VISU AID

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

January 20, 2014

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

Re: ENSC 440 Project Proposal for **Now I See**, a Travel Aid for the visually Impaired

Dear Dr. Rawicz,

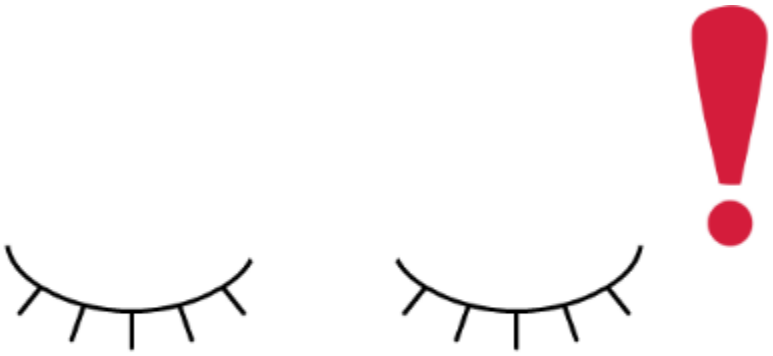
Please find the project proposal documentation for a travel aid or the visually impaired, **Now I See**, enclosed herein. This document outlines our goal to design and implement a device that will allow the visually impaired patients to perceive presence of obstacles in their proximity, so as to assist them in navigating through a complex environment, providing them independency and freedom to explore.

The main objective of this proposal is to provide background information, a basic overview, and a possible design of our proposed device, as well as, additional information regarding the budget and scheduling of this project.

VisuAid is a vibrant company consisting of three enthusiastic biomedical students: Anita Kadkhodayan, Steven YM Lee, and Daria Numvar. Please feel free to contact us for any concerns or questions; we will be very much delighted to address your inquiry as soon as possible. You can reach us by phone at 604-763-4010 or by email at akadkhod@sfu.ca.

Sincerely,

Anita Kadkhodayan



PROJECT PROPOSAL for **NOW I SEE**

A Travel Aid for the Visually Impaired

Project Team: Anita Kadkhodayan
Steven Lee
Darya Namvar

Contact person: Anita Kadkhodayan
akadkhod@sfu.ca

Submitted to: Dr. Andrew Rawicz – ENSC 440W
Dr. Steve Whitmore – ENSC 305W
School of Engineering Science
Simon Fraser University
January 20, 2014

EXECUTIVE SUMMARY

"There is no better way to thank God for your sight than by giving a helping hand to someone in the dark". - Helen Keller[1]

The ability to live independently is a significant and desirable quality for the visually impaired, and moving around without a direct help from another individual serves a large part in it.

VisuAid proposes herein a project to implement a travel aid for the visually impaired, titled **Now I See,** that will provide the user a sense of presence of obstacles to be used in navigating. Utilizing a depth camera, our device will examine the space in front of the user and inform the user of any obstacles (including holes) through a vibratory interface to the forehead. The spatial image is split into 15 subsections (3 vertical and 5 horizontal) each of which is mapped to corresponding 3-by-5 array of vibrating motors placed on user's forehead. With this information, the user will be able to "sense" the obstacles and their relative positions, thereby acknowledging and avoiding them. With the device mounted on user's head, allowing for a large range of motion, the user can also estimate the size of the object through detecting edges by moving the head around.

A number of electronic tools have been developed to provide sense of vision through sensory substitution, where the visual information captured by a camera is interfaced to the user. While these devices have their own merits, the level of details one can perceive using these devices are yet nowhere close to allowing them to navigate through a space with physical obstacles. Moreover, currently commercially available navigation aids for the visually impaired utilize expensive high tech components, which render the devices barely affordable. **Now I see** utilizes cheaper and well established technologies, costs estimated at $250.

VisuAid is a company consisting of three dedicated, enthusiastic working biomedical engineers with backgrounds in image processing, robot vision, and mechanical hardware design. This project is estimated to be completed within total of 14 weeks, with the total budget estimated at $500.

