harmony innovation

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January 26th, 2015

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

Re: ENSC 440 Project Proposal for a Musical Rehabilitation Assistance Device

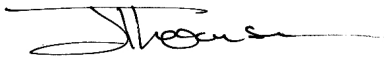
Dear Dr. Rawicz:

Find attached our Proposal for a Musical Rehabilitation Assistance Device, which details our project for ENSC 440 – Capstone Engineering Science Project. We intend to design and build a prototype system for rehabilitation patients, which will provide auditory and visual feedback while they learn to walk again.

This proposal gives an introduction and background to the project, provides an overview of the product design, a breakdown of the project schedule, and a budget forecast with potential funding sources. It also provides an analysis of the marketplace.

Harmony Innovation is a partnership of five late-term engineering science: Sam Chu, Ryan Colter, Elnaz Heidari, Adam Prochazka and James Thomson. If you have any questions or concerns about our proposal, please feel free to contact me by phone at 604.726.4171 or by e-mail at jbthomso@sfu.ca.

Sincerely,



James Thomson
Partner
Harmony Innovation

ENCLOSED: Proposal for a Musical Rehabilitation Assistance Device

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Proposal for a

Musical Rehabilitation Assistance Device

Project Partnership: Sam Chu
Ryan Colter
Elnaz Heidari
Adam Prochazka
James Thomson

Contact Person: James Thomson
jbthomso@sfu.ca
604.726.4171

Submitted to: Dr. Andrew Rawicz (ENSC 440)
Steve Whitmore (ENSC 305)
School of Engineering Science
Simon Fraser University

Submission date: January 26th, 2015
Version: 1.0

EXECUTIVE SUMMARY

Learning to walk again is hard work. Everything we've read and everything we've seen tells us this is true. There's no magic pill or futuristic gadget that will replace hard work. You can choose not to walk, or you can choose to let some apparatus walk for you. But if you want to walk, with your own two feet, using your own muscles, and with the freedom of movement that billions of people enjoy on this planet today, it's going to take hard work.

We're not offering a substitute for hard work. We're not going to make your dreams come true. That's on you. If your dream is walk again, and you're willing to put in the hard work to make that happen, we can help. Our goal is to be the soundtrack of your recovery. We want you to hear your success with every footstep.

Our goal is to develop a rehabilitation assistance device that will provide auditory and visual feedback for patients learning to walk again. The product will use a sensor array attached to the patient's arms and legs to transmit position data to a software package. The software will analyze the data and, if the movement falls within a preset envelope, the patient will hear music. This provides positive reinforcement for the performed action, and helps teach the patient the proper movements.

Harmony Innovation is a partnership of five late-term engineering science students with a diversity of skills in hardware, electronics, and software design. We have chosen an Agile management framework for this project, divided into Planning, Design, Development, Integration and two Testing phases, Alpha and Beta. Each phase is clearly defined and has stated deliverables, which need to be provided on specified dates. Beginning on January 11th, 2015, our goal is to deliver the finished prototype by April 10th, 2015. We have determined a preliminary budget of $662.00, which we will acquire through several sources.

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1. INTRODUCTION

An essential skill of the human species is to be able to successfully perform basic motor functions. The majority of humanity takes these skills for granted - we learn them at a young age and, once internalized, use them subconsciously. However, there are many instances where these essential skills could be lost. Our goal, motivated by one of these scenarios, is to assist in the recovery of an essential skill; we aim to supplement and improve the rehabilitation process of a person learning to walk again.

