ENSC 305W/440W

Post-Mortem

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1.0 Introduction

The following documentation describes high-level functionality for the final prototype of the Hermes camera slider motion controller, along with the software, hardware, and firmware design process. A comparison table between estimated and actual costs and a schedule will be provided in this report. In addition, major challenges, solutions, group dynamic, and individual reflections on the project will be covered.

1.1 Project Background

In cinematography and video production, smooth motion is key to natural and fluid cinematic shots. The Hermes camera slider motion controller is an innovative solution to capturing smooth time lapse and stop motion recordings. Both professional filmmakers and independent videographers could use the Hermes as an add-on to their existing sliders and download the application available on the Apple App Store (pending submission) on their Smart phones to control camera movement. Motor installation and iPhone application are designed with a minimal learning curve, and competitive pricing, below current competitions will make Hermes the ideal candidate in film market.

2. System Overview and Features

The following section outlines the primary functionality of our product. The following figure outlines the high-level block diagrams of the motor control block and phone control block.

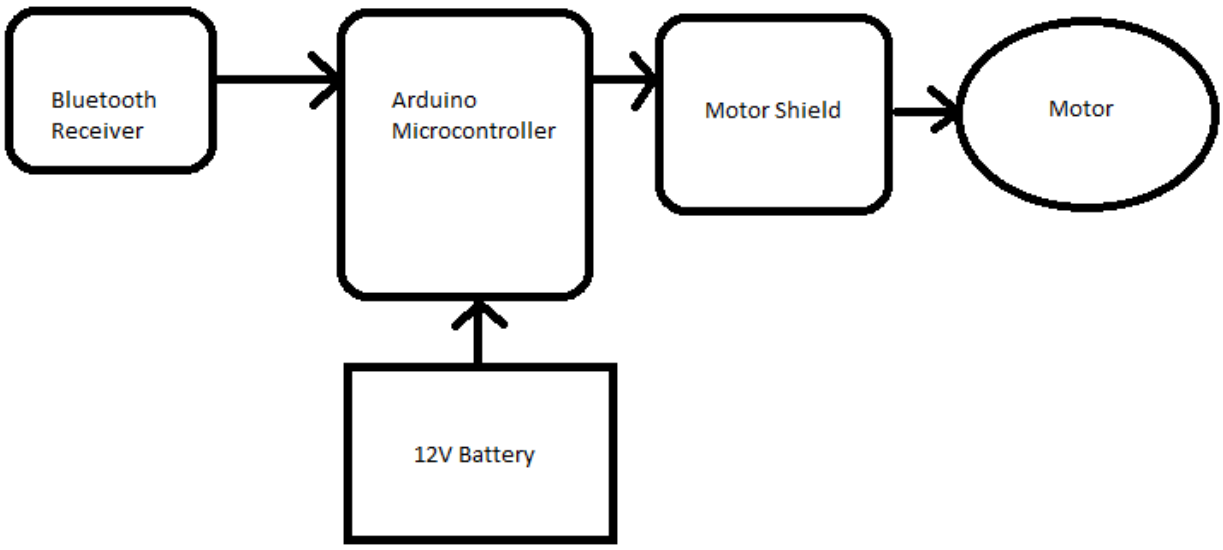

Figure 1: Block Diagram of Motor Unit

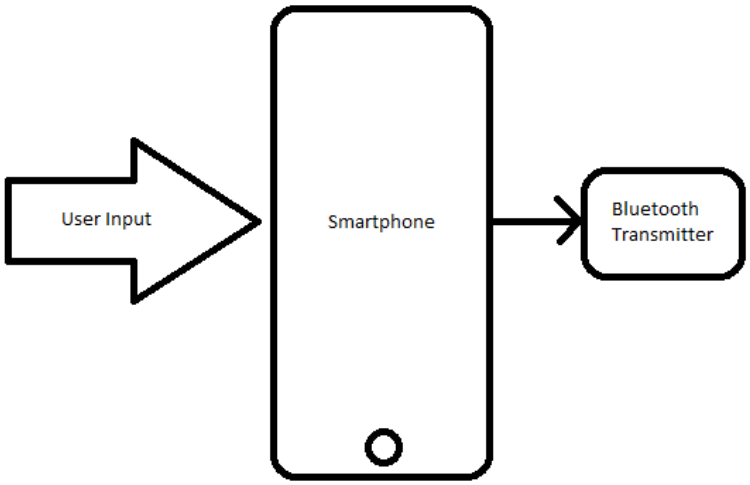

Figure 2: Block Diagram of Phone Control Unit

The Hermes camera slider is a means to provide a professional level photography experience to the amateur photographer. Our product offers the unique experience provided by a substantially lower price tag, and a smoother user interface than commercially available models.

