Pill-Matic Product Post-Mortem

Rev. 1.1

Connor Dueck , Devon Louie, Adam Gabriel, Jerry Yao, Peter Hsu
ENSC305W, ENSC440W
4/20/16

Contact Person:
Connor Dueck
cdueck@sfu.ca
604.839.5671

Health-Assist

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Letter of Transmittal

April 18, 2016

Dr. Andrew Rawicz

School of Engineering Science

Simon Fraser University

Burnaby, British Columbia, VSA 1S6

Re: ENSC 305/440 Post-Mortem for the **Pill-Matic Pill Dispenser**

Dear Dr. Rawicz,

Enclosed is the Post-Mortem document for the Pill-Matic Automated Pill Dispenser. This document aims to provide context for our Pill-Matic prototype from an engineering design aspects as well as strengthen the business case for bringing such a product to the mass market. We have also highlighted the highs and lows during the development of this product and how we overcame challenges both individually and as a group. Finally, we provide some information regarding the logistics behind the Health-Assist team; including scheduling, workload distribution, and task assignments.

We have also enclosed the learning reflections of each member of Health-Assist in the appendix, as well as the meeting minutes that we have recorded since the beginning of our Capstone. These documents enabled us to keep track of what we have set out to accomplish all the way to our completed objectives and goals.

The Health-Assist team is made up of five senior engineering students from Simon Fraser University with the goal of creating products that promote a healthy and smart lifestyle. The team is made up of Conner Dueck, Adam Gabriel, Jerry Yao, Peter Hsu, and Devon Louie.

If there is any concern or question regarding anything related to our product or company, feel free to contact Connor Dueck by email at cdueck@sfu.ca.

Sincerely,

Connor Dueck
CEO of Health-Assist

1. Introduction

The Pill-Matic is a medical solution designed for patients that require multiple doses of different medications per day at different prescribed times. Its goal is to create a seamless integration system between a mobile Android app, a central Raspberry Pi, and the Pill-Matic dispenser, so that taking pills will no longer be such a tedious and daunting task for the average senior. At pre-defined user specified times, pills will be automatically available for use with the correct variety and number of pills already pre-set as well. These functions can be set either on the machine itself through a touchscreen on the physical dispenser, or through the Android Health-Assist mobile application that will form a Bluetooth connection with the dispenser. Through this, we not only limit the amount of human error in such an important daily task, but also ensure convenience and ease for those that especially require it.

2. System Overview

The Pill-Matic can be generally broken down into three modules that provide the overall technical aspect of the product. The first is hardware, which primarily covers the construction of the prototype. Next, the firmware covers the programming of the Raspberry Pi which serves as the brain behind the Pill-Matic. Finally the software module revolves around the creation of the Android mobile application.

2.1 Hardware Overview

On our hardware level, we have a completed prototype that is capable of selecting the correct hopper number (maximum of 8 allowable different types of pills) for the right type of pill, and also the number of pills needed. The dispenser contains a break-beam sensor that allows itself to see exactly how many pills have been dispensed so that it can either continue to dispense or stop. There is also another set of break beam sensors that allows the Pill-Matic to detect whether or not the user has placed a medication cup correctly into the dispensing holder. Everything about the Pill-Matic is designed for user safety, as the main target market for the product are seniors. Figure 1 shows the final completed prototype of the Pill-Matic.

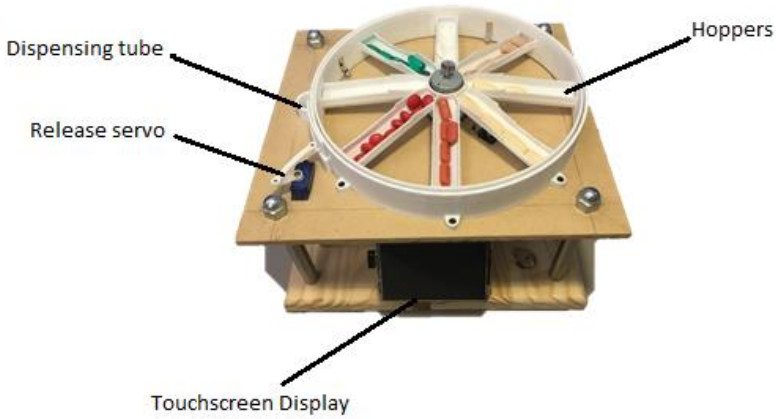

Figure 1: Final prototype of the Pill-Matic

2.2 Firmware Overview

The programming of the Raspberry Pi 2 and the subsequent creation of the GUI was the main goals of the firmware module. The intended purpose was to allow user to interface with a 3.5” touchscreen display that is mounted on the dispenser. Here, not only can the programming and scheduling of pills be done, but also it allows different levels of users to interact with the scheduling. With a username and password input, we ensure that only those responsible are able to change the pill dispensing time slots. Again, this comes back to our team’s focus on safety. The Pi will also be responsible for translating the Bluetooth signals received from the mobile application to the dispenser, and acts as the control unit for the hardware.

2.3 Software Overview

The software of the Pill-Matic consisted of the Android mobile app development. The code was written using Python in the Kivy Development Tool, and was chosen due to its simplicity and extensive functionality. On the Health-Assist application, users can add pills and schedule times for dispensing. The information is then transmitted to the Pi through Bluetooth and the Pi gets updated with the new schedule that the user has now set. Figure 2 shows the interaction between the app and the dispenser.

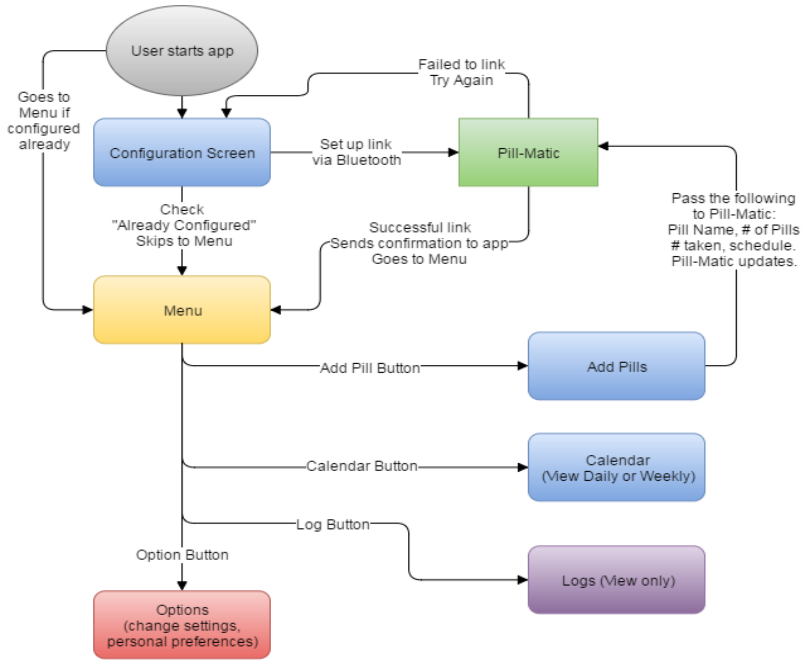

Figure 2: Mobile application flowchart

3. Product Logistics

3.1 Components and Cost

For the Pill-Matic, we had set out with a very modest budget proposal from the very beginning, and by purchasing parts and materials through cheaper sources, we have managed to stay well within of our initial budget. Table 1 below illustrated the expenditures we had undertaken for the prototype.

