ENSC 305W/440W Grading Rubric for Post-Mortem

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project. Includes clear background and motivation for the project.	**/05%**
Body of the Document	Provides a high-level description of main functions and project modules. Outlines materials, costs, and schedule (both estimated and actual).	**/15%**
Problems/Challenges	Outlines major technical challenges encountered. Explains how these were resolved. Details any major changes in scope and design.	**/05%**
Group Dynamics	Includes a discussion of how the team was organized, any problems that arose, and how they were resolved	**/05%**
Individual Learning/Work-load Distribution Chart	Includes a one-page, individually written reflection upon what was learned from the project, both technically and interpersonally (each team member writes a page about their learning experience). **The workload distribution chart outlines major technical, administrative, and support tasks and indicates who participated significantly in those tasks.**	**/25%**
Conclusion/References	Summarizes outcome and evaluates the project. Includes discussion of future plans, if any (or explains why project will be abandoned).	**/10%**
Meeting Agendas/Minutes	Includes an appendix that provides all the meeting agendas and minutes produced by the team over the course of the semester. (NB. Neatness does not count here.)	**/20%**
Presentation/Organization	Document looks like the work of a professional. Ideas follow in a logical manner. Layout and design is attractive.	**/05%**
Format Issues	Includes title page, table of contents, list of figures and tables, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	**/05%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent.	**/05%**
Comments		

Image Sensor Shifting System for Cameras

Post Mortem

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1. Introduction

The purpose of this document is to reflect on the past 3 months of work and examine the current and future states of Motus' Image Sensor Shifting System (ISSS). Work on this project started in early September, 2013 and continued through the early part of December 2013. Also included in this document is a discussion of project finances, group dynamics and workload sharing, a schedule comparison, and individual comments from each of Motus' engineers on their experiences working on this project.

The purpose of the ISSS is to achieve auto-focus, while keeping the primary shifting mechanism contained within the body of the device instead of in the camera's lens. The basic theory is to shift the position of the image sensor in order to have it placed within the depth of focus range to capture a clear image of an object.

Current focusing systems drive the integrated motor within the lens to move the focal glass and project the focal point to meet at the position of the fixed image plane at the image sensor. Instead, the ISSS is designed to have a fixed focal glass and use the motor to shift the image sensor to the focal point instead. The ISSS has the following advantages over current focusing technology: it can support many different types of lenses; it is capable of providing manual lenses with an auto focus feature; and finally, macro mode can be achieved by using the ISSS.

The ISSS can support many types of lenses since it provides a variable flange focal distance. Since every type of lens has its own flange focal distance (FFD), the distance between the lens mounting flange and the image sensor is specified. For instance, if the user wants to snap a Pentax K mount 45.46mm FFD lens on a Micro Four Third (19.25mm FFD) camera, he or she needs to have a 26.21mm long extension tube adapter in between the lens and the camera to move the lens further from the image sensor. However, using the extension tube adapter has some disadvantages. First, different lenses require different adapters. For example, the user has the Micro Four Third camera. If the user wants to use the Pentax K lens, he or she needs a Pentax-K-to-M4/3 adapter. Likewise, if the user wants to use the Canon EF lens, he or she needs a Canon-EF-to-M4/3 adapter. Secondly, most adapters do not have mechanical connection or electronic communication pins between the lens and the camera. This means the motor integrated within the lens is not able to perform auto focus feature. Finally, while some adapters do have electronic connection between the lens and the camera, they are very expensive. For example, the Metabones Canon-EF-Lens-to-Sony-NEX Smart Adapter is $399.

Motus' ISSS also allows manual focus lenses to have auto focus functionality. The ISSS does not need to shift the position of the focal glass – instead it shifts the position of the image sensor, and the glass lens is stationary. The shifting sensor is able to be placed on the image plane within the depth of focus.

The ISSS performs macro mode as well. Based on the object image and focal distance relationship, longer distances between the rear nodal point of the lens and the image sensor will allow the lens to focus on closer objects. The rails in Motus' ISSS are 10cm meter long, meaning the image sensor can be shifted up to 10cm away from the rear end of the lens. The ISSS is able to capture objects that are very close to the lens.

Motus predicts that photographers who have different types of lenses will want to use all of their lenses with one camera, and photographers who have old manual focus lenses may want to perform auto focusing. In addition, photographers who want to do macro photography but are not willing to pay over $1000 on a macro lens can make use of Motus' ISSS as well.

2. Current State of the Project

As of December, 2013, Motus has a working prototype of its Image Sensor Shifting System. The current system consists of a ball screw image sensor shifting system, ¼ inch image sensor, 58mm camera lens, Arduino Uno microcontroller, 3A rated current stepper motor driver and laptop.

When the user sends a command to take a picture, the shifting system will move image sensor to capture all images inside rail range. At the same time, the laptop will perform real time image processing to calculate the sharpness value of every frame. The position of the image sensor that captures most focused image will be recorded, and the motor moves the image sensor back to this position again after the full range scan is finished.

3. Project Challenges

Many challenges have been faced during the lifecycle of Motus' prototype. Some of the challenges have been solved by using alternative solutions, however, there are still some unresolved issues which will be addressed in future iterations of the project.

3.1 Optics

The current optics design has deviated slightly from the original specifications. The original idea was to use a full frame image sensor to capture a 36mm x 24mm image projected by the lens. However, due to lack of funds and limited knowledge on image sensor technology, this idea was discarded. During the research stage, another potential solution was found which was to use a mirrorless camera to serve as an image capture tool. The idea is to put the whole camera on the movement system and expose its image sensor. It transfers image data to the local workstation via a HDMI cable. The advantage of using a mirrorless camera is that it has a relatively big image sensor and is able to auto control the sensitivity of light. Putting the whole camera inside an enclosure will increase the size of the overall system and the relatively large pixel size will slow down image processing. Therefore, this solution was also discarded. In the end, Motus decided to use a tiny webcam's 1/4 inch image sensor. The webcam's image sensor is cheaper, easier to install, and can transmit data over USB.

