BME Design-Fall 2018 - Stephan Blanz
Complete Notebook

PDF Version generated by

Stephan Blanz

on

Dec 12, 2018 @03:08 PM CST

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Team contact Information

▪ Stephan Blanz ▪ Oct 10, 2018 @11:33 AM CDT

Last Name	First Name	Role	E-mail
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Guo	Rick	BPAG	jguo77@wisc.edu

Project description

▪ Stephan Blanz ▪ Oct 09, 2018 @10:35 PM CDT

Course Number:

BME 400

Project Name:

Somatosensory stimulation apparatus for rodent cages

Short Name:

Hindlimb Stimulator

Project description/problem statement:

Peripheral nerve injuries are common, debilitating and costly. Approximately 2.8%-5% of all trauma patients in the US sustain such an injury with nearly 100,000 peripheral nerve repairs being performed annually costing approximately 150 billion dollars. The most important clinical outcome following nerve repair, is functional ability, and despite advances in microsurgical technique, poor functional outcomes are frequent. Unfortunately, the cause for outcome variability is unknown and functional outcome is difficult to assess and measure experimentally.

The goal of this project is to design and validate an experimental apparatus that can provide somatosensory stimulation (i.e. vibration) to the hindlimb of a rodent would greatly improve the ability to assess nerve regeneration in rats for a wide range of studies- including but not restricted to, surgical repair methods, tissue engineering and neural interfacing.

About the client:

Dr. Aaron Suminski is a scientist with the University of Wisconsin, Department of Biomedical Engineering. He collaborates with Dr. Aaron Dingle, a post-doctoral researcher, with the University of Wisconsin, Department of Surgery, Poore lab. The Poore lab's research focus is clinical and experimental microsurgery, with an emphasis on peripheral nerve regeneration and repair. Together they are researching the effectiveness of various treatments and methods of nerve repair.

2018/09/21-Client Meeting

▪ Stephan Blanz ▪ Oct 09, 2018 @10:41 PM CDT

Title: Advisor Meeting Notes

Date: 9/21/18

Content by: Stephan Blanz

Present: Stephan Blanz, Royal Oaks, Rick Guo

Goals: Initial Meeting with client. Determine immediate priorities and set expectations

Content:

Injured nerves leads to a level of disability.
Rodents have historically been a model for nerve repair.
Vibrational stimulation of varying magnitudes
Old design: 3 nose poke holes (yes, no, maybe; left, right, don't know)
Design -> cause injury to nerve, test progress of rehabilitation
Next step: implant electrodes that replace function (artificial signal in nerve through electrode)

Look into foot physiology for sense

Independently vibrate two feet. Isolate to only feet, not other parts of the body.
Be able to get into device by themselves. (can put whatever in device to fix them in desired position)

Two alternative forced choice experiment

Come up with repeatable, reliable computer stimulation

Interface needs to be on a computer (think about TTL input)

Cleaning think bleach safe.

Conclusions/action items:

- Research rodent hindlimb anatomy to determine which **vibrations** it is sensitive to
- When frequencies have been determined, ensure that the product can be **user controlled** over the range of frequencies

2018/09/14-Advisor Meeting Notes

▪ Stephan Blanz ▪ Sep 21, 2018 @01:52 PM CDT

Title: Advisor Meeting Notes

Date: 9/14/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

In **progress reports**, highlight pertinent changes.

Have prepared agenda for **client meeting**. Think: design specifications, quantitative metrics, IP concerns. Do background research on relevant literature and existing devices. Brainstorm on how to solve the problem. Think about emailing agenda to the client.

Conclusions/action items:

Meet with client

2018/09/21-Advisor Meeting Notes

▪ Stephan Blanz ▪ Sep 21, 2018 @01:54 PM CDT

Title: Advisor Meeting Notes

Date: 9/14/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Update website with group picture, progress reports and deliverables as required.

On progress reports if there is not much change, highlight it. Put important info in an email as well.

Progress report should show a trajectory of progress. Both where you are and where you plan on going.

Use as a tool to schedule. Set overall deadlines and then work your way back to where you are to establish schedules.

Ask if the vibrations from limb could be felt elsewhere in the body at certain points during client meeting – would this influence design specifications.

Think about which stimuli we would like to use on rodent.

Continuous stimulation vs tap for stimulation.

Could we use cold to stimulate?

Conclusions/action items:

Meet with client and develop PDS.

2018/09/28-Advisor Meeting Notes

▪ Stephan Blanz ▪ Oct 09, 2018 @10:45 PM CDT

Title: Advisor Meeting Notes

Date: 9/28/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Advisor agrees with defining short term goal of vibrational stimulation. Plan to find several commercially available devices that can achieve this and use these for a design matrix. Use pictures in design matrix.

