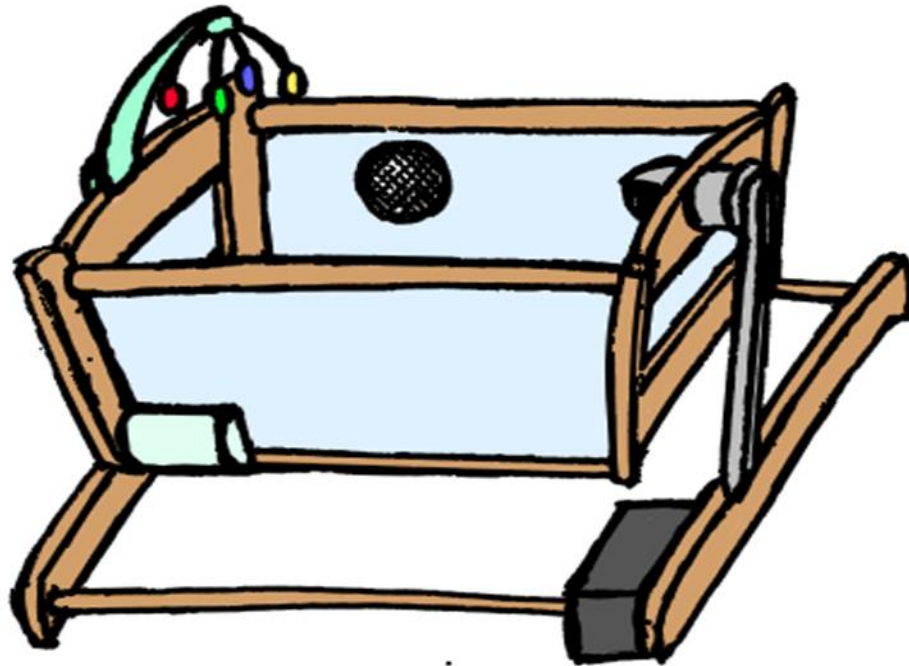




MARCH 10, 2016



SMARTY BABY CRADLE

POST-MORTEM

FANCHOU MENG, YU LIU, XIAOYE LYU, & KIRU SRI

SIMON FRASER UNIVERSITY
School of Engineering



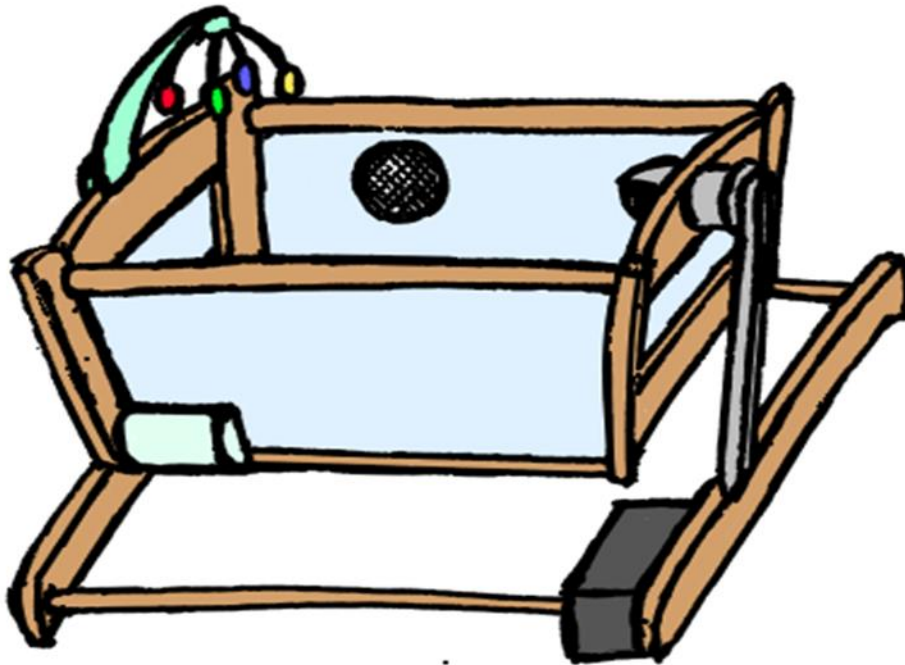
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1. Introduction

