ALNAIR INNOVATIONS

April 13th, 2011
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Post Mortem for Color Deficiency Aid Device *ColorAid*

Dear Dr. Rawicz:

The Alnair Innovations document attached describes the process our team went through as we designed and implemented *ColorAid.* The device is designed and implemented to support and aid those who are color deficient and to help them better cope with the surrounding.

In this document, the current state of the device, deviations from our original plans, and the future plans for the device will be detailed. Budget and timeline originally created and what actually did occur will be compared. Finally, personal experiences including interpersonal and technical aspects gained through the project will be discussed.

Alnair Innovations consists of five students with backgrounds in engineering physics and electronics engineering: Arash Ahmadi, Henry Chan, Jun Hong, Claret Ramos and William Seo. For further inquires about our company and proposal contact our CEO Claret Ramos via email at ckr@sfu.ca, or by phone at (604) 839-9322.

Sincerely,

Claret Ramos
Chief Executive Officer
Alnair Innovations

Enclosure: Post Mortem *for Color Deficiency Aid Device ColorAid*

POST MORTEM FOR COLOR DEFICIENCY AID DEVICE
COLORAID

PROJECT TEAM

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SUBMITTED TO

Dr. Andrew Rawicz – ENSC 440
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ISSUED DATE

April 13th, 2011

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1. Introduction

ColorAid is a device that detects colors. To assist those who suffer from color deficiency, Alnair Innovations, for the past thirteen weeks have designed and implemented a device, *ColorAid*. This report is a retrospective examination of the entire process of the development of the device.

2. Current State of the Device

There are three main subsystems in *ColorAid*, and they are the color sensing subsystem, the user interface subsystem and the central control subsystem.

The device has a power switch and three control buttons, “okay,” “mode” and “back.” The device requires a standard 9V battery to power up. Once the device is on, the company logo will be displayed on the LCD screen, and the device will have undergone the standard initialization procedures. During the startup initialization process, previously saved color data will be retrieved and required data will be placed into arrays accordingly for later use. The main page with two options, “sample” and “album,” will then be displayed. Since the device has just started up and has yet to sample any color, the other options, “color,” “save” and “wizard,” will not be displayed. The user has a choice to sample a color of an area of interest or to view previously saved colors. Once color data have been obtained, the RGB values, the color name and the sample of color will be displayed with the full five options menu.

As soon as the device is off, the sampled color data will disappear unless the data are saved. Currently, the device can handle up to three saved colors.

The features “Save”, “Album”, “Color”, and “Sample” are fully functioning. The feature “Wizard” was described in the Functional Specification document as a feature available in the final production system only; however, we decided to implement a demo of this feature for the prototype. Additionally we added a battery meter on the tip right of the LCD screen so the user can see the level of their battery.

2.1. Color Sensing Subsystem

In the color sensing subsystem, the most important task is to provide accurate color detection on a consistent basis. Since color readings will differ due to illumination and light intensity, the color sensing subsystem has to be capable of isolating external light source, and, in the mean time, provide its own light source to illuminate the color of the area of interest. Once the color sensing subsystem has received the signal to sample a color from the central control subsystem, the sampling procedure will proceed. The sampled RGB values will be sent back to the central control subsystem for further analysis.

2.2. User Interface Subsystem

The user interface subsystem consists of an LCD screen, a power switch and three control buttons, “okay,” “mode” and “back.” User controls the power to the device by switching it either on and off with the power switch. As long as the device is powered on, the LCD screen is always on to give instructions or feedbacks to the user. The okay button allows the user to select the highlighted option displayed on the LCD screen. The mode button lets the user to toggle through the options shown on the LCD screen while the back button takes the user back to one level higher in the menu.

2.3. Central Control Subsystem

The central control subsystem acts as a communication channel between the color sensing subsystem and the user interface subsystem. Typically, when the user interface subsystem sends a signal to the central control subsystem requesting to sample a color of an area of interest, the central control subsystem will immediately forward the signal to the color sensing subsystem. Once the color sensing subsystem has done the requested sampling and has sent the RGB values back, the central control subsystem will then start analyzing the RGB values and will try to map the readings to a specific pre-defined color name. The analyzed data will be placed as global variables for further access by the user interface subsystem.