The 3D Printing of the enclosure and hoppers were done through a Vancouver based company that made it extremely cheap for us to print, and we had specifically chose ASB as the printing material due

to its price. For a mass-production however, this would need to be changed to PLA material since our product does have aspects of food safety and oral ingestion.

For the budget, we plan on applying for the Wighton Fund to solve the remaining dollar amount, and if it does get rejected; then opt to pay it out of our pocket split five ways.

Table 1: Expenditures of the Pill-Matic as of April 20, 2016

Item	Description	Total Price $ (CAD)
Pololu Dual DC Motor Driver	1A, 4.5V-13.5V	6.78
Pololu 6mm Mounting Hub		10.89
12V, Gear Motor with Encoder	12V, 58RPM, 60:1 Gear	29.21
12V, Gear Motor with Encoder	12V, 17RPM, 200:1 Gear	29.21
DFRobot Micro Server		9.58
3.5" TFT Resistive Touch Screen	For Raspberry Pi	39.56
12vDC 5A power supply		33.80
Socket Head Screws -3/4" x 4-40		8.70
HS-311 Servo Motor		10.45
Raspberry Pi 2		59.99
Bluetooth Module		15.99
Test Pieces	3D Printing	30.00
Storage Hoppers	3D Printing	65.31
Outer Ring and Enclosure	3D Printing	30.90
MDF, Small Nuts	Hardware Purchases	9.00
Nuts/Bolts	Hardware Purchases	9.78
PVC Pipe	Hardware Purchases	5.14
LockTite	Hardware Purchases	10.07
2 X Arduino Pro Micro	Previously Owned	10.53
Main Board Components	Previously Owned	10.00
Taxes		56.54
Total		491.43
ESSEF Funding		415.00
Remaining		76.43

3.2 Schedule

From the very start, our team had set out with strict and early deadlines to ensure that we had plenty of time to test, debug and finish up before the demo. In fact, in our initial proposal we had recommended a nearly 3-week earlier completion date of Mar 31, 2016 for everything except documentation. However, during the course of this project, we discovered numerous issues that were extremely time consuming, especially in the software department, and we had to stretch our deadline to April 15, 2016. This still put us in a great position to finish everything by the demo, as we had specifically chosen a later date of April 20, 2016 to present in order to give us even more time for flexibility. Figure 3 below shows the Gantt

chart from our initial proposal compared to the actual timeline of the Pill-Matic. From April 15 to April 29, we spent our time debugging, testing, and just ensuring everything runs as smooth as possible.

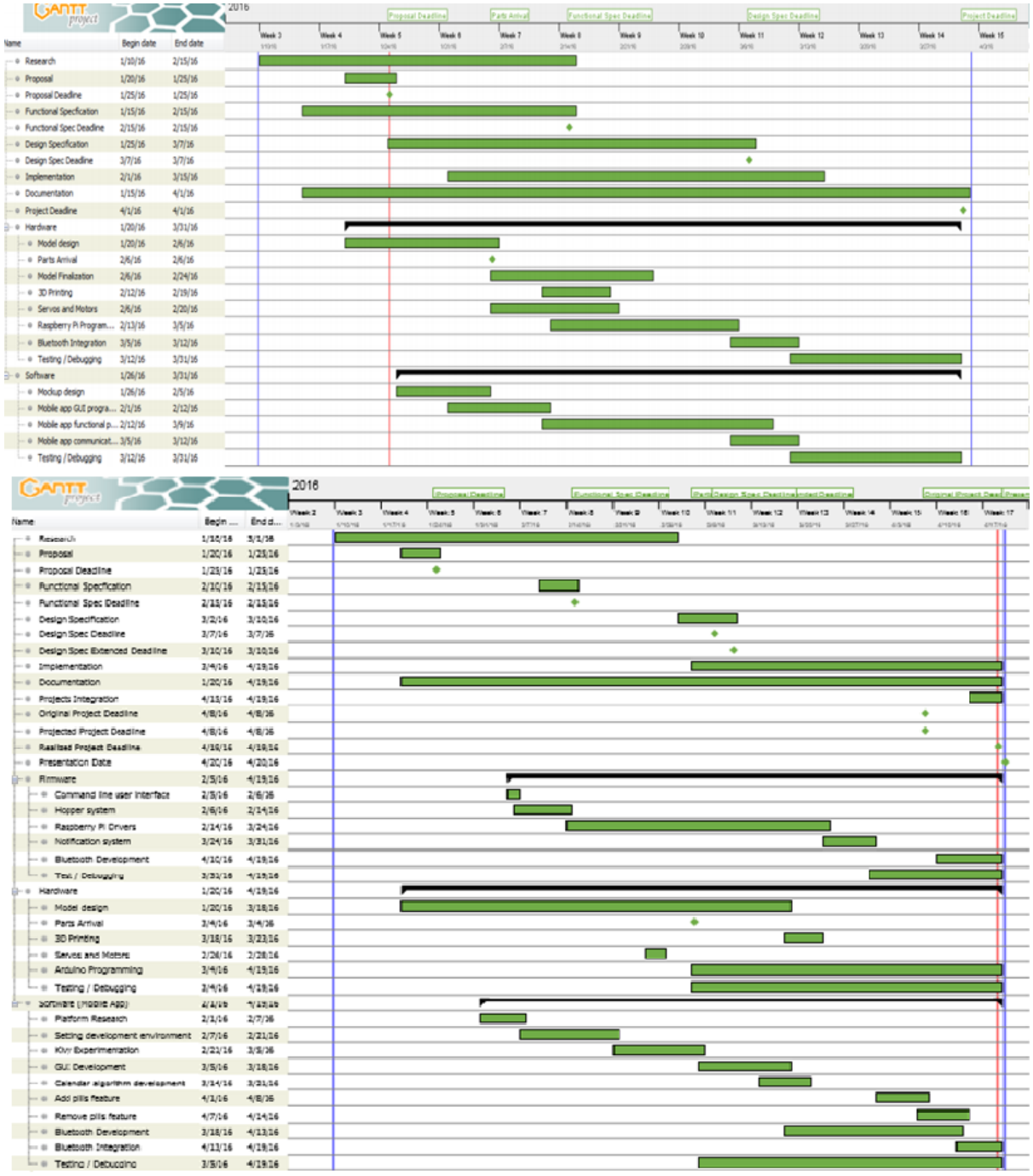

Figure 3: Planned Gantt chart (Top) vs. Actual Gantt Chart (Bottom)