TABLE OF CONTENT

INTRODUCTION

According to CNIB[14] (formerly, Canadian National Institute for the Blind), there are more than a million Canadians living with blindness or a significant loss of vision. Except for some rare cases of adaptions to be able to "see" through acquired techniques such as echolocation, most visually impaired persons have to rely on other means of aid in order to move around. Help from another person with normal vision or a guide dog, though common and reliable solutions, presents dependency issues to the impaired.

As we can imagine, there have been a large amount of effort devoted to help visually impaired to achieve mobile independency. While procedures involving visual prostheses are becoming more common with promising results, but they are origination specific and quite invasive in nature. The risks, costs and limited applicability of these surgeries naturally divert patients to tools and aids, such as a white cane which has been *the* tool used by the visually impaired in mobility for centuries. With recent growth and development of electronics, new tools utilizing digital camera technology and others are being introduced every day.

Some examples include: tongue display units, or TDU, in which the visual image is translated to an array of electrodes placed on one's tongue[3], visual-to-auditory sensory substitution that encodes the visual information into phonological codes[12], tactile displays on the back which provides encoded vibratory signals to ones back[5], and a forehead display which is similar to TDU but is interfaced on one's forehead[2]. It is notable that they all aim to provide visual information to the user. In other words, deducing of the locations of present objects is left to the user, resulting in long train time and limited application in navigation.

Meanwhile, with growing availability of various proximity sensors and depth cameras, also growing rapidly are the R&D efforts in assistive electronic devices focusing on the mobility and navigation of the visually impaired.

INTRODUCTION (cont'd)

Our company, **VisuAid**, has been founded in recognition of this growing interest in the sector, which promises to be enormously socially beneficial while lucrative.

Some examples in this type of devices are: a sonar glove[6], a cane utilizing a proximity sensors[4], a robotic cane that pulls the user away from objects[8], an all-around sonar head band[6], a mobility aid based on robot vision technology[10], and, most notably, a navigation guide[13] that uses a depth camera to inform the user of the obstacles in his/her path.

This last device was an undergraduate project by a group of students at University of Pennsylvania, titled, Kinecthesia[13]. This device was of a particular interest to us as it is quite similar to our device. Detailed differences in functional and design specification will be further discussed in the following Related Work section.

SYSTEM OVERVIEW

The goal of our proposed project, **Now I See**, is to design and implement a device that will identify obstacles (including sudden drops) in the frontal proximity of the user and inform the user through a vibratory stimulation interface placed on the forehead. The obstacles will be detected based on the depth image from the depth camera and the orientation of the user's head, where interface provides stimulations corresponding to 15 (3 vertical, 5 horizontal) sub-directions with respect to the orientation of the user's head. This will also enable the user to be able to estimate the size of the object simply by moving his/ her head and thereby detecting the edges. With successful implementation of **Now I See**, **VisuAid** aims to improve the quality of life of the visually impaired through mobile freedom and independency.

Figure 1: System Overview

RELATED WORK

While the related work mentioned above, Kinecthesia, is clearly a related work to our project and its design specification and source code are public domain, our implementation, **Now I See**, will not include any of their work. Kinecthesia has the following characteristics:

1. Depth image is obtained using depth camera mounted on user's waist, which means field of view is also vertically centered at waist level and always facing forward. A simple and adequate solution for this set up with minimal image processing involved, but has limited horizontal resolution as the waist is much harder to turn, and no vertical resolution.

2. Depth image is divided into three horizontal subsections, left, middle, and right. and three corresponding vibration motors are installed on device

3. Depending on depth/proximity observed in each subsection, corresponding motors are activated if predefined threshold is passed

Our project, **Now I See**, is different in these aspects:

1. Depth camera is mounted on user's head. This allows device's functions to be applied in larger range of directions, thereby enabling spatial resolution in two-dimensional space. However, significant image processing is required

2. Field of view is divided into 15 subsections: (left, forward left, forward, forward right, right) X (up, low, ground), and 15 corresponding vibration motors are installed on forehead

3. Motors are not only activated with obstacles but also with sudden drops in height (such as downward stairs or an edge)

PROJECT OBJECTIVES and PROPOSED DESIGN SOLUTION

Based on the above mentioned project scope, a proposed design for **Now I See** consists of a hardware device and software package.

