Dr. Andrew Rawicz
Faculty of Applied Science, School of Engineering Science
Simon Fraser University
Burnaby, BC, V5A 1S6

Re: ENSC 440W/ENSC 305 Capstone Project: A Proposal for automating food dispensing and removal system for SFU research labs.

Dear Professor Rawicz,

Please allow this report to serve as a proposal for our ENSC 440w and 305w capstone project. This report will illustrate in detail our idea for a capstone project: an automated animal feeder to improve laboratory experimentation.

Our organization, Optimaus, is comprised of 4 engineering science students: Kevin Killy, Robert Lepine, Kyle Griffiths, and Kenny Woo. We have been in contact with the circadian rhythms laboratory at SFU, and we are designing our feeders for installation in said lab. We have also consulted Teresa Dattalo, a research technician working in the animal research centre, who has met with us multiple times to discuss our product and what would be most beneficial to the labs. Teresa has also given us a tour of the labs such that we could take necessary measurements and notes on available power and wiring.

We hereby confirm that this report was written entirely by the members of Optimaus; we have received no external advice or assistance in writing this report. We also confirm this report has not been previously submitted for academic credit at this or any other institution.

Sincerely,

Robert Lepine
Optimaus - CEO

Optimaus

A Proposal for AutoFeed

An Automated Animal Feeder for Laboratory Testing

<u>Prepared for:</u>

Andrew Rawicz - ENSC 440
Steve Whitmore - ENSC 305
Respected staff of
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EXECUTIVE SUMMARY

Optimaus wishes to solve a problem experienced by researchers that involves the routine feeding of laboratory animals. Currently researchers need to feed rodents on a set schedule. They also need to remove all food that they fed the animals after a set amount of time. Optimaus hopes to make a device which can automatically dispense and retract food from the animal at programmable times. Currently we are working closely with the circadian rhythms lab at Simon Fraser University headed by Professor Ralph Mistleberger to gather requirements and cages for prototyping. The AutoFeed design poses a solution to automate the feeding of the rats in Dr. Mistleberger's labs.

Optimaus consists of senior engineering students from the School of Engineering Science, dedicated to design and implement a reliable product for the client. There is a need for this type of product in the market. That market consists of labs across North America who feed animals on a strict schedule. Implementation of this product could relieve graduate students from spending hundreds of working hours a semester doing mundane tasks. AutoFeed could also save research labs costs associated to graduate student wages. We have carefully planned to design, develop and test AutoFeed toward a working product. If time permits we plan to make more units to be used in the SFU Animal Research Centre lab.

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GLOSSARY OF TERMS

API
Application programming interface. Provides a means of communicating with a particular application using programming functions provided in various programming languages.

Arduino
An open-source microcontroller used to control physical objects, in our case, motors.

Controller
Refers to the microcontroller being used, in this case, the Arduino.

Dispensing Apparatus
Mechanical apparatus that allows and restricts access to food during desired feeding times.

Google Calendar
Google's online calendar application. This will be used to schedule desired feeding times.

PWM output
Pulse width modulation digital outputs. These outputs will be used to drive the motors required to operate the dispensing apparatus.

Raspberry Pi
A single-board computer. This will be used to interface with the Google Calendar API at a high level, before signalling the Arduino of desired actions in the physical world.

User Interface
This refers to a graphical view that will allow users to create and edit the feeding schedule. We will be using Google Calendar.

INTRODUCTION

Canada is one of the most automated countries in the world. In all industries, Canadians are consistently being relieved of doing routine tasks as automation takes over. This is a major component to what makes Canada a first-world country and separates us from the rest of the world. At Optimaus, we wish to further progress the automation movement in the laboratory research industry. In research environments, people who are highly educated are sometimes forced to do mundane tasks when a simple solution of automation could save many man-hours. Optimaus wishes to automate the feeding of rodents in an SFU lab. At irregular intervals, students are currently required to enter the labs in the middle of the night to administer food for research purposes. Our project, AutoFeed, will automatically feed the rats in order to relieve the students from coming to the lab at awkward times of the day or night. Our product will do something known as temporal restriction: a research technique that involves feeding the rats for a given amount of time then removing food entirely. Therefore, we have made the retraction of food a priority to achieve satisfied clients. To better visualize how we will restrict access to the food, please refer to Figure 1.