Conclusions/action items:

- Determine range of vibrations
- Find suitable commercial product that an end-user can manipulate the output within the prescribed range

2018/10/12-Advisor Meeting

▪ Stephan Blanz ▪ Dec 12, 2018 @01:22 PM CST

Title: Advisor Meeting Notes

Date: 10/12/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Advisor Meeting 10/12/18

Feedback for improvement on presentation:

- Practice with clicker beforehand. Practice how to recover if something happens
- Practice the presentation as a team. Makes the individual portion as well as the transition go smoother. Also verify all props are in place at the beginning.
- Take out overview slide
- Make a point to introduce client, and client's background and why propose product
- Be more specific and **highlight and emphasize** key points in talk, ie. Cell phone vibrator would need three different motors. Member's of audience didn't understand differences. Or methods of stimulation.
- Try to anticipate audience and where gaps between presentation and audience knowledge would exist, and fill those gaps in early in presentation
- Engage the audience. Be enthusiastic. Smile! Fake it until you make it.

Comments on project moving forward:

- Identify which components of the project require precision. Amplitude, vibration?
- Isolate vibration. Figure out best method for doing so.
- Think about cuffs to vibrate. That way you could have independent vibration and rodents could be independently moving. Think about piezo buzzers.

Conclusions/action items:

- Take feedback on presentation and ensure future success

2018/10/19-Advisor Meeting Notes

▪ Stephan Blanz ▪ Dec 12, 2018 @01:24 PM CST

Title: Advisor Meeting Notes

Date: 10/12/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Advisor Meeting 10/19/18

Look into piezo with leads coming off. Might be able to find one with leads coming off it.

Downside of piezo: they are voltage driven, require high voltage.

Thor labs has very small piezo speakers.

Also, voice coils might be viable options. Bottom line, there are small things that can work with a cuff.

Recommend getting a set of cheap earbuds and seeing if they produce an amplitude high enough to feel (voice coil).

For Arduino, look at implantable light transceiver.

Conclusions/action items:

- Explore piezo as vibrational motor

2018/10/26-Advisor Meeting Notes

▪ Stephan Blanz ▪ Dec 12, 2018 @01:26 PM CST

Title: Advisor Meeting Notes

Date: 10/12/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Advisor Meeting 10/26/18

Voice Coil: Still needs to be researched more. Play with amplitude (volume) and frequency. It is possible to make an audio file that will do this.

Is it possible to break apart a headset and preserve voice coil?

Client: Keep client updated on progress and the investigation of various methods.

Design / Fabricate Platform should be the next step. Can order motors from amazon and start testing platform design.

Think about materials and mill a component with those materials.

Be sure to attend show and tell and Tong lecture in upcoming weeks.

Conclusions/action items:

- Consider Milling a platform

2018/11/02-Advisor Meeting Notes

▪ Stephan Blanz ▪ Dec 12, 2018 @01:28 PM CST

Title: Advisor Meeting Notes

Date: 10/12/18

Content by: Stephan Blanz

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with advisor to discuss progress

Content:

Advisor Meeting Notes 11/2/18

Think about testing. There will be a lot of variables to test. Break problem down to testing the device in various ways vs testing with rat. Collect data on subcomponents: amplitude of vibration, frequency of vibration, energy input, energy output. Ultimately you want to stimulate. Be able to report data on stimulation parameters (amplitude and frequency).

Apply design principles: mass that is off-centered by a certain amount, what kind of energy would get out? Energy in vs energy out? How is it coupling to rat? Inertia transfer to platform. How much are you coupling into rat's foot.

Comments on Notebook

Make sure to document work you're doing. Put in entries as you're doing.

Comments on Report

Ensure all team members read entire notebook. Can use track changes to edit sections other than own.

Try to use the same voice throughout paper.

Background section: relevant physiology and biology.

Could use short introductory paragraph talking about relevant pieces of information. Bridge in between that talks about link between two needs to be evaluated.

Beef up sections in include more detail on everything.

Be sure to relate pictures (CAD drawing of cam) to what it does and how it does it.

Keep in mind for figures and captions that they should be able to stand alone against the paper.

References should mostly be journals and scientific articles.

Next Meeting Times: Monday morning, or between 3 and 5. Tuesday before 11 and Wednesday Afternoon.

Thanksgiving week: Monday other than noon.

Conclusions/action items:

- Try to bridge relevant pieces of the paper to show relevance / importance in a unifying context

2018/10/4-Design Matrix

▪ Stephan Blanz ▪ Oct 10, 2018 @12:16 AM CDT

Title: Design Matrix Creation

Date: 10/4/18

Content by: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Create Design Matrix Criteria

Content:

Each motor was rated according the the following criteria (weights in parentheses):

Segregation of Stimulation (25): The degree to which the vibrational stimulation is localized to one hindlimb of the rat. A score of 5 would imply that any vibration applied to one hind-leg platform would be undetectable in the other hind-leg platform. A score of 3 would imply that when vibration is applied to one hind-leg platform there is a measurable vibration in the other hind-leg platform between 0 and 0.1 times the amplitude of the applied vibration. A score of 1 would imply that when a vibration is applied at one hind-leg platform there is a measurable vibration at the other hind-leg platform between 0.5 and 1 times the applied vibration.