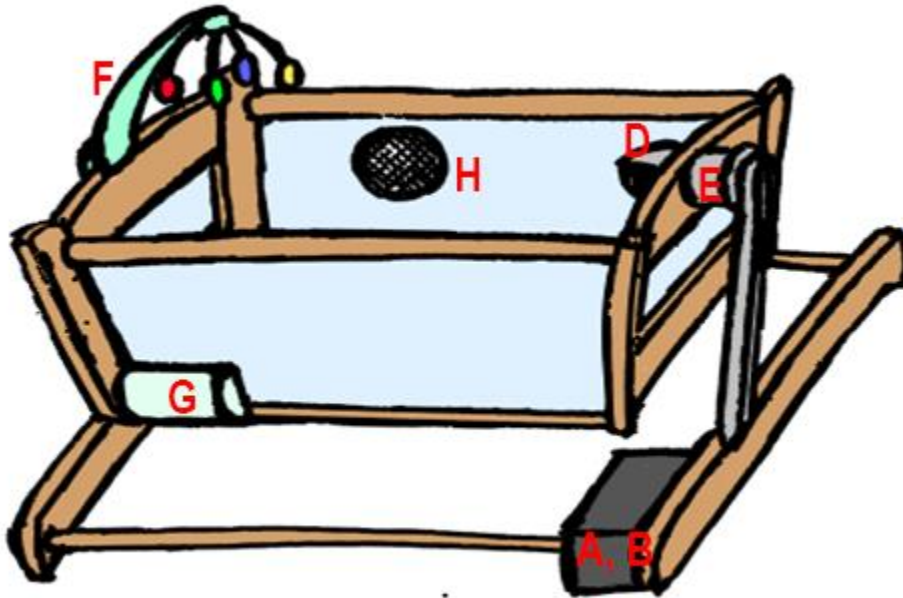
Parents in this age are always busy. The old days of one parent being the bread winner and the other staying home is gone. Raising a child can be tough especially an infant. They're day to day activity are limited by the needs of the baby. Basic chores like cooking and cleaning are out trumped by the baby crying. There are also the times when the parent is unable to hear the baby cry, for example when the parent is showering. Only if there was a way to give the parent a little bit of extra time to get to their infant.



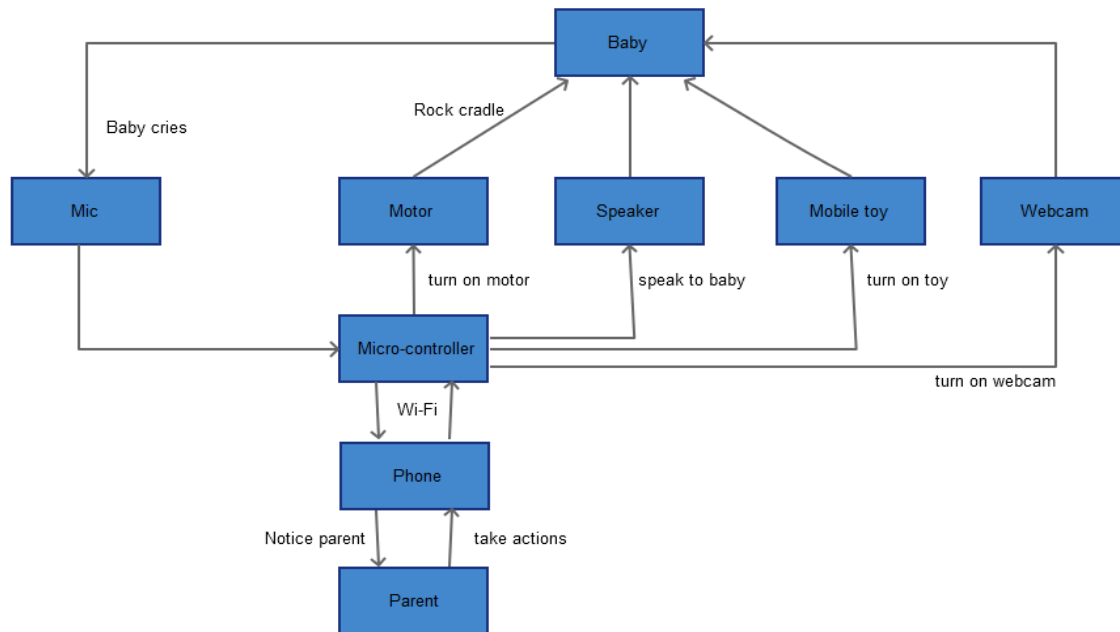
The solution to this problem is the Smart Baby Cradle by Baby Rock. It will help parent find a balance between caring for the baby and something they need to do. It will give the parent extra precious time to get to the baby. It is a complete system, which provides instant wireless communication to monitor and comfort the baby. With the use of an Android phone, the parent will be able to control the whole system: rocking the bead, speaking to the baby, turning on the mobile toy and monitoring the baby via webcam.