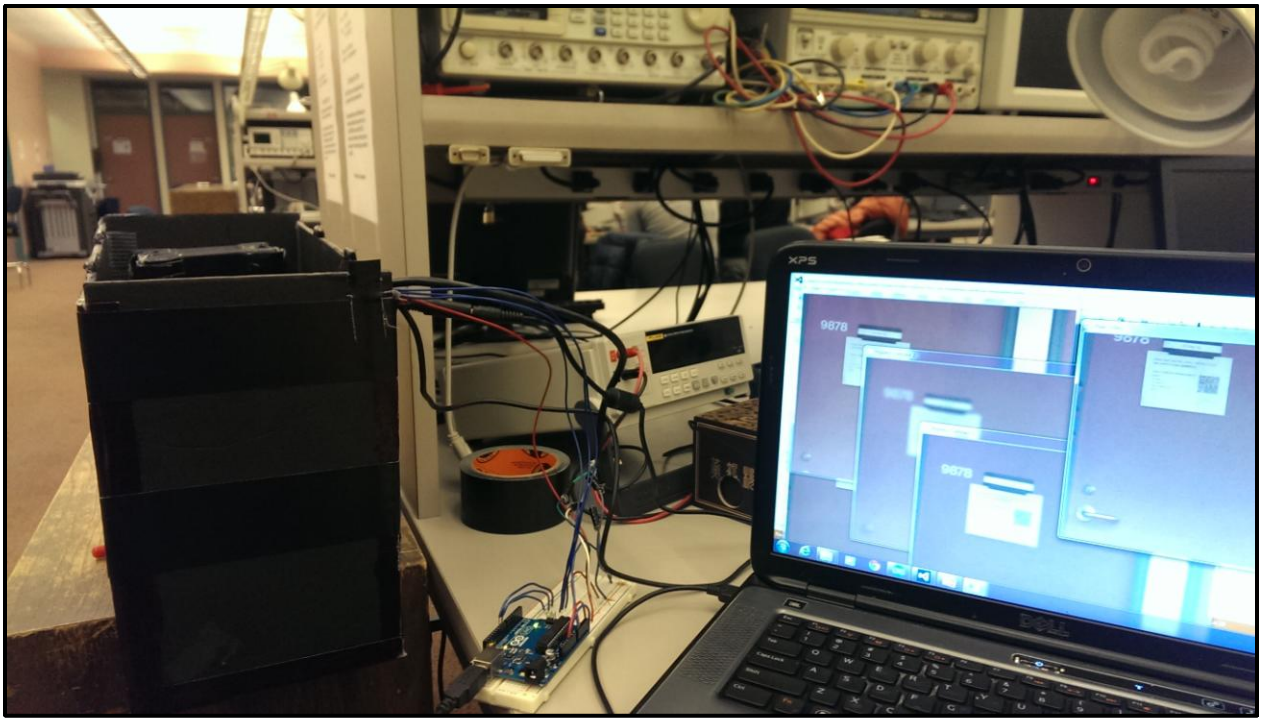

Figure 1 – Motus' ISSS project (including laptop)

3.2 Shifting System: Motor and Rails

During earlier design stage of ISSS, Motus planned to use ball screw linear actuator to be the linear shifting system. When ordering the rail from an online vender, the rail length of our shifting system was requested to be 10cm, in order to satisfy the minimum focus distance requirement. Unfortunately, even the rail length of shifting system that vender sent us is around 10cm, the total size was much larger than we expected. Then an alternative shifting system, a gear train driven by DC motor, had be developed to reduce the total size of shifting system, but offering less accuracy than the ordered rail system. For the first prototype of ISSS, the ball screw linear actuator has been finally selected, because accuracy is more important than size at this stage.

Another challenge is the alignment between the image sensor and lens. Due to the lack of time and funds, we did not design and build a particular jig that can control the location and motion of the image sensor corresponding to the lens. This misalignment issue causes changes in the images that are captured by the sensor, which increases the difficulty of calculating the relative sharpness value of each image.

3.3 Motor Control

During the early stages of development, Motus planned to use bi-directional communication between the microcontroller and the local workstation so that both could send and receive data simultaneously. Due to technical challenges, however, this idea was discarded. Instead, one-way serial communication was established between the workstation and microcontroller. This proved to be all that was needed in order to return the motor carriage to the point of maximum focus.

3.4 Image Processing

Two main image processing algorithms were considered during the development of Motus' ISSS. The first involved computing a fast-Fourier transform on any given image frame and then performing frequency analysis on the resulting dataset. In doing this, a measure of sharpness could be obtained by looking at the frequencies present in the image. Lower frequencies correspond to a shallow intensity gradient, whereas high frequencies would indicate the presence of sharp gradients in the image, which can be treated as edges in the source image.

The second algorithm (which was chosen for implementation) involves running a Laplace filter over the source image, which computes a sum-of-differences between adjacent pixels. The resulting greyscale image shows highlights around parts of the image that are "sharp." That is, the areas with sharp intensity gradients become more pronounced in the output image. This output image is then analyzed for the highest value, which is then taken to be the sharpness value for that particular frame in the video stream.

One disadvantage to using this method is that it can be slow to calculate a sharpness value for a given frame, which limits the speed at which the motor can move the carriage from one end of the rail to the other. To resolve this issue, a slower speed is used, which gives the algorithm enough time to process each frame.