4. Business Case

4.1 Target Market

Our primary market for the Pill-Matic is aimed at people aged 65+ who require a steady stream of medication daily in order to remain healthy and active. This demographic of people is expected to increase by a significant margin due to the aging baby boomer generation - who are also expected to have the finances available to purchase an item like the Pill-Matic. Our product also seeks to follow the growing trend of the “Internet-of-Things”, as smart household integration becomes more popular prevalent in the modern culture today. Similarly, due to our dispenser being capable of creating different user accounts, we can also see caretakers at senior homes use this to keep track of the pill schedule for multiple patients. This is our secondary target market, and is a relatively strong and stable industry for the Pill-Matic to enter as this could result in a number of units being bundled together to be sold immediately.

4.2 Pricing Scheme and Revenue Sources

The cost we did for the prototype version of the Pill-Matic is currently sitting at around $500 dollars CAD. If the product were to go towards mass-production we can expect to see the manufacturing costs lower in certain areas, but also increase due to higher functionalities being required as well as paying for any support staff and engineers. One area for improvement for example, is the 3.5” inch touchscreen that currently sits on our prototype, and is too small for the average senior to use with ease. At the very least the completed model will need a 6” touchscreen. Similarly, our prototype costs do not take account of the software and firmware creation – something that will be extremely expensive to support in the future, as we will need to hire dedicated engineers to build refined versions. However, we can expect materials cost to lower, as mass 3D printing will be significantly cheaper, and parts can be order in bulk to save costs. Combined, the costs should still end up around $500 dollars, and we use this number to plan our pricing scheme.

Currently if the product to enter market, we plan to sell it for $700 CAD, so that our profit margin will be around 25%, and it can still be cheaper than some alternatives on the market today as shown below in section 4.3.

Another plan if we were to tackle our secondary market of caretakers and medical staff is to propose a subscription model in which we can lease units out for large hospitals or senior homecare centers in return for a monthly payment. We can then provide on-the-ground support staff to help with any technical issues or simply just to provide tutorial services at different locations.

4.3 Competition

Our competitors all have similar but also vastly different products than the Pill-Matic. On one hand, we have companies like Ivation whose dispensers tend to be of the cheaper variety with very limited functionalities, and on the other, Phillips with a very expensive monthly subscription dispenser that allows for a much greater range of functionalities. However, one thing that makes the Pill-Matic stand out is our integration of the automated dispenser product as a technology platform where users can interact with it through a mobile application. We have also tried to add features that are not seen on our competitor’s machines, while also maintaining a competitive price. Table 2 shows a comparison of different available features between the Pill-Matic and its competitors.

Table 2: Comparison of competition vs. Pill-Matic

	Ivation	E-Pill	Phillips	Pill-Matic
Retail Price (CAD)	$150.00	$995.00	$49.00 Monthly	$700.00
Pill Capacity	336	700	1000	100 per hopper * 8 hoppers = 800
Reminder System	✓	✓	✓	✓
Max # of Alarms	4			2 Billion (Expandable with SD card)
Custom Scheduling		✓	✓	✓
Tamper Proof	✓	✓	✓	✓
Smartphone Notifications				✓
LCD Touch Screen				✓
Usage Record				✓

5. Technical Challenges

5.1 Hardware

The hardware design of the Pill-Matic can be broken down into three main sections: the motor/servo controller, the Raspberry Pi, and the mechanical components.

The motor and servo controller is based on an Arduino Pro Micro and is responsible reading sensors, detecting pills, rotating the main storage disk and dropping pills. Information about hopper number and how many pills is sent to the controller through a serial connection with the Raspberry Pi. With this information, the controller must decide the most efficient way to reach the desired hopper and must then dispense the correct number of pills.

The Raspberry Pi is the brain of the Pill-Matic and is responsible for all scheduling tasks as well as user inputs. Attached directly to the Pi is a 3.5 inch TFT touchscreen display and is the only way the user can interact directly with the machine. Along with the screen, a Real Time Clock and buzzer are attached directly to the pi for time keeping and alerts.

The original design for the Pill-Matic involved feeding pills, through the use of gravity, to a dispensing disk which would hopefully grab and dispense one pill at a time. Through much discussion, it was

decided that the design would not work for all shapes and sizes of pills. For the machine to be able to accurately dispense any type of medication, we decided to throw out the original design and switch to a dispensing mechanism based on vibration. Vibration allows us to control the flow of pills through the machine and with the help of a servo controlled gate, dispense the correct number of pills.

Challenges

From the hardware side of the project, one of the most challenging aspects was determining how to accurately and reliably dispense one pill at a time. Because medications come in various shapes, sizes and weights, a system had to be developed with could dispense medication regardless of is physical features. To accomplish this, we researched products that count and sort medication and determined the best way to approach the problem was with vibration. Using vibration to push the pills along a v-shaped ramp helped shift the pills into an easily dispensable formation as well as give use complete control over the movement of the medications through the machine.

Another hardware challenge which affected the performance of our final product was the lack of experience with designing parts to be 3D printed. Because of this, many of the parts which looked good in software, did not print as planned and had to be modified later. Finding ways to fix the parts resulted in a less accurate prototype and wasted precious time. We tried to remedy this somewhat by printing smaller test pieces first to ensure that the quality of printing was good enough before we sent in the actual project designs.

5.2 Firmware

Challenges

The firmware of the Pill-Matic device controls all major systems and interfaces with the smartphone application. In order to control the hardware, a custom serial protocol was devised and implemented to allow for checking in both the input and output streams. The self-control systems of the firmware keep track of the names of the medications, where they are stored, how many pills are contained in each hopper, and many other key functionalities, all the while processing notifications to see if it is time to dispense pills. The Bluetooth subsystem must be able to connect and send files to and from the device quickly and reliably, as well as translate these files back into regular calendar files for the self-control systems to use. All whole system presented many challenges due to their complexity.