The Hardware Device

The hardware design of **Now I See** involves an assembly of core electronic components and a user interface module. The core hardware device for **Now I See** will have: a depth camera for the depth image, an accelerometer for the orientation of the camera/ user's head, a processor, a microcontroller, a set of vibration motors, miscellaneous electronic components for the control circuit and materials to create a mount for the device on the user. The high level overview of the core hardware device is illustrated below, followed by corresponding implementation objectives listed:

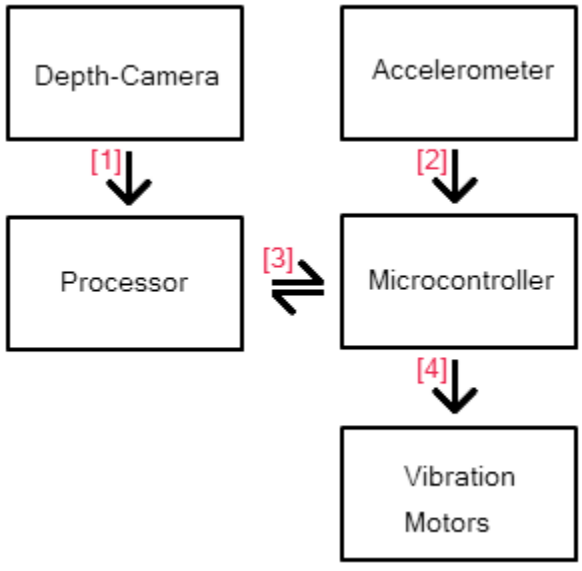


Figure 2: Hardware Flow Chart

PROJECT OBJECTIVES and PROPOSED DESIGN SOLUTION (cont'd)

The Hardware Device (cont'd)

1. Interface between depth camera and processor is established to obtain raw depth image data

2. Orientation of camera is calculated using microcontroller based on data from accelerometer mounted on camera

3. Bidirectional communication is established between microcontroller and processor

4. Based on the state data from processor, vibration motors are activated

The user interface module will include a camera mount and a head band, consisting of 15 vibration motors installed over the forehead area. We acknowledge the potential risks associated with our project, as **Now I See** will be in contact with the user's skin (forehead) and consists of electronic devices. Therefore, the user interface portion of the hardware has following objectives:

1. Device is electrically insulated to user, as to prevent electrocution in case of faulty connections

2. Measures are taken to be able to absorb any moisture at and around point of contact, as to prevent any causes that may nullify effort mentioned in design objective 1 above

PROJECT OBJECTIVES and PROPOSED DESIGN SOLUTION (cont'd)

The Software Package

The software package of our device covers two aspects of controlling of the hardware components. First is a set of image processing nodes, which will serves as the main decision making body of **Now I See**. This set will include: a distance correcting algorithm that will transform the raw depth image to a cylindrical distance image based on the orientation of the camera, a ground detection algorithm, a decision making algorithm to divide the image to the subsections, and an evaluation algorithm to evaluate and decide on the state of each subsection. An open-source image processing library will be used for image pre-processing. The project objectives for the hardware devices are illustrated below:

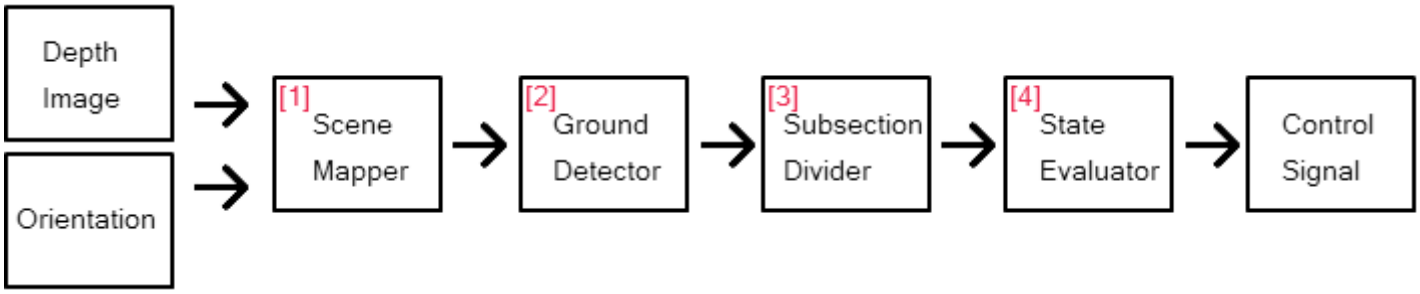


Figure 3: Software Flow Chart

1. Raw depth image is mapped to cylindrical plane to obtain relative proximity based on orientation of camera

2. From above image, it is determined if ground can be seen

3. Depending on detection of ground, current scene is divided into subsections, varying in size appropriately

4. For each subsection, existence and proximity of obstacles are determined and type of state to be sent to microprocessor is chosen

PROJECT OBJECTIVES and PROPOSED DESIGN SOLUTION (cont'd)

The Software Package (cont'd)

The other aspect of the software package is the microcontroller firmware, which will be implemented for the following:

1. Data signal from accelerometer is read and orientation of the camera is calculated and sent to processor
2. State information of each subjection is received from processor and appropriate signal is applied output pins

BUDGET and FUNDING

Budget

A proposed budget for each key components and the overall are illustrated in the table 1 below:

Component	Part	Unit Cost	Qnt.	Cost
Depth Camera	XBOX 360 Kinect Sensor	$110	1	$110
Microcontroller	Arduino Uno, REV 3	$30	1	$30
Processor	Raspberry Pi- Model A	$30	1	$30
Vibration Motors	Vibration Motor, Flat Coin	$5	15	$75
Accelerometer	IC Accelerometer, XY AXIS	$5	1	$5
Additional Parts, Overhead, Tax, Shipping, etc.		_	_	$250
			Total	**$500**

Table 1: Estimated Budget

We expect to find and purchase most of parts without much difficulty, as most of them are commonly available both online and offline.

Funding

Several funding options are currently being considered. Applications to the Wighton Engineering Development Fund and the Engineering Science Student Endowment Fund have been prepared. With these contributions and addition of parts library access, about 50% ~ 60% of estimated cost is expected to be covered.

As our proposed project aims to mainly benefit the visually impaired, funding request to various related organizations are also planned, such as World Blind Union (WBU) and Canadian Federal of the Blind.

SCHDEDULE

Project Milestone

Some notable deadlines are outlined in the Project Milestone figure below:

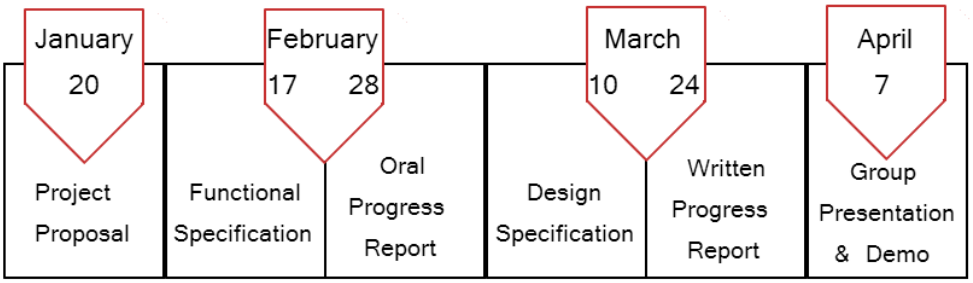


Figure 4: Project Milestone

Project Schedule

A Gantt chart is prepared below to illustrate the proposed schedule:

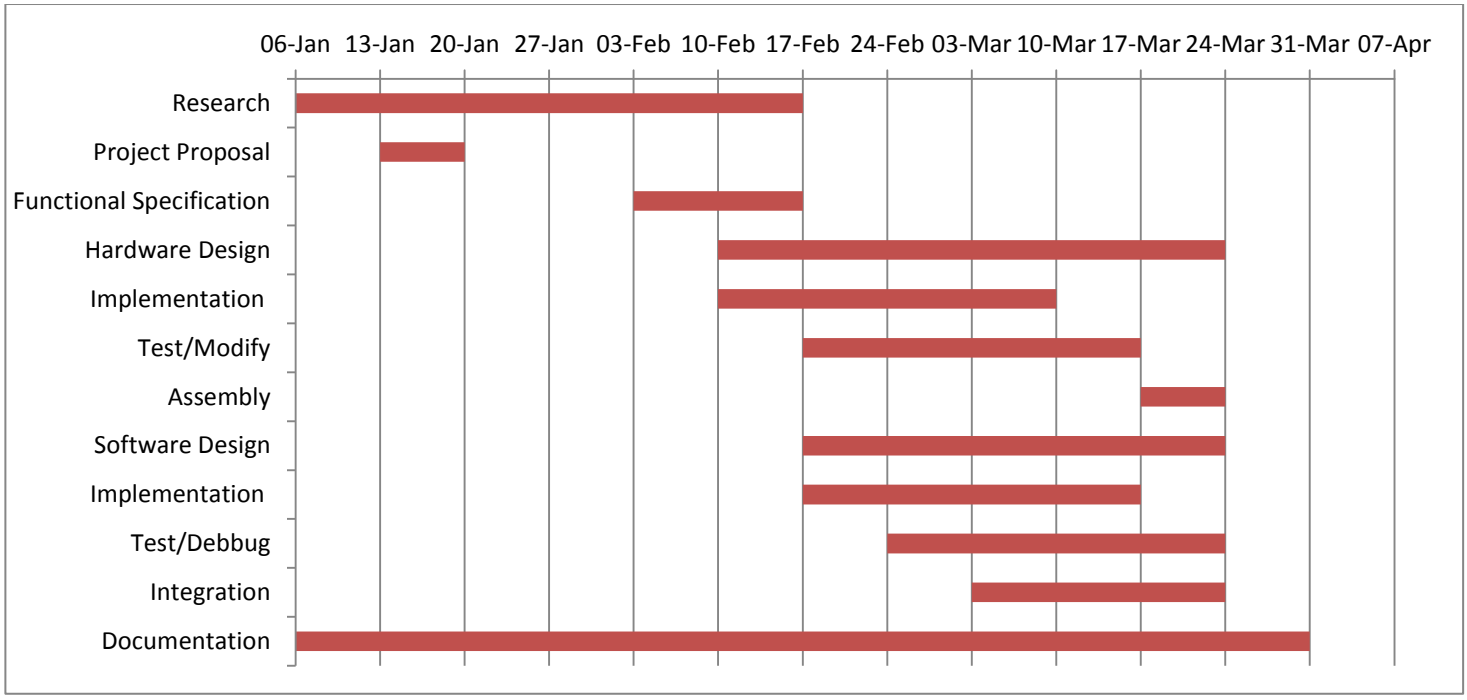


Figure 5: Gantt chart for planned project implementation schedule

COMPANY DESCRIPTION

VisuAid is a venture tech company that was founded out of School of Engineering at Simon Fraser University with a vision to make life better for those around us. Our company consists of 3 biomedical engineering students and each member brings a unique background which makes our combination very creative.

Steven Lee is a 5th year biomedical engineering student and is the Chief Executive Officer (CEO) of **VisuAid**. His main role is to oversee the overall flow of current project, especially hardware design and implementation.