4. Future Work

4.1 Performance

Issue: The selected image isn't always the one that is the most in-focus. While the image sensor is in the depth of focus, the CPU is still analyzing the previous frame and misses the current focused image.

How to fix: While the image is being processed, slow down the motor's speed.

Issue: The image sensor cannot adjust to changes in brightness (no auto ISO control). If lighting conditions are too bright or too dim, the contrast is too low.

How to fix: Use an image sensor with an auto ISO control feature.

Issue: Improper alignment between the sensor and lens.

How to fix: Use alignment tools to align the lens and the image sensor in their proper positions.

4.2 System Size

Issue: The ISSS's size is bulky. The rails are too long, the motor is too large, and the bellow increases the required size of the system.

How to fix: Replace the system with shorter rails and a less powerful motor, and remove the bellow in favour of using a light-proof enclosure. However, shorter rails will shorten the nearest focus distance.

Issue: The ISSS requires a local workstation to run the image processing algorithm.

How to fix: Load the OpenCV library on an embedded device that has a processor powerful enough to run the image processing algorithm at a reasonable rate (approximately 20 frames analyzed per second).

4.3 Focusing Speed

Issue: The ISSS's focusing speed is slow due to contrast detection auto focusing

How to fix: Replace with the on-chip phase detection image sensor.

4.4 Portability

Issue: The ISSS is not portable, since images have to be shown on a local workstation's monitor.

How to fix: Attach a LCD display.

4.5 Power Source

Issue: The ISSS's motor is required to plug in 110V 60Hz since the motor requires too much current.

How to fix: Replace with a smaller motor.

4.6 Usability

Issue: The ISSS is not easy to operate due to the current prototype not having an easy interface for end users. It requires a person who is proficient in C++ to make adjustments to the image processing algorithm.

How to fix: Invest more time developing a robust user interface that gives full control over the algorithm's parameters and image output.

4.7 Lenses Adaptability

Issue: The ISSS cannot use different mounting type of lens. While the ISSS provides variable flange focal distances, the physical shape of the mounting mechanism is not able to have other types of lenses attached.

How to fix: Replace the mounting mechanism with a hybrid mounting ring.

4.8 Focus Points

Issue: Only images with flat surfaces can be processed. The image processing algorithm processes entire image's sharpness value. When the object is not perpendicular to the camera's lens, certain areas of the image may be out of focus.

How to fix: Set up multiple focus regions on the image. The image processing will only calculate sharpness values within those regions.

5. Finances

Motus originally applied for $350.00 CAD for this project, however we were awarded $500 since the committee decided this project would need additional funding to be successful. This estimation proved to be quite accurate, and while Motus attempted to reduce costs in several areas – including both motor and motor driver selection, the budget was still slightly exceeded. Table 1 includes all of the projected project expenditures. Table 2 includes all of the actual project expenditures.

Products	Cost estimated ($ CAD)
Image Sensors (2-3 Units)	$50.00
Microcontroller	$100.00
Motor	$50.00
Supplies for the mounting fixture	$50.00
Lenses (1-2 with different focal	$50.00
Power Supply	$20.00
In total	$320.00
Total Funding Applied	$350.00
Total Funding Received	$500.00

Table 1 – Budget applied at the beginning of the project

Products	Cost ($ CAD)	Tax &Shipping
Total budget available	$500.00	
Motor System	$157.94	$88.98
Webcam	$23.99	$0.00
Microcontroller	$33.00	$3.96
Stepper Motor Driver	$45.00	$5.40
Power Adapter (12V, 3A)	$15.00	$1.80
Lens (2 lenses with different FFD)	$110.00	$0.00
Material for Enclosure	$45.00	$5.40
Female adapter 2.1 Jack	$1.50	$0.70
In total	$537.67	
Total remaining funds	$0.00	

Table 2 – Actual expenditures

6. Schedule

Figure 1 below is the schedule created at the beginning of the semester.

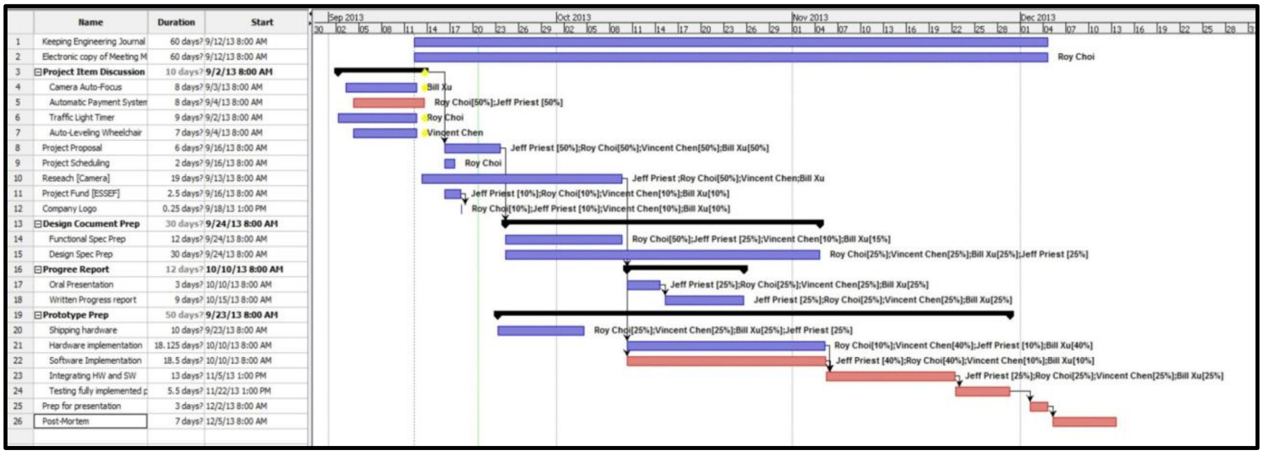

Figure 2 – Schedule created at the start of the project's lifecycle

The initial schedule lacks certain details that were not known until further into the project's development. As a result, certain deadlines deviated somewhat from their planned completion times. To solve the issues that arose from these discrepancies, another timeline was produced roughly half way into the project's development. This new schedule included more detail and helped all members stay on track. More time was allocated for implementation and testing, and prior tasks were updated to reflect delays in the acquisition of certain components such as the motor, which had its shipment delayed due to local flooding at the time the order was processed.