2. System Overview

The system contains an Arduino Mega Microcontroller board with the six components: microphone, motor, speaker, mobile toy, wifi module, and webcam. (fig) The microphone is used to detect the baby's cry and signals the microcontroller to activate the system. The microcontroller will notify the parent's by sending signal to the Android smartphone, which will intern show a notification. The parents will have full control of all the functions: playing music through the speaker, turning on the mobile toy, rocking the cradle, and monitoring their baby through the smartphone app.



- a) Micro-controller: a mater control that get data from webcam and send control signal to the stepper motor, the speaker and the mobile toy. It also communicates with the Android application to provide remote control.
- b) Wi-Fi module shield: allows the micro-controller to deal with the data communication through Wi-Fi network.
- c) Router: provides Wi-Fi network environment for the communication between the micro-controller and the phone application.
- d) Webcam: Takes a live video of the baby. The information is than processed by the micro controller and will allow the parents to monitor the baby through their android smartphone.
- e) Stepper motor: provides required torque to rock the cradle and is controlled by micro-controller. It rotates in one direction until it hits a required position and then to the other direction until it hits the opposite required position.
- f) Mobile toy: is used as a distraction for the baby, it is controlled by the motor drive using pulse width modulation in order to control the DC motor that the toy attaches too.
- g) Mic: collects sound data from the baby to identify if the baby cries and is controlled by micro-controller.
- h) Speaker: allows the parent to speak and comfort the baby. It is controlled by the micro-controller.
- i) Android application: provides remote control and communicates with the micro-controller.



3. Business and Financial

Competition

There is only one real competition, out in the market right now. It is buy Fisher Price and called the 4 in 1 Smart Connect Cradle'N Swing. We found the price to be roughly \$360 USD. As with our system it can be connected to a smart phone but doesn't feature as much function as our Smart Baby Cradle.

The other thing with our Smart Baby Cradle it includes a camera which replaces the need for a baby monitor.

Estimated Sales

We plan to mass produce the product after we finalize the prototype. The price of the prototype which we completed was around \$410. We plan to mass produce the product overseas. It would bring down the cost of the product to under \$160 to produce per unit. This product can potentially be sold around \$300.

According to Statistics Canada there was roughly around 388,729 new parents every year. If 20% of the new birth use smart baby cradle, the market size for Canada is 77,746. If our product can gain 50% of the market share and the unit profit is \$125, we can make revenue of \$23,323, 740 and a net profit of \$9,718,225 before paying employees and marketing. If we were to expand to the United States we would be able to make a lot more profit.