3. Deviation from Proposed System

3.1 Central Processing Unit

For the microcontroller, there is only one deviation from the proposed plan. In our functional specification document, we listed general and physical requirement for the unit. The requirements from the functional specification [1], [R64] to [R73], illustrate the microcontroller functionality.

The functional requirements [R64-II], [R65-II], [R66-II], and [R67-II] specify minimum number of input and output ports and methods to communicate with the sensor unit and the display unit. The color sensor ADJD-S311 sends serial data through Two Wire Interface to the microcontroller, and Nokia 6300 uses parallel digital inputs and outputs Arduino Mega 2560 has the TWI connection ports and has 54 bidirectional digital ports. The requirement [R70-II] is also fulfilled automatically since Arduino Mega 2560 is powered up by using 9V DC battery.

The requirement [R68-II] specifies the user interface layout and its functionality. This requirement is fulfilled by creating five different menu selections for users.

The requirement [R69-II] is somewhat in a gray region, due to the fact that there are infinite numbers of colors in real life. We tried our best to quantize colors using a prevalently used color table, but the memory space exhausted very quickly. The quantized method we used is selecting sample colors and then create database for those colors.

The physical requirements are all fulfilled.

3.2. Color Sensing Unit

The main component of the color sensing unit is Avago's ADJDS311. This miniature color sensor was used in the prototype of our device. The spectral response of its photodiodes was suitable since it accounted for the range of wavelengths corresponding to the human's visible spectrum. The spectral response for each color R, G, and B, has wide bell shapes which means that the sensor is responsive to more wavelengths than one with narrow bell shape curve.

Our color sensing unit follows the functional requirements specified in the functional specification [1]. One of a few deviations found is the Physical requirement [R80-II], which indicates that the sensor shall be positioned on an aperture of the casing with an area of 10 mm x 10 mm. Instead of a square aperture, we made a circular aperture with 10 mm diameter. The aperture shape was modified because we did not possess the right tools to make a square aperture with those dimension, instead a 10mm diameter drill bit was used. This deviation does not affect the performance of the sensor.

3.3. User Interface Unit

In this unit one deviation is meant for the improvement of the user interface and easier use of the product; while the other deviation is forced as a result of limitations due to the characteristics of the LCD used in the product.

A minor deviation is introduced in the “Sample Page” menu. When the user decides to sample a color he/she must press the “Mode” button instead of the “Ok” button while in the “Sample Page” menu. There will be no confusion for the user due to this change since all necessary instructions have been explained on the display.

“Sample” function enables the user to sample a color successfully and obtain its corresponding RGB values. This 24 bit RGB data is displayed in the “Color” page of our menu. In this section, the color sampled is also displayed on the screen by mapping 24 bit RGB values to 12 bit RGB values. Even thought Nokia 6100 LCD indicates it is capable of showing a 12 bit RGB color, it may be difficult to differentiate a few colors due to limitations on the control of the contrast of the LCD. Originally, the color LCD CFAF240400D-030T from Crystalfonts was purchased. This LCD had 24 bit RGB resolution. It was a more suitable LCD screen for our project. Unfortunately, 12 days after the order was made, the company informed us they were only able to ship the LCD screen without breakout board and the part was back ordered until May. Without the board we were not able to connect the LCD to the Arduino board. As such, we were force to quickly find a new LCD screen which was Nokia 6100 LCD.

4. Future Improvements of System

4.1. Central processing Unit

The future work for our prototype includes creating a more complete database for color. Arduino Mega comes with 256KB flash memory, but to include more extensive color data we might provide more external memory space.

Even though Arduino Mega is lighter and smaller than functional requirement, we can go further to build our own PCB Layer and mount ATMega2560 chip to reduce size and also reduce the power consumption.