Development of the prototype has been divided into multiple subdivisions because these subdivisions can be worked on in parallel. For example, image processing can be worked on in a different phase of development than the optics system. In addition, shipment duration has been lengthened. Some sections will be developed faster than other sections, so it is better to make the purchase as soon as possible to minimize the downtime waiting for the shipment.

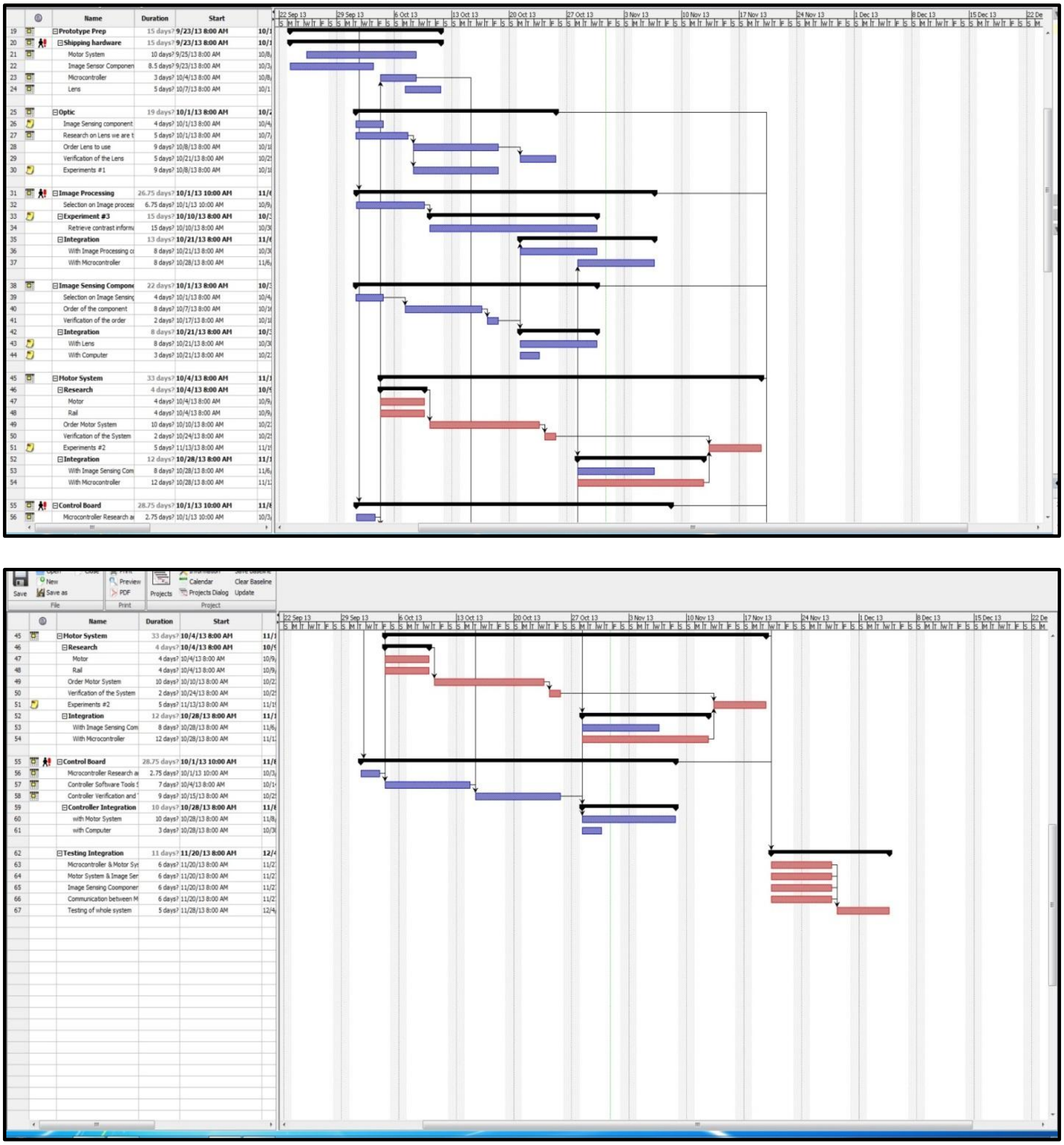

Figure 3 – Schedule created in mid-October

7. Group Dynamics

Motus consists of two computer engineering majors, and two systems engineering majors. Each member brought a different set of skills to the group. There were no major conflicts during the course of this project, and perhaps one of the contributing factors to this was having good communication between all group members. Meeting minutes were taken regularly, and email communication took place almost daily.