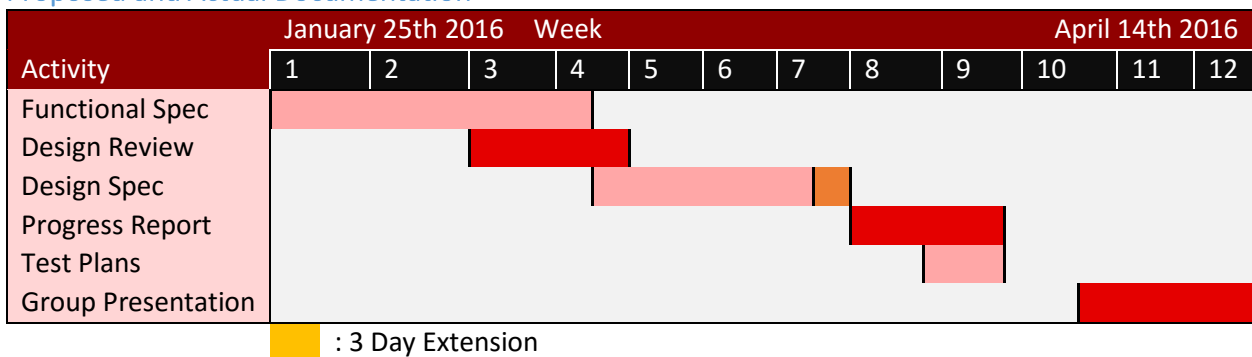
Funding and Expenses

The total funding we received is \$300. We had to use money from our own personal account in order to fund the rest of project.

Components	Estimated	Actual	Difference
Baby Cradle	\$95	\$25	\$70
Stepper Motor (Old)	\$105	\$38	\$67
Stepper Motor (New)	0	\$55	\$-55
Motor Driver	\$25	\$30	\$-5
Power Adapter	\$25	\$25	\$0
Microcontroller	\$34	\$68	\$-34
Camera	\$32	\$43	\$-11
Microphone	\$19	\$74	\$55
Speaker	\$6	\$6	\$0
Wifi Module	\$76	\$15	\$61
Mobile Toy	\$10	N/A	\$10
Others (wires, belts, hardware)	\$75	\$31	\$44
Total	\$502	\$410	\$92