4.2. Color Sensing Unit

Avago's ADJDS311 color sensor is a good reflective color sensor. However, this component is very sensitive to distances at which it senses, and 1mm difference may change radically the values of RGB obtained. The sensor also does not measure colors found at the bottom of the CIE 1931 color chart accurately. A future improvement would be to purchase other types of color sensors currently available in the market. An alternative would be to test Hamamatsu's photodiodes and photodiode arrays, those with photodiodes with a sensitive wavelengths corresponding to the human's visible spectrum, and also with sensitivity curve with a wide bell shape to be able to be sensitive to more wavelengths of light.

Another improvement for this unit is to place the sensing unit in the same PCB as the microcontroller, this will reduce space. Conversely, another option is to place the color sensor as an attachment to the case like a probe, meaning that it could be connected to the case by an extension wire. This way, the sensor can be extended in order to reach objects that cannot be otherwise reached.

Additionally, a special cover on top of the sensor can be added for its protection.

4.3. User Interface Unit

Although this product can support most color blind individuals, however there is still much room for improvement if the device is to be used by professional artists or other specified applications.

A small QWERTY keyboard can be provided to the user to save the desired color in any name that may be easier to remember. Also, the user can look up colors through their RGB values or vice versa. Better quality push buttons can be used to replace those of the prototype, an alternative is Tactile Switches.

Another major step for improvement can be made by using an LCD with higher resolution and number of pixels. With higher number of pixels, more number of colors can be displayed on the LCD without being limited by the contrast of the LCD.

The wizard option can be developed into a greater range where the user is able to view analogous, complementary, and triad relationships of the sampled colors.

5. Company Resource

Our initial fund from EFSSS is $500 and the actual amount spent for the project is $546.94. The deficit amount is $46.94, 9.4% over the resource amount. The threshold for budget deficit is above 10%.

Even though the deficit amount is under the threshold level, it is quite close to the marginal amount. We also excluded wages for five talented engineers. If we include all the wages and the outside contract, the current fund is not enough and we must find out other ways to raise money.

5.1 Project Budget

Table X shows the comparison of estimated cost, actual cost and the deviation incurred along the way. The estimated cost to build *ColorAid* is $810. The actual cost incurred is $546.94. We have over budgeting on this project.

Table 1: *ColorAid* budget

Parts	Estimate Cost	Actual Cost	Deviation
Sensor	$ 400.00	$ 44.68	$ 355.32
Microcontroller	$ 200.00	$ 190.22	$ 9.78
LCD screen	$ 120.00	$ 144.37	-$ 24.37
Power unit	$ 40.00	$ 35.15	$ 4.85
Casing	$ 30.00	$ 87.42	-$ 57.42
Speaker	$ 20.00	$ -	$ 20.00
Misc.	$ -	$ 45.10	-$ 45.10
Total Cost	$ 810.00	$ 546.94	$ 263.06

There are four parts we need to justify (marked with red on Deviation list): Sensor, LCD screen, Casing, and Miscellaneous.

Sensor: When we first designed our model, we considered buying a spectrometer to detect color spectrum of object. However, due to the size limit and difficulty on portability, we forfeit the idea and choose less expensive color light sensor.

LCD screen: We purchased an extra LCD screen to split the task among designers.

Casing: The casing itself is under $30, but to cut the plastic case requires special drill bits for the Dremel and coping saw. Additionally, a special cover was made for the casing to protect the LCD and to cover imperfections made when cutting the case. This glossy layer displayed the button's names, company logo and product name printed in color, which required extra materials.

Miscellaneous: Buttons, Switches, Capacitors, Stranded wire, Light to frequency converter. The light to frequency converter was part of sensor device in early design, but as we found a more suitable sensor, this device became obsolete in our design.

6. Timeline

We have completed our project in time for the presentation, and have demonstrated the effective use of the time allotted. We utilized all labour and resources efficiently by designing coding algorithm and reviewing datasheet for each part when waiting for the arrival of the components. We also met all the deadlines for the documentations and even had our presentation and demo in early April. However, the time used for debugging was longer than expected and this is probably because we had underestimated the complexity of how the device could get. Figure 1 shows the Gantt chart of our projected timeline and the actual timeline.