Task	**Jeff**	**Roy**	**Bill**	**Vincent**
Documentation	**X**	**X**	**X**	**X**
Optical Lens			**X**	
Image Sensor Research and Selection			**X**	
Image Processing – Development	**X**			
Image Processing – Testing	**X**	**X**		
Motor Integration		**X**		
Motor Control	**X**	**X**		
Engineering Project Management		**X**		
Enclosure			**X**	**X**
Shifting System				**X**
Final Assembly				**X**
Integration	**X**	**X**	**X**	**X**

Table 2 – Workload distribution

8. Individual Reflections

8.1 Jeff Priest

My goal going into this project was to find a group of hard-working, enthusiastic individuals who wanted to create a cool project that we could all be proud of by the end of the semester. Having just spent nearly four months working with Roy, Bill and Vincent, I can honestly say that I have accomplished this goal. Working with these guys has been a great experience, and I would gladly work with each of them again.

My primary role for the duration of this project was to work on the image-processing software that would provide a measure of how "in-focus" a given image was. Much of my time was spent researching various algorithms for detecting how blurry or sharp an image was, and deciding which one would be best suited for our project. One of my biggest challenges was estimating how accurate the algorithm needed to be without necessarily having the hardware to test it on. There are many factors to consider, such as frame-rate, hardware timing requirements, data transfer speeds, and hardware interface requirements. To reduce the amount of risk in making the wrong choice, I ended up researching multiple algorithms that could all be made viable. The remainder of my time was mostly spent on implementation and testing.

Since changes to the image-processing application often required updates in motor control behaviour, I also assisted with the motor control implementation. This involved establishing serial communication between the image-processing application and the microcontroller, and figuring out the best way to take advantage of the hardware that would leverage the strengths of the image-processing algorithm. During this process I was using knowledge gained from courses such as ENSC 215 and ENSC 351, which both proved useful when troubleshooting technical issues.

I am very proud of what we have been able to accomplish in just a few short months, and am happy to have worked with such a talented and dedicated group of engineers. The experience and skills we have gained in this course will no doubt prove to be very valuable in our future careers.

8.2 Roy Choi

It was really fortunate for me to work with highly educated four engineers on preparing a prototype that proves out concept of moving image sensor to achieve auto-focus feature in the camera. Throughout iterative planning and multiple online and offline discussions, our company, Motus, successfully finished developing Image Sensor Shifting System (ISSS).

My primary role in the Motus is to manage and coordinate the project and develop firmware for the motor. For the project management, I have managed to create a schedule from beginning, and edit the schedule till the end of the project. In addition, I have managed to keep track of weekly progress of every member. I have been sent a weekly email to members to send me progress report of individual tasks. After retrieving all the progress report, I have created a meeting minute reflecting the reports. Also, I kept tracking of all the financial expenses that were spent in project development progress. This four months of experience have taught me how to manage project; for example, making a better schedule and meeting minutes.

Another responsibility I took in Motus was to develop Arduino code that moves the rail by communicating with image processing. Since I have never used Arduino before, I had to learn how to use the board itself. For example, if I want to use some specific pins in the board, then I have to look into the board diagram to verify the pins. Fortunately, the Arduino software is using C++ language to program the board; and CMPT courses I have took became handy for this task. A challenge I faced while implementing motor control logic in Arduino was that the motor we got was not following standard. For example, the motor I got wasn't following standard wire connection law, so I had to perform multiple experiments to figure out wires inside motor. This progress delayed my implementation of motor control logic significantly. This experience has taught me how to handle shipment.

I additionally assisted Jeff in implementing communication and image process algorithm handling code in Visual Studio. This was not my main responsibility, however, whenever Jeff is not available, I took the code and develop the code, then let Jeff know later what I implemented. As a result, I learnt how the OpenCV works to perform image processing. By doing this, I learnt much more about C++ language coding in both image processing and any logic implementation.

8.3 Bill Xu

In the past four months, my teammates and I have been working diligently on the ISSS Capstone project. Starting from the beginning, we have carefully discussed the possibility of the theory and verifications on its feasibility. We clearly set our goal and divided detailed tasks to each individual. Through the whole project timeline, my biggest gains are able to learn more knowledge on optics and mechanics, and experience those software applications such as image processing and motor control which I never experienced before.

My primary responsibility of the ISSS is to study the optical theory behind the ISSS, to test its possibility, and to provide any optical data to my teammates when it is needed. I have photography background and always want to produce a camera with the ISSS built in. At the beginning, I felt that I have enough knowledge on optics and image sensor technology. However, a short period after the project started, the situation is not as good as I expected. An optical system does require accuracy which forced me to consider details on these factors such as, type of lens, relationship between the object distance to the lens and the image distance to the lens, relationship between depth of field and the object distance, depth of focus, aperture value, image sensor's dimensional size, and image sensor's light sensitivity. From this experience, I have learnt a big lessen which is never feel overconfident about the project even though I am really familiar with it.

Since the project idea came from me, I am very glad my teammates support this project topic. All team members are enthusiastic and passionate about the ISSS. I believe there are three factors lead us to be successful on this project. First, all members feel passion about it. We know we were creating a totally new concept of auto focusing system. It is a revolution. Second, each individual has his own specific assigned tasks. Vincent was focusing on doing the shifting mechanical system; Roy was implementing the motor control; Jeff was programming image processing; and I was testing the optics system. Each individual is knowledgeable on his assignment. Third, communications among all team members are efficient and informative. Whoever was in doubt, we were patient to answer his questions step by step; whoever needed assistances, we were willing to give him a hand.

Overall, I am very pleased with the success of our project and the team behind it. From the initial planning stages to a full-fledged prototype, it has been a pleasure to work with a group committed to bringing forth their skill sets. If possible, I will continue to do this project with Vincent, Roy, and Jeff in the future. They are the best team members who I ever met.

8.4 Vincent Chen

From last four month, my team puts great effort working on project of develop image sensor shifting system (ISSS). Before we started to build our prototype of ISSS, we tested the functions of individual components and individual combined assemblies, including imaging system, shifting system, and image processing system.