As previously mentioned, the hardware control system required the implementation of a custom serial protocol, over USB-Serial. Designing this protocol presented many challenges, such as how to fit the required information into small enough packets to be transferred over serial, how to allow for checking so that if we dispense the wrong number of pills or another error occurs the user can be notified. In addition to this the protocol must also allow the firmware to be aware of when the other side is finished writing. This was accomplished by using a binary string to transfer data over USB-Serial from the Raspberry Pi to the Arduino. The communication protocol is based on a binary string of length 8. Outbound from the Pi to the Arduino the least significant bit represents whether we want to zero the hoppers, the next 3 bits represents which hopper we want to dispense from, the next 3 bits from that represents the number of pills we would like to dispense and the final bit represents whether or not to drop the pills from the containing level down to the cup. In the opposite direction, the first bit represents success or failure, 1 being failure, the next 3 are the hopper that was dispensed from and the next 3 represent the number of pills being dispensed. This means that when we dispense pills we expect

the output and input to be the same and are able to check the success or failure of the command based on this.

The self-control systems of the firmware are challenging due to the sheer number of parameters that need to be stored. Date, number of pills, medication name, hopper number, owner, the list goes on and on. Originally the firmware was written in C++, which presented its' own challenges due to cross compilation for the Raspberry Pi. In addition to the problem of cross compilation, C++ doesn't deal with files well and if a power loss occurs while a process is changing a file, corruption may occur. To deal with these issues, we switched to the bash programming language. This allows the code to be natively run in both Ubuntu (development machine) and Raspbian (Raspberry Pi) without cross compilation. In addition, bash handles files exceptionally well. Every parameter that the device knows about (number of pills, medication name and so on) is stored in a file. This allows easy access and essentially forces object oriented programming, which is a desired trait because it leads to high cohesion and low coupling of the code.

The last set of challenges were associated with syncing to the smartphone application. In order to do this, we need to connect over Bluetooth, transfer some data, then in the case of importing from the phone, re-write the local files with the new data we received. Originally we planned to transfer the entire file as one piece. This became a problem because it was impossible to transfer a file over Bluetooth from bash due to limitations in the language. Because of this we decided to send individual lines, this requires a custom interpreter on either side to take the file that was transferred and make it usable. This added additional complexity to the Bluetooth subsystem.

5.3 Software

Challenges

The Android mobile application developed for Pill-Matic acts as an auxiliary tool that allows the user to review information regarding their schedules without having to be physically near the machine. The application includes features to allow the user to transfer schedules to and from Pill-Matic via Bluetooth, add or edit existing pills, view daily or weekly schedules and view logs regarding the application. During the conceptualization stage of Pill-Matic, the mobile application sounded like a moderate task that could be finished with abundant time left. However, due to inexperience with the development tool and environment, the whole process became much more complex.

Health-Assist's mobile application for Pill-Matic was developed using Python with Kivy and Python for Android. Android in nature uses Java as the development language. Since members of the development team was familiar with Python, using Kivy and Python for Android would allow us to avoid having to pick up Java, which is much more difficult in terms of syntax and structure. It became clear early on that Python for Android was not supported for Windows and we had to adopt Linux virtual machines in order to do the compilation into an APK file to be installed on an Android phone. Unfortunately, there were great difficulties in setting up the environment as Kivy had many dependencies on other features that had to first be installed and there were no clear guidelines as to what Kivy required as a dependency. This heavily delayed the development schedule.

Since Kivy is not a well-established (2011), many of the features expected while developing an application were not available. We had to come up with work arounds and play around with the code until we obtained a working platform. One of these issues includes the fact that data grids and all native

Android development functions were inaccessible to Kivy or Python for Android. Fortunately, Python has a library called Pyjnius which allowed us to import native Java Android functions directly into our code and be used in a Pythonic manner.

However, a lot of work was spent into using algorithms to help sort and organize the schedule file in such a way that it could be displayed on the application. This was particularly time consuming as our convenient virtual machines or computers were unable to test the code as the functions required were Android specific only. This meant needing to upload the code to the phone and having to test it manually.

Unfortunately, whenever the application crashes on the phone, we are unable to easily track and locate the root problem, thus we have to constantly recompile and re-upload onto our phones and test it in order to make sure it still works as intended. Furthermore, due to the fact that Pyjnius was used, we were unaware of particular conventions that were required in order to avoid the application from crashing. Thus many hours were spent painstakingly looking through what was the cause of the application crash, which ended up being missing a simple line of code.

6. Group Dynamics

Health-Assist operated with a modular approach in regards to organization. While we met up every week for our weekly meetings on Fridays, we each had our own directives in terms of work completion. However, Connor Dueck did provide a strong voice in the direction of the project as he was the Lead Hardware developer, and the Pill-Matic was at heart, a hardware-intensive product.

Group atmosphere was always kept very positive throughout the development process as every member knew each other before this project, and there was a strong commitment in ensuring that people always had an equal say in raising their concerns or opinions.

In the last few weeks before the presentation, we had group integration sessions in which we were all involved in the integration, debugging and testing of the final product; resulting in members catching up on what the others have been doing and making sure that everyone has an equal understanding on the fundamentals of the project.

One challenge our team did face was the meeting of certain deadlines right as they are due, especially during the writing of the proposal. In order to remedy this problem, we immediately decided as team to begin work on the documentation a week prior to due dates. Similarly, by breaking down the group effort into modular pieces, communication between the group also slowed down, but we bypassed this by having frequent meetings to update each other and also have an active Skype conversation.

Table 3: Workload Distribution of the Health-Assist Team

	Tasks (P – Primary, S – Secondary, L – Limited)						
Member	Hardware	Firmware	Software	Testing	Integration	Logistics	Documentation
Connor	P			P	S	S	L
Devon		P		P	S	L	L
Jerry				S	L	P	P
Peter			P		L	L	L
Adam			P			L	S

7. Conclusion

From a scribbled design on a notebook to a completed working prototype has been one of the most satisfying projects that any of us at Health-Assist have done before. While it was certainly hard work, we managed to accomplish a great deal from both a technical perspective, but have also created lasting documentations for any future capstone teams seeking to follow our footsteps and improve upon them.

We believe that from a business and marketability standpoint, the Pill-Matic also has great potential in bringing some modern upgrade to a stagnating industry, and that in the future the Pill-Matic could be seen as part of an ecosystem of biomedical products that are linked via cloud. The product itself has very clear cut costs in terms of R&D as well as manufacturing, but we believe that at our recommended price point, it is still a very tantalizing product in the dispensing pill market today.

Our group during the entire process remained good friends, and have always treated both the project and each other with respect and enthusiasm. Health-Assist is a team that has very strong interdependence between each other, as every member has strengths and weakness that are complementary to the others. While our team has decided not to pursue this project any further, we have all agreed that everything that we have built for the Pill-Matic is something that will be cherished and memorized for our lives.