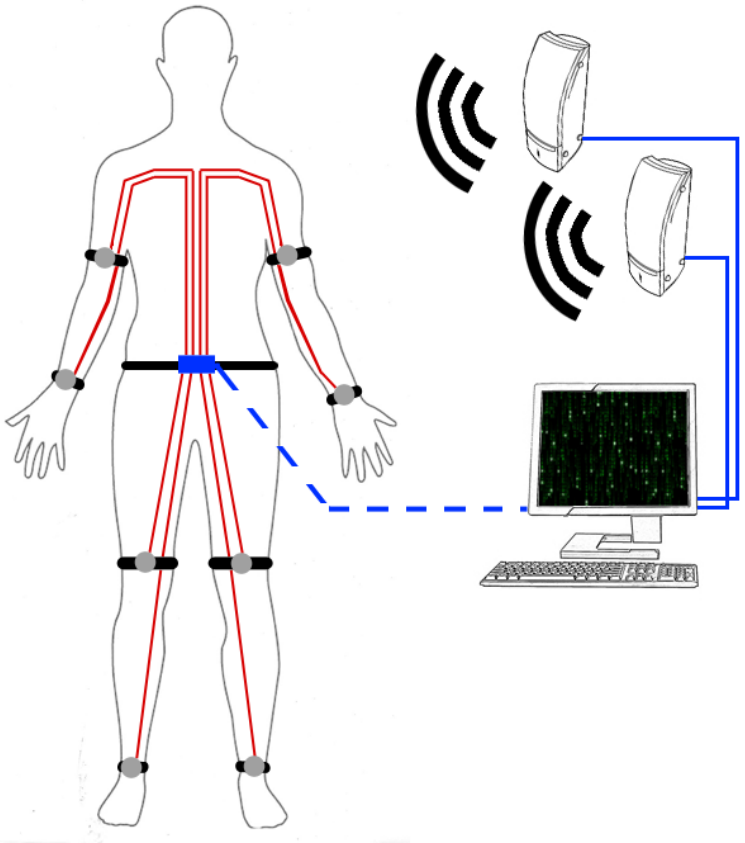

Figure 1: High level design concept

Our project will include the research and development of a tool that will provide auditory feedback to patients undergoing rehabilitation and to the physiotherapists administering the process. Currently, a patient would perform a certain motion or series of motions as instructed by a physiotherapist. The result is the performance of the action, successful or unsuccessful, and the response of the therapist. Our product adds automated feedback to the process, in the form of music, to assist in the learning process. This tool will be especially helpful for patients who choose to supplement their rehabilitation independently and will provide direct feedback to based on the movements taught by the physiotherapist.

2. PROJECT OVERVIEW

2.1. Scope

The musical rehabilitation assistance device will integrate various sensor, control and software components into a single system. Sensors will be placed on the limbs (see Figure 1) such that they can record positional values when the exercise is being performed and movement is achieved. We can monitor the movement and associate a component of the music to each limb. The sensors used will consist of gyroscopes and accelerometers. The data will be fed to a black box containing a transmitter and controller worn on the body. This device will transfer the data to a personal computer which will execute the appropriate feedback. The software side of the project involves use of an algorithm, such as Linear Discriminant Analysis, to analyze the sensor data and provide the proper response. If the proper movement for the exercise is achieved, the PC will play the component of the music associated with that limb. When all components play fully, each limb is demonstrating the correct movement.

Another feature will allow the physiotherapist to record and create a set of custom motions for the patient to follow. This custom motion data will be recorded and used as a guideline to compare the patient's movements. As such, our product is not restricted and limited to a few motions, and the tool is flexible in allowing the physiotherapist to use it for numerous types of exercises. Our product will use 3-axis positional information sent to a personal computer with software that will interpret the data to see if the patient's motions lie within the predetermined range.

2.2. Risks

Development of our product must satisfy factors we discover during research. We must ensure that the product will be attractive for use in assisting rehabilitation. There are certain edge cases that the product must accommodate: patients that have suffered extreme injuries resulting in lost limbs will require a modified design, and people suffering from hearing impairment may not be able to use the product in its original design. As development proceeds, Harmony Innovation will address as many of these scenarios as possible. Anticipation and prioritization of such cases will be a challenge for our company during development.

2.3. Benefits

The Musical Rehabilitation Assistance Device will be customizable; the user will be given feedback during both independent and/or assisted ambulation exercises; in the realm of parallel bars to mechanical aids like walkers, crutches, canes, and so on. The tool will not be developed to replace any form of personal interaction which is crucial to the patients' rehabilitation process. The Physiotherapist will remain vital to the operation, and the tool will supplement pre-existing methods. Similarly, it will also not replace necessary devices that are already used, such as assistive belts to prevent patient falls.

3. Market Analysis

In the modern era, technology advances at a increasingly rapid rate. In the areas of medicine and health, new innovations are highly valued by the community, as they have the potential to improve our quality of life. People who are in the process of regaining lost motor control, either injury or illness, have their quality of life severely impacted. The Musical Rehabilitation Assistance Device can help people regain control of their limbs, to ensure they can still lead a life of quality.

3.1. Segmentation Analysis

The target market for this product is the healthcare sector, specifically rehabilitation. This sector will be able to utilize the technology in its original design, though it could be modified to reach other areas. The technology uses positive feedback, and thus lends itself to learning of all types, from scientific study to early childhood development. Since applications in these areas may be varied, the viability of the product outside of the original intended market is less clear.