First of all, in order to accommodate the diverse needs of up and coming photographer, our slider system is able to operate in a variety of modes. The first of which is the live mode, which provides real time control of direction, speed, and damping values of the slider system for an organic shooting experience. Second is the time-lapse mode, which allows for extended motion filming, over a specified distance over a designated period of time. Lastly is the stop motion mode, which allows the photographer in question to take a series of pictures between camera movements.

Furthermore, due to the fact that the safety of the user was considered a major concern during the design of the Hermes system, the system was designed with safety in mind. The first of these features is a kill switch, which allows the user to halt the slider movement at any time during its process in the event of an emergency.

In order to make our slider more environmentally friendly, the mount for the motor was constructed with the renewable resource of wood. The use of this material served the dual purpose of reducing the total weight of the system, an important feature for a mobile camera slider.

The Hermes motorized slider is triggered through the use of a mobile app. The user input from the smartphone app communicates with the brain of the system, an Arduino Uno microcontroller,, through the use of Bluetooth information packets.

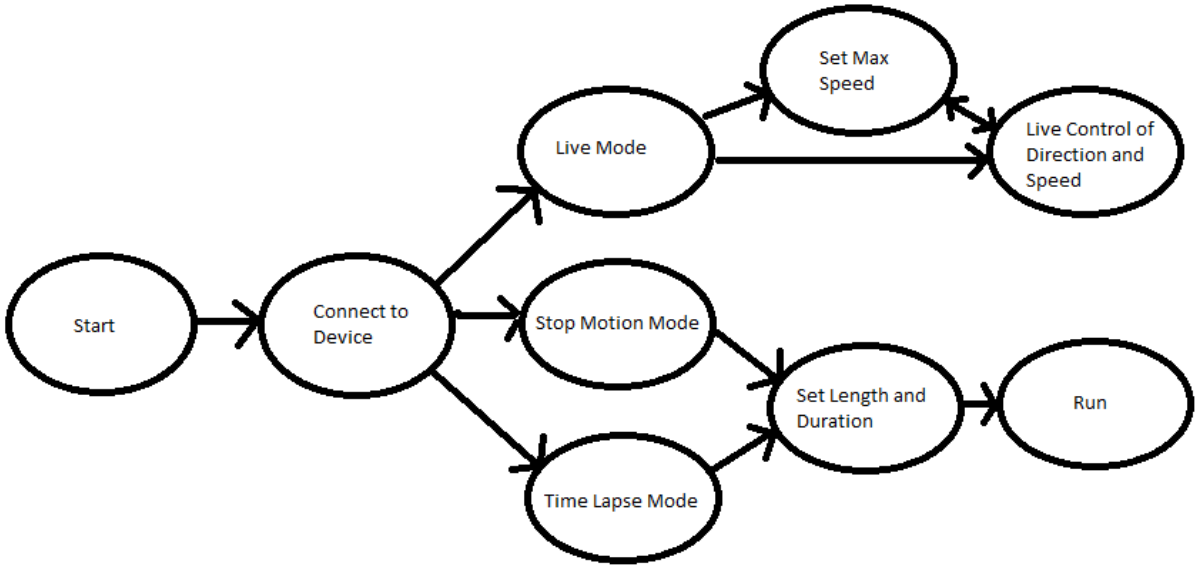

Figure 3: Block Diagram of User Control

As can be seen in the preceding diagram the user options are relatively limited. In the live mode they can control the slider in real time as well as setting maximum speeds. Stop motion and time-lapse are very similar to one another. The user sets the length and time desired and then the slider is set to move along the track. These two modes continue to function even with a disconnect from the user app.