From a development point of view, we believe that there are still numerous improvements that could be made including a mobile app notification system, larger input screens, refining a modular case, enlarging the pill compatibility list, increase efficiency and speed in dispensing, and also to add more optional features such as factory resets and empty all hopper states. We also believe the mobile app can be pushed unto other OS platforms such as iOS and Windows to allow a larger pool of users to interact with the Pill-Matic.

Appendix A – Meeting Minutes

Health-Assist

AGENDA

January 29, 2016

10:20am-11:00am

TASC 1 Tables

Purpose of Meeting: To discuss problems with project proposal, assign rolls for next assignment, setup plan for all future meetings.

Items for Discussion:

- Project proposal recap
- Assign team rolls

Present: Devon Louie, Peter Hsu, Adam Gabriel

Absent: Connor Dueck, Jerry Yao

Purpose of Meeting: To discuss problems with project proposal, assign rolls for next assignment, plan for all future meetings.

Minutes:

Devon called the meeting to order at 10:30.

A. Problems with assignment #1 project proposal and solutions

Minutes were approved as amended:

- All in attendance have agreed the problems were
  - Starting too late

    - Not having clear rolls (who was doing which part of the document)
    - Deadline for submission to final assembler was too late
- To fix this we will take the following actions:
    - Assignment must be started at least 1 week in advance of the deadline for people to contribute to
    - Assignment rolls will be assigned prior to 1 week in advance of the deadline
    - The deadline for submission to final assembler is 3 days before the actual deadline of assignment (allows for proof-read & formatting)
        - Parts of assignment must be submitted 3 days before (no exceptions)
    - Assignment rolls will be related to overall rolls in the project (ie. Hardware engineer write hardware design and software engineer write software design)
    - All member must be reasonably available (at least 0.5/day per day) over the final period in order to meet.
        - If you are not must inform ALL member of the team ahead of time
    - If a member does not write it and does not inform other member, then the group will use the 3-day grace period to either reassign it or collaborate on it.

B. Assign rolls for next assignment

- Peter
    - Final assembly of document
    - Proof read of entire document
    - software technical correctness, process details, engineering standards, analysis, justification
- Jerry
    - Letter of transmittal/Abstract (whichever applies)
    - firmware technical correctness, process details, engineering standards, analysis, justification

- Devon
    - firmware technical correctness, process details, engineering standards, analysis, justification
    - software technical correctness, process details, engineering standards, analysis, justification
- Connor
    - Hardware technical correctness, process details, engineering standards, analysis, justification
- Adam
    - Introduction
    - Executive summary
    - Conclusion/References
    - Proof read of entire document

Discussion: All attending members discussed all bullets above and agreed that this was a fair distribution.

C. Scheduling future meetings

Discussion: All attending members discussed the best time for meetings

Action: All future meeting will be weekly on Fridays from 10:30am to 12:00pm (meetings may go less than expected time). Devon will prepare the meeting documents for each meeting and also structure the meetings. He will also act as minute taker and be responsible for leading the meeting.

D. Next Meeting Date

The next meeting was arranged for February 5, 2016 at 10:30am-12:00pm in TASC1.

E. Other Business

None.

Meeting was adjourned early at 10:42am due to completion of meeting.

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AGENDA

February 9, 2016

1:30pm-2:30pm

TASC 2 Tables

Purpose of Meeting: Status report on tasks, take a look at examples of functional specification.

Items for Discussion:

- Status report
- Review assignment examples

Present: Devon Louie, Peter Hsu, Adam Gabriel, Connor Dueck

Absent: Jerry Yao

Purpose of Meeting: Status report on tasks, take a look at examples of functional specification.

Minutes:

Devon called the meeting to order at 1:35pm.

A. Assignment #2 Status Report

- Peter
  - Python based tool for making android app.
    - Kivy
- Devon
  - Started on FW functional spec
  - GUI is a blank box
  - Backend firmware is coming along, blocked by not having hardware

- Adam
  - Market research
    - Talking to people that use a device like this
      - Adam's mom (Nurse)
        - Home use only, cannot compete with hospital
        - Questions to ask
          - # of pills / day
          - # of different types of pills
          - System currently used to dispense/regulate
          - Is there a need for something like this?
          - How often do people take the wrong?
- Connor
  - Hardware blocked by parts
  - 3D printing
    - Outside vs. Engineering lab
    - Going to prototype design by only printing out 1/8 of the total project
  - Laser cutting
    - $2/minute
  - IR Breakbeams
    - Working, outputs are inverted (ie. Active low)

B. Review Assignment examples

- We have all reviewed 3 examples of previous assignments.

Discussion: All attending members discussed all bullets above and agreed that this was a fair distribution.

C. Scheduling future meetings

Discussion: All attending members discussed the best time for meetings

Action: Submissions to Peter and Adam for assignment 2 are due on Friday Feb, 12.

D. Next Meeting Date

The next meeting was arranged for February 12, 2016 at 1:30pm-2:30pm in TASC2.

E. Other Business

None.

Meeting was adjourned early at 2:09pm due to completion of meeting.

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AGENDA

February 19, 2016

3:20pm-4:00pm

ASB Hallway Seating

Purpose of Meeting: Status report on hardware that has been delivered

Items for Discussion:

- Hardware parts that have been delivered

Present: Devon Louie, Peter Hsu, Adam Gabriel, Connor Dueck, Jerry Yao

Absent:

Purpose of Meeting: Status report on hardware that has been delivered

Minutes:

Devon called the meeting to order at 3:20pm.

A. Parts that have been delivered

- Connor discusses which parts have been delievered and gives a brief overview of what each does
- Connor discusses how parts are to be fabricated

B. 3-D Printing

- We will get the test parts printed at the same place we are going to print the final device
- Laser cutting will also be done in Vancouver
- Everyone agrees that the hardware design for the hopper is ready for 3-D printing

C. Motor Driver

- Motor currently overshoots the desired spot, this can be easily remedied
  - Only requires custom motor controller

C. Next Meeting Date

The next meeting was arranged for February 26, 2016 at 1:30pm-2:30pm in TASC2.

Meeting was adjourned early at 3:50pm due to completion of meeting.

Health-Assist

AGENDA

February 26, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Status report on all tasks, hardware review.

Items for Discussion:

- Status report
- Review 3-D and discuss changes

Present: Devon Louie, Adam Gabriel, Connor Dueck, Jerry Yao, Peter Hsu

Absent:

Purpose of Meeting: Status report on tasks, take a look at examples of functional specification.

Minutes:

Devon called the meeting to order at 10:37am.

A. Should we increase the capability of the machine to more than 1 type of pill?

- Connor brings pills to demo
- Connor
    - New design requires new 3-D printing
    - Uses vibration to control the number of pills dispensed
- Various group members debate design
    - We are going to go with the new design for increased functionality

- Discussion of how to format the storage
    - We decide to have pills move outward from the centre, because moving it inward from the outside is more difficult.
- 100micron transparent blue

B. App Status Report

- Setting menu working
- Create interfaces
    - Schedule, etc
- Mapped out software GUI flow

C. Design Report

Discussion: Have all submissions ready for Adam by Saturday March 5th at 12:00am or whenever Adam get's up.