Frequency Range (20): How closely the vibration range of the motor matches the desired vibration range. A score of 5 would imply that the motor has a range larger than but including 70 Hz to 100 Hz. A score of 3 would imply that the motor has a range of 70 Hz to 100 Hz but has limited resolution within this range. A score of 1 would imply the motor does not produce vibrations within the 70 Hz to 100 Hz range.

Ease of Integration (15): The ease of creating an interface between the motor and the rat. A score of 5 would imply that the interface could be designed within two weeks. A score of 3 would imply the interface could be designed within a month. A score of 1 would imply that it would take more than one month to design the interface.

Size (15): The design must be able to fit on a laboratory bench and hold one adult rat. The cage has a minimum size of 30 cm × 30 cm × 60 cm. A score of 5 would imply the motor could be used with a cage of dimensions 30 cm × 30 cm × 60 cm. A score of 3 would imply the motor could be used with a cage of dimensions 35 cm × 35 cm × 60 cm. A score of 5 would imply the motor requires a cage larger than 40 cm × 40 cm × 60 cm.

Ease of Achieving Desired Effect (5): The ease of controlling the motor. We will need to create code that will manipulate the motor. A score of 5 would imply that there is a sufficient amount of documentation on how to control the motor. A score of 3 would imply that there is a some documentation on how to control the motor. A score of 1 would imply that there is little to no documentation on how to control the motor.

Safety (5): The safety of the design. The design should not harm or cause discomfort for the user or rat. A score of 5 would imply that there is little to no chance that the rat or user will be harmed. A score of 3 would imply that there is some chance that the rat or user will be harmed. A score of 1 would imply that there is a high likelihood that the rat or user will be harmed.

Criteria	(Weight)	Linear Actuator		Micro Vibration Motor		Precision Vibration Motor	
Segregation of stimulation	25	5/5	25	4/5	20	4/5	20
Frequency range	20	3/5	12	3/5	12	5/5	20
Ease of integration	15	3/5	9	2/5	6	3/5	9
Size	15	3/5	9	4/5	12	5/5	15
Ease of acchieving desired effect	5	5/5	5	3/5	3	4/5	4
Cost	5	3/5	3	5/5	5	4/5	4
Total	**85**		**63**		**58**		**72**

Conclusions/action items:

- Precision Vibration Motor wins

2018/12/02: Motor Testing

▪ Steven Oakes ▪ Dec 12, 2018 @10:41 AM CST

Title: Motor Testing

Date: 12/2/2018

Content by: Royal Oakes

Present: Stephan Blanz, John Beckman, Rick Guo

Goals: Describe the testing procedure for the motors.

Content:

An experiment was conducted to determine the response of the linear resonant actuator (LRA) motor and eccentric rotating mass (ERM) motor under different conditions. Each of the two motors were placed into three different positions with an accelerometer (Figure 1). The direct placement configuration was used to determine the motor's response to different voltages, since there may be discrepancies in actual performance from the datasheet. The dampened configuration was used to determine what the rodent might perceive from the leg being stimulated by the motor during use of the cage. The off-target configuration was used to determine what the rodent might perceive from the leg not being stimulated during use of the cage.
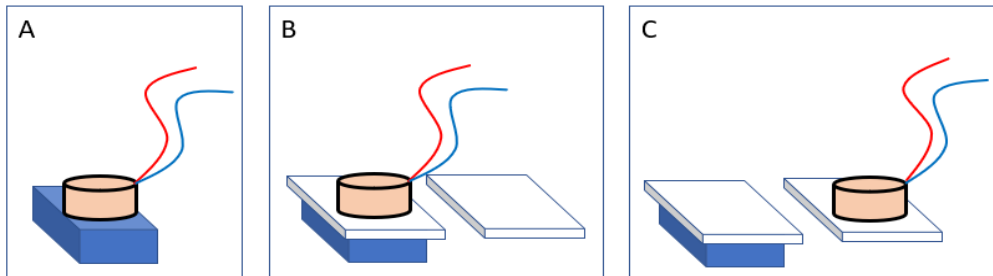

Figure 1. The configurations of the accelerometer (blue) and the motor (beige) used in our experiment. (A) The direct placement configuration. (B) The dampened configuration. There is a foam pad (white) separating the accelerometer and the motor. (C) The off-target stimulation configuration. The motor is placed on the adjacent foam pad to the accelerometer.

In each configuration, a motor was vibrated at various voltages. The voltages tested in each motor spanned the range specified in the motor's datasheet at 0.5 V increments. Each motor was powered using a PWM signal with a max voltage of 5 V. Thus, a 2.5 V signal in this experiment corresponds to a duty cycle of 50% and a 3.5 V signal corresponds to a 70% duty cycle
.