My group partners did great job on their individual tasks. Jeff was working on image processing technique from the beginning of this term. Image processing is the most important and challenging part since it is highest level of command in our control algorithm, and the result of image processing can impact the performance of ISSS significantly. Roy was managing all the meeting minutes and financial resource. He started design our control algorithm and digital communication after we receive our rail assembly. Bill was focusing develop the theory of our imaging and auto focusing technique, and his great knowledge in photograph provide excellent support during integration stage.

My main task was providing hardware support to satisfy all the requirements for optical theory and digital control. To optimize hardware system design in order to minimize errors during final integration. Trouble shooting the prototype of ISSS to find out the performance limits and boundaries, and then modified currently hardware system to achieve better results.

I was enjoying document all the drawings for our project, including mechanical drawings, assembly drawing and electrical schematics. These drawing helped me to understand the best solutions to solve troubles when I stuck with some problems during integration.

9. Conclusion

After several months of hard work, our efforts have paid off and a viable prototype has been created. While we may decide to not take the project any further at this time, we are quite confident that the prototype can be improved even further with more iteration. That said, we are very happy with how the project turned out, and feel that we accomplished what we set out to do at the start of the semester which was to create a system that could perform auto-focus and still make use of multiple lenses without the need for an expensive adapter. The group members comprising Motus worked extremely well together, and we would all happily work together again in the future.

Appendix

Group meeting

September 06, 2013

1:30 pm

IRMACS

Meeting called by: Group **Type of meeting:** Sharing an idea about group project

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Idea for capstone project

Minutes

Agenda item: **Jeff Priest's item** **Presenter:** Group

Discussion:

1. Electric Car – Tesla
2. Blind people replacement of cane – heptic feedback device with sensor
   a. wearable
3. Automatic payment for gas
4. Live radar for aero system

Discussion: Vincent Chen's item

1. Automatic surface-stabilization for wheel chair

Discussion: Bill Xu's item

1. Automatic movement in Image senser-shift
   a. Instead of moving lens itself
   b. http://en.wikipedia.org/wiki/Flange_focal_distance
   c. Varying distance between sensor and the lens will vary the type of mount
   d. Modern technology uses phase detection and contrast detection
   e. Enables camera to use whichever lens

Discussion: Roy Choi's item

1. Pet translator
   a. It's already out.
2. Displaying timer of green light timer left on the traffic light
   a. Combine with navigation to let driver know if they have to stop or go based on the current speed.
3. Implementing magnetic chip on the phone enabling user to use whichever thing: for example, credit card

and personal ID.

Group meeting

September 11, 2013
1:00 pm
Lab1

Meeting called by: Group
Type of meeting: Sharing researched idea
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi
Absent: none

Please read:
Please bring: Research on the items

Minutes

Agenda item: **Project Idea**
Presenter: Group

Discussion:

1. Image-sensor shifting idea meets our requirement for capstone project.
2. Have to ask idea from some TA, Lucky, and Mike for their opinions on this idea, and other ideas too.
3. NFC technology on cell phone is mainly software project which may not be good project idea for Engineering project
4. Traffic light project might be too hard because transmitting of data from each traffic lights can interrupt other traffic lights which are close by.
5. Auto-surfacing wheel-chair may require too much works.

Conclusions: Talk to Mike, Lucky, and TAs for Idea

Action items	Person responsible	Deadline
✓		
✓		

✓

✓

Group meeting

September 12, 2013

12:30 pm

Lab1

Meeting called by: Group **Type of meeting:** Sharing researched idea

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi

Absent: none

Please read:

Please bring: Research on the items

Minutes

Agenda item: **Project Idea (Cont'd)** **Presenter:** Group

Discussion:

1. Mounting CMOS may interfere with other devices inside camera, which may lower the quality of CMOS
2. It may be hard to move the image sensor inside camera because it may be latched to board inside
3. Which motor should we use for moving the image sensor
4. NIKON D5100 & D7000 has motor in the lens and body, but this technology is to move lens.
5. Wheel chair item has been changed to "baby stroller"
6. Baby stroller that can roll up the stair may be good item.
7. Will the baby stroller be marketable?
8. Yes – Roy, Maybe – Jeff, Bill, Vincent
9. For traffic light, we don't really have to integrate this with navigator.

Conclusions: Keep continuing research and we will finalize the item on the Friday 13th

Action items	Person responsible	Deadline
✓ Keep researching	All	Friday 13th
✓		

MOTUS

Group meeting

September 13, 2013

1:00 pm

Lab1

Meeting called by: Group
Type of meeting: Item
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi
Absent: none

Please read:

Please bring: Research on the items

Minutes

Agenda item: **Project Idea** **Presenter:** Group

Discussion:

1. Since displaying counter above traffic light is too simple for ENSC 440 capstone project, make traffic light full digital may be better item – like full digital board tells the same information with additional information: possible information would be weather, existence of accidents, and traffic information.
2. Traffic light item may cost up to $5000 based on City of Toronto: Transportation Service
3. Poll has been held to decide which item to go with, and the candidates were: shifting image sensor for auto focus, traffic light, automatic payment via cell phone, and baby stroller that can go up the stair
4. Everyone had 2 votes, and image sensor idea has chosen with 4 votes.