4. Schedule

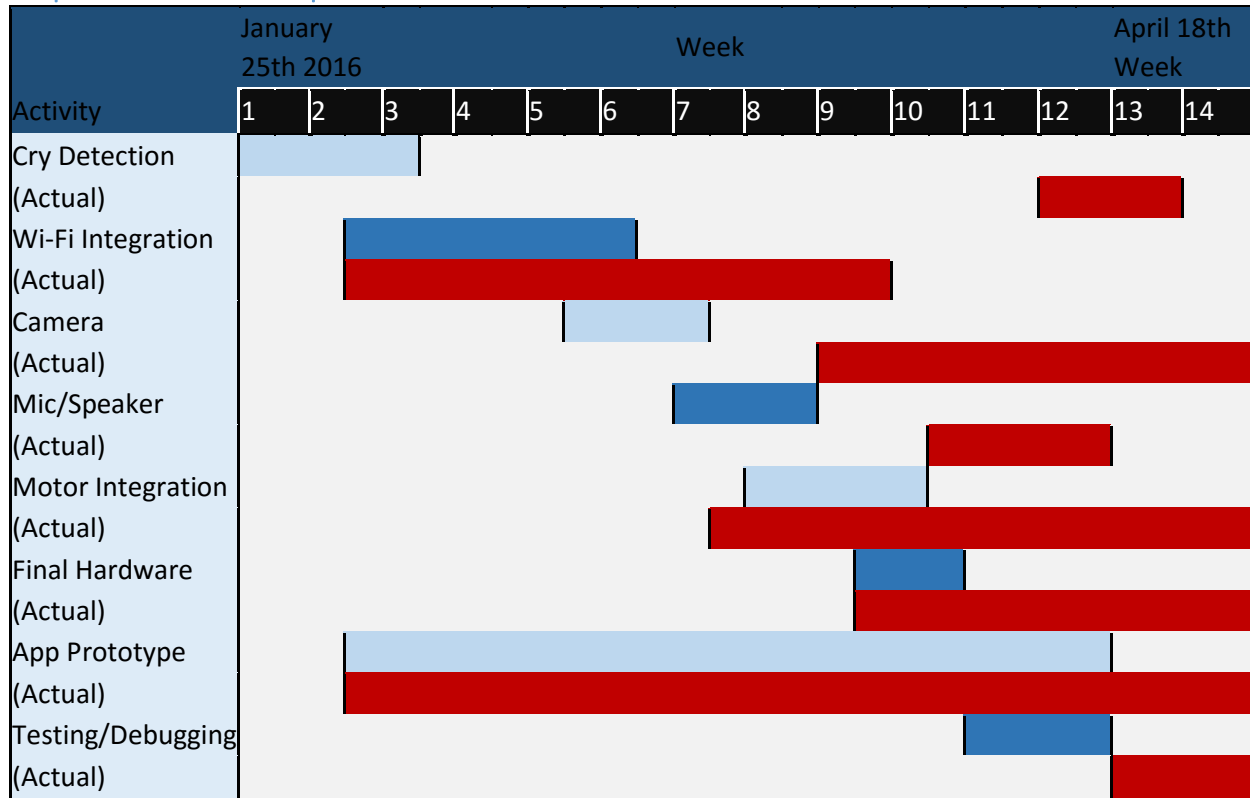
Proposed and Actual Documentation



The previous table is the proposed Gantt chart for documentation, we followed the documentation almost exactly except for the Group Presentation which we started a week later than we were supposed to finish.



Proposed and Actual Implementation



The table above was the proposed implementation of the project in blue compared to the actual development time in red. We were unable to follow these procedures due to receiving later than expected. There were many issues we had with development.

5. Challenges

Mechanical Issues

The main function of the Smart Baby Cradle, other than the Android App, is to rock the cradle using a motor. Since we need the precise angle, rotation time and smooth action, amongst the different type of motors: windshield wiper motor, linear actuator and servo motor, we chose to use stepper motor as our ideal source of mechanical action. Stepper motor can be easily controlled and coded using. Firstly, we calculated the minimum torque required to rock the cradle.

We decided to purchase a motor with a torque of 48N.M that is more than sufficient to achieve our goal. However, we mistakenly ordered the wrong stepper motor from Digi-Key which only has a torque of 48mNM. In order to make up mistake, we decided to use a pulley system with ratio of 10 to increase the torque since we weren't going to use an actual baby for the demo. When we tested it, the cradle could be rotated but with a limited rotating angle and missing steps for stepper motor. This cause us a big delay for our project progress since the mechanical system was already built up for this motor. After a discussion, we decided to buy a new stepper motor with three times of the torque and corresponding motor driver. Although, this mistake caused extra time and \$80 of our budget, we could finally accomplish the rocking function.



The other issue we had with the mechanism is we decided not to implement the mobile toy due it being out of budget. It would have taken a long time to build our own although it would have been cheap we decided it was best not to build it.

Software Issues

We had issues with the webcam feature. It requires decoding the video signal from the Arduino to the android. We initially wanted to buy an IP Camera, but we ended up deciding on an ArduCam. We initially thought this would allow us to have more control of the camera, as well as have the Arduino control everything as one system. It turned out that when the Arduino sent the signal received from the ArduCam, it would output the RAM storage position instead of the actual code stored in it, so we were unable to broadcast video form the ArduCam to the phone.

One major problem we had was Multi-threading. We were unable to run more than one feature at a time. This was due to limitation in the hardware of the Arduino. This could have been potentially fixed if we had decided to make the prototype with a Raspberry Pi.

6. Group Dynamics

Our group consisted of four engineers: Fanchao Meng, Eric Lu, Nick Liu, and Kiru Sri. Each of the engineers had different engineering background. We divided the work according to each other strengths and what each person wanted to learn. Fanchao is a Computing engineer. The other 3 are all systems engineers .

