Home Air Monitor

September 20, 2014
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 440/305W Project Proposal for Home Air Monitor (H.A.M)

Dear Dr. Rawicz,

On behalf of our team, I am enclosing the proposal for our ENSC 440 project. Our product will help homeowners detect air pollutants in their living space in an economical manner. It will use affordable components and a flexible system design, allowing the user to control which areas they would like monitored. When the air quality is not within the ideal levels of a healthy home, an alert will be sent to a mobile device to notify the user.

The following proposal outlines our design and planning for the Home Air Monitor. This includes our proposed solution, system overview, budgets, and resources we have consulted thus far.

Our team consists of three dedicated members that have now joined to form the company Clean Space. We have Joanne Leong, Peterson Poon, and Elaine Chiang, all fourth year Engineering students at Simon Fraser University. Should you have any concerns about this proposal, please feel free to contact me at eychiang@sfu.ca.

Sincerely,

Elaine Chiang

Chief Executive Officer

Home Air Monitor

A cleaner, healthier home

Project Team:

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Submitted To:

Dr. Andrew Rawicz
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1.1

1. Executive Summary

With pollution being released in the air increasing daily, certain measures must be taken to protect ourselves and our homes. While Vancouver may have better air quality than that of neighbouring cities, many illnesses are still being caused due to improper monitoring and care for our living space. Air quality is defined by the Fraser Health as "the state of air around us" and it is up to us to understand how the air quality, both indoors and out, can impact our lifestyles. For many of us, the majority of our lives are spent indoors in locations such as school, work, and home. In these environments, poor ventilation, mold, dust, and pollution can all play a major role in our respiratory health and well being.

To mitigate this issue, the government has funded multiple projects such as the Air Quality Health Index (AQHI), which is a public tool for Canadians to protect their health against the effects of pollution. It displays the local conditions, and also evaluates your risk level by factoring in variables such as your geographical location, physical health, and age. While this is useful information, we feel that more proactive actions need to be taken to improve the air we come into contact with on a day to day basis.

Another alternative for improving air quality at home is by purchasing air purifiers or air monitors to clean and observe the dust and pollutant counts indoors. While these are useful, air purifiers are only able to clean a limited number of rooms at a time, and cannot guarantee the entire living space's cleanliness. Meanwhile, air monitors are often expensive and can only offer a numerical value of dust counts in a room. These are the problems our Home Air Monitor design would try to alleviate.

The objective of Clean Space is to create a device that allows the user to take control of their indoor space and to monitor the dust levels before they enter their home. This device will observe the dust as it crosses a filter, and be able to alert the user on their mobile device when a filter has become too dirty to continue filtering effectively. Not only will this eliminate the dust that enters ventilation systems at home, it will also reduce the cost of premature filter changes and cleaning time.

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4. Introduction

The problem our group would like to solve involves the investigation of dust and pollutants within the air in our everyday lives. We were concerned with the amount of dust that gets caught in ventilation systems at home and how easy it is to forget to clean an area of a living space that is not often frequented. The goal of our group is to build an air quality management system for use in the home environment. The main component of our system will consist of a dust sensor, which can be placed in various locations around the home, and a mobile application that will receive information from the sensor to inform users when to clean or replace filters.

The dust sensor will connect to a Wi-Fi-capable Arduino, which collects numerical data and compares it to previous data. When the sensor detects a certain level of dust particles, the mobile application will use the data and notify the user to perhaps replace or clean their furnace air filter. This saves the user time as it is not necessary to manually check an air filter for cleanliness periodically.

This system has other potential uses as well, in attics, air ducts and even a PC tower case, which can get extremely dusty over time. People do not often open up a PC case to clean, but if the user can be notified and reminded when to clean it, it would be very convenient and people may clean their PCs more often.

