School of Engineering Science • Burnaby, BC • V5A 1S6

December 18th, 2011
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
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Re: ENSC 305/440 Post Mortem Report

Dear Dr. Rawicz,

Attached is the post-mortem report for the RYB Paint Mixer designed by FASM Solutions. We have successfully completed the prototype version of the RYB Paint Mixer. As seen in the demonstration, apart from minor difficulties, most components of the device are functional. The RYB Paint Mixer is a self-contained device, dispensing accurate amount of desired paints. It is a cheap and portable alternative to those currently available in the market.

This document reports the prototype functionality, future improvements, budget and time constraints for the RYB Paint Mixer. This document also includes a section where, FASM Solutions, team members will share their experiences during the development of the RYB Paint Mixer.

FASM Solutions has a dedicated team of four 4th year engineering students, Sasan Hezarkhani, Faiz Parkar, Milad Maleksabet and Ajaypal Khakh. For more information or concerns, please contact me via email at sha39@sfu.ca.

Sincerely,

Sasan Hezarkhani

Chief Executive Officer

FASM Solutions

Enclosure: *Post Mortem Report for RYB Paint Mixer*

POST MORTEM REPORT FOR PAINT MIXING DEVICE: RYB MIXER

FASM SOLUTIONS

Project Team

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Submitted to

Dr. Andrew Rawicz
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Glossary

RGB	Color model (Red, Green, Blue)
RYB	Color model (Red, Yellow, Blue)
GUI	Graphical User Interface
LED	Light-Emitting Diode
CDN	Canadian Dollars
CSA	Canadian Standards Association
PDF	Portable Document Format
DC	Direct Current

1. Introduction

The RYB mixer is a mixer that uses five colors, red, yellow, blue, black, and white to provide the desired paint color. The color of interest can be inputted to the RYB Mixer through a touch screen or by using a wireless pen. The product works with 8-bit values for each color in the RGB model and automatically converts it into a customized Red Yellow Blue (RYB) ratio. The paint of interest is, then, dispensed from the gravity cups into the dispensing tubes. The amount of paint going into the dispensing tube is controlled by the solenoid valves. The final paint is mixed in a container provided by a user. This document will provide the current state of the RYB Paint Mixer. At this point, FASM Solutions have developed a functional prototype of our device. We are going to mention the current prototype functionality, budget and time constraints associated with the RYB Paint Mixer. We will also discuss the future improvements of RYB Paint Mixer in this document.

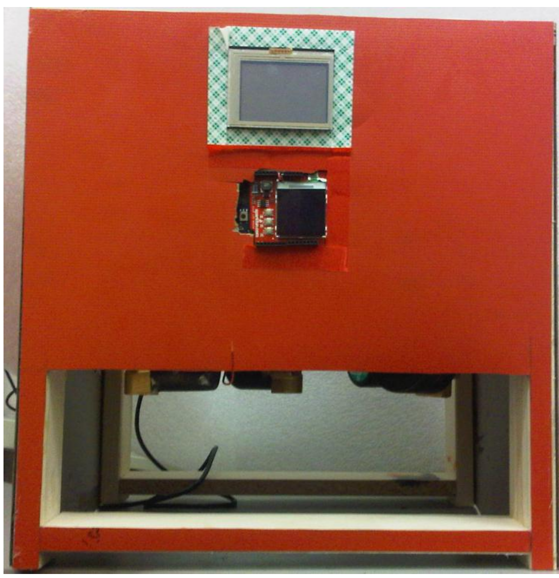

Figure 1: Front view of RYB Paint Mixer

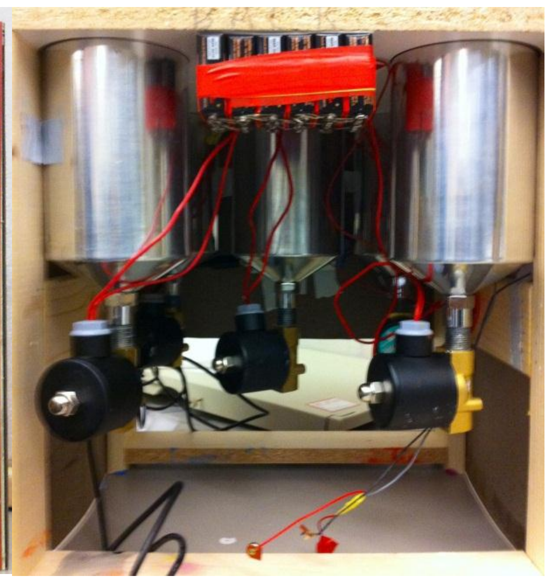

Figure 2: Rear view of RYB Paint Mixer

1.1. Prototype functionality

The RYB Paint mixer is fully functional at this time. Overall, the functionality of the RYB Paint Mixer can be thought to be dependent on the correct functioning of three, major, constituents of the RYB Paint Mixer:

- Mixing Unit
- Touch screen and Microcontroller
- Wireless sensor

1.2. Mixing Unit

The mixing unit consists of the gravity cups, connectors, solenoid valves, and a primary circuit that drives the mixing unit. Currently, we are able to test the functionality of the mixing unit. Paint flows successfully form the gravity cups into the solenoid valves. Solenoid valves are connected to the gravity cups by stainless steel connectors. During testing, we can confirm that paint does not leak at the junction of gravity cups and the solenoid valves. Once the paint reached the solenoid valves, the valves opened for the correct amount of time. After the colors coming through different solenoid valves dropped on each other, we were able to get the color of our desire. This ensured us that the valves are opening and closing for correct amount of time. The driving force behind the valve opening is the circuit that consists of five MOSFETs and a multiplexer. It is this circuit that decides which value is going to be opened and which valve is going to be closed. This circuit gets the color information from an Arduino mega 2560 microprocessor. We will be discussing the microprocessor in the next section. Having the valves opened for a correct amount of time and achieving the color of desire ensured that the circuit is functioning properly.

1.3. Touch Screen and Microcontroller

As mentioned above, the user can input the color of desire through a touch screen or a wireless pen. Then, the colors are encoded into the 8-bit values in the RGB model, which gets automatically converted into a customized Red Yellow Blue (RYB) ratio. The detection and conversion of the RGB values is done by the, Arduino Mega 2560 microprocessor. We loaded an image of the color detection, touch screen detection, and the valve control algorithms on the microprocessors. These algorithms were integrated before they got loaded on the microprocessor. In addition, there is a LCD that displays the color that is currently dispensing from the RYB Mixer. This LCD is also controlled by the microprocessor. During the testing cycles, we were able to confirm that the dispensing color, the displayed color (on the LCD) and the inputted color were the same. This confirmed that the microprocessor, touch screen, and the LCD are working properly. Despite of the correct function, sometimes the touch screen freezes. We concluded that it was because the tough screen is fairly old and overused, before we got it.

1.4. Wireless Module

The wireless module of the RYB Paint Mixer consists of a color sensor, transmitter, and a receiver on the main circuit board. The wireless pen senses the RGB values of the color surfaces. These values are then sent over to the transmitter, which is operated by the Arduino Uno microprocessor. The transmitter wirelessly transmits the RGB values. These values are then received by the receiver, which is operated by the Arduino mega 2560 microprocessor. Then, the microprocessor automatically converts these RGB values into the RYB ratio. During the testing process, initially, we made the transmitter to transmit the R, G, and B values, separately. This technique did not work due to some delay issues. To overcome this, we used the following method to transmit and receive the RGB values:

On the transmitter side: FINAL_NUMBER = R+ (G*255) + (B*(255^2)),

And on the receiver side, the RGB values are recovered as follows:
R = floor (FINAL_NUMBER%255)
G = floor (FINAL_NUMBER/255) % 255
B = floor (FINAL_NUMBER/(255^2)) % 255

2. Deviation from Design

The prototype of the RYB Mixer, given the budget constraint and timing issues, has a few changes when compared to the final product shown in the design document. Firstly, the dispense mechanism is been put as a direct gravity flow under each color cup. Fabrication of the angled tubes was not achieved, which would drop each color onto a small central area. This would allow the user to just leave the collection container under the tubes, whereas the prototype relied on the user manually moving his or her container under each valve. Next, our wireless sensor could not be miniaturized into a pen-like form. Currently it is quite dependent on being operated by the designers, and not common users due to calibration and wireless communication issues that needed to be handled giving no time for pen enclosure adjustments. To meet the prototype demonstration deadline, the electrical circuit is set and assembled on connected breadboards instead of PCB boards mounted onto the microcontroller.

3. Future Improvements

3.1. Mixing Unit

As mentioned earlier, the final product will have the tubes attached to the valves that will channel the paint into a more precise and small area for collection. Given that the paints will be delivered one at a time, the dispense functionality will require less steps by the user. Once all the paints are collected, the user can simply mix them to achieve the final color. In terms of dispensing, modifications can be made to the pressure applied on the paint in the gravity cups, which could improve the rate of flow through the valves. Another possible area of improvement can be the incorporation of a power supply unit that will replace the battery packs and allow the device to operate by just plugging it into a power outlet. The enclosure will be re-fabricated to hold all circuitry efficiently and remodeled to match what has been proposed in the design specifications. Lastly, cleaning methods will be reviewed as to which is the most environmentally friendly, has the most efficient waste disposable method and help us meet the requirements set in the functional specifications.

3.2. Touchscreen/Microprocessor

To start, the final product could get a different orientation for the touchscreen to make it more ergonomic, as seen in the final design. A product with the latest touchscreen technology can allow for a better user interface and can handle data for many more menus such as color profiles. Cheaper alternatives for microcontrollers with similar memory capacity can help lower the budget and the overall cost of the retail product. Prototype was run through a circuit built on the breadboard, hence the final circuitry will have PCB board attached to the microcontrollers for efficient use of space and avoid cases of wires and MOSFETs being detached while the device is being moved.