We assigned positions to each person, but we never really followed the set structure in practice, since our group is so small. Fanchao Meng was the CEO, Eric Lu was the CTO, Nick Liu was the CFO, and Kiru Sri was the CIO. Everyone managed the team pretty evenly, except Fanchao since he had the strongest software development, he assemble the android app. He assigned each one of us a component to test and implement with Arduino.

We didn't have any real disputes while working together. Everything went smooth and the team worked really well together. The only disputes that were there was about how to implement certain components. For example the motor, some of us wanted to implement it using a DC motor, and the others wanted to use a stepper motor. We compromised and used a Stepper Motor, and decided that we would implement the DC motor of we couldn't get the stepper working.

7. Workload Distribution

Task	Eric	Nick	Kiru	Fanchao
Documentation	x	x	xxx	xx
Software Development	xx	xx	x	xxx
Hardware Development	xx	xx	xxx	x



Assembling	xx	xx	xx	x
Debugging and Testing	xxx	xxx	x	xx
Team Management	x	xx	xx	xxx
Meeting Minutes	xx	x	xx	x

8. Conclusion

This project was a success in our books. Android development was new to every single group member, and we were able to successfully implement the Smart Baby Cradle. It was missing some features, and the app wasn't fully complete, but we did know what was needed and left to finish the cradle. We had a great team, with great chemistry. Each group member learned new and valuable material by the end of it.



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Appendix A: Reflections

Fanchao Meng

Designing and implementing a project is always tough. Even though during my study career in SFU I did lots of projects or labs, nothing is like the 440/305 course because we have to go through the entire life cycle of developing a product or prototype. Fortunately, I got 3 great partners who worked so hard with me to accomplish our goal. Each one of us has different background and knowledge. However, in order to finish our design, we have to share our knowledge and skills to reach our same destination.

Technically, I learned lots of mechanical and circuit knowledge that I did not have before. Kiru and Eric had stronger mechanical skills than me. Working with them helped me to understand the motor, the gear system and the belt system. We discussed our design and brought the solution together. I really enjoyed learning things from them. Even though each of us had our own tasks and responsibilities for the project, we always worked together. Seeing how they solved the mechanical problems made me interested in the field that I never worked before.

I also improved my programming skills during this semester. I had Java programming background, but Android application was another story. I spent a long time to figure out how to read data from the WIFI server and how to send data to it. During the application development, I met lots of barriers. I did lots of researches and learned lots of tutorials online. I also talked to some people who were in Computing Science major to help me understand the Android development concepts. I enjoyed the process when I tried to fix bugs and the mistakes that I made. During this process, I learned that for a project, no matter how tiny the mistake was, it might have huge influence on the result. This improved my critical thinking and programming skills, such as testing for each sections or methods was more effectively than testing for the whole program after development. It would be so hard to find out the problem when I had hundreds of lines of codes.

Problem solving was another thing that I learned a lot from this course. It was impossible to accomplish a project with no problems or errors. Solving those problems determined if we could finish our goal on time and it determined our project's functionality. Whenever we met problems or challenges, we used all resources that we could find to help us, like the professors, TAs and friends. We learned from them, such as how they solved the same problems. We also learned from our mistakes or misunderstandings ever time when we solved problems.

Non-technically, the most important thing that I learned would be time management skill. At the beginning, we set up our schedule and felt that we had enough time to finish our design. However, the fact was that many unexpected things happened to delay our schedule and plan. Kiru got a part-time job and I got a part-time job as well in the middle of the semester. Our purchased items got shipping issues due to the Chinese Spring Festival. We made mistakes about the motor and had to order a new one. The mechanical design of the cradle was more difficult than our expectation. All those things bothered us and we had to delay our design and schedule. Things like this will always happen during our studying and even the future career. After this course, I think all of us have much better time management skill than before.



I also want to thank to my teammates, Eric, Nick and Kiru. We became good friends after this project. We did have discussions and different opinions during the project development. But since we had the same goal, we worked together effectively and at least I felt really comfortable to work with those great people. Team work is always important for any fields or projects. All of us know how to work in the group environment effectively and how to give others useful feedbacks.