3-D printing send in by Monday

Cut circuit board by Thursday

Firmware done by March 13

Software done by March 20

D. Next Meeting Date

The next meeting was arranged for Friday March 4, 2016 at 1:30pm-2:30pm in TASC2.

E. Other Business

None.

Meeting was adjourned early at 11:36am due to completion of meeting.

Health-Assist

AGENDA

March 4, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Status report on all tasks, design spec updates, more 3-D printing critiques.

Items for Discussion:

- Status report
- Design spec updates
- 3-D Priting critiques

Present: Devon Louie, Adam Gabriel, Connor Dueck, Jerry Yao, Peter Hsu

Absent:

Purpose of Meeting: Status report on all tasks, design spec updates, more 3-D printing critiques.

Minutes:

Devon called the meeting to order at 10:30am.

A. Status Reports

- Connor shows the new CAD design in solid works.
    - New design requires new 3-D printing

    - Uses vibration to control the number of pills dispensed, instead of gravity or some other feeding mechanism.
    - Various group members debate design
        - We are going to go with the newer design for increased functionality
    - Discussion of how to format the storage
        - We decide to have pills move outward from the centre, because moving it inward from the outside is more difficult.
    - Print type is white plastic (blue was silly)
- Devon talks about the firmware and his current progress
    - C++ is difficult to use, due to the cross compilation
    - thinking about switching languages to bash.
    - Bash also allows for easier file access
- Peter talks about the software progress
    - Nothing major to report, looking into the Kivy and playing with its' functionality

B. Design Spec Update

- Everyone agrees to have it complete before tomorrow morning so that Adam can compile the document.

C. 3-D Printing Critiques

- See section above

D. Next Meeting Date

The next meeting was arranged for Friday March 11, 2016 at 10:30pm-11:20pm in TASC2.

E. Other Business

None.

Meeting was adjourned at 11:36am due to completion of meeting.

Health-Assist

AGENDA

March 11, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Status report on all tasks.

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 10:32am.

A. Connor - Hardware:

- Pill dispensing mechanism
  - Current pill dispensing mechanism does not work. The pills do not come down the mechanism due to gravity alone
  - Using vibration has been proposed, will try for next week meeting

B. Peter - Software

- Still learning how to use Kivy, nothing to report other than that.

C. Devon - Firmware

- Command line user interface working, provides basic functionality to device.
- Need to figure out how to communicate over USB-Serial
    - Will use AT commands as stand in for testing as the behavior is similar

Misc.

D. Next Meeting Date

The next meeting was arranged for Thursday March 18, 2016 at 10:30am-11:20am in TASC2.

E. Other Business

None.

Meeting was adjourned at 11:20am due to completion of meeting.

Health-Assist

AGENDA

March 18, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Status report on all tasks, hardware review.

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 10:37am.

A. Hardware:

- Mill out platform base
- Pill dispensing mechanism

- Vibration seems to ‘work’
- Final assembly this weekend

B. Software

- Calendar to be done
- Bluetooth to be done
- User to be done as well

C. Firmware

- GUI to be done
- Figure out how to send integers to the Arduino

Mac

D. Next Meeting Date

The next meeting was arranged for Friday March 26, 2016 at 10:30am-11:20am in TASC2.

E. Other Business

None.

Meeting was adjourned early at 11:36am due to completion of meeting.

Health-Assist

AGENDA

March 26, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Progress reports

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 10:30am.

A. Hardware:

- Final assembly is complete, this is the hardware platform we are going to be working with
- All sensors are in place and controllable by the Arduino, we need to make it interface properly with the Raspberry Pi
- Compatibility with pills is okay, at least two type work > 90% of the time, trying to make adjustments for more pill compatibility

B. Software

- Adam is now working on the calendar and import/export template methods
    - Adam needs to learn the language and how to use Kivy
- Peter is working on Bluetooth and will integrate Adam's work into his once they are both complete
    - Work is progressing

C. Firmware

- GUI is now done, we can use it to add hoppers, pills, schedules and users, we can also log in and out
- Connor and Devon work on communicating from RPI to Arduino
    - The RPI works with AT commands but cannot communicate effectively, tinkering with the code to read and write from the USB-Serial commences.
    - More work needs to be done, Devon will work on the implementation over the week and come back next week with something new.

Misc.

D. Next Meeting Date

The next meeting was arranged for Friday April 1, 2016 at 10:30am-11:20am in TASC2.

E. Other Business

None.

Meeting was adjourned late at 11:28am due to completion of meeting and Devon having to go to class.

Health-Assist

AGENDA

April 1, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Progress reports

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 10:30am.

A. Hardware:

- Have added new features
  - Different vibration motor
  - Added tape to the dispensing hole to prevent pills from stacking
  - Removed the cross bar to reduce the amount of jamming that occurs

B. Software

- Adam is now working on the calendar and import/export template methods
  - Calendar is implemented
  - Importing/exporting the template files is more work, currently having problems reading and writing to files, seems to be a permissions issue
- Peter is working on Bluetooth and will integrate Adam's work into his once they are both complete
  - Work is progressing

C. Firmware

- Connor and Devon work on communicating from RPI to Arduino
  - We are now able to get the communication working, but there is a long delay on the Raspberry Pi side, Connor does not like this, Devon agrees that if possible it should be reduced.
- Bluetooth work is starting

Misc.

D. Next Meeting Date

The next meeting was arranged for Friday April 8, 2016 at 10:30am-11:20am in TASC2.

E. Other Business

None.

Meeting was adjourned at 11:10am due to completion of meeting.

Health-Assist

AGENDA

April 8, 2016

10:30am-11:20am

TASC 2 Tables

Purpose of Meeting: Progress reports

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 10:30am.

A. Hardware:

- Nothing to report, pretty much feature complete

B. Software

- Adam is now working on the calendar and import/export template methods
  - Calendar is implemented

    - Got past permissions problems, import/export now works
- Peter is working on Bluetooth and will integrate Adam's work into his once they are both complete
    - Able to send files back and forth between two Bluetooth enable cellphones, one acting as client and the other as server.

C. Firmware

- RPI is now able to more consistently interface with the Arduino, there still a delay which Connor wants removed
- Currently Bluetooth implementation cannot be launched from command line
- Software implementation sends lines, firmware implementation sends files, this will not work. Firmware will need to be adapted to send lines instead of files.

Misc.

D. Next Meeting Date

The next meeting was arranged for Friday April 15, 2016 at 10:30am-11:20am in TASC2.