Data was collected from the accelerometer using an Arduino UNO and was sent to MATLAB for processing as described in Royal Oakes' design ideas. First, the motor was powered and 128 samples of the acceleration vector were collected from the accelerometer at 1 kHz. This number of samples was chosen due to memory limitations of the Arduino UNO. Second, the data was imported to MATLAB. Third, the magnitude of the acceleration vector was computed. Fourth, the Fourier transform of the accelerometer magnitude was computed using the MATLAB fast Fourier transform [1]. This method was used rather than sending the data one sample at a time because literature suggests that our method leads to more accurate data [2].

[1] "Fast Fourier transform - MATLAB fft." [Online]. Available: https://www.mathworks.com/help/matlab/ref/fft.html. [Accessed: 12-Dec-2018].
[2] A. Hjort, M. Holmberg, V. Ziemann, and K. Gajewski, "Measuring mechanical vibrations using an Arduino as a slave I/O to an EPICS control system," 2015.

Conclusions/action items:

Complete the testing of the motors and record their data.

Finish the report and final presentation.

2018/12/02: Motor Testing Raw Data

- Steven Oakes - Dec 12, 2018 @10:50 AM CST

Title: Motor Testing Raw Data

Date: 12/2/2018

Content by: Royal Oakes

Present: N/A

Goals: Present the Raw Data from the Motor Testing

Content:

The legend for the raw data is presented below. The data was collected as described in the Motor Testing Protocol page. The coin motor is the linear resonant actuator (LRA) motor and the cylindrical motor is the eccentric rotating mass (ERM) motor.

=== Definitions ===
<type> is the measured value from the acclerometer:
- "mag" is the magnitude of the acceleration vector.
- "xData" is the acceleration along the x axis of the accelerometer.

<value> is the pwm voltage applied to the motor. The voltage can be solved for by voltage = (value/255) * 5.

=== Legend ===
<type>_<value> -> The direct placement of the coin motor on the accelerometer.
noise_<type>_<value> -> The cylindrical motor on a different pad in rodent cage.
noise1_<type>_<value> -> The cylindrical motor on the same pad in rodent cage.
coin_direct_<type>_<value> -> The coin motor on the same pad in the rodent cage.
coin_noise_<type>_<value> -> The coin motor on a different pad in the rodent cage.
cyl_dir_<type>_<value> -> The cylindrical motor directly on the accelerometer.

Conclusions/action items:

None.

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2018/09/07-Sense Feeling

▪ Stephan Blanz ▪ Oct 09, 2018 @10:55 PM CDT

Title: Research Notes on Sensory Cells

Date: 9/7/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Determine the effects various cells have on "feeling"

Content:

How do we sense feeling?

The tactile corpuscles (also known as Meissner corpuscles) respond to light touch, and adapt rapidly to changes in texture (vibrations around 50 Hz).

The bulbous corpuscles (also known as Ruffini endings) detect tension deep in the skin and fascia.

The Merkel nerve endings (also known as Merkel discs) detect sustained pressure.

The lamellar corpuscles (also known as Pacinian corpuscles) in the skin and fascia detect rapid vibrations (of about 200–300 Hz).

- The **Rapidly Adapting (RA) or Meissner corpuscle end-organ** mechanoreceptor underlies the perception of flutter[6] and slip on the skin.[7] They have small receptive fields and produce transient responses to the onset and offset of stimulation.
- The **Pacinian corpuscle or Vater-Pacinian corpuscles or Lamellar corpuscles**[8] underlie the perception of high frequency vibration.[6][9] They also produce transient responses, but have large receptive fields.

Conclusions/action items:

- Two frequency ranges: ~ 50Hz and 200 - 300 Hz
- Document contains hyperlinks in case I need a refresher

2018/09/28-Hindlimb Stimulation methods

▪ Stephan Blanz ▪ Oct 09, 2018 @10:53 PM CDT

Title: Research Notes on Techniques Currently Used to Stimulate Rodents

Date: 9/28/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Determine what is currently being used to stimulate rodents

Content:

Hindlimb stimulation

 via 50 ms air-puff [1]

thin acupuncture needles (0.14 mm) were inserted into the paws and a 0.2–1 mA, 1 ms electrical pulse was delivered [2]

10-150 Hz [3]

g.USBamp (g.tec) and the coin motor (YBI027, Φ=10 mm, YB motors, Republic of Korea) for stimulation system is operated through NI cDAQ
 operation of the vibration motor is managed by Data Acquisition Toolbox (MathWork, U.S.A.) 4 second stimulation in anesthetized mice [4]

Typically, the sensation of warm is elicited at temperatures of 34–37°C, while the sensation of pain is elicited at temperatures of 42–48°C [5]

The sensation of pleasant or innocuous cooling is typically elicited at temperatures of ~23–29°C, while the sensation of cold pain is significantly variable, with multimodal distribution of the cold pain threshold recently reported, corresponding to modal threshold temperatures of 23.7°C, 13.2°C and 1.5°C, respectively [5]

[1]   M. Murayama and M. E. Larkum, "Enhanced dendritic activity in awake rats.," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 106, no. 48, pp. 20482–6, Dec. 2009.