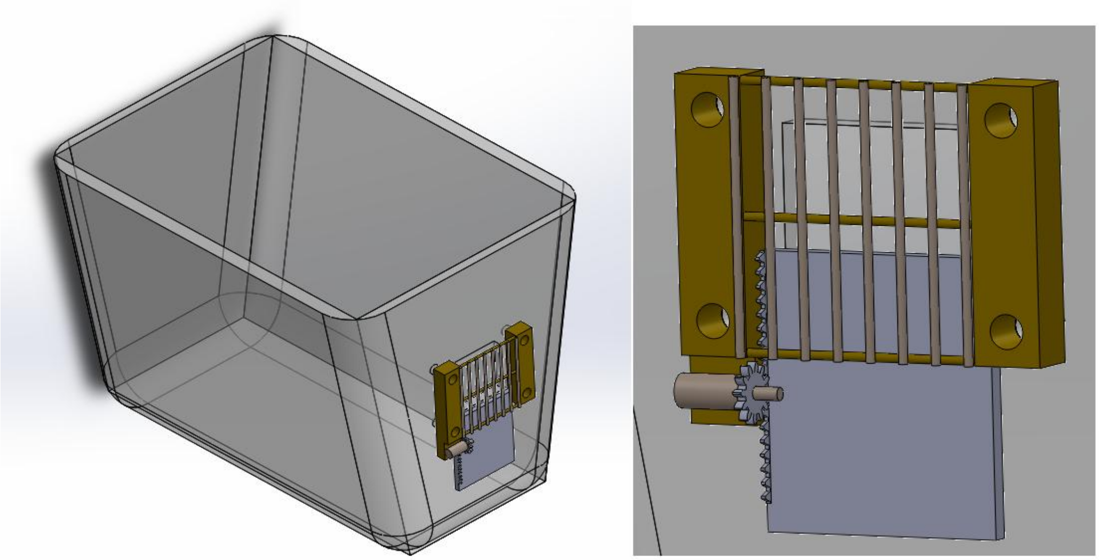

Figure 1: Optimaus' Concept for a Controllable Food Door

Traditional rodent feeders do not retract food at all. Our value-add as that we will be restricting the food at remotely programmable times. Our solution will interface with a web application that allows the user to create a feeding schedule. The interface will be based off a calendar application where feeding periods appear as events on the calendar. Currently, students are required to enter the lab several times a day to feed the animals. With the AutoFeed solution the animals can be fed automatically for up to a week, relieving many man-hours and saving money over the long term. At Optimaus we believe that our product is useful and will help the research community test their hypotheses in an easier and more reliable way. Optimaus is composed of four engineering students at Simon Fraser's school of Engineering Science who have made it their goal to take on the automation of animal feeders. With the integration of our skills in hardware, software, and physics, Optimaus will make AutoFeed a success.

SUMMARY OF PRODUCT

Our project will consist of a Google Calendar interface that allows the user to set up feeding schedules remotely. Calendar apps are already intuitive and easy to use. However, our decision for using an online Google Calendar user interface is further backed by the fact that the psych lab already has all of their other rat activity data automatically uploaded to a Google Drive folder. Therefore, a Google Calendar feeding schedule will seamlessly fit into their current practices. Notifications at the start and end of a feeding cycle will be pushed from the Google Calendar and sent from a computer, in this case a Raspberry Pi, to an Arduino controller. With help from the Arduino controller, these notifications will ultimately actuate electric motors to power the feeding system that will administer and retract food from the rats. Our Arduino board will need several PWM outputs to control electric motors powering the movement of the mechanical parts of our feeder systems. We hope that a single Google Calendar interface, computer, and Arduino chip will control 10 to 16 feeders. A high-level overview of the different components of AutoFeed can be found below in Figure 2.