Eric Lu

So many things going on in this amazing course for a period of 4 months is taking place in my life. I have never been through any experience or challenges or teamwork like the way I went through in Engineering Science 440 305 courses. Not like any co-op work experience or any other simple project groups, capstone project is a completely open minded course to encourage us by using everything we learnt from university and all interests and passion we have on engineering to put into a project which we really put efforts on. I could be responsible to say that there are so many aspects I learned and grew which could be a huge benefit to my future as professional engineer and even as a person.

Our team is composed in the beginning of the term with all types of fields: software developer, mechanical designer, electronic technician, etc. As the member with strong experience on mechanical field, I took care of all the mechanical design and implementation of our project. However, the most important thing I learnt is that do not make mistakes in the beginning for something really minor or stupid. There was a situation, we found out that the initial stepper motor we ordered is too weak to rock the bed. This mistake is made since I was too lazy to recalculate the torque in specific unit to order components when other partner calculated already. We all got pass on this mistake and then lead us an even bigger problem in the end.

Furthermore, even I was focusing on mechanical parts of the project. While the demo date was approaching, when our software developer was busy on preparing final exams, I realized that I have to take over the field I was not familiar with as well. In that period, I studied myself with all the tutorials and sources I can find to solve the problem. Finally, at the moment I figured out the task we were trying to achieve, I stated to love software and felt the interest on software development too. I have learnt with microcontrollers, Wi-Fi connection, user interface, code debugging, voice recognition and everything were so challenging but full of fun!

I could not say more to show the gratitude towards all my team members: Randy, Nick, Kiru. The things four people could accomplish is with no limitation. We had an efficient and friendly helping environment among us, and that is valuable that we all treat capstone serious and willing to give a hand while others are in trouble. The smart baby cradle would not be completed without them.

Nick Liu

The past four month was definitely an amazing journey in my whole university studying period. The capstone project experience was very different from the previous co-op experience, since our group had to do everything from the scratch such as project idea brainstorming, designing, implementing, testing, integrating and demonstration. Turing an innovative idea into a functional product was quite challenging at first but very rewarding in the end. Experiencing the full product development cycle would definitely be an asset in my future engineering career.



At the beginning of the term, our team was split into two sub-groups, one was focusing on the mechanical design and the other was responsible for electronic and software design. Everyone worked on their specialized areas. As a system engineering student with previous mechanical design and machine shop experience, I was taking care of the mechanical part of our project. The most challenging part was to choose the right type of motor with sufficient torque for rocking the cradle. We mistakenly ordered a stepper motor with torque less than the minimum required value and its corresponding motor driver. This mistake significantly delayed our project progress. It was also a waste of our financial budgets since we had to buy another set of motor and driver which cost us extra \$100. Motor installation, noise isolation and pulley system design were also the major challenges we have encountered. These challenges had strengthened my knowledge about mechanical design and problem solving.

This project also provided me the opportunity to expand my knowledge towards other Engineering fields. After completing all the mechanical requirements for our project, I had the chance to contribute the software part along with my teammates. One of the major challenge was to detect baby's crying and send a notification to parents' electronic devices via Wi-Fi. At first, we used an Arduino compatible microphone to detect the crying. The major drawback of this method was that the microphone was sensitive to all kinds of sound. It could not specifically distinguish the baby's crying from other kinds of sound. After doing a lot of research and self-studying, we used the voice recognition shield which gave us an accurate and satisfying result. Before the capstone project, I had no experience working on the micro-controller and android app development. During the project, I had gained a lot of knowledge of using micro-controller to control motor, music via Wi-Fi connection. I also learned some knowledge of user interface design, application development and software code debugging.

Our team dynamic was very good throughout the term. Everyone actively contributed to the project and respected the ideas and works from others. Even sometimes there were some minor conflicts of ideas, we could always find a way to compromise.

Overall, capstone project was a great experience which taught us to think and act as a professional engineer. I would like to thank all my teammates for all their hard working and effort towards the project. Without the teamwork and support from each other's, the smart baby cradle would not have been completed.