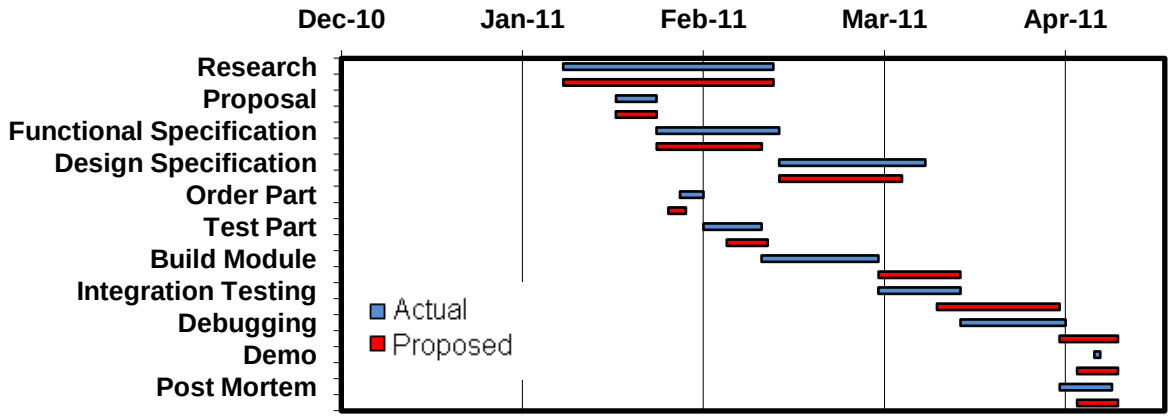

Figure 1: Projected and Actual Timelines

7. Personal Experience

Claret Ramos

Through the course of this project, I have increased not only in technical knowledge, but also have learned about group management and leadership. I am colorblind, so since very young I have struggled with color perception in my daily activities and it prevented me from choosing the career path I originally intended to pursue. Since very young, I thought of designing a device that would help me recognize colors, especially when I was on my own and I would have no aid from others. This project has enabled me to find a practical solution not only to those with color deficiencies, but others.

In this project I had exposures to different stages of a project development. Initially I researched about human color perception, the human eye, colorimetry, spectroscopy, types of colorblindness, challenges colorblind people face, talked to other colorblind people and ask for their experience. Once I had a better understanding of the subject we proceeded to investigate how to go about designing the device, what parts we needed, and how everything will come together. This part was not straight forward and changes were made along the course of the term.

As a project manager I was involved in every single step of the development of our prototype. I participated in the development and testing of the control system for the user interface. By doing so I learned about Arduino's development boards and gain experience programming in C/C++ and Arduino's serial communication libraries. I was responsible for the development of the software for the sensor unit. This task was a bit more complicated since the sensor we purchased had a somewhat vague datasheet and the company would not offer technical support since the product was discontinued in 2010. Many hours were spent testing the sensor unit, especially when testing different calibration sources. Of course, calibration task was difficult for me since I am a colorblind so I was assisted by my team members who ensured that the colors sampled by the sensor were accurate.

Additionally, I learned about hardware design, implementation, and testing. An important experience was the development of the casing for our product. At first I used a Dremel kit, and I realized the bits I had would not cut the plastic at low speeds, and at higher speeds they would melted the plastic. I had to research about cutting plastics and using coping saws. Two cases were cut in order to get a decent final case. It was not an easy task to ensure all our components would fit in a case and would be wired up properly. Everything had to be laid out and mapped in a way to fit many wires into a small box and parts broke in the process. After that, different case covers were created in order to cover the imperfections made when cutting the case, and to display the logo and labels. This was done by scanning each part, layering them on Adobe Photoshop and designing the extra layer corresponding to the cover. The cover made the prototype look more realistic and professional.