Darya Namvar is a 4th year biomedical engineering student and assumes the role of the Vice President of Execution at **VisuAid**. She is responsible for micro-management of current project, quality control of hardware components and brand designs.

Anita Kadkhodayan is a 4th year biomedical engineering student and undertakes the Vice President of Software position at **VisuAid**. She is in charge of designing, implementing, and debugging of the software component of the current project.

These titles and corresponding tasks have been assigned based on the background and interest of each person. However, all the members are required to take part in design, implantation, and trouble-shooting during the project cycle. More detailed information about each member of **VisuAid** can be found as part of this proposal package as resume attachments.

CONCLUSION

Our team at **VisuAid** looks forward to this invaluable opportunity to reach out and make a difference in the lives of those with visual impairment. **Now I See** will deliver to the users a new means to be more aware, safer, and more independent.

Utilizing readily available and affordable technology, our proposed project, **Now I See**, will be a reasonable choice and an easy-to-use solution to navigation assist for those with limited vision. Use of a depth camera will deliver a reliable real-time scan of user's surrounding; our intelligent and robust obstacle detection software will pick out any obstacles that may endanger the user; and through our intuitive and comfortable user interface, the user will be able to easily steer away from danger.

VisuAid is a team built with a clear goal in mind, supported by dedication, innovation, and hard work. With a small proposed budget of $500 and estimated 14 weeks of design and implementation schedule, **Now I See** will prove to be a lucrative venture with an added promise to significant social benefits.

REFERENCES

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Anita Kadkhodayan

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North Vancouver, BC V7M 1P1
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Email: akadkhod@sfu.ca

EDUCATION

Simon Fraser University, Burnaby, BC — Sep 2009-present

4th Year Engineering Science Student

- Biomedical Engineering with GPA of 3.59

SKILLS AND QUALIFICATIONS

- Programming languages: Python, MATLAB and C++
- Hardware description language: VHDL, using Simulink and Altera software
- Integrated Development Environment: Multi debugging application, Arduino platform
- Circuit analysis programs such as P-Spice/ LP-Spice
- Familiar with lab equipment such as protocol analyzer, oscilloscopes, DMMs, power supplies and function generators, also skilled in soldering
- Skilled with Microsoft office such as Word, Excel, Outlook, PowerPoint, One Note
- Operating system Environment: Windows and Linux
- Excellent communication and customer service skills

TECHNICAL WORK EXPERIENCE

Embedded System Engineer — May-Dec 2013

Intel of Canada

- Developed tests to check validity and functionality of different blocks of ASIC controller of the solid state drive or SSD, using Python programming language
- Performed manual measurement of signals, and analyzed data traffic over a communication channel such as PCIe and SATA, using protocol analyzer
- Debugged and modified existing firmware using integrated development environment (IDE) to match the new requirements as well as enhance the features in C/C++ programming languages
- Tested skewed silicon under extreme voltage and temperature specification to ensure validation of various blocks of the ASIC controller and recorded the data

Image Processing Research Assistant — Sep-Dec 2011

Biomedical Optic Research Group, SFU

- Learned about optical coherent tomography imaging technique by clinically measuring patients' retinal parameters.
- Analyzed Volumetric images of the optic nerve head for diagnosing early glaucoma using MATLAB and AMIRA programming software
- Generated a clinical report using Graphical User Interface (GUI) to efficiently determine glaucomatous eye and how far it has progressed
- Maintained and revised the existing segmentation MATLAB codes and ran data analysis simulation tests for many samples in order to use the results for publication paper

TECHNICAL PROJECTS

Biomedical Pulse Oximeter Design Jan-Apr 2013

Biomedical Instrumentation

- Designed infrared absorption rate measurement circuitry using infrared LED and photodiode to create single-wavelength pulse oximeter
- Built 3-lead ECG sensor circuitry and wrote algorithm and GUI on Arduino platform to calculate and display ECG measurements and heart rate