[2]   M. H. Mohajerani *et al.*, "Spontaneous cortical activity alternates between motifs defined by regional axonal projections.," *Nat. Neurosci.*, vol. 16, no. 10, pp. 1426–35, Oct. 2013.

[3]   J. H. Edwards and G. C. Reilly, "Vibration stimuli and the differentiation of musculoskeletal progenitor cells: Review of results in vitro and in vivo.," *World J. Stem Cells*, vol. 7, no. 3, pp. 568–82, Apr. 2015.

[4]   C. Yeon, D. Kim, K. Kim, and E. Chung, "Sensory-evoked potential using a non-invasive flexible multi-channel dry EEG electrode with vibration motor stimulation," in *IEEE SENSORS 2014 Proceedings*, 2014, pp. 519–522.

[5]   J. R. Deuis, L. S. Dvorakova, and I. Vetter, "Methods Used to Evaluate Pain Behaviors in Rodents.," *Front. Mol. Neurosci.*, vol. 10, p. 284, 2017.

Conclusions/action items:

- Using Vibration: 10-150 Hz
- Refer back to this in case we decide to stimulate using other methods

2018/10/04-Touch Screen

▪ Stephan Blanz ▪ Oct 09, 2018 @11:32 PM CDT

Title: Touch Screen Chamber

Date: 10/4/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Competition Research

Content:

Lafayette instruments provides various rodent enclosures for use in training. They have one in particular where the rat can be trained to touch a "touch screen." However, they have no product that stimulates hindlimbs.

Link: http://lafayetteneuroscience.com/products/rat-touch-screen-chamber
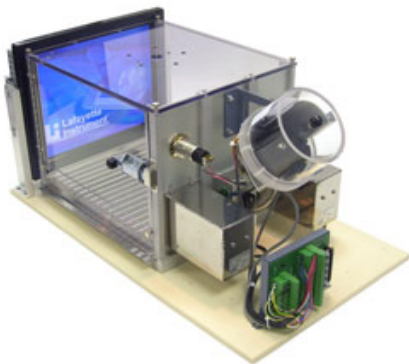
Conclusions/action items:

- We have a novel item.
- We might be able to incorporate an existing product for additional features

2018/11/22-Vibration Mechanics in Various Motors

▪ Stephan Blanz ▪ Dec 12, 2018 @12:47 PM CST

Title: Vibration Mechanics in Various Motors

Date: 11/22/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Vibration Calculations and Determining Best Fit for Project

Content:

Three motors are commonly used to create vibration.

LRA (Linear resonant actuator): Have a more narrow frequency range. Amplitude is somewhat variable [1]. The page shows how to calculate amplitude based on mass.

ERM (Eccentric rotating mass): Have a wider frequency range. However, amplitude is coupled with frequency [2].

Piezoelectric Motors: Have both variable amplitude and frequency. However, from datasheet these appear to be too fragile for our needs [3].

Conclusions/action items:

Forward the video to Rick so he can begin calculations.

Piezoelectric motors may be to sensitive for our needs.

Consider using a combination of LRA and ERM motors.

References:

[1]   "Linear Resonant Actuators – LRAs," *Precision Microdrives*. [Online]. Available: https://www.precisionmicrodrives.com/vibration-motors/linear-resonant-actuators-lras/. [Accessed: 12-Dec-2018].

[2]   "Vibration Motors – ERMs and LRAs," *Precision Microdrives*. [Online]. Available: https://www.precisionmicrodrives.com/vibration-motors/vibration-motors-erms-and-lras/. [Accessed: 12-Dec-2018].

[3]   TDK, "PiezoHapt™ Actuators," *Electric Double-Layer Capacitors (EDLC / Supercapacitors) | TDK Product Center*. [Online]. Available: https://product.tdk.com/info/en/products/sw_piezo/haptic/piezohapt/technote/tpo/index.html. [Accessed: 12-Dec-2018].

11/27/18-Coding Guidelines

▪ Stephan Blanz ▪ Dec 12, 2018 @02:23 PM CST

Title: Coding Guidelines

Date: 11/27/18

Content by: Stephan Blanz

Present: Rick, Royal

Goals: Establish guidelines/ objectives to adhere to while coding

Content:

I found an article that basically did exactly what we want in terms of gaining accelerometer readings, through an accelerometer and arduino and then found the FFT in MATLAB.

Additionally, I analyzed the code Rick used to create readings in one dimensions, and created an excel diagram from that data. When comparing this graph with the data we collected using Royal's program including 3 accelerometers, we had significantly different results. I believe the code Rick found to be insufficient, also he was unable to tailor it to our applications so we will proceed with Royal's code and use 3 axis accelerometer measurements.