3.3. Wireless Sensor

In addition to miniaturizing the sensor object, which includes the camera sensor, the transmitter and the microprocessor, the sensor itself can be upgraded to produce better RGB values and eliminate the color tint in the LED used to capture the RGB luminosity. The microprocessor will be optimized to use one AA or AAA battery, which will provide beneficial when adjusting the entire circuitry to fit in a pen-like frame.

3.4. Budget

The budget presented in the FASM Solutions progress report was adjusted towards the demonstration on Dec 16th, as we required an additional Arduino Mega 2560 processor to replace the faulty one. In addition, 3 more IRF510 MOSFETs were purchased as a backup for those available on the circuit and were eventually used to replace the ones that burned out during testing processes. This brings an addition of $80 to the final budget as of Dec 1st, and a total expenditure for this project to $670 dollars. As mentioned in the beginning of this project, $500 was provided by ESSEF. The team members of FASM solutions, due to last minute procurements and shipping costs, incurred the additional cost of $170.

4. Personal Experiences

4.1. Sasan Hezarkhani

Going through ENSC 305 and 440 has improved me in numerous ways. Not only I have learned new things in technical aspects, I have learned how to be a better person. With the challenges that were present during this project course I have learned how to plan my time to get tasks done. Once titled as the CEO of the project I was forced to manage not only myself but the other team members. This provided the opportunity for me to understand how scheduling, risk analysis and task prioritization work in a real project. Having a stronger background in software development, the electrical part of this project was a challenge for me. However, as time went by I quickly learned new things and applied my learning from past courses that I took at SFU. As team work was a necessity for getting this project done, I learned how to better my communication skills and patience. With the amount of documentation needed for this project, not only I learned how to write a technical report, I learned how to document a complete project from pre-production.

4.2. Milad Maleksabet

This course was one of the best courses which I have ever taken in SFU. This course improved my academic knowledge and also improved my management skills. In point of academic knowledge, I leaned programming with Arduino Microcontroller, feedback-control system, hardware interrupt, and color code conversion. In point of management skills, I learned about the project scheduling, budget managing, team cooperating, and project marketing. This course was an extreme challenge for me, because it was a test for me to find out about what I learned in my past 4 years in SFU.

4.3. Faiz Parkar

To begin, this project proved to be a major learning opportunity as well as a chance to reflect on what skills learned over the past years of Engineering can be improved and applied to be suit the production of the device. I was able to determine how I can apply some of the electrical knowledge as well as programming fundamentals. Most importantly, I gained experience in dedicating oneself towards achieving a goal for the betterment of the team project rather than for one's satisfaction. The amount of documentation involved in this course was rigorous but worthwhile. It taught me a great deal about the type of detail and research required to produce professional reports. The research was a major component for me as the CFO as well as the programmer on the color conversion algorithm. The 3 months required for development were not enough to completely learn the details of color theory, but it useful to learn how color spaces are integrated into digital algorithms. I don't think I would have personally caught interest in that topic in any other situation, so I give a lot of credit to this project for the doors it has opened for the future. Familiarizing myself with Arduino and how these microprocessors can be programmed was a new challenge, but I felt intrigued to pursue work on these components to gain experience and also provide a valuable contribution to the team. Given our product choice, there were various components involved, each with a different aspect of engineering. Working with the valves was an interesting learning experience with a short learning curve, but useful in understanding how products can be integrated to work with digital and electrical components. As CFO, I was able to improve my hardware procurement skills and also communicate my thoughts and concerns with the team on what to purchase to minimize our overall budget. Lastly, the final integration which produced component failures was an important learning aspect about the nature of how any technology can react to real world stimuli; how to overcome those failures and bring the project back on track to meet deadlines. There were some initial communication problems and misguided work delegation, but as a weeks progressed, our team was strong and dedicated in producing the best prototype we could of a complex integrated product. In conclusion, I would say I definitely saw myself working harder than I ever have in my career as a computer-engineering student.

4.4. Ajaypal Khakh

For the past 13 weeks, I have gone through enormous learning cycles. My primary role was to fabricate the device and do the research and documentation. I have improved my overall personality. Every day was a new challenge and the unexpected was expected. This changed my attitude towards the work. Now, I can easily handle the situations that scared me off in the beginning.

I have learned skills that are essential to work in a group. I have become more patient and understandable. I realized that a person have to be patient and to try to understand and integrate varying ideas. Understanding and listening to the group members is vital for success.

I have learned the time management skills and understood that the time management is a vital thing that needs to be done well if a success is desired. We succeeded in completing our project because we managed our time wisely.

I have also improved my communication skills. I realized that communication between group members is vital for having a happy team. Communication enabled me to overcome the hurdles that seemed impossible to overcome individually. It allowed integration of our parts and preparation of well-documented reports. It turned out that meetings are most productive when we limit our discussions on the project. Now, I feel confident when I ask a question or answer someone else's question.

5. References

[1] "Protecting Workers Exposed to Lead-based Paint Hazards a Report to Congress" (January 1997), http://www.cdc.gov/niosh/c1-98112.html

[2] "*Just Paint*", Golden Artists Colors, November 2004, http://painting.about.com/od/acrylicpaintingfaq/f/acrylics_freeze.htm