Kiru Sri

I would like to overall thank Eric, Nick, and Randy for allowing me to join their team. I initially started this semester without a team, as I just had finished 8 months of co-op. They were great to work with and were very focused on new what they were doing.

This project was great, it allowed me to experience a beginning of a company. I have a more in depth knowledge about what limits a company in making a product, especially budgeting, and the amount of times and money wasted on prototyping a product. The documentation is also very important. I need to set my goals in paper first before I go onto to make the product. This way whatever I want a project to have will be implemented.



The other thing I have learned is I have a better understanding of how a computer works, although I did experience this in Ensc 215, we never really got to plug anything into the HC12 microcontroller. This was a more hands-on experience with the Arduino, as well as Raspberry Pi.

The most important thing I learned is to trust the team. I usually like to know everything that is going on in a project, and be there for all the steps. I was working part time this semester, and was unable to meet as much as I liked. We split the parts and we each worked individually on our own parts of the project. Overall it came together well. Each person did their own parts and everything came together nicely.

This was a great experience for me, and I decided that I am going to take on personal projects because of this course. I want to expand my knowledge in app development and microcontrollers. There are some projects I have in mind that I can see myself implementing because of the Smart Baby Cradle.



Appendix B: Meeting Minutes

January 8th 2016 from 10:30 AM to 12:00 PM

Meeting Agenda

Discussion:

- Discussed Ideas for Capstone Project.
- Automated Water Tap for showers.
-

Actions Items

- Brainstorm other possible Ideas for Projects.
- Proposal for ESSS Funding.
- Discuss with Andrew about Ideas.



January 15th 2016 from 10:40 AM to 11:40 AM

Meeting Agenda

- Project Requirements
- ESSEF Application
- Funding Estimates
- Timeline

Actions Items

- Prepare Presentation for ESSEF Funding
- Order Parts
- Design and Review
- Logo and Company Name



January 21st 2016 from 10:40 AM to 11:40 AM

Meeting Agenda

- Proposal
- Finalizing features
- Splitting Sections
- Deciding on Parts

Action Items

- Split Proposal
- Finish Write-Up for each person's part for Proposal



January 28th 2016 from 12:00 PM to 12:30 PM

Meeting Agenda

- Purchasing Required Parts
- Baby cradle Design
- Decide on Microcontroller

Action Items

- Simultaneously work on Arduino and Raspberry Pi
- Assign each member a function to work on.



February 4th 2016 from 11:00 AM to 11:45 AM

Meeting Agenda

- Split Functional Specifications
- Parts haven't arrived yet

Action Items

- Work on Wi-Fi connection Arduino and Computer
- Brainstorm Mechanisms for rocking Cradle



February 19th 2016 from 11:45 AM to 12:20 PM

Meeting Agenda

- Design Review
- Parts still haven't arrived
- Disassemble Cradle
- Resolution of Camera

Action Items

- Mounting Parts onto Cradle
- Implementing Webcam on Raspberry Pi
- Android to Arduino Wi-Fi connection



March 4th 2016 from 1:00 PM to 2:00 PM

Meeting Agenda

- Split Design Specifications
- Microphone will it work?

Action Items

- Finish Design Specifications
- Find compatible microphone for voice recognition



March 11th 2016 from 12:00 PM to 1:00 PM

Meeting Agenda

- Gears Ratio
- Motor for Raspberry Pi and Arduino
- Microphone Module or Shield for Arduino

Action Items

- Build Gears
- Test Motor on Raspberry Pi



March 18th 2016 from 4:00 PM to 5:00 PM

Meeting Agenda

- Torque of Motor
- Webcam not compatible?

Action Items

- Order New Motor
- Researching Video Decoding



April 1st 2016 from 10:00 AM to 2:00 PM

Meeting Agenda

- Debugging Codes
- Implementing New Motor

Action Items

- Implement Motor with Arduino
- Find Driver for Raspberry Pi



April 17th 2016 from 6:00 PM to 7:00 PM

Meeting Agenda

- Prepare for demo

Action Item

- Finish PowerPoint