Conclusions: Our project item has been finalized to shifting image sensor for auto-focus

Action items	Person responsible	Deadline
✓ Prepare company logo and name	All	Sep 18th
✓ Prepare presentation for funding	All	Sep 17th
✓ Gantt Chart	Roy	Sep 18th
✓ Templates of document	Jeff	Sep 18th
✓ More research on how auto-focus works in camera	All	Sep 18th

Group meeting

September 18, 2013
1:30 pm
Lab1

Meeting called by: Group
Type of meeting: Project meeting
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi
Absent: none

Please read:
Please bring: Action items from last meeting minute

Minutes

Agenda item: **Project Idea** **Presenter:** Group

Discussion:

1. Funding presentation and application has been submitted on Sep 17th
2. Name: Focus, Logo: shape camera 'F' shape and replace 'o' with a real lens image, then 'cus' (Roy)
3. Name: Motus, Lux, Ocularius, and visum (Jeff)
4. Name has finalized with Motus with votes.
5. Prepare proposal.

Conclusions: Name has been settled down to 'Motus", logo is on the way

Action items	Person responsible	Deadline
✓ Proposal prep (Introduction)	Bill	Sep 20th
✓ Proposal prep (executive summary, Finance)	Jeff	Sep 20th
✓ Proposal prep (System overview)	Vincent	Sep 20th
✓ Proposal prep (Marketability, project timeline)	Roy	Sep 20th
✓ Proposal prep (Company profile, title page)	All	Sep 20th

MOTUS

Group meeting

September 20, 2013
1:30 pm
Lab1

Meeting called by: Group
Type of meeting: Project meeting
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi
Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Project Idea** **Presenter:** Group

Discussion:

1. Combine documents to make one proposal to hand in at Monday.
2. Should we order parts now? Not for now.

Conclusions: Finish project proposal by Sunday Sep 22th, then review group-wise, then submit for Lucky on Monday

Action items	Person responsible	Deadline
✓ Finish project proposal (letter, company logo)	Jeff	Sep 22nd
✓ Finish project proposal (Title page, more on timeline)	Roy	Sep 22nd
✓ Finish project proposal (System overview)	Bill, Vincent	Sep 22nd
✓ Research on specific model we are going to use	All	Sep 25th

Group meeting

September 27, 2013
1:30 pm
Lab1

Meeting called by: Group
Type of meeting: Project meeting
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest
Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Project scheduling / Time resource management preparation
2. Plan 1 for prototype:
   - ✓ Install lens outside black box: black box should be completely dark inside for possible image corruption.
   - ✓ Lens will shoot out image to plain inside the black box.
   - ✓ We will install another webcam behind the box catching projected image on the plain.
   - ✓ Installed plain and webcam will do job of image sensor, which means for focussing, we are going to move whole plain and webcam inside
   - ✓ Webcam will be wired to another PC for image processing
3. Open CV / Matlab for image processing
4. Calculation for Hyperfocal distance

Conclusions:
Research how to use OpenCV or Matlab for image processing
Figure a way to process image inside the black box
Finish Project Scheduling /Time Resource management discussion on the canvas

Action items	Person responsible	Deadline
✓ Research on OpenCV and Matlab	Jeff, Roy	Oct 2nd
✓ Figure a way to process image through black box	All	Oct 2nd
✓ Finish Project Scheduling /Time Resource management discussion on the canvas	All	Oct 2nd

✓ Research what does image sensor outputs	Roy	Oct 2nd

Group meeting

October 9th&11th, 2013
1:30 pm
Lab1

Meeting called by: Group **Type of meeting:** Project meeting
Facilitator: Group **Note taker:** Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest
Absent: none

Please read:
Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Webcam is ready, and plus is the webcam is real small
2. Unfortunately, image sensor for webcam is really small, which makes this job way harder
3. Another option needed
4. Another option 1. Used camera

Conclusions: Keep researching about image sensor option

Action items	Person responsible	Deadline
✓ Research on OpenCV and Matlab	Jeff, Roy	Oct 18th
✓ Find another option for image sensor	All	Oct 11th
✓ Keep researching on the image sensor option	All	Oct 18th
✓ Work on Functional Specification	All	Oct 14th

Group meeting

October 18th, 2013
1:30 pm
Lab1

Meeting called by: Group
Type of meeting: Project meeting
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest
Absent: none

Please read:
Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Motor system is shipped
2. The system is way heavier and bigger than expected
3. Decision: keep using the system, but still research another option for research purpose
4. Alternate option for image sensor 1. Used camera

Conclusions: Motor system is ready

Action items	Person responsible	Deadline
✓ Research on OpenCV and Matlab	Jeff, Roy	--
✓ Find another option for motor	All	--
✓ Keep researching on the image sensor option	All	Oct 23rd
✓ Research how to work with the motor system	Vincent	Oct 23rd

MOTUS

Group meeting

October 23- 25, 2013

1:30 pm

Lab1

Meeting called by: Group **Type of meeting:** Project meeting

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Motor isn't working properly (turning back and forth repeatedly)
2. Communication between Arduino and Computer (Image processing)
3. Image processing is using contrast detection method.
4. Used camera is not a valid idea due to the price

Conclusions: Keep working on parts assigned to each person

Action items	**Person responsible**	**Deadline**
✓ Research on OpenCV	Jeff, Roy	--
✓ Find a way to rotate motor	Roy	--
✓ Keep working on the image processing algorithm	Jeff	-
✓ Research on communication between Computer and the microcontroller	Roy, Jeff	-

Group meeting

October 30th, 2013
1:30 pm
Lab1

Meeting called by:	Group	**Type of meeting:**	Project meeting
Facilitator:	Group	**Note taker:**	Roy Choi
Timekeeper:	Roy Choi		
Attendees:	Bill Xu, Vincent Chen, Roy Choi, Jeff Priest		

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Motor isn't still working properly (turning back and forth repeatedly)
2. Communication between Arduino and Computer (Image processing)
3. Get ready for the oral progress report

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Working on the progress report (Schedule and Financial)	Roy	--
✓ Working on the progress report (Optic)	Bill	--
✓ Working on the progress report (Motor system)	Roy, Vincent	-
✓ Working on the progress report (Image Processing)	Jeff	-