3.2. Competition analysis

We are building a new product to the market, and at this point in time there are currently no competitors that are using this technology in this form. Positive reinforcement is used in many learning fields, but the area that we are focusing on does not currently utilize this type of technology or application. Therefore, we are not competing directly with another product but rather with the current method of administering rehabilitation and the perception of our product's ability to supplement that process.

3.3. Research Rationale

In discussions with the kinesiology / biomedical department, we have allotted further resources to research in the early phases of the project. Research will also be done in the use of the technology with regards to learning disabilities and special needs and the interaction with physiotherapists, caregivers and the individuals themselves.

4. Project Planning

Figure 2 shows the proposed schedule for the project. It follows an Agile management strategy, with each phase clearly defined below. Also shown are the deliverables for the project with their delivery dates.

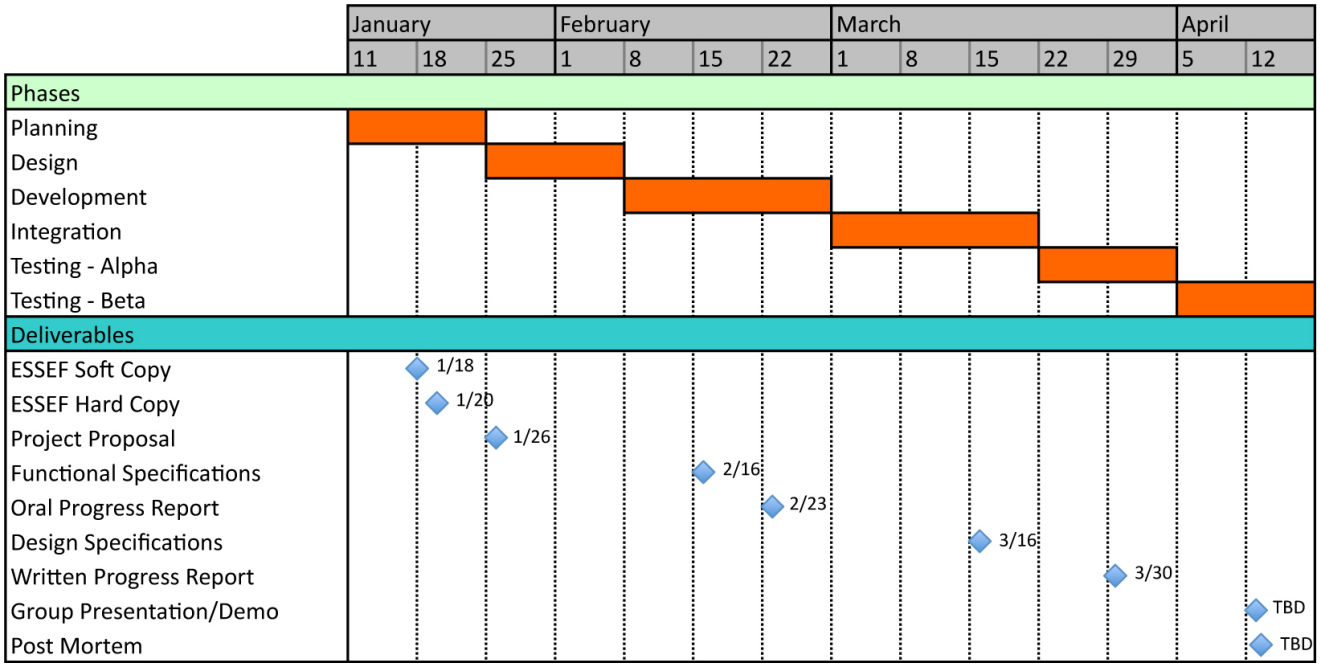

Figure 2: Agile Gantt chart with dated deliverables

Planning Phase 2 weeks (10 working days)
Assemble a development team and determine the nature of the project to execute. Develop a high-level overview of the project, including preliminary functional aspects and budget. Identify sources of funding. Complete the Project Proposal.

Deliverables:
- ESSEF Project Funding Application – January 18 (soft copy) & 20 (hard copy)
- Project Proposal – January 26

Design Phase 2 weeks (10 working days)
Generate a high level model of the product. Begin defining its functional specifications and divide it into development areas (hardware, electronics, software, etc). Assign individuals or groups to each development area, and generate development plans with specific milestones.

Deliverables:
- Functional Specifications (draft)

Development Phase 3 weeks (15 working days)
Divide into development groups and execute development plans for each area. As this phase progresses, review progress versus the development plans and rationalize as necessary. Finalize the functional specifications for delivery. Develop an integration plan with specific milestones. Begin assembling design specifications.