E. Other Business

None.

Meeting was adjourned at 11:10am due to completion of meeting.

Health-Assist

AGENDA

April 15, 2016

10:20am-11:00am

TASC 1 Tables

Purpose of Meeting: To discuss problems with project and resolve them, as well as discuss progress

Items for Discussion:

- Discuss problems
- Discuss resolutions

Present: Devon Louie, Peter Hsu, Adam Gabriel, Connor Dueck, Jerry Yao

Absent:

Purpose of Meeting: To discuss current issues and discuss possible resolutions

Minutes:

Devon called the meeting to order at 10:30.

A. Problems with hardware

- Vibration was not sufficient to dispense pills in a timely manner
  - Putting a spacer between the hopper and the motor fixes the issue
- May not have enough power to drive motors and raspberry pi
  - Put raspberry pi on a separate power supply, change the raspberry pi USB cable, since the old one is broken
- Enlarge the pill hole
- Re-soldering connections

-

B. Problems with software

- Bluetooth doesn't work?
  - Need to send file instead of line by line
- No lock or alarm page

C. Problems with firmware

- Bluetooth doesn't work from command line
  - More work, can get it working
- Problems reading the response from Arduino
  - Connor gave Devon a test Arduino board to use to fix this problem

E. Other Business

None.

Meeting was adjourned early at 10:42am due to completion of meeting.

Health-Assist

AGENDA

April 19, 2016

10:30am-11:20am

ASB LAB1

Purpose of Meeting: Progress reports

Items for Discussion:

- Status reports

Present: Devon Louie, Adam Gabriel, Connor Dueck, Peter Hsu, Jerry Yao

Absent:

Purpose of Meeting: Status report on tasks and steps to completion

Minutes:

Devon called the meeting to order at 11:00am.

A. Hardware:

- Nothing to report

B. Software

- Adam nothing to report
- Bluetooth is working, with minor bugs, will be ironed out after the meeting.

C. Firmware

- RPI communicates without delay to the Arudino, Connor is happy
- Bluetooth can be launched from command line automatically, enables GUI to use Bluetooth
- Bug fixes to make phone template feature work properly

D. Presentation

- All group member agree presentation needs to be made today and we need to practice it both individually and as a group

Misc.

D. Next Meeting Date

Never (maybe one after the Demo but we will see)

E. Other Business

None.

Meeting was adjourned at 11:23am due to completion of meeting.

Appendix B - Personal Reflections

Connor Dueck – Chief Executive Officer, Health-Assist

Our project was split into three main sections and then combined at the end to form a working product. As the group member with the most hands-on hardware experience, I was responsible for the electrical and mechanical design as well as the assembly of the hardware.

Some of the most challenging aspects of this project involved mechanical design. As a system engineer, I have some experience with 3D modelling and hardware design, but my knowledge and skills were definitely tested during the last four months. Although I have taken a class on Solidworks and had a piece 3D printed, I had never designed parts, from scratch, to be printed and the evidence of this is present in our final product. Deciding on part thicknesses, orientation and how to mount components were decided on a “looks good enough” basis as I had no other experience to base the decisions on. Parts had to be modified after printing to make up for mistakes and oversights in the design process, which made final assembly more time consuming.

As the individual sections of the project began to wrap up, I spent many hours working with Devon to integrate out two systems. He was responsible for firmware on the Raspberry Pi and his system had to communicate with the Arduino based hardware system. The majority of the time was spent testing our communication protocol to ensure correct values were being sent and received on both ends of the system as well as general testing to ensure the correct numbers of pills were being dispensed.

From a technical point of view, I was able to sharpen my Solidworks skills and learn quite a lot about hardware design and designing for 3D printing. Through many hours of frustration and struggle, I also learned new methods for testing and debugging along with new problem solving techniques. As for soft skills, I learned a large amount about organization, timing and group dynamics. Deciding on meeting times, deadlines and workloads started off as a struggle, but by the end of the project, everyone was on the same page and things moved more smoothly.

In the end, I am extremely pleased with the way our group performed together and the product we built. The five of us were able to take an idea scribbled in a notebook and build a fully functional prototype. Without the efforts of each individual group member, we would not have been able to create a working product.

Devon Louie - Chief Financial Officer, Health-Assist

In my opinion, this project was a great opportunity to gain experience writing code from a different point of view than I had ever done before. I learned how to plan out an entire system, then how to go about implementing it in an effective manner. In additional to technical skills, I also gained insight into the difficulties and benefits from working in a group on a large scale project. Our group of 5 divided the project into 3 main sections, firmware, software and hardware. I was the lead engineer of the firmware section.

My experience writing firmware is fairly deep, as I worked as a coop at Sierra Wireless as a firmware engineer and continue to work there during my studies. Despite this experience, I had never approached a project from scratch and had to create an entire functioning system, with many subsystems. I had the opportunity of working hands on with the Raspberry Pi, which I used to implement the entire firmware package. At work and through school, my programming experience stopped at the GPIO level. While

working on this project I was able to go much deeper, delving into writing drivers to control touch screens, buzzers and implementing real time clocks. Based solely on breadth of material covered, this project gave me the opportunity to deal with much more than I had previously.

There were many obstacles while writing the firmware. Bash is not a very nice programming language to debug in, and the syntax is not the friendliest, but that became a relatively small problem as I quickly became familiar with the language, eventually getting to the point of comfortably using dynamic variables, something I had never done before in any programming language. In addition to this, I had never worked with a Raspberry Pi before, so I did not know how flexible the platform was. There were many parts of the project, including the USB-Serial connection to the Arduino and Bluetooth to the smartphone app, which I did not know would work until I tried them.

I was lucky and formed a group with some friends, but we had not communicated in a long time, due to coop and it took a while to get everyone on the same page. Although some members were more technically experienced than others, it did not prevent anyone from contributing themselves fully toward the completion of the project. A major problem we experienced was the inability to adhere to deadlines. This was because everyone had their own problems and somehow Capstone always was pushed to the back of the priority list. Eventually we set internal deadlines far ahead of the actual deadline in order to encourage early completion, but the success of this practice was highly varied. Despite this, we never missed an actual deadline.

In conclusion, this project was a great experience. Technically I was challenged and learned a whole new field I had never dabbled in before. I had to plan an entire system, and all of its parts, then implement them so they can run on a Raspberry Pi and interface with the smartphone application and hardware. I was also given the opportunity to work with great team mates, who were supportive of each other and tough when necessary. I have gained an amazing project to talk about during future job interviews and when people ask me what I do at school I can just answer “I am Devon Louie, lead firmware engineer at Health-Assist.”