5. Background

Filters in home furnaces and air ducts need to be replaced regularly, but many people do not follow the recommended period of cleaning or changing filters every four to six months. This decreases the cleanliness of the air in a home and consequently impacts the health of an individual. We hope that by developing an affordable and easy-to-use system, households can improve their quality of life, even just by reducing the amount of pollutants in their home!

There are many respiratory related illnesses such as asthma, allergies, and even fibrosis in the lungs that can be caused by having too many pollutants in the air. Common house dust is unavoidable, but when the amounts of dust mites reach a certain concentration, vulnerable individuals have a higher risk of asthma, which can lead to an increase in allergic reactions to dust. With over 235 million people currently affected by asthma worldwide, there is a need for something to track and reduce the amount of dust in a home.

Although asthma cannot be cured, we believe that by monitoring the home air quality and replacing air filters when needed will assist many families with prevention against these illnesses.

6. Benefit of Product

A social benefit that this product could bring to the public is the opportunity to affordably live in a cleaner and healthier home. This device would be useful for people that have asthma, allergies, or respiratory problems to detect the levels of dust and pollutants within their living space. Many people are also not aware of how frequent they should change filtration devices at home, causing unnecessary spending on new filters. Our project will be able to alert the user when it is the optimum time to replace a filter, creating a more efficient process. We are also designing with flexibility in mind, so that these sensors can be placed where the user chooses to, and monitor dust and pollutants in the areas they feel most necessary.

There are many educational benefits for our group in working on this project. One of them is that we have the opportunity to develop a mobile application, which is something we have all wanted to do, but have had little exposure to through course work. Another is that we get to use an Arduino, which is a commonly used piece of hardware in the work force that we have no experience with. Getting the chance to understand the process required to develop a new product will be beneficial to us as we graduate from university and seek jobs.

7. Possible Design Solutions

In order to achieve our project goals, the big design problem was broken into two smaller and distinct problems. One problem was how we would actually detect when a dust filter is considered to be unclean. Another problem was how we would alert the user that the filter was in need of a change. For the dust detection problem, we came up with the following three solutions.

A potential solution was to attach a fan on one side of the filter and have a sensor on the other side to detect airflow. We would be able to control the velocity of air going through the filter, and the sensor would be able to detect how much of the air actually reached the other side. If there were limited airflow detected, that would signify the dust build up is too high and the filter needed to be changed. The main problem we saw was that dust could be dislodged from the filter if we blew air through it with too much force. The gaps within a filter that allow airflow are also quite fine, meaning our sensor would have to be very sensitive and isolated from the surrounding environment. This would not have been possible, as we wanted our sensor to be versatile and be used in any filtration device. Also, it would have been difficult to detect airflow on the other side, as some furnaces have multiple filter layers that combine to form the full filtration device.

Another solution was to use a light source to shine through the filter and have a light sensor on the other side. By calibrating the sensor to detect how much light should be received if the filter was dust free, we would be able to differentiate between a clean and dirty filter. For example, if the sensor were not receiving enough light, it would mean there was too much dust in the filter, and signal that it needed to be cleaned. A problem we saw with this was that different pollutants and dust particles could absorb different amounts of light, which would not accurately signify when a dust filter was full without complex experiments and calculations. Another big flaw was that the light source and sensor would need to be aligned perfectly in order to provide accurate results. The thickness of each filter would also be a factor in the calculations, which also added complexity to the usability of our product when a user wanted to add in new sensors.

The final solution was to purchase two air monitor sensors and place them on either side of the filtration device. We would collect the air particle count from each sensor, and compare the count from outside the filter to the count after filtration has happened. When values got too similar, it would signify that the filter is no longer doing its job and needed to be changed. The two sensors would be connected to an Arduino, and be able to send information to our server to process calculations. This initial idea eventually became the basis for our final design solution.