3. Budget

ESSEF fund run by ESSS was our source of income to cover expenses, and Cassiar MediaWorks lent us the Hedron slider through the semester for testing and installation purposes. Details are summarized in the following table:

Table 1: Estimated and Actual

Item	Estimated Cost ($)	Actual Cost ($)	Difference ($)
Raspberry Pi and Power Adaptor	60.00	51.71	+8.29
JR DS8231 Ultra Precision Servo	90.00	27.00	+63.00
Arduino Uno	40.00	39.14	+0.86
Nano Bluetooth Dongle	5.00	0.00	+5.00
Edimax WiFi Adapter	15.00	0.00	+15.00
Cirago Bluetooth and WiFi	45.00	25.82	+19.18
22.2 V 2.6 Ah Battery	100.00	0.00	100.00
Smart Charger	37.00	0.00	+37.00
Enclosure	100.00	0.00	+100.00
Contingency	98.40	243.32	-144.92
Adafruit Motor Shield for Arduino		51.64	
Breadboarding wire bundle		7.77	
N3 Cable		18.31	
3D Printed Gear		8.00	
Premium Female/Male Jumper Wires		2.52	
5V 2A Switching Power Supply		10.29	
Bluefruit LE - Bluetooth Low Energy		25.82	
Apple Developer Account		119.00	
Total	590.40	387.02	+203.38

4. Schedule

Time management is one of the main challenges that each team will face in order to meet the scheduled deadlines. As it is shown in Figure 1, there are many differences between the estimated and actual timelines. Building the iPhone application, Smart phone and controller communication, and debugging/testing took much longer than preliminary planning suggested, fortunately however, the original schedule was designed conservatively enough to allow for heavy deviation. Given this, we were more than able to complete the entirety of the project on time.