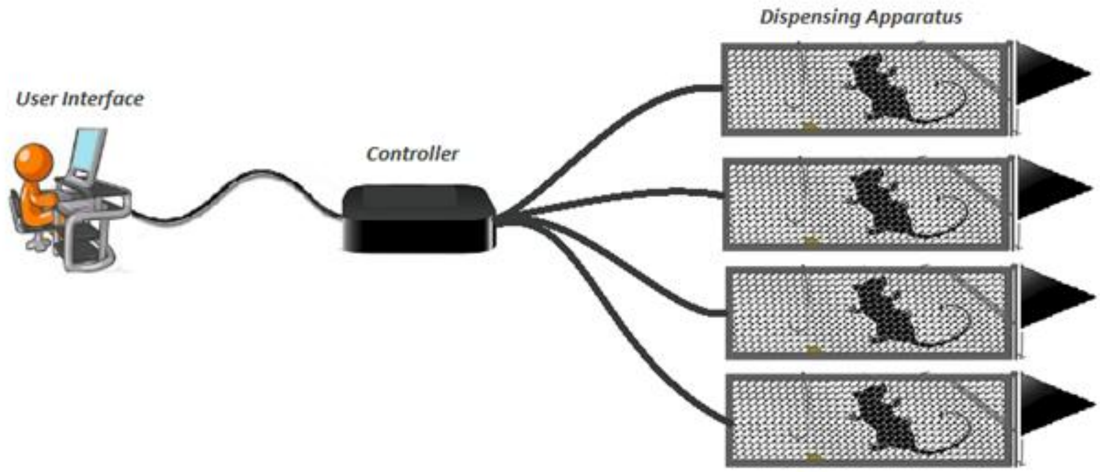

Figure2: A High-Level Overview of the Components of AutoFeed

The mechanical portion of our project will be a feeder that can be retrofitted onto the cages. The feeder will have a bulk amount of food and a door that will open and close to grant and retract access to food. There will also need to be a sensor telling the system when there is almost no food in the bulk storage unit. This sensor will output to the Arduino controller and create a notification on the Google Calendar with a message saying out of food.

RISKS AND BENEFITS

There are some risks associated with our project. First and foremost, we do not want to injure the rats. The moving parts of our feeder system needs to be designed such that there is no way for the rats to get harmed. Therefore, the safety of the animal will be a focus during the design phase of our feeder mechanics. Secondly, temporal restriction experiments are compromised by feeder systems that permit the rat to remove food from the feeder and store it elsewhere in the cage. Storage of food inside the cage is also a concern because the animal can mix feces with food leading to contamination and sickness. As such, our feeder must be designed such that the rat can only eat the food in the feeder, not carry it around and save it for later.

If we design our project to minimize these risks, then the benefits to a programmable animal feeder far outweigh their sum. A major benefit to automating a temporal restriction feeder is that lab rats can be fed at night without a student's or lab tech's presence. The feeding of rats between the hours of 12:00am to 4:00am is relevant to many research topics, but is often not conducted due to the undesirability of working throughout these hours. As previously explained, temporal restriction involves the administration of more than enough food, then after a certain time period, the full retraction of all the food. This means that a student would have to arrive at a certain hour to deliver the food and then wait out the duration of the feeding period to later remove the food. Given that a feeding period can be as long as 3 hours, without an automated feeding process a student could be required to stay present in the lab from 1:00am to 4:00am. Ultimately, 24-hour feeding schedules are currently not conducted because work during certain hours is too undesirable. Our automated animal feeder will allow for more robust research by making the feeding process feasible at all hours of the day. Another major benefit to an automated animal feeder is that they will greatly reduce the amount that students or lab techs are handling the animals. Bites from the mice and rats are not uncommon, and after getting bitten the student could drop the animal by reflex. By taking the feeding duties out of the hands of the students and automating it, the chance of injury to both the students and the animals is greatly reduced.

MARKET ANALYSIS

Our market is the laboratory research industry; specifically research labs working with animals. Our client is the Animal Research Lab in the Neurosciences department of SFU. Feeding in lab environments is, at the moment, done by hand. Current practice includes placement of the food into a hopper which is hung inside the animal's cage, where it rests upon a screen allowing the animals to withdraw food and consume it. There is one competitive product designed by Mayo Clinic Engineering Department. Mayo Clinic's feeder is far too large. In order to be valuable, the lab requires more than 10 feeders and the size of the competitive product makes it unusable because they would not all fit into the lab. Furthermore, the feeding schedule on Mayo Clinic's feeders must be entered manually in the lab for each cage. Our product beats the competition because the feeder schedules can be entered remotely and AutoFeed is small enough to fit on many cages in the lab.

During the design of our prototype, we will be consulting graduate students: the end user. Having the opportunity to consult the end users during the design phase is extremely beneficial. Because we know who we are designing for we can keep our users in mind every step of the way during the development of AutoFeed. We can now complement our design decisions on what the experienced individuals who will be using the product actually want. Having early feedback from our customers will inevitably allow us to design a better product. Furthermore, the fact that neurology students were involved in the design process can be used as a marketing tool during commercialization: our product was design by neurologists, for neurologists.

