. I was very fortunate to have the opportunity to work with a small group of extremely self motivated and accountable members.

One of the many valuable experiences I learned during the past four months was to realize that in most cases nothing goes as planned and scheduled. The first solution is to have a realistic estimate of the project's magnitude and to always leave extra time for unexpected issues that may come up. Another solution is to have an alternative plan for each subsection of the project in case something goes wrong with the original plan. Also I have learned to keep record of everything for example documents, calculations and even emails as they may become useful at some point. Besides the life and management experiences I have gained, I was able to develop many technical skills including.

Although we had many disagreements during the design process, the point that my partners and I all agree on is we all had so much fun and were able to satisfy our desire to complete a working prototype in the limited time we had, no matter what came in our way. When we did not agree on a task sometimes was upsetting but at the end it was all constructive toward our mutual goal. I hope to continue working on this project with my partners and to be able to take it to the next level and hopefully make Pulze™'s way open to the market.

Piraj Fozoonmayeh

VP Hardware

We have done so many labs in our engineering courses, but I never learned anything practical. I gained a lot of hardware and software experiences, by observing the problem and finding and debugging the solution. Our project had a big amount of hardware and software, therefore putting everything together was a big challenge for us.

In this project I have explored almost all of the feathers of the PIC microcontroller such as different kind of interrupts, different type of timers, LCD, A/D and USART. The challenges arose from the limitation of the microcontroller and the compiler. I started by reading the datasheet and sample codes. Since I was really comfortable with the logics and algorithm the most challenging part of programming the microcontroller was the initialization of A/D, Timer, LCD and UART.

I also have updated my JAVA experience, by writing codes to run on the cell phone.
I also learned lots of LabView tricks and techniques.

Since the ECG signal is very noisy, I learned a lot about noises and filters, specially the 60 Hz noise. In the course of this project we made more then 15 different configuration for the ECG and we learned a lot from each of them. We also had a test signal that was not suitable to be fed to our microcontroller; we tackled this problem by first making filters and amplifiers.

We tried to join other groups at the beginning, since it was only 2 of us, but unfortunately or should I say fortunately, we couldn't find any. The amount of work was excessive, but it paid off at the end. I believe everything can be accomplished by hard work

Mojtaba Gharehbaghi

VP software

When I first started the course I didn't have a clear idea of what these two courses are about and what I should be expecting. I was expecting just another course in the university. But at the end I realized that this course was very different than any other course I had taken. Even though the load of the course and amount of work to be done was excessive, the sense of satisfaction and accomplishment at the end of the course proved to me that all the hard work was another big step towards a brighter future.

In this course I acquired the skills to be able to program and implement a PIC microcontroller. I researched and read a lot about the functionalities and capabilities of a microcontroller and at the end we were able to deliver a functional microcontroller.

Moreover I acquired necessary skills to implement the theories that I had studied during the last 5 years in this project. I was able to get hands on experience on functioning analog circuits.

I was able to study and understand a new wireless technology and successfully program Bluetooth modules so they can communicate together. Furthermore I refreshed my Java coding memory and got hands on experience in AT commanding via HyperTerminal for cell phone applications. The exposure I got to different materials, methods, programming languages and hardware was remarkable.

I realized that there always is more than one solution to a problem. Moreover, in this project I learnt that in order to find the best way to solve a problem is to try different methods and have an opener mind to the issues that come up.

5 Budget and Funding

5.1 Budget

Budget approximation and finalized cost of the Wireless Heart Attack detector, PULZE™, is presented in Table1. As apparent in the table, we went over budget, mainly due to two reasons. Firstly, the purchased ECG heart monitor was defective and since the money back guarantee period was only for one week, we were unable to get a refund for our expenditure. Therefore more money was spent to purchase parts and circuitry to design and build the ECG heart monitor in our team. Secondly, the expensive Bluetooth module we purchased failed to work in the process of programming due to a hardware failure. So we had to purchase another Bluetooth module from a different company, but at a cheaper price. The functionalities of the cheaper module were more satisfactory than the more expensive one, which proved to us expensive devices are not always superior to the cheaper equipments.

Table 1: *Estimated and Final Budget Breakdown*

Sub System	**Estimated $**	**Final $**
Amplifier and Filter	70	130
MC	300	60
Biosensors	15	40
Bluetooth	150	245 + 150
Circuitry	50	100
Total	**585**	**725**

5.2 Funding

It is expected in most cases that the cost for developing a prototype is much greater than the per unit production cost for commercialized devices. Once the mass production phase has started, parts can be purchased in bulk and the expensive development tools will not be required, therefore, reducing the costs extensively.

To obtain the capital required for this project, PLT applied for the Engineering Science Student Endowment Fund (ESSEF) and we were funded in the amount of $560. Furthermore we obtained some free components from Fred Heep which was authorized by the School of Engineering Science.

A detailed record of all the transactions is kept by the group to ensure proper reimbursement to members. The over expenditure was also divided equally between group members. In the long run, we will seek investors and venture capitalists in funding our company and the commercialized version of PULZE™.

6 Schedule

The estimated Gantt chart and Milestones for PULZE ™ project is presented in Figure 1. All the estimated millstones were hit except the final demo date. The project was delivered two days late on December 17, 2007 due to an unexpected hardware failure.