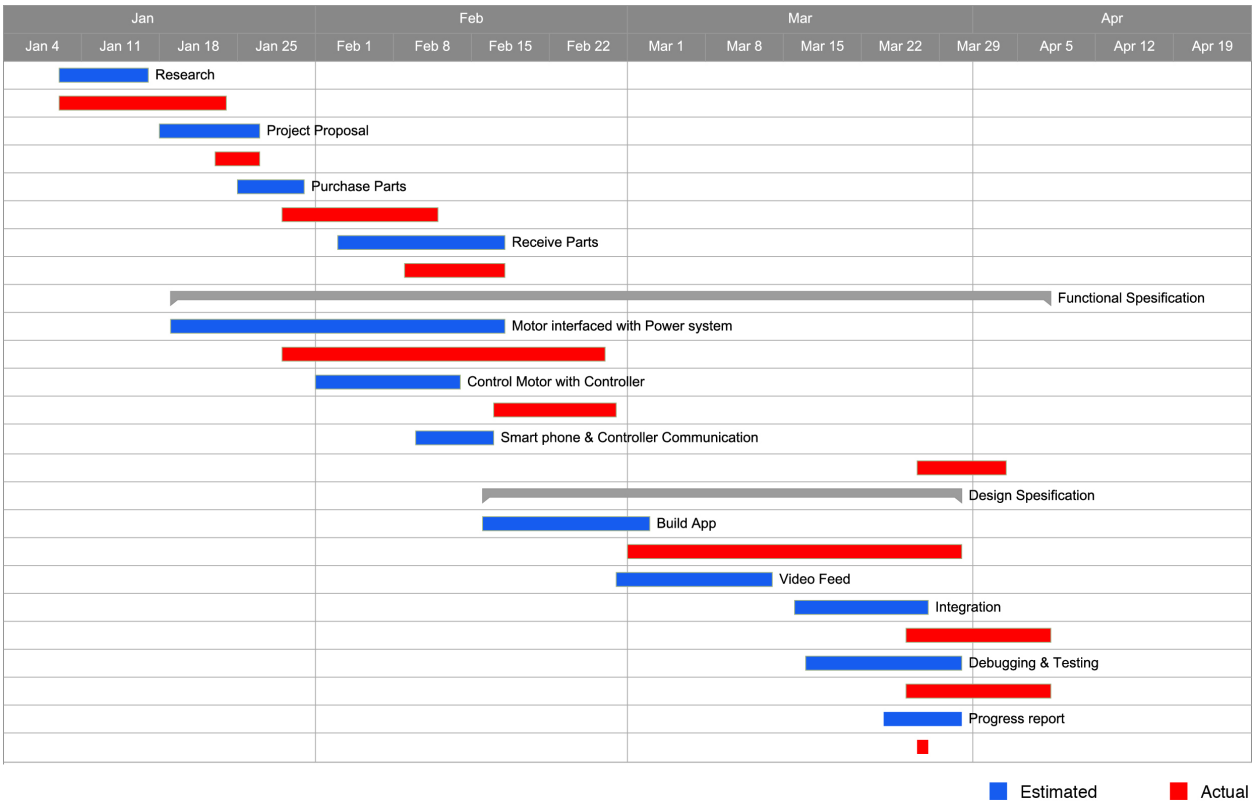

Figure 1: Estimated and Actual Timeline

5. Problems/Challenges

The main technical challenges that we encountered revolved around the diverse range of speed and precision that the slider was required to move at. After lengthy research, the solution presented itself in the form of a powerful stepper motor in conjunction with a custom arduino library, in order to allow for smooth stepper motion at speeds lower than 1 RPM, as well as for motor acceleration, which allowed for faster motion under larger loads.

In terms of the mount, difficulty stemmed from the weight limitations, as well as the high degree of precision that is required for the mounting of electronic components. The issue of weight was solved through the use of light wooden material as opposed to the sheet metal that was originally considered. The issue of high precision was solved mostly through trial and error as well as through meticulous design and measurements.

6. Group Dynamics

The vitaMotu team is structured in order to take advantage of the wide range of specializations possessed by our members from computer, electronics, system and engineering physics. All of the team members have great academic and industrial experiences in various fields such as firmware engineering, hardware engineering, and mobile application development. For technical role distribution, each member took a role on both development and testing tasks. Good communication, attending meetings, sharing ideas, dedication and work ethics were all employed to minimize group conflicts. Meeting minutes were taken regularly, close to twice a week, and other communication such as e-mail and Google docs are utilized as a central hub for project files and document sharing.

7. Workload distribution & Reflections

The following table summarizes the workload distribution among group members. The load was distributed equally based on individual experiences.

Table 2: Workload distribution

Task	Behnaz	Brendan	Calvin	Justin	Martin
Documentation	xxx	xx	xx	xx	xx
Software Development	-	-	-	xxx	-
Hardware Development	x	xxx	xxx	x	x
Firmware Development	xx	xx	xxx	xx	xxx
Assembling & Soldering	xx	xxx	xxx	x	x
LANC	xxx	x	xx	x	xxx
Debugging & Testing	xxx	xxx	xxx	xxx	xxx
Team Management	xx	xx	xx	xx	xx
Meeting Minutes	xx	x	x	xx	xx

8. Individual Learning

Justin Raine - CEO

Over the last four months, I have had the pleasure to work with the vitaMotu team in developing the Hermes motion controller for use with camera slider systems. Acting as CEO and Lead Software Developer, I have experienced the benefits of working closely in a team with a united focus as well as encountering – and overcoming – numerous design and technical challenges.

As a fourth-year student at Simon Fraser University, I have experienced a wide-range of group dynamics from combative partners to those willing to take on the entire project themselves. Over the last semester, however, I have had the opportunity to work in a team with clear vision and shared enthusiasm for a quality end product. This has extended my experience working within a group beyond simply that of an easy project. Instead, I now understand the accomplishment and camaraderie that comes with team collaboration and tackling difficult problems as they arise.

Healthy team dynamics promote effective communication. As projects become more and more complex and technical in nature, clear communication becomes vital to the success of the team. I experienced this all throughout the semester. As someone who previously worked with a film company, I acted as a domain expert to a fair extent. As a result, I was tasked with communicating the user's needs and expectations to the team. While I was unable to do so perfectly, this experience has highlighted the potential challenges such a task faces.