The potential solution for how to alert the user when a filter needed to be changed began with using three LED lights to show the status of the filter. Red would signify a change was needed, yellow to signify that the filter was getting dirty, and green to signify a clean filter. We then realized that the places we wanted these sensors to be placed were areas not regularly frequented by people, which is why LEDs would not have been as effective of an alert. Our final idea to alert the user was to develop a mobile application that would send alerts to the user when our calculations show that a filter needed to be changed.

8. Proposed Design Solution

Our proposed solution was based off of the design using two air monitor sensors. However, instead of using two sensors and comparing data collected from both, we decided to use only one sensor and will compare it to a preset threshold. The threshold will be based on an experimented dust particle count of a clogged up filtration screen, and also on accepted air quality values. In order to create a compact device that can be applied easily, the design of the Home Air Monitor will consist of only one optical dust sensor connected to an Arduino Yun for data processing. With the Arduino's capability to connect to the Wi-Fi network, the data collected from the optical sensors can be transmitted to another application. The device would be practical in many appliances at home including furnaces, air ventilation ducts, and desktops. The device would also ideally be compact enough to be applied near filtration screens without any obstruction to airflow or functionality. An algorithm will be used in the Arduino to compare the dust particle count collected to a given threshold that is pre calculated based on the area of the filtration screen. When the number of dust particle count surpasses the preset threshold, the device will then transmit a signal to an external application and will alert the user for a filter replacement. The mobile application will be an extension of the Home Air Monitor device, allowing the user to interact and configure a device that is connected to the same Wi-Fi network.

Aside from the core functionality of the Home Air Monitor, further development in the future can include multiple Home Air Monitor devices working on a single Wi-Fi network. This allows the application to support multiple devices and receive multiple alerts from different devices. The Home Air Monitor application can also be implemented to other mobile platforms and operating systems to allow greater user access.

Some risks that we foresee with this project mainly reside with the calibration and communication between our hardware and software devices. The Home Air Monitor will be dependent on a preset threshold value based on further research and testing with the product. If we are not able to determine an appropriate threshold within the given time frame, our product will be difficult to validate the appropriate conditions of a filter. Another risk lies with our design of the hardware device. If it becomes too large, we will not meet our goals of creating a versatile system that can fit in any filtration devices. Aside from the risk involved, we believe the Home Air Monitor will not cause any potential hazards at home and will not disrupt any appliances when used. Since the device applies externally near a filtration screen, the Home Air Monitor will not interfere and damage other existing electric circuitry.

9. System Overview

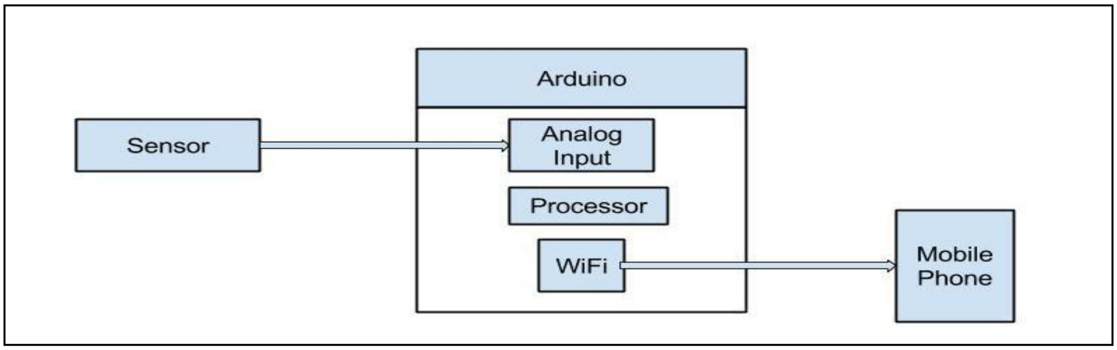

Figure 1: System Block Diagram: Elaborates on communication between devices.