Digital Circuit Design school project Jan-Apr 2012

Digital System Design

- Designed and implemented circuits using VHDL description language on a field programmable gate array (FPGA) to produce a picture puzzle game
- Analyzed digital circuits with Quartus, Modelsim and logic analyzer to detect signal errors, demonstrate waveforms and program Nios II processor on Cyclon II series FPGA

OTHER WORK EXPERIENCE

Customer Service Representative Aug 2009-Nov 2012

Talbots Women Clothing Store

- Provided outstanding customer service by handling customers professionally with care and patience with no complains in more than 3 years
- Keen on keeping updated with the company's new plans and helping them to achieve their best by adapting to new changes and work well under pressure

VOLUNTEER WORK

Art Gallery Jul-Aug 2009

North Vancouver, BC

- Engaged in craft activities with kid with disabilities

Community Organization Representative Jul- Aug 2009

North Shore Multicultural Society, North Vancouver, BC

- Created and initiated new ideas to attract more people and raise awareness

AWARDS

SFU President's Entrance Scholarship Sep 2009

INTERESTS

Playing piano, yoga, painting, reading

Darya Namvar

1420 Terrace Avenue
North Vancouver, BC, V7R 1B4

cell: 604-782-4921
dnamvar@sfu.ca

EDUCATION

Simon Fraser University, Burnaby, BC Sep 2010-present

3rd Year Biomedical Engineering Student

Capilano University, North Vancouver, BC Sep 2008-Apr 2010

University Transfer program

SKILLS AND QUALIFICATIONS

- Proficient in Eagle, Solidworks and AutoCAD software
- Proficient in Labveiw and Matlab programming software
- Excellent understanding of hardware description language such as VHDL as well as computer programming languages such as C++
- Experienced in circuit analysis programs such as P-Spice/ LP-Spice
- Microsoft Office and Excel
- Familiar with basic lab equipment such as oscilloscopes, DMMs, power and function generator
- Excellent communication and customer service skills
- Compassionate, responsible and committed to service-oriented work

TECHNICAL WORK EXPERIENCE

Exoskeleton Wrist

Biomedical Menrva Rehabilitation Lab, SFU Jan 2013-present

- Created a wrist exoskeleton for stroke patients to help them regain the ability to move their hand
- Designed for 6 different function modes: flexion/extension, ulnar/radial deviation, circular motion in both passive and semi-passive mode
- Designed a double-sided Printed Circuit Board in Eagle and built the PCB by soldering the parts on the board
- Adjusted the gain of the PID controller in Labview to stabilize the system
- Designed a control box for the PCB in Solidworks and assembled the design
- Assembled the exoskeleton wrist

TECHNICAL PROJECTS

Digital Circuit Design, Digital Systems Design Jan- Apr 2012

- Designed and implemented circuits using VHDL description language on a field programmable gate array (FPGA) to produce a picture puzzle game
- Analyzed digital circuits with Quartus, Modelsim and logic analyzer to detect signal errors, demonstrate waveforms and program Nios II processor on Cyclon II series FPGA
- This project was designed so that the 16 different pieces of the picture puzzle could move all over the screen with different speeds

TECHNICAL PROJECTS (Cont'd)

Hand shaking USB, Engineering Technology and Society Sep-Dec 2010

- Designed and implemented a magnetic field in a flash light so that it could recharge the battery by shaking
- Designed the device to be used as a USB phone charger and flash light

OTHER WORK EXPERIENCE

Math Tutor Sep 2007-present

Self Employed

- Tutored grade 7 to 12 math to high school students

Customer Service Representative Oct 2007-Jan 2008

Future Shop, West Vancouver, BC

- Provided outstanding customer service by handling customers professionally with care and patience
- Keen on keeping updated with the company's new plans and helping them to achieve their best by adapting to new changes and work well under pressure
- Proven ability to quickly master new job skills and to use common sense approach to solve problems

Customer Service Representative Oct 2006- Jun 2007

Old Navy, West Vancouver, BC

- Sensitive to customer needs, likes and dislikes and successful in increasing sales volume
- Able to handle a number of overlapping activities
- Worked cooperatively with a wide range of responsibilities