If this product were to be commercialized, our customers could be either cage manufacturers or universities and private laboratories. Firstly, with cage manufacturers as our customer, our product would be an automated feeder system attachment; a supplementary feature to attach to the traditional cage. Lastly, with universities or private laboratories as our customer, our product becomes a complete cage assembly with an automated feeder. During the design of our prototype we will be retrofitting a finished cage. In order to target universities and private laboratories as our customer, we would either need to buy third party cages or design our own. A profitability analysis of each potential customer group is required prior to commercialization, but it is worth noting that we have multiple market options. Another important point about commercialization is that customers in the animal research laboratory industry would require several feeders in order to have successful experiments. Many animal subjects are required in order to gather enough data. Therefore, for every customer we acquire, we would be selling our feeders in bulk. For example, in the SFU animal research centre, the standard number of test subjects for a single experiment is 16. Using SFU as an example, if we were to sell our feeders to SFU, we would be selling at minimum 16 units. Furthermore, the lab at SFU usually runs several different tests concurrently. Therefore, if our feeders are successful, the SFU lab may purchase higher multiples of 16 units. Because we would be selling in larger quantities to each of our customers, our revenue would inevitably increase.

BUDGET AND FUNDING

Below, in Table 1, is a bill of materials and all of the planned costs of development for AutoFeed with a 15% contingency.

Equipment	Cost
Acrylic Sheets x4	$30.60
Lego Gears and Racks x10	$28.85
DC Motors x10	$38.00
Push Buttons x20	$17.00
Transistors (5 pack) x3	$3.00
Arduino Mega 2560	$60.00
Raspberry Pi	$39.95
8GB SD Card	$15.00
Raspberry Pi Power Supply	$9.50
Power Adapter AC/DC x10	$79.50
USB Cables x2	$6.00
Tax 7.00% PST	$22.92
Tax 5.00% GST	$16.37
Contingencies 15%	$55.00
Total	**$421.69**

Table 1: Bill of Materials

We have planned for the cost of AutoFeed to be substantial, and we therefore require funding to support the project's development. We have submitted an application for funding from ESSEF, and are hoping for funding for the full amount of the project. In the case that there are remaining expenses not covered by ESSEF donations then we will apply for more funding from Dr. Andrew Rawicz via the Wighton Fund. We are confident that we will cover all of our costs with both of the listed funding options.

TIME SCHEDULE AND PLANNING

We realize that bringing a project such as ours from conceptualization to completion is time intensive. Given that we are working with strict time-constraints, we have devised a thorough time schedule that will allow a complete prototype of AutoFeed to be realized. Figure 3 is a Gantt chart containing all documentation, preparation, design, and testing tasks required for the completion of our project.