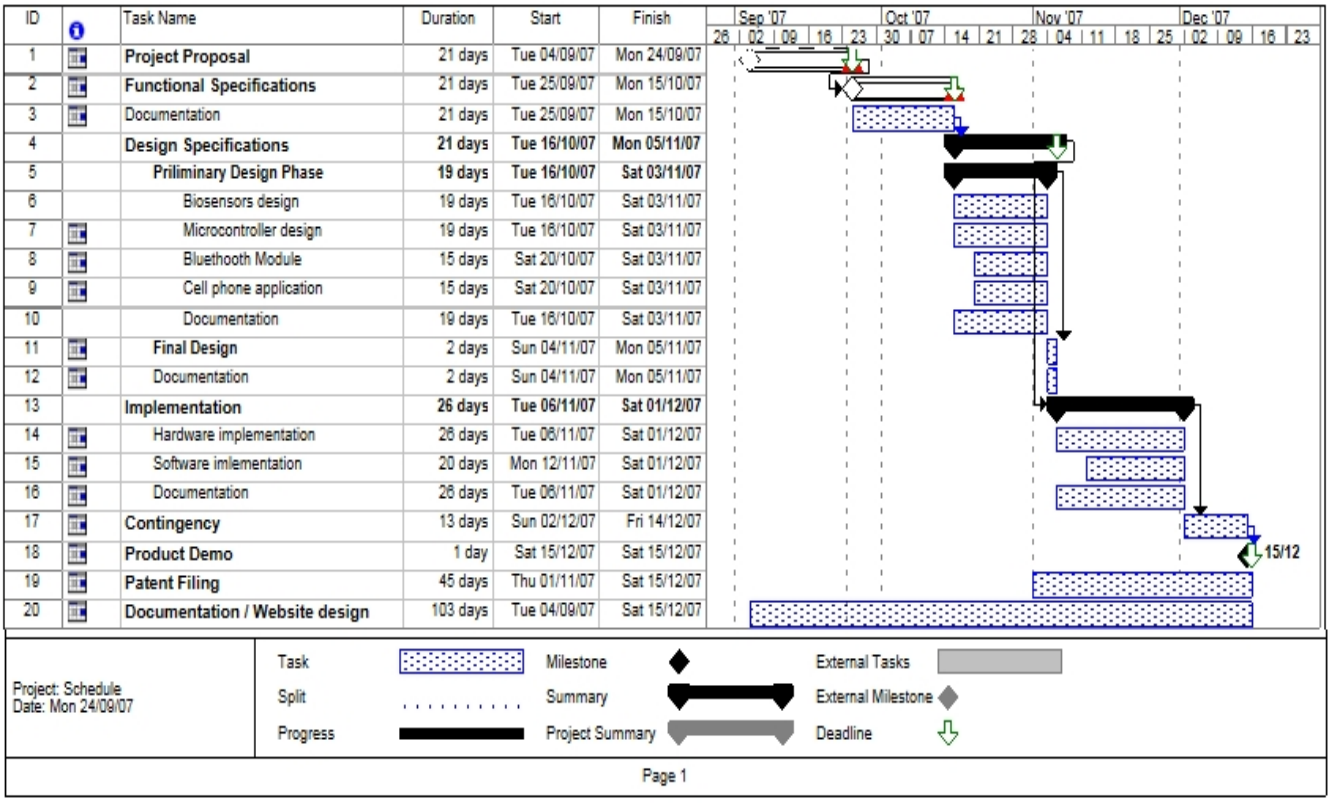


Figure 5: Project Gant Chart

7 Ecological Footprint and Environmental Assessment

Ecological Footprint assessment is the comparison of human nature's consumption with the capacity of Mother Earth to regenerate. Although in the proof of concept phase of the project ecological footprint was not considered as a vital part, but as we move on to mass production phase, it becomes a significant issue.

We can analyze the environmental impact of our product in two separate elements. First the casing and physical design of PULZE™ and second the internal components which constitutes analog and digital circuitry and the batteries.

The casing of the product can be designed from materials that have the least impact on the environment or non-toxic recycled materials. For the internal parts rechargeable batteries can be used to eliminate the disposal of the used batteries.

Another important issue to consider in the production phase is the lifecycle of the material used in the casing and internal circuits. If proper materials with suitable lifecycles are chosen, the ecological footprints would be minimal.

8 Conclusion

The immense need for prompt medical assistance for heart attack victims is evident and we at PLT are committed to design a reliable and cost effective device to detect and alert medical personnel in a timely manner to save lives.

In most cases, heart attacks come at you in a flash and by providing PULZE™ in today's market, we hope to some what ease that element of surprise and give you a better, healthier piece of mind.

Precision Lifestyle Technologies is making a difference in people's life by innovation and invention of leading edge devices. Our passion in the field of telemedicine and bio-medical engineering has enabled us to undergo extensive researches to provide an effective device. By introducing PULZE™ in today's market, we hope to accomplish our mission of making it easily accessible to everyone and effective in every way. We strongly believe that PULZE ™ is amongst the leading technology pioneers in today's market.