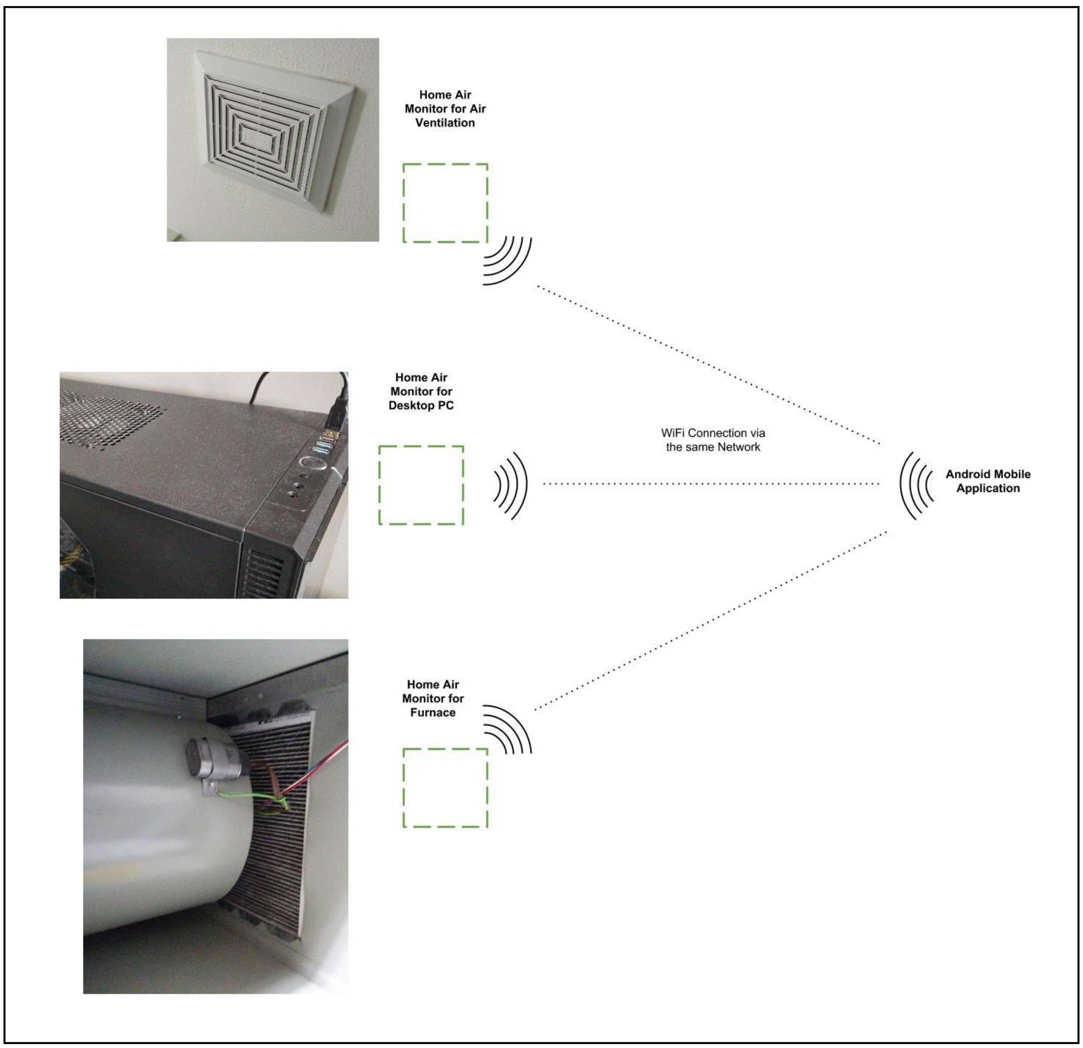

Figure 2: Overview of Proposed Design and Usage

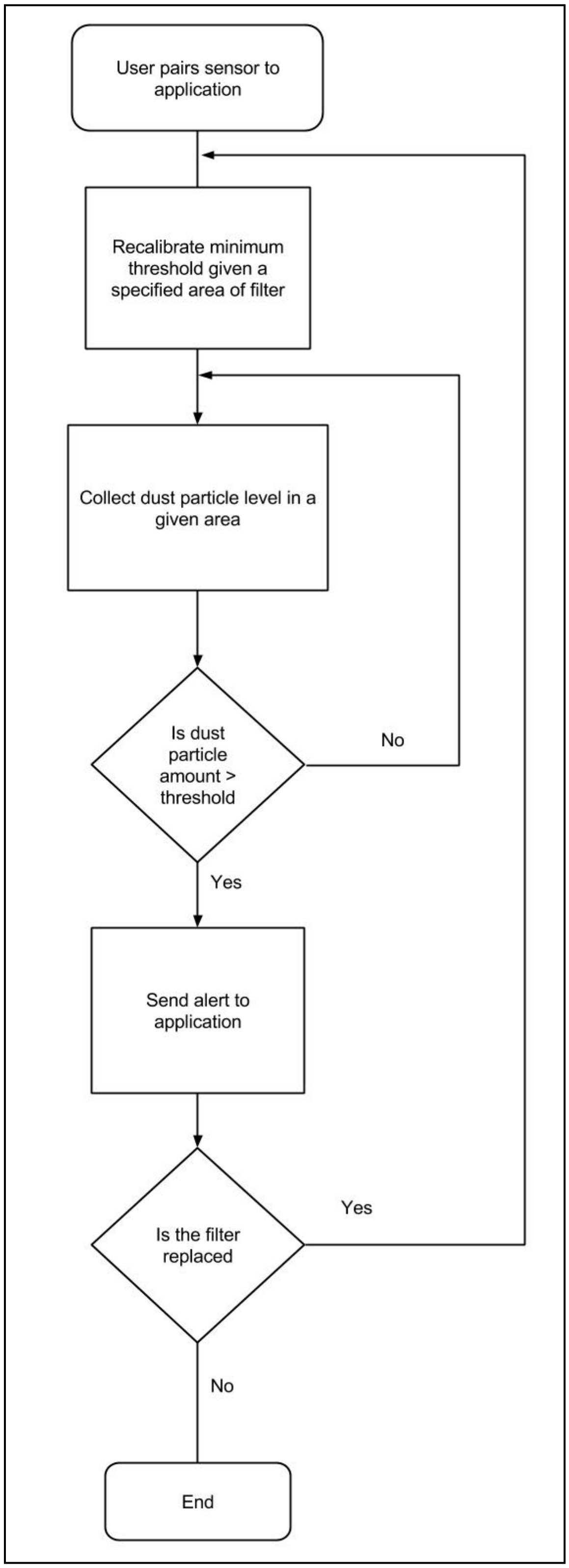

Figure 3: System Flow Chart

10. Budget & Funding

Equipment List	**Estimated Unit Cost**
Arduino YUN	$80.40
Optical Dust Sensor (SHARP GP2Y1010AU0F) x 2	$10.75 x 2
Dust filter screens	$45.00
Transparent Box	$25.00
Acrylic Sheets	$15.00
Wires	$5.00
Simulation materials (Fan, dust)	$15.00
Total Cost	**$206.90**

Table 1: Budget and Cost Breakdown

The Arduino YUN and Optical Dust Sensor are essential for our project to work, while the dust filter and simulation materials are necessary for our testing and demonstration purposes.

We have applied to ESSEF for funding, and will also be applying for the Wighton Fund closer to the end of semester. Group members will have to cover the remaining costs.