Furthermore, specific technical challenges required very specific, clear communication within the group. Throughout the software development process I was required to work closely with Calvin Scott, our Firmware Engineer, in developing the communication protocol between the hardware and the mobile app. Through this process I learned the shortcoming of purely verbal communication and how additional aids in communication, such as internal documentation and diagrams, can greatly enhance this vital inter-team communication.

In addition to team-related technical challenges, several issues arose within my designated area of responsibility which forced me to seek out new information and solve new problems. Prior to ENSC 440W, I had no technical knowledge of the Bluetooth LE protocol or device implementation. This project challenged me to seek out the range of hardware available to independent inventors and tinkerers as well as the details of the protocol and how communication is facilitated. As someone keenly interested in personal electronics, this too will prove to be vital experience.

Overall, my experience working with the vitaMotu team has been greatly beneficial to my development as an engineer and a highlight of my school career at Simon Fraser University. I would like to thank my team and professors for this opportunity and encourage the school to implement more long-term team projects and positive team building throughout the engineering curriculum (and, of course, the checks and balances necessary to ensure a positive dynamic exists for all those willing to work hard, contribute, and behave respectfully to those within the team).

Brendan Keane - COE - Archduke of Arboreal Artifacts

Throughout my engineering degree, I have thought that there has been a troubling lack of hands-on project work: ENSC 440 was to me, the chance to fix this problem. The aim of this project was not only to gain hands on experience associated with working with a product from inception to production, but also to finish this course with a functional product.

Our team was formed largely from pre-existing friendships, which was a huge advantage in terms of communication and teamwork. In combination with a broad spectrum of experiences that comes with possessing group members from most streams of engineering, there were few fields we did not have personal experiences in. Although I naturally fell into somewhat of a leadership role, my well rounded, motivated, and all around exceptional team left the position largely unnecessary, making the overall experience undoubtedly a privilege.

During the early stages of the project I acted by ensuring that each step in our design was working towards a practical, and implementable solution. Due to the fact that I was lucky enough to work with such a highly motivated team, this mind set proved to be an asset, as the large amount of free flowing ideas were able to be channeled and focused on specific goals. Throughout this portion I learned the importance of keeping structured, regular meetings, as well as defining finite, quantifiable goals for each group member in order to maximize productivity. Towards the bulk of the project I took on the lead role for hardware and operational design and implementation. This comprised largely of basic motor and mount functionality and construction. This gave me a chance to really get my hands dirty with the various steps of mechanical design and fabrication. Additionally, due to my focus on overall functionality, I worked closely with Calvin throughout the construction of the Arduino code.

If I were to participate in a project like this again, I would be more rigorous in my selection of minor parts, while less rigorous in my selection of some major parts. During the early stages of the project, I spent much time familiarizing myself with motor design and functionality in order to insure that the selected device operated to specifications. The problem with this method was that due to the high degree of uncertainty in many aspects of motor function, the exact specifications were difficult to pin down without a good deal of time consuming testing. Therefore, in this case the better solution was to simply acquire an easily available motor to run tests with, and set a base line, and upgrade later if the system demands it. In regards to problems with small parts, major time delay resulted from tracking down specific parts required for various electronic parts. I initially assumed that any variety of part required for basic assembly would be readily available, sadly this was not the case. If done again I would plan out and acquire the exact components needed for assembly ahead of time instead of waiting for the last minute.

Overall I would consider this project a success. Although there were a fair share of problems along the way, overcoming them added a lot to the experience of taking a project from a faint idea, all the way through to a functioning model. In the end I am confident that we developed a product that any enthusiast would be proud to own.

Calvin Scott - CIO - Sultan of Soldering, Grossly Incandescent Beacon of Breakfast

While developing the Hermes Motion Controller with the team at vitaMotu, I have gained vital experience in team dynamics and independent development. Along with this I have learned the importance of proper communication and planning. Without splitting up the design into discrete parts, we would have never completed the working version of our product. However, without proper planning and management, successful integration of our separate parts would have been much more difficult. Bringing all of the pieces together required the team to have somewhat of an understanding of the individual portions that each other was working on.