MOTUS

Group meeting

November 1st, 2013
1:30 pm
Lab1

Meeting called by: Group
Type of meeting: Project meeting
Facilitator: Group
Note taker: Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest
Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Motor isn't working properly (turning back and forth repeatedly)
2. Communication between Arduino and Computer (Image processing)
3. Working on the Design Specification

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Work on the Motor control	Roy	--
✓ Design Specification (Introduction, Optic)	Bill	
✓ Design Specification (System overview, Motor Overview)	Vincent	--
✓ Design Specification (Executive Summary, Image Processing overview, conclusion)	Jeff	-
✓ Design Specification (Microcontroller and motor control overview and Finances)	Roy	-

Group meeting

November 8th, 2013
1:30 pm
Lab1

Meeting called by: Group **Type of meeting:** Project meeting
Facilitator: Group **Note taker:** Roy Choi
Timekeeper: Roy Choi
Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest
Absent: none

Please read:
Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Bought Microstep driver and external power supply for the motor (Roy)
2. Unidirectional communication will be held from computer to Microcontroller (Roy)
3. Design Specification deadline has been delayed to next week

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Work on the Motor control	Roy	--
✓ Design Specification (Introduction, Optic)	Bill	
✓ Design Specification (System overview, Motor Overview)	Vincent	--
✓ Design Specification (Executive Summary, Image Processing overview, conclusion)	Jeff	-
✓ Design Specification (Microcontroller and motor control overview and Finances)	Roy	-

Group meeting

November 13 - 15, 2013

1:30 pm

Lab1

Meeting called by: Group **Type of meeting:** Project meeting

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Microstep driver is not working (Roy) – going to check the store again
2. 200 steps is 1 bite, and 1 bite represents 5mm in the rail movement (Vincent)
3. Stepper motor is working based on the voltage across on 4 inductors placed at the north, east, south, and west of the motor. – Correct phase sequence will turn the motor (Roy)
4. Figured out how to use Microstep driver (Roy)
5. Image processing is processed via finding sharpness values for each pixel, then average it though whole picture. After that rail will continuously move from one end to the other end, while image sensor attached on the block will capture the real-time video. (Roy, Jeff)
6. Serial communication is established from Computer to Microcontroller (Roy, Jeff)
7. Working on the enclosure for the whole system (Bill, Vincent)

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Work on the Motor control	Roy	--
✓ Keep working on the image processing algorithm, if there is better one	Jeff	
✓ Finish enclosure for the whole system	Vincent, Bill	--
		-
		-

MOTUS

Group meeting

November 18, 2013

1:30 pm

Lab1

Meeting called by: Group **Type of meeting:** Project meeting

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Motor is working!! (Roy)
2. Currently coded so that it will move forward and backward based on the input given from the computer (Roy)
3. 50 steps approximately moves the rail by 1 mm (Roy)
4. Motor is turning with rate of 2ms (Roy)
5. Enclosure for the whole system is built (Bill, Vincent)
6. Webcam now is placed inside the Camera Bellow for light proof (Bill, Vincent)

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Work on the Motor control	Roy	--
✓ Keep working on the image processing algorithm, if there is better one	Jeff	--
		-
		-

Group meeting

November 20th, 2013

1:30 pm

Lab1

Meeting called by: Group **Type of meeting:** Project meeting

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Our demo is at November 26th.
2. Work on the power point presentation for the demo
3. Integration between image processing and microcontroller is done (Roy, Jeff) – it now moves from one end to the other end while webcam is capturing real-time video. This real-time video is being image processed continuously.
4. Switches are placed at the each ends for safety features. (Vincent)
5. Test for the switches are done (Roy)

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Implement switch logic on the Arduino	Roy	--
✓ Final presentation	All	
✓ Integrate webcam and the lens on the motor	Vincent, Bill	--
		-
		-

MOTUS

Group meeting

November 21-23, 2013

1:30 pm

Lab1

Meeting called by: Group

Type of meeting: Project meeting

Facilitator: Group

Note taker: Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Integration between software and motor is done
2. Full test is undergoing.
3. Work on the final presentation based on the Lucky's note given in the ENSC 305 lecture.
4. Switch logic is implemented (Roy)

Conclusions: Keep working on parts assigned to each person

Action items	Person responsible	Deadline
✓ Final presentation power point	All	--
✓ Keep testing and optimize code for image processing	Jeff, Roy	--
		-
		-

Group meeting

November 25, 2013

1:00 pm

Lab1

Meeting called by: Group **Type of meeting:** Project meeting

Facilitator: Group **Note taker:** Roy Choi

Timekeeper: Roy Choi

Attendees: Bill Xu, Vincent Chen, Roy Choi, Jeff Priest

Absent: none

Please read:

Please bring: Action items from last meeting minute

Minutes

Agenda item: **Camera project** **Presenter:** Group

Discussion:

1. Several defects found on the image processing algorithm:
   - ✓ Small changes in the scene will results in high randomness in the sharpness calculation – this is due to the size of the image sensor. Since the image sensor size is too small, even small changes will affect the image a lot.
   - ✓ Exposed light will change sharpness value by a lot. –this is due to how it is calculating sharpness value. Since sudden flash light will result in high contrast value. – Not really fixable unless the image sensor itself can balance the brightness automatically.
2. Saves 3 pictures to local drives. – These three pictures will be pictures with highest sharpness value. User has to choose which picture to use it.
3. Work on the final presentation based on the Lucky's note given in the ENSC 305 lecture.
4. Come by 9a.m tomorrow

Conclusions: Keep working on parts assigned to each person

Action items	**Person responsible**	**Deadline**
✓ Final presentation power point	All	--