One of the things this code did however was only sampled the arduino in one axis, which I thought was a poor choice.

However, the group did find that by collecting the data on the arduino and sending it in batches, that they achieved better results than by sending the data as soon as it's collected [1].

Conclusions/action items:

Record accelerometer on all 3 axes.

Don't use code you don't understand.

Send data in batches.

References:

[11]   A. Hjort, M. Holmberg, V. Ziemann, and K. Gajewski, "Measuring mechanical vibrations using an Arduino as a slave I/O to an EPICS control system," 2015.

2018/10/04-Precision Vibration Motor

▪ Stephan Blanz ▪ Oct 09, 2018 @11:16 PM CDT

Title: Advisor Meeting Notes

Date: 10/4/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Potential Source of Vibration

Content:

Precision Microdrives has a motor that seems to operate within the frequency range our preliminary research has led us to believe we'll see a rodent response.
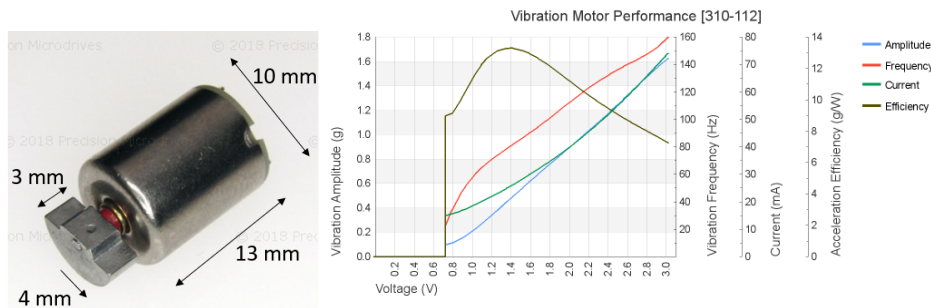

Figure 1 a(left) Vibrational motor based on rotating weight which creates vibrations when spun. b(right) Frequency vs Voltage curve will be used to establish ranges when testing.

Conclusions/action items:

- Produces ~30 Hz to ~160 Hz vibrations

2018/10/05-Slide-in for Vibrational Motor

▪ Stephan Blanz ▪ Oct 09, 2018 @11:08 PM CDT

Title: Possible Design Idea for Securing Motor

Date: 10/05/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Design and evaluate a method of attaching motor

Content:

After finding the motor, I wanted to create a method of attaching this to the platform. Since the motor functions by rotating a semi-circular weight, it should be possible to create a platform with a cylindrical cut-out in which the motor could slide into. The vibrations of the motor would be transferred on contact to the platform.

Limitations are it might not be a 1:1 transfer.
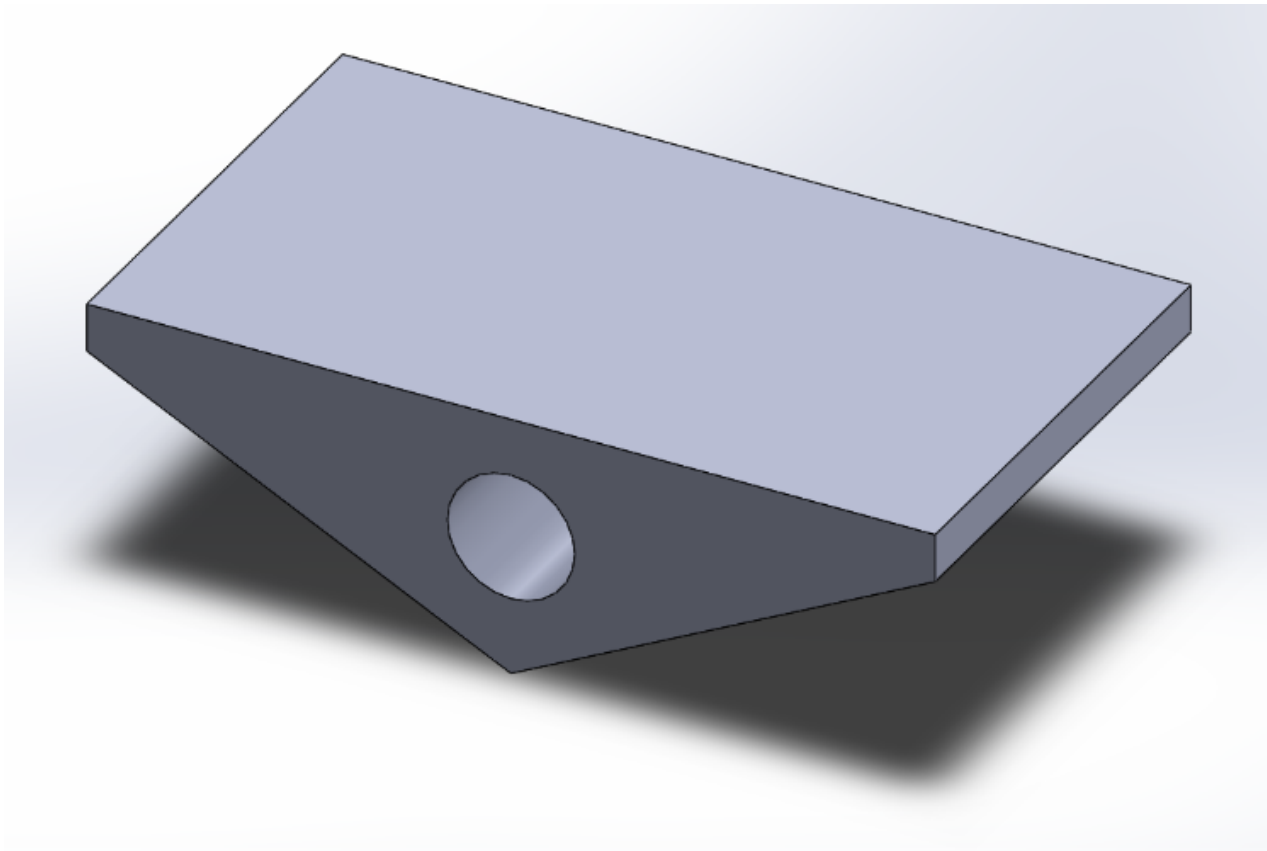
Also, dimensions at this point are still variable. However, should be small enough to fit a rodent foot pad.