Going through my engineering science degree and studies I have largely not come across many projects that have pushed me to learn as many new skills as I have throughout this project. Through mistakes and rigorous hours of debugging I have come out with a wider range of technical abilities including soldering and embedded system/software design. More classes like ENSC 440 would bolster both the technical and soft skills that are developed with self-directed projects like these. In fact, without this class, some options such as Engineering Physics may face a degree without building any of these design oriented skills.

If I were to face a project like this again I would do much that I did the same, but perhaps I would dedicate more time to learning and understanding other parts of the project in order to help make the final integration more seamless. Along with this, I would possibly keep more documentation throughout the process, as once it was time for my team members to help debug some dysfunctional code, I had to completely explain portions over and over again for them to get an idea of what was happening.

Though doubts arose during the development process of how our product was faring and how complicated it was getting, the team here at vitaMotu luckily had no extenuating arguments or disagreements. All issues regarding the direction that the design was heading was worked out intelligently and with thought to each of our opinions. Only a couple instances of miscommunication occurred throughout the entire semester, and they were completely harmless since they only affected general progress meeting times. Keeping in touch with a designated chat group was key to knowing exactly what everyone was doing and if they were on top of what they were assigned - without necessarily to meeting in person.

Having a diverse set of engineering students completely balanced the workload throughout the project, and our group dynamics were the closest possible case to being ideal. Though originally built with pre-existing friendships, I have also gained a new friendship with my team member Behnaz Edalat along with strengthening the bonds of those I previously knew. Having the chance to face the Capstone project with a group as dedicated as the one I am apart of now is - without a doubt - a great privilege, and I wish the best for everyone who I have had the pleasure of working with.

Martin Palibroda - CTO - Viscount of Debugging

Working on the Hermes camera slider has been a great opportunity for me. Before this, most work that I have done has consisted of assigned work with limited degrees of freedom. However, working in a relatively flat organization has taught me many skills that will be invaluable to my future career, as well as providing a new level of self-understanding.

One of the things that went well was our general group dynamics. There were never any feuds, non-contributors nor large problems. On the other hand, the issues that did crop up included differing of opinions on some subjects, and perhaps a sense of apathy that developed towards documentation as the burnout increased. For the first, I learnt a twofold lesson: sometimes it is best to temper view of a subject and try and view it with an unbiased eye. This ensures smooth group dynamics and prevents the stifling of innovation. The flipside of this is, however, that sometimes it is best to stand one's ground. I had been strongly opposed to any unnecessary soldering of components, though other group members were eager to connect all components, making a svelte circuit. A consequence of this ultimately was the destruction of our circuit which required the replacing of both the Arduino and motor shield to repair, resulting in a week's loss of productivity. We were lucky that both these parts were stocked locally or the damage would have been worse. Had I been more insistent on what I felt was right in that case we likely could have avoided this mishap.

On the technical side I improved my ability to develop embedded software, improved my ability to construct prototype hardware and vastly improved my documentation skills. I have extensive experience with embedded software for an undergraduate student, and this project further developed these software skills, especially improving on my ability to decipher and debug others' code. On the hardware side I improved on my ability to construct prototype materials, using wood and other materials. Though I did not use Solidworks, observing my partners do so gave me a basic understanding of the software. Finally, the experience making the various technical documents greatly helped me in two ways. In the first it stood to sharpen my writing ability which had not been exercised much since leaving high school. For the second it gave me an insight into the workflow that goes into creating a highly technical document, as well as developing this ability. I foresee this being a great asset to my future working repertoire.

My biggest regret of the project is not keeping more in sync with the development of the firmware of the project. My first co-op term working as an embedded software developer for Optigo Networks gave me lots of experience on working with embedded software, as well as developing best practices for coding. As I was the one who ultimately ended up fixing quite a few of the serious bugs in the firmware, keeping more on top of the development of the code would have sped up this process dramatically.

Overall, it has been a pleasure to work with my incredibly talented partners, and I would be glad to work with any of them in the future. I have learned many technical and interpersonal skills from this project, and I am eager to see its success in continued development.