11. Schedule and Task Division

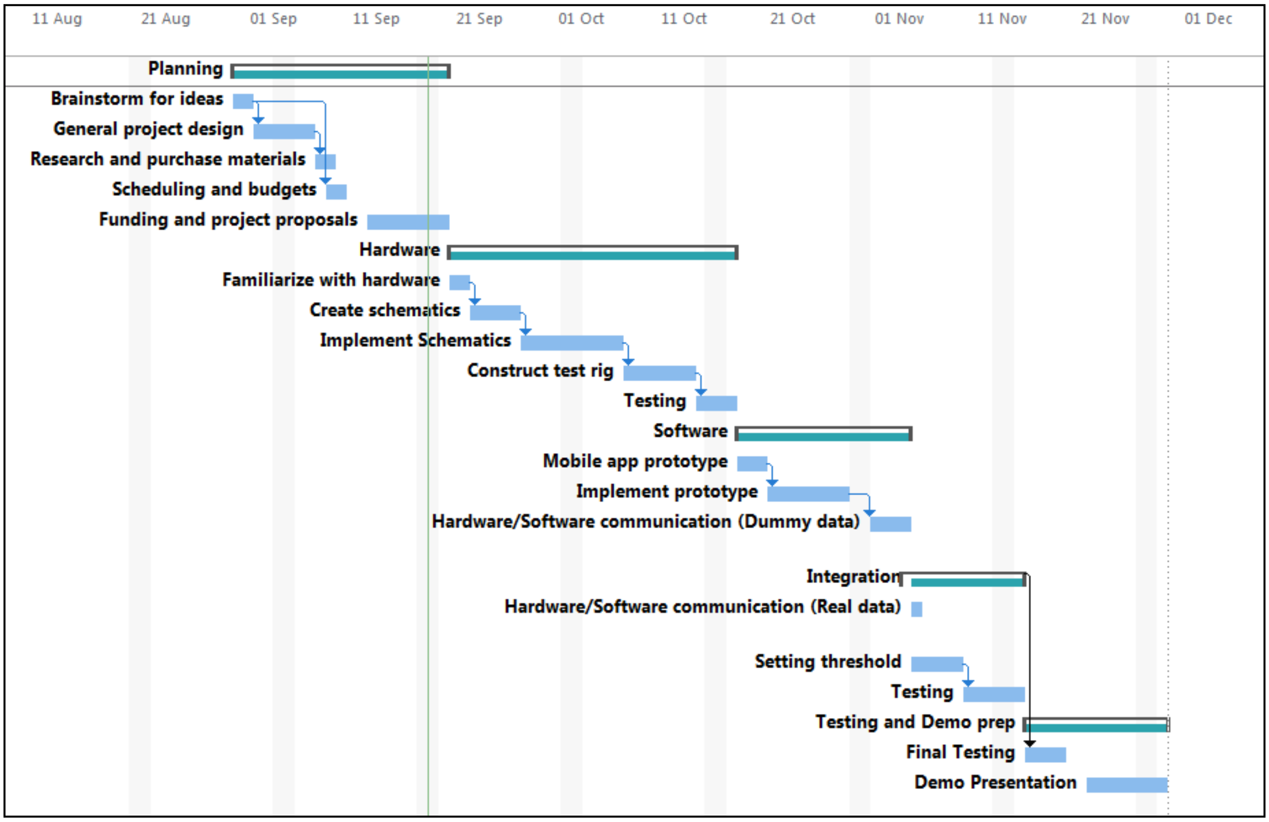

Figure 4: Gantt chart outlining timeline and planning for entire project.

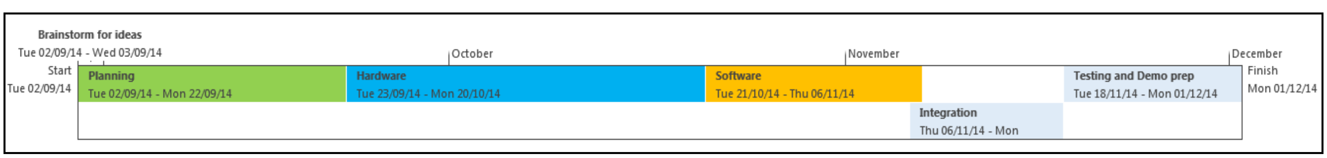

Figure 5: Timeline to summarize time spent on each portion of project.