Conclusions/action items:

- If used, need to test that vibrations are transferred 1:1. If not, create tuning curve.

2018/11/25-Earphone Standoff

Title: Earphone Standoff

Date: 11/25/18

Content by: Stephan Blanz

Present:

Goals: Create a standoff for headphones so they can be attached to the rodent

Content:

The first version of the designed needed a cutout to accommodate the wires coming off the headphone. It also needed a smaller standoff between the cradle and the outer surface. Below are versions 1 and 2 of the design.
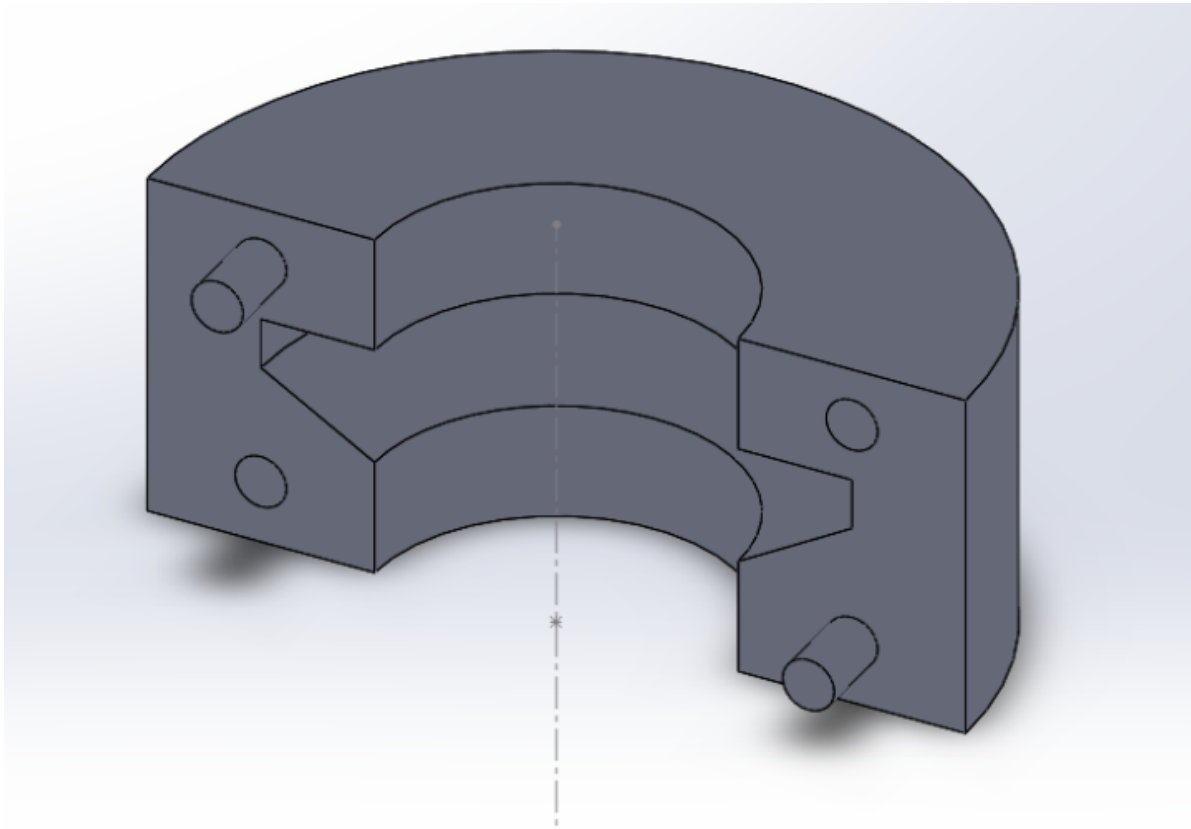