Behnaz Edalat - CFO - Paints in All the Colours of The Wind

Since the beginning of this project, our group has taken different stages to design, implement, debug, and test the vitaMotu Hermes camera motion controller. We started by brainstorming on the subject of project through the first few meetings. Different tasks have been taken based on technical and academic background of members. We started researching on various aspect of the project, and worked on the functional and design specification in parallel. Communication between mobile application and controller, integration, testing and debugging took longer than what we expected, but we could complete the entirety of the project on time.

In this project, I contributed to implementing LANC in the Arduino platform, assembling and mounting the motor, helping in testing and debugging, and taking minutes during our weekly meetings. When I started this course, I have no knowledge of LANC protocol and didn't know how to implement it in Arduino platform. I researched and read more details about LANC protocol, and learned how to make a connection between camera and microcontroller. As LANC is a bidirectional serial open collector communication port by SONY, which we were able to send different commands to camera for capturing images, start/stop recording, focusing and many more application. We used a Canon camera sponsored by Cassiar MediaWorks for testing. The Canon company has its own commands for LANC protocol, which some of the commands were different from the original protocol. Martin and I could build the circuit based on the online diagram for LANC by using two resistors, a BJT, and a diode. We were able to make the capturing image to for in all the live, time-lapse and stop motion. Unfortunately, we couldn't implement the recording command to work on Canon cameras, but we would consider it as the future alterations. Helping Brendan on mounting motor on the slider teaches me more hands on experiences that I never had a chance to learn in university.

Besides academic learning, I also found out spending more time on research phase would save us more time in integration, and testing phases. Proper planning and setting timeline conservatively helped us during this project and we could complete different stages of this project on time. My teamwork skills has been improved by working in a team for almost 4 months.

Overall, I learned valuable hands-on experience in a real engineering project that we planned from beginning. I wish we had more chances in SFU to take project-based courses to examine our academic knowledge, and use them in practice. Moreover, my team works skills have improved by working in a team through the whole semester.

9. Conclusion

Over the course of this project we were able to create an innovative product, easily meeting the industry standard of quality. This product manages to meet our functionality goals, while still maintaining its highly portable and easy to use outlook. Possible follow up for this project would include hardware to support a live video feed as well as the addition of another degree of camera motion. These features as well as further accuracy improvements and debugging will ideally be addressed before seeking financial backing in order for product launch. Additionally, the control app will be posted on the app store upon project completion in order to contribute to the open source community, which has played a major role throughout project development.

Appendix A – Minutes and Agendas

vitaMotu Meeting Agenda

Meeting Information

Date:	January 8, 2015
Time:	13:30 – 14:30
Location:	ASB 9886
Meeting Lead:	None

Agenda Items	Presenter
1. Introduction	Multiple
2. Outline team member history and strengths	Multiple
3. Capstone project idea brainstorming	Multiple
4. Determine next meeting date	Justin Raine

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	January 12, 2015
Time:	13:30 – 14:30
Location:	ASB 9886
Meeting Lead:	Behnaz Edalat

Agenda Items	Presenter
1. Idea Proposals:	Multiple
2. Collision warning glasses for the blind	Justin Raine
3. Aftermarket adaptive cruise control	Justin Raine
4. Automatic bench press spotter	Brendan Keane
5. FM radio commercial skipper	Martin Palibroda
6. Energy monitor for athletes	Brendan Keane
7. 3D printed hive for bees	Calvin Scott
8. Steam game purchasing booth (like redbox)	Calvin Scott
9. Automatic adjustable backpack	Martin Palibroda
9. Automated sprinkler system	Behnaz Edalat
10 Schedule next meeting	Behnaz Edalat

.

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	January 16, 2015
Time:	13:30 – 14:30
Location:	ASB 9886
Meeting Lead:	Behnaz Edalat

Agenda Items	Presenter
1. Presented results of meeting with Mike	Justin Raine
2. Presented research on ability to monitor fatigue levels	Brendan Keane
3. Talked to Dr. Kamran who said it requires high level of expertise to monitor fatigue	Behnaz Edalat
4. Current leading idea is smart sprinkler	Mulitiple
5. Schedule next meeting	Calvin Scott

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	January 20, 2015
Time:	19:30 – 21:30
Location:	ASB 9886
Meeting Lead:	Justin Raine