I learned that everything seems straight forward as a concept, but implementing and executing ideas are not that straight forward. Much complication had come along the way, and one had to be ready to

analyze and make quick decisions in order to continue with the development without major setbacks. Some additional expenses were made. For example, we had originally purchased a high resolution LCD screen, which was perfect for our project. Unfortunately, the company selling this product had run out of the breakout board for this device and they sent only the LCD, leaving us with no way of using the LCD. Given that, we lost a few weeks of software development on the LCD screen and we were forced to find a new LCD screen which had lower color resolution, as there was no other available at the moment.

I gained experience working with a team of four brilliant students of different backgrounds. When engaged in a team work, it is very important to understand each person's strengths and weaknesses, and nurture of each other's suggestions. Not only that, but by brainstorming together, great ideas come up and different ways of implementing things are discussed, which allows everybody to learn new ways of working. I learned about how to be organized, follow a tight schedule, manage other people, ensure everybody is well and make sure all the units can be integrated and work as a whole. Although few minor conflicts occurred, there were easily settled by addressing and resolving the individual concerns. Overall, the project was a success and I am very happy that I was able to work with an excellent team of engineering students and I hope this project serves of valuable experience for their future projects.

Henry Hin Heng Chan

Throughout this project, in the past 13 weeks, I have learned a lot technically and interpersonally. Our group consists of five talented individuals from SFU Engineering Science. For a semester-long project like this, it is impossible to work as a big group on every single components of the project. Therefore, we have split into two subgroups to work on the sensor component and the LCD component separately. I was happy to be placed in the LCD subgroup, and most of my technical skills gained in this project were from working on the LCD component. Besides, we worked on the documentations as a big group, and most of my interpersonal skills were learned from working with other people.

From the technical perspective, I have become familiar with Nokia 6100 LCD display and Arduino I/O board. Arduino I/O board uses its own C-like programming language. For a fourth year engineering physics student like me, who had not programmed in two years, working with Arduino I/O board could refresh, or even extend, my knowledge in programming. I was totally unsure about how to write the code for the LCD display at the beginning of the semester. Luckily, with the help of my group mates, I was able to refresh my programming skills in a very short time. By coding on the I/O board, my programming skills have even enhanced over the past 13 weeks. I have also learned about Nokia 6100 LCD display. Due to the time constraint, some sample functions of the LCD display, such as printing character strings and printing rectangles, were used. Although sample functions were provided, I still had to understand what the code was supposed to do, before using them. It is very important to fully understand how a device works since this understanding will allow you to efficiently troubleshoot any

problems occurring on the device. I hope to have further opportunities in the future to work with such LCD displays and to develop everything from scratch.

From the interpersonal perspective, I have learned various skills to work with a group of people. I have learned that communication is very important when working as a group. Even when we were split into two subgroups, we still scheduled to have meetings every week. By meeting and exchanging emails, we understood what others were working on, and this allowed us to learn about every detail in different components as well as to contribute our ideas even if we are not experts on some components. Working as a group means lots of different opinions, and above all, it is very important to respect everyone's ideas and to come up with an idea which everyone agrees on. Planning ahead as a group is another main ingredient in succeeding in projects, and this is the main reason why our group met all the deadlines for documentations and completed the project in time. We also learned from our mistakes; therefore, we must not afraid of making mistakes. Group mates are always willing to help when we make a mistake or don't know about something. Pushing yourself and being pushed by the group are other things needed for a successful project.

Personally, I feel lucky to work with my group. This is not a group just wanted to meet their academic purposes or to learn technical skills, but this is a group that is fun to work with. Encouraging one another and trusting each other could lead to amazing results and friendships.

Arash Ahmadi

From a technical point of view, I have been able to expand my programming knowledge to work with micro-controllers. While working in a C/C++ environment, I learned how to develop drivers on an Arduino micro-controller and create communication ports in order to control various peripherals connected to the micro-controller. One of the challenges in programming the Arduino micro-controller was the inability of the Arduino software to debug the developed code. Also, the program developed to run the micro-controller consisted of a onetime execution and a loop execution part which I had never encountered before. At the end, I managed to overcome this new challenge to gain more knowledge and be more prepared in a real working environment.