Jerry Yao - Chief Operating Officer, Health-Assist

Very rare are we as students given the chance to work from a bareback design to a fully-fledged prototype with such limited supervision. The capstone project was a fantastic way for me personally to gain a ton of experience working with people from other streams of engineering. If there was one thing that stood out to me the most was when our group was working on the Functional Specifications for the Pill-Matic, and I just suddenly realized exactly just how many features that we needed to pack in order for us to fulfill our requirements. It was probably at that moment that I saw that we could really make a “wow factor” system.

For me personally, I was involved with the testing of pills compatibility as part of the hardware debugging team. In particular, we wanted to achieve the initial goal of being able to dispense any type of pill that we could potentially get our hands on, and so I set out to find the best method of improving our dispensing mechanisms to allow for this variety. From changing the base grooves of the tube, to linearizing the tube shake, we tried numerous methods of ensuring that both large and small kinds of pills would work in our system. Finally I set up a flap method that involved breaking the monotony of the larger pills so that they would not be able to stack on top of each other as they arrive unto the pill tube. At the same time, the flaps allowed smaller pills to easily fall and roll underneath, ensuring that the sizes

and shapes of the pills were ultimately indifferent to the Pill-Matic. It's this constant battle of testing and debugging and revising that has helped me learn more about the QA involved in a finished product, and has made me appreciate the amount of work that is needed in order for a company to launch a product.

During the hardware prototyping phase, I was taught how to use the ProtoMAT by Connor who had used it frequently during his last research term. This was invaluable as I had never seen a circuit board plotter in action before, even though it is a core component of building electronics.

As I was a compliance specialist during my co-op days, I was also put in charge of making the test cases and ensuring that they would work during our demo. This is something new to me, as I had always followed test plans, but have never actually made any myself, giving me valuable insight into deciding what to test and what to not. There was definitely some decision making involved as I had to gauge which test cases were deemed to be critical and which ones are trivial – since had I put everything I wanted to test for in the plans, the document might have stretched by at least triple!

Lastly, I want to say that working with my team was a blast. We all strove to improve the end product and despite disagreements, we compromised and listened to each other frequently for feedback. We were friends before the project, and I believe that with a completed capstone under our belt, we have formed an even stronger bond.

Peter Hsu - Chief Information Officer, Health-Assist

This project has given me many insights as to the development process of a prototype from conceptualization to the physical prototype. It has provided me with a view of how I would be developing in a larger part of a system. In addition, I have learnt how to use valuable tools that I will use again in the future. This project has also shown me how tools comes with a trade-off and depending on the project, certain trade-offs are more worthy than others. Aside from the technical side of the project, I have also experienced working with four other group members and the difficulties that come along with it in terms of communications and agreement. During this project, I was the lead developer of the mobile application of the project.

In terms of technical skills, developing the mobile application has exposed me to more tools that could potentially help me in the future for employment. I was able to learn the structure of the application and how it to develop features for it by reading up API references and documentations. I also learnt that having an outline of what to develop immensely decreases the amount of time wasted on constantly tweaking sections to meet what is required. For example, we had the whole graphical user interface clearly drawn out and outlined, which allowed me to develop that whole portion in days. But when it came to developing the rest of the application, many hours was spent coming up with how to complete it and led to constant trial and errors.

I also believe that if I had to do something similar in future projects, I would put much more consideration into the development tool and the environment that comes with it. Although I was familiar with the language used to make our application, both the tool and environment were very different from what I had been exposed to, thus I had quite a learning curve to go through before I could effectively start building the application. This learning curve consumed much of my time and was one of the reasons why our application development ended up being pushed back by weeks.

Communication amongst the members was something that we had drastically improved upon from the beginning of the project. Although we all knew each other from other friends and courses, we never worked together as a team. This meant that we initially had a slight barrier when it came to discussing roles and our overall progress on the project. As the project progressed, communication became more crucial due to the need to know how each other were implementing certain features to avoid incompatibility during the integration phase. This quickly transformed the performance of our overall project and we reported to each other what we had accomplished. Unfortunately, there ended up being last minute inconsistencies that had to be fixed, but they were relatively minor and were taken care of without much hassle.

I believe that this project has given me an excellent insight as to what to expect of a typical project with other group members. In personal development, it meant being able to reason to myself and others why we should use certain tools and environments to develop our product. But at the same time, it also means being able to appropriately assess the time required to pick up a foreign development tool and be able to use it proficiently to development effectively. I have also learnt how to communicate roles, tasks and progress amongst other members in the project and to clarify the set out requirements so that we avoid confusion and issues during the integration phase. I believe that with these new knowledge of mobile application development, communication skills and the experience of having worked with a project will be highly beneficial to me in the future. Capstone had provided me with a great overall experience of product development.

Adam Gabriel- Chief Technology Officer, Health-Assist

Capstone was an incredible unique opportunity to grow both on a personal level and as an engineer. The chance to build a fully functional prototype from scratch is a truly a “once in a degree” learning experience and it was a pleasure to share it with good friends.

In terms of contribution to the group, I was the Chief Technology Officer. Fancy terms aside, my role in the team would be better represented by the title “Secondary Software Engineer”. Together, Peter and I were given the task to develop an android companion application for the device. I personally was responsible for a number of the mobile applications core features including the day view calendar, week view calendar, as well as adding or removing pills from the existing schedules.

This semester was filled with obstacles and challenges that mainly stemmed from the use of Python Kivy to develop our android application. This project was not only my first experience programming with Python, but also developing an application using the Kivy environment. The combination of two new experiences led to nearly more time spent researching how to implement my ideas then actual coding. Due to the rather steep learning curve of Kivy, the early stages of software development were well behind the scheduled deadlines. If I were to undertake a similar project again, one thing I would consider changing is the implementation of the mobile application. With only four months to build a fully functioning prototype, I would not recommend developing an android application using an unfamiliar technique and programming language.

Beyond learning Python and Kivy, Capstone has helped me to sharpen a number of other technical skills. Each of the features I developed on our application involved a different algorithms to modify or display the information sent in a .txt file from the Raspberry Pi. These algorithms were incredibly tedious to implement and included quite a lot of code. Long and tedious code, coupled with learning a new

programming language and environment, resulted in an unbelievable amount of time spent debugging. Testing and debugging line by line drastically improved not only my attention to detail but my patience.

For a Capstone group consisting of five friends, the level of communication and coordination was not at the level I expected at the start of the semester. After the first document was completed minutes before the due date, the group decided to set aggressive internal deadlines for all further assignments. This helped me focus on the task at hand and my increase in productivity was surprising.

Overall, I am incredibly proud of what our group has accomplished in as little as four months. Over the course of a single semester, five friends became teammates and transformed an idea on paper into an unforgettable project. I want to thank my teammates for the great memories.