AWARDS

1st year science calculus award Apr 2008

- From the department of mathematics and statistics of Capilano University
- Received 600$

INTERESTS

- Playing the guitar
- Painting
- Fashion and Beauty Design
- Auto Racing

Steven Lee

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604-763-4010 yml2@sfu.ca

EDUCATION

School of Engineering, Simon Fraser University, Burnaby, BC

Fifth year, Biomedical Engineering **Sep 2010 – Present**

Minor, Computing Science **Sep 2005 – Nov 2007**

TECHNICAL WORK EXPERIENCE

Ericsson Canada, Burnaby, BC **April – Dec 2013**

Software Testing Professional (Regression/ Smoke Testing)

- Created automation tools in Perl and VBA to aid team in scheduling tests, debugging errors, and maintaining test infrastructure
- Maintained testbeds for regression testing of OS for Edge Router Chassis

Robotic Algorithms and Motion Planning Laboratory, Simon Fraser University

Research Assistant **May – Sep 2012**

- Designed and wrote algorithms in C++ for gesture detection and object detection using Microsoft Kinect and OpenNI library with computer vision library (OpenCV) under ROS
- Revised GUI of mobile manipulator robot and sensors in Python to increase usability and add control functions

Republic of Korea Army, Korea

Radioman **Jun 2008 – May 2010**

- Established strategic radio communication networks and relay stations, including deploying antennae and setting up combat transceivers
- Maintained and operated FM/ AM radio communication equipment and networks

Groen Environmental Systems Inc., North Vancouver, BC

Systems Developer/ Field Assistant **May – Nov 2007**

- Engineered circuitry and constructed working prototypes to confirm concepts and file for patent of remote controlled HVAC terminal unit that harvests energy from and controls the air flow
- Assisted installation, inspection, and replacement of HVAC systems in field

SKILLS

Software

- Proficient in C++, Mathworks MATLab, Microsoft Office Word, PowerPoint, Excel
- Familiar with Perl, Python, VHDL, VBA, Prolog, Robot Operating System (ROS), Arduino IDE, OpenGL, OpenNI, OpenCV, Adobe Photoshop

SKILLS Cont'd

Hardware

- Experienced with general lab equipment (Oscilloscope, Function Generator, DMM, etc.)
- Familiar with Arduino prototype boards, Altera Cyclone series FPGAs, Microsoft Kinect sensor

OS Environment

- Experienced with Microsoft Windows, GNU/Linux based OS

PROJECTS

4 Link Robot Simulation and Control

Introduction to Robotics **Aug – Dec 2012**

- Mathematically modeled and wrote control and trajectory planning algorithms in C++ to simulate and control 4-link manipulator robot in group

3D Game Programming

Introduction to Computer Graphics **Aug – Dec 2012**

- Programmed in C++ using OpenGL to create interactive 3D first-person shooting game

Physiological Monitor Design and Prototyping

Biomedical Instrumentation **Jan – Apr 2012**

- Designed infrared absorption rate measurement circuitry using infrared LED and photodiode to create single-wavelength pulse oximeter
- Engineered temperature measurement circuitry with thermocouple to build thermometer and wrote algorithm on Arduino platform based on collected database for error compensation
- Built 3-lead ECG sensor circuitry and wrote algorithm and GUI on Arduino platform to calculate and display ECG measurements and heart rate

Electronic Circuit Designs

Microelectronics/ Introduction to Electro-Mechanical Sensors and Actuators **May 2011 – Apr 2012**

- Designed analog zero-gravity detection circuit using accelerometer for free-fall detector
- Constructed active component derived circuitries to make current mirrors, differential amplifiers and analog frequency response filters using Butterworth and Sallen-Key designs

Morse Code Decoder on FPGA

Digital Systems Design **May – Aug 2011**

- Collaborated in team of three to program Altera Cyclone series FPGA in VHDL into Morse code decoder and video card and display the decoded messages on screen