Throughout this project I managed to strengthen my interpersonal skills. Although I have worked on many previous school projects as a team, however I had never worked in a team with such diversity of skills where each member was valuable for a certain aspect of the project. We managed to create a team with one goal and divided the tasks appropriately to accomplish our goal. Time management was another skill that I developed throughout this project where we managed to set and meet deadlines one at a time and reach our final goal. As a result,

through great project management, team work, and communication we managed to schedule our project presentation on time and without any extensions.

The experience and knowledge that I have gained throughout this course was very valuable. As an Electronics Engineering student I have learned that the technical skills I have accomplished over my academic years at SFU have been very useful but not sufficient in order to carry out the project. I have learned that there are no boundaries for knowledge, and I had to expand my knowledge in the field of science in order to accomplish this project.

William Seo

For the past 13 weeks, the interpersonal skill that I have improved the most upon is reading skills. I used to hate reading textbooks, especially the ones with no picture. By doing severe research about color documentation and flipping programming language text books, my reading skill has been improved. The benefit is that now I can read more paragraphs with given amount of time and I can also do better in the exams, since I can understand more clearly.

Along with the reading skill, time management is another valuable skill that I have improved upon throughout the semester. I have taken two other courses, along with ENSC 440 and ENSC 305. For each of the courses, I had to do its own project and home work problems. I had to distribute my time to study each subject, by having successfully done so, I believe I have gained a valuable skill mentioned already.

My communication skill has also improved. I tracked money flow of the company and raised issues with uncertain money flows. I asked each team members about the purchase they made and reimbursed with cheques for the damages. The clear communication skill is also vital for Chief Financial Officer.

For the technical skills I have done soldering to implement the LCD screen on top of Microcontroller and done some software programming.

Jun Ki Hong

For the past 13 weeks, majority of my task covered research and documentation. Lots of readings were done, in order to understand the process of color sensing. I dare not say I fully understand the process, but my understanding has definitely increased. The operation of the sensor of the sensor, including calibration process, and the actual sensing of the color was also studied and methods to implement were devised.

Working in a group has taught me to be more patient and understanding. A great need to be patient and to try to understand and integrate varying ideas was observed. Listening to each other was vital in the completion of the device. Different people understand things differently. Even though a same issue is being dealt, people can view different aspects of the issue. Though individual understanding is usually never sufficient for a completion of the given task, ideas integrated sufficed. It wasn't yelling at each other, nor contending with, but it was cooperation and collaboration in patience that helped. Understanding before constructive commenting appears vital. When understood, constructive criticism, not personal slandering is what we need.

Having a functional specification and design specification was vital in succeeding in the project. I have learned the importance of planning ahead so as not to meander as we go through the entire process. Not knowing what the outcome, the project would have been impossible to complete. But with the specifications documents, we did, and were successful with the completing the project.

Deadlines, internal and external, are vital. When in a busy schedule, adequate time allotment for all the tasks needed is a must. Only when deadlines are met and stuck to, full efficiency of the time in hand is possible. Keeping the deadline in mind helped me to plan my work and to complete the task given.

Regular meetings to communicate as to the progress of the individually assigned components of the project were necessary. It was in these meetings that we learned of each other's progress, problems, and possible solutions. This way, we did have easy integration of all the parts into a final device. One important thing about meetings was that we need to stay focused on the topics that need to be discussed and need our full attention. At times, there were discussions irrelevant, and those could be surely done away with.

I learned the importance of asking right questions, at the right time, to the right person. There are many knowledgeable people who are willing to help and teach. We just have to utilize those resources, having done the best within our reach. We do make mistakes. I have learned that it is a part of the learning process, and that there is no need to fear.

In conclusion, within a group, there has to be not only encouragements from each other but reminders of the obligations. The way we treat each need to be respectful and considerate. Different schedules, lifestyle, and more cause us to complete tasks assigned in a varying manner. That must not hinder us from trusting and supporting each other. When we start to

acknowledge each other's strengths and support with encouragements and more, things start to occur.

Sources and References

[1] Alnair Innovations, “Functional Specification”, February 16th 2011.

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