Deliverables
- Functional Specifications (final) – February 16
- Oral Progress Report – February 23

Integration Phase 3 weeks (15 working days)
Begin integrating individual development areas into a final product state. As this phase progresses, review progress versus the integration plans and rationalize as necessary. Some debugging is expected in this stage, but the goal is to exit this phase with a functional, if unreliable, prototype. Complete design specifications for delivery.

Deliverables
- Design Specifications – March 16

Testing – Alpha Phase 2 weeks (10 working days)
Identify and prioritize all bugs (A, B, C, D; see issue classification guidelines in Bug Tracker) and begin fixing in order or priority. New features can be implemented during this phase, but the focus is robustness.

Deliverables
- Written Progress Report – March 30

Testing – Beta Phase 1+ week (5+ working days)
Identify and prioritize all bugs, but debugging is reserved to A and B class issues only. The project is now closed to new features, and all C and D issues are now "as designed". Prepare for group presentation and post-mortem.

Deliverables
- Group Presentation/Demonstration – TBD (Mid-April)
- Post Mortem – TBD (Mid-April)

5. PROJECT BUDGET

Table 1 shows the proposed preliminary budget for the project.

Equipment List	Estimated Unit Cost
Gyroscopes ($8 x 12)	$96.00
Accelerometers ($8 x 12)	$96.00
Controller	$150.00
Wireless network card	$150.00
Wire	$20.00
Fuses	$50.00
LEDs	$30.00
Fabric	$70.00
Total Cost	$662.00

Table 1: Preliminary budget

The gyroscopes, accelerometers, wire, and fuses represent the sensor arrays. We plan on fusing the electrical components to protect our system from damage and avoid additional costs to replace them. The controller and wireless network card are for communication the sensor data with a PC. The LEDs are for testing and visual feedback. The fabric is for constructing bands for attaching the sensors to the body.

Funding for this project will come from multiple sources. We have already approached the Engineering Science Student Endowment Fund, who fund projects of this nature multiple times a year. Further funding may be available from the Canadian Institute of Health Research, the National Science and Engineering Research Council, and National Institute of Health.

6. Company Details

Sam Chu

Sam is a fifth year electronics engineering major with a strong passion for learning about new technological innovations and advancements. He has previously worked as a Quality Engineer with Broadcom, responsible for creating and setting up automated tests. Throughout his education, he has gained strong experience in building and designing circuits, as well as exposure to a variety of programming and scripting languages.

Ryan Colter

Ryan is a fifth year computer engineering major. He worked as a Software Engineer at SeaChange International, implementing services to increase cross-platform functionality and quality control. His strengths are digital systems architecture, electronics design, low-level software, and control systems.

Elnaz Heidari

Elnaz is a fourth year systems engineering major with a strong background in finance. Before entering the engineering sciences, Elnaz was pursuing a minor in business with courses in accounting, marketing, math and physics. She has previously worked for RBC and taken many sub courses in the financial industry. While studying at SFU she has excelled in design, hardware, and problem solving.

Adam Prochazka

Adam is a fourth year systems engineering major with a strong affinity for the electrical field. He completed his First Year Electrician Apprenticeship in high school before deciding to focus on design by studying engineering. He has worked in construction as well as in engineering shops, acquiring a plethora of hands-on skill and experience, both electrical and mechanical.

James Thomson

James is a fifth year engineering physics major. He previously earned a Bachelor's Degree with Honours in Sound Technology from Liverpool John Moores University, and spent seven years as a sound designer, both freelance and for software giant Electronic Arts. He worked as a research technician for the Laboratory for Alternative Energy Conversion, designing and building test apparatus, and as a quality lead for AFCC, a fuel cell development company, conducting quality inspections and defining best practices for their Supplier Quality team.

7. CONCLUSION

Nothing defines the human species quite like walking. It is possibly the single most important evolutionary advance in human history next to the opposable digit. By learning to stand and walk upright, we freed our hands to use tools, and thus our minds to do great things. To lose such a hallmark of our humanity is tragic. It is our goal to be part of the process of getting it back. We want to help patients with injuries or illnesses to regain control of their limbs so that they can return to living their lives. Through positive feedback, we can assist in rehabilitation and hopefully make the processes quicker and more rewarding. We believe the Musical Rehabilitation Assistance Device will be a great tool for both physiotherapists and patients to use during their rehabilitation period. The Musical Rehabilitation Assistance Device is flexible enough to monitor a variety of motions and situations. We hope we can help all those people in their rehabilitation process to improve quicker and more efficiently.