Agenda Items	Presenter
1. Review submitted ESSEF project proposal document	Multiple
2. Review/finalize ESSEF proposal talking points	Multiple
3. Create short Powerpoint presentation	Justin Raine

Other Notes or Information

- Presentation to ESSS is scheduled for 9:15 PM in ASB 9705. Dress nicely :)

vitaMotu Meeting Agenda

Meeting Information

Date:	February 2, 2015
Time:	13:30 – 14:30
Location:	ASB 9886
Meeting Lead:	Justin Raine

Agenda Items	Presenter
1. Discuss Raspberry Pi 2 release	Multiple
2. Parts order status – who's going to do it?	Justin Raine
3. Discuss setting up a meeting with Dr. Shahram Payandeh to consult re: hardware, motor, gears, etc…	Behnaz Edalat
4. Discuss HDMI input on RPi, nix feature?	Justin Raine
5. Discuss LANC protocol, position within feature-set priority	Justin Raine
6. Start talking about Function Specification document	Multiple

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	February 4, 2015
Time:	13:30 – 14:30
Location:	Lab 5
Meeting Lead:	Justin Raine

Agenda Items	Presenter
1. Get update on Tuesday's meeting with Dr. Payandeh	Brendan Keane
2. Discuss motor selection	Brendan Keane
3. Update on purchasing. How do we want to handle expenses and tracking?	Justin Raine
4. Update on system design – Raspberry Pi + Arduino	Justin Raine
5. Revisit Functional Specification rubric and discuss work breakdown	Multiple
6. Schedule next meeting	Justin Raine

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	February 13, 2015
Time:	10 –13
Location:	SFU Dinning Hall
Meeting Lead:	Behnaz Edalat

Agenda Items	Presenter
1. Parts are ordered and will be delivered tomorrow	Justin Raine
2. Use Brendan's Arduino for now, Raspberry pi will be used if necessary	Multiple
3. Discuss safety aspects of our design	Behnaz Edalat
4. Update on puchasing	Calvin Scott
5. Slider will be brought to the next meeting	Justin Raine
6. Schedule next meeting	Martin Palibroda

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	February 22, 2015
Time:	11 – 14
Location:	ASB 9886
Meeting Lead:	Calvin Scott

Agenda Items	Presenter
1. Got all parts in meeting	Justin Raine
2. Got the stepper Motor	Brendan Keane
3. Start coding Arduino Uno	Calvin Scott
4. Search different libraries on Arduino	Multiple
5. Schedule next meeting	Behnaz Edalat

Other Notes or Information

- None

vitaMotu Meeting Agenda

Meeting Information

Date:	March 11, 2015
Time:	13:30 – 15
Location:	Lab 5
Meeting Lead:	Martin Palibroda

Agenda Items	Presenter
1. Define live mode	Justin Raine
2. Finalize different modes	Multiple
3. How to decode 20-bytes packet for Bluetooth	Calvin Scott
4. Calculate max speed	Brendan Keane
5. Search on LANC protocol	Behnaz Edalat
6. Debug Arduino Uno code	Multiple

Other Notes or Information

Live Mode: -Mode: 1 char
-Direction: 1
-Speed: 3

Time-Lapse Mode: -Mode: 1 char
-Max speed: 2
-Damping: 2 (rpm)
-Start position: 4
-End position: 4
-Repeat: 1

vitaMotu Meeting Agenda

Meeting Information

Date:	March 14, 2015
Time:	11 – 14
Location:	ASB 9886
Meeting Lead:	Brendan Keane

Agenda Items	Presenter
1. Define different modes	Justin Raine
2. Define min and max speed	Multiple
3. Make decision on Arduino failure	Multiple
4. Find damping equation	Branden Keane
5. Email Prof. Bonnie Gray to use 3D printer in her lab	Behnaz Edalat
6. Find universal mounting hub for motor	Brendan Keane
7. Find acceleration library on Arduino	Multiple
8. Schedule Next meeting	Calvin Scott

Other Notes or Information

- Arduino Uno stopped working, Calvin will change the cable, and tries it with new one to test it at home. If it still didn't work, he will buy a new one from RP electronics tomorrow.