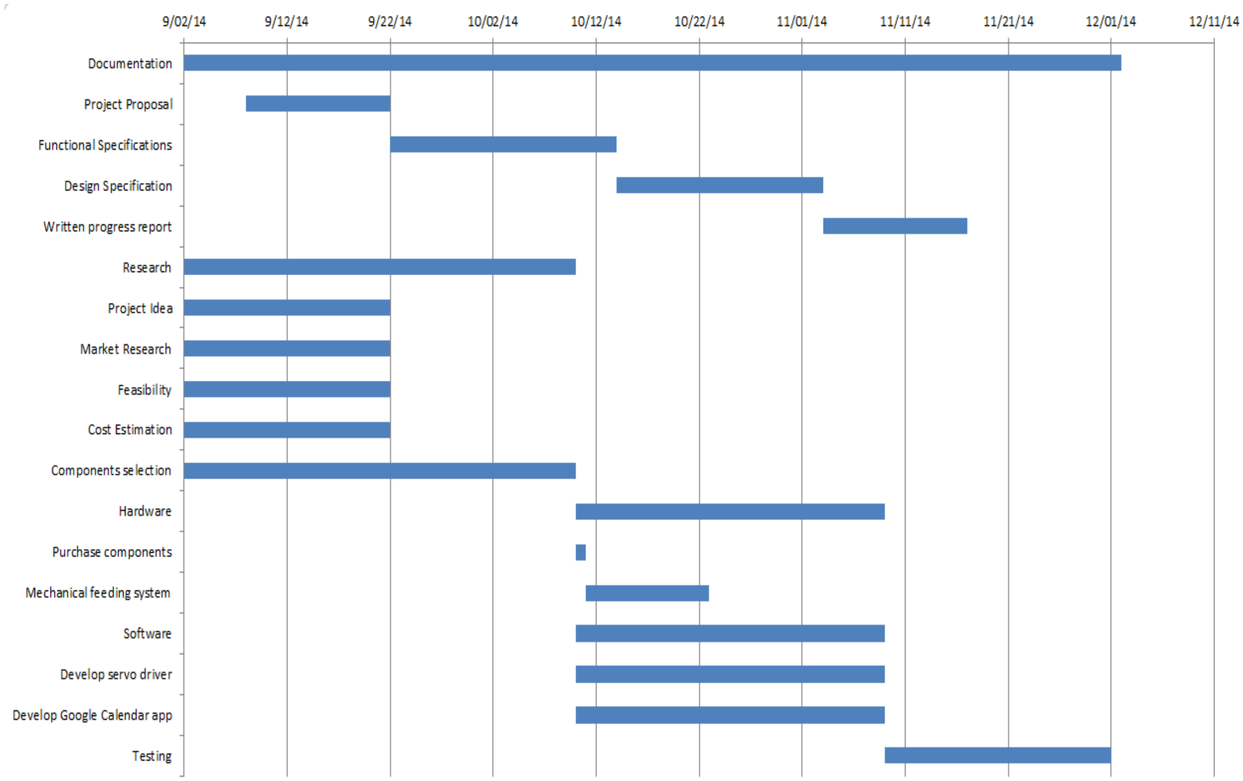

Figure 3: Time Schedule

Following the timeline in Figure 3 will be our objective throughout the semester. However, we realize that we are entering the unknown. As with any engineering project, we need to assume there will be unforeseen complications that slow our development down. Therefore, we are treating the development of AutoFeed as a living process. Our ultimate goal is to successfully develop our product. The timeline in Figure 3 will hold us accountable for continuous progression towards the completion of AutoFeed. Our timeline will allow us to adjust our workload accordingly through unexpected complications. Optimaus is prepared for the unexpected. We are ready to analyze our progress against our obstacles to prioritize our efforts and remain on schedule.

CONCLUSION

As we move forward into the design and development phase of AutoFeed, we will be focusing on completing a single feeder. Upon the completion and testing of our prototype, if time permits, we will then endeavour to assemble and install more feeders into the lab. In animal research laboratories, many animal subjects are required to receive enough data from experiments. Therefore, we hope to provide the SFU animal research centre with a suite of feeder units such that they can fully implement AutoFeed into their experimentation practices. It is our ambition to have 10 feeders installed in the lab by the end of the semester. The Optimaus team members can be found in Figure 4. We are extremely motivated to have the opportunity to develop AutoFeed. The dedication of the engineers that comprise Optimaus makes the complete automation of laboratory feeders possible.

Figure 4: The Optimaus Team

APPENDIX A – OPTIMAUS TEAM MEMBERS

Rob Lepine - Chief Executive Officer Is a fourth year System's Engineering student at Simon Fraser University. He has extensive hands-on experience working in the underground labs at SFU developing safer bicycle helmets. This extends to working on repair and maintenance of the housing system for the experimental rats at SFU, and from this exposure has recognized the need for regulating temporal feeding times for rats and mice within the Animal Research Center (ARC) lab, to improve research standards when testing circadian rhythms for rodents.

Kyle Griffith - Chief Design Officer Is a fourth year Engineering Physics student with experience in C++, Matlab, and assembly. Kyle spent his first coop in Germany working in the Material Sciences department of Technische Universitat Darmstadt where he had experience working on Pulsed Laser Deposition. For his second coop he spent in Philippines for a land development company where he focused on soft skills such as technical writing and acted as a liaison between engineers and government officials. Kyle's international experiences from the super automated to the labour intensive makes him a great candidate for Chief Design Officer

Kenny Woo - Chief Technology Officer Is a 4th year Computer Engineering student at Simon Fraser University. Kenny's experiences lie mainly in being a code monkey. He has co-op experience in network infrastructure and testing in embedded systems at Ericsson. Prior to that, he spent many long hours assisting non-technical customers in cable TV and internet troubleshooting from the comfort of a call centre in Downtown, Vancouver for Shaw Cablesystems. In his free time, he may be found attached to a volleyball.

Kevin Killy - Chief Operating Officer Is a 4th year Electronics Engineering student at Simon Fraser University. Kevin has experience with hardware description languages and the programming of digital logic controllers. Kevin also gained work experience as an instrumentation engineering student while working for an oil and gas company. Another valuable work experience under Kevin's belt was gained while he working as a quality assurance software analyst for a start-up company. From this position, Kevin developed the skills needed to create robust test cases for engineering projects. Furthermore, the knowledge Kevin gained on the dynamics and organization structure of start-up companies will be invaluable to Optimaus moving forward.

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