The timeline and Gantt chart above accurately summarizes the time we will be spending on each portion of our project. While planning and researching is scheduled for the first three weeks, there will be research and planning done throughout every step of the project. Our milestones are outlined as each colour block in our timeline (Fig 5), and are completed when our Planning, Hardware, Software, and Integration stages are complete.

In order to maximize our experience with hardware and software development, we will be dividing all tasks up equally. We plan to have weekly meetings to determine tasks for the upcoming sprint, and allow our group members to decide which portion they would like to work on that week.

12. Sources of Information

For this project, our main sources of our hardware information are taken from the SHARP GP2Y1010AU0F and Ardunio YUN spec sheets. We have also found documents that show how to connect the Arduino YUN to Wi-fi and how to create communication with Luci between our devices. We will be using the Android developer site, which will give us access to the SDK and information on how to develop our mobile application. In order to design and create our app user interface, we will be using Fluidui, which is a free tool to prototype android applications. We will also be using our own personal knowledge from previous classes, and also the expertise of our Professors and Teaching Assistants.

13. Company Profile

Clean Space is a new company that aims to provide new solutions in managing the air quality of modern homes. We are a company consisting of three Simon Fraser University engineering students that would like to provide a smarter way in improving the quality of life at home. Unlike traditional air purifiers, Clean Space tackles everyday appliances by monitoring the quality of the filtration screens that are often missed by purifiers and can cause a potential hazard if left unattended.

Elaine Chiang - Chief Executive Officer (CEO)
Elaine is a fourth year Systems Engineering student at Simon Fraser University and has experience in software testing, quality assurance, and usability design from her co-op at MacDonald Detwiller and Associates. She also had the opportunity to work with mobile application development throughout her two co-op semesters at Seeker Solutions. She has experience programming in C, C++, C#, and Java from her school work, personal projects, and work semesters. Her time at Seeker has also enabled her to understand the design aspects and organization required to completing a project from start to finish. Elaine is always eager to explore new technologies, especially those that contribute to improving healthcare and safety in our society.

Joanne Leong - Chief Finance Officer (CFO)
Joanne is a fourth year Computer Engineering student at Simon Fraser University and has experience in mobile testing, software development and design from co-op's at Sierra Wireless and Microserve. She has experience developing web applications using self-taught html, SQL, .NET and javascript. She also has additional programming experience using C, C++, C# and Java. Her hardware related experience has come from using FPGA's in coursework, including the more recent Xilinx Zedboard. Joanne is an avid problem solver, works well in team environments and hopes to contribute her experience and abilities to assist in achieving the team's project goals.

Peterson Poon - Chief Operating Officer (COO)
Peterson is a fourth year Computer Engineering student at Simon Fraser University and has experience in mobile and wireless testing with Nokia and Netgear. He is fluent with various programming languages like C, C++, Java, and is also a self learner in querying databases with SQL. Along with programming, he also has experience with microcontrollers, and was able to configure an Altera Cyclone II with VHDL, as well as a Xilinx FGPA. Peterson is a very active team member when it comes to group work and will always take on new challenges and contribute his skill set to his team members.

14. Conclusion

Clean Space is dedicated to providing homeowners with an affordable way of keeping their living space as healthy as possible. With our design of the Home Air Monitor, we focus on creating the most portable, convenient, and flexible system possible to allow the average homeowner the freedom to decide what areas to monitor. By connecting alerts to a mobile device, users have the ability to monitor their air quality effectively, and minimize the time and cost of maintaining a home.

While there are air monitors in the current market, ours will be improved due to it's compact design and effective communication through utilization of mobile application alerts. We hope to improve the health and decrease respiratory illnesses in Canadian homes one dust alert at a time.

We have outlined above our project design, system overview, budgets, and goals in order to make our project a success. Clean Space is excited to take on this project and hope to accomplish all our goals within the given time frame.

15. References

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