Figure 1. Initial design features a cradle for the earphones and a standoff
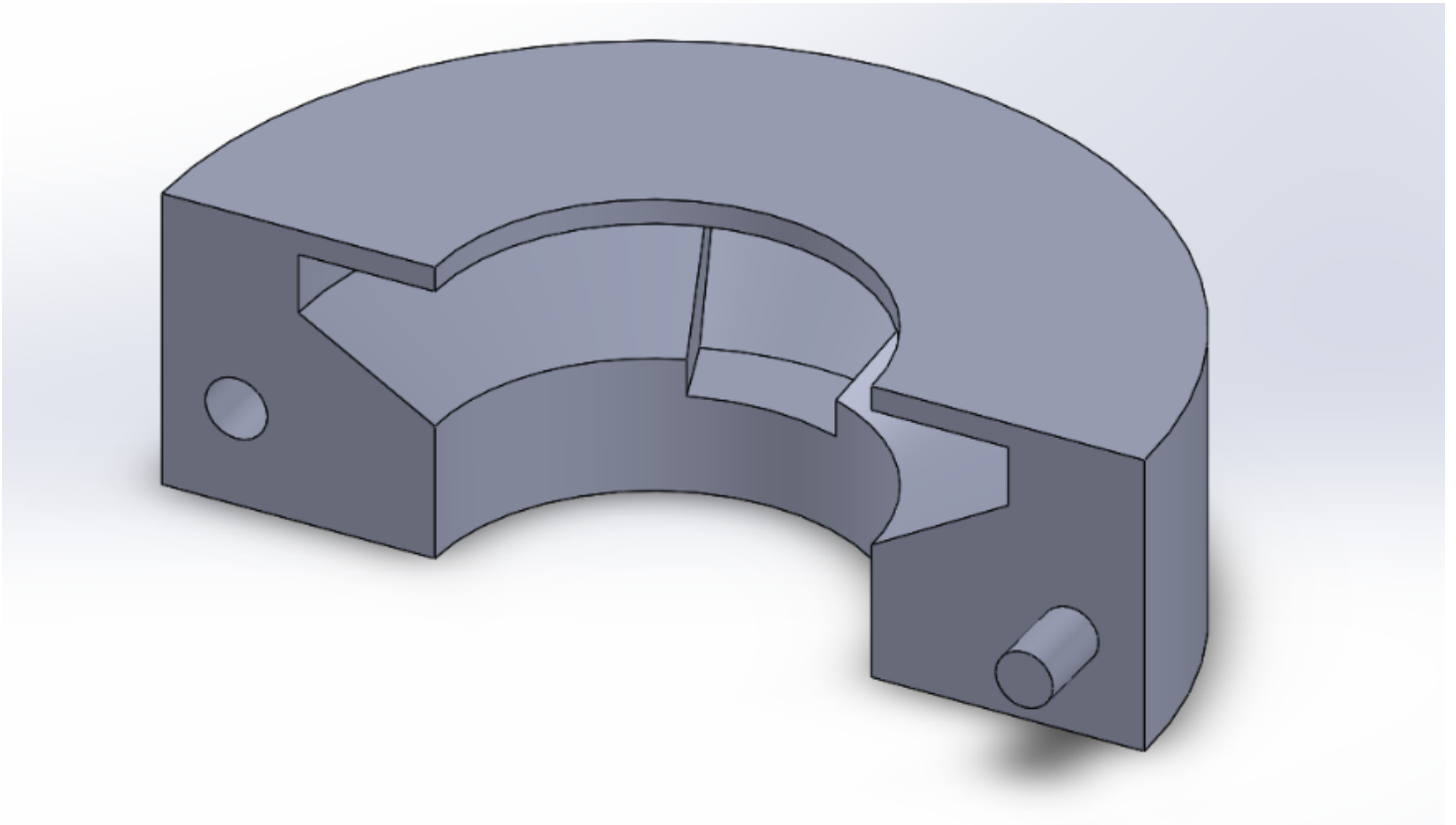
Figure 2. Improvements to original design featuring a cradled cutout for the earphone and a small standoff to transmit the vibrations.

Conclusions/action items:

This is an alternative to the current vibrational motor that we are using.

2018/11/25-Slide-in Part 2

▪ Stephan Blanz ▪ Dec 12, 2018 @01:52 PM CST

Title: Possible Design Idea for Securing Motor

Date: 11/25/18

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Design and evaluate a method of attaching motor

Content:

Create an updated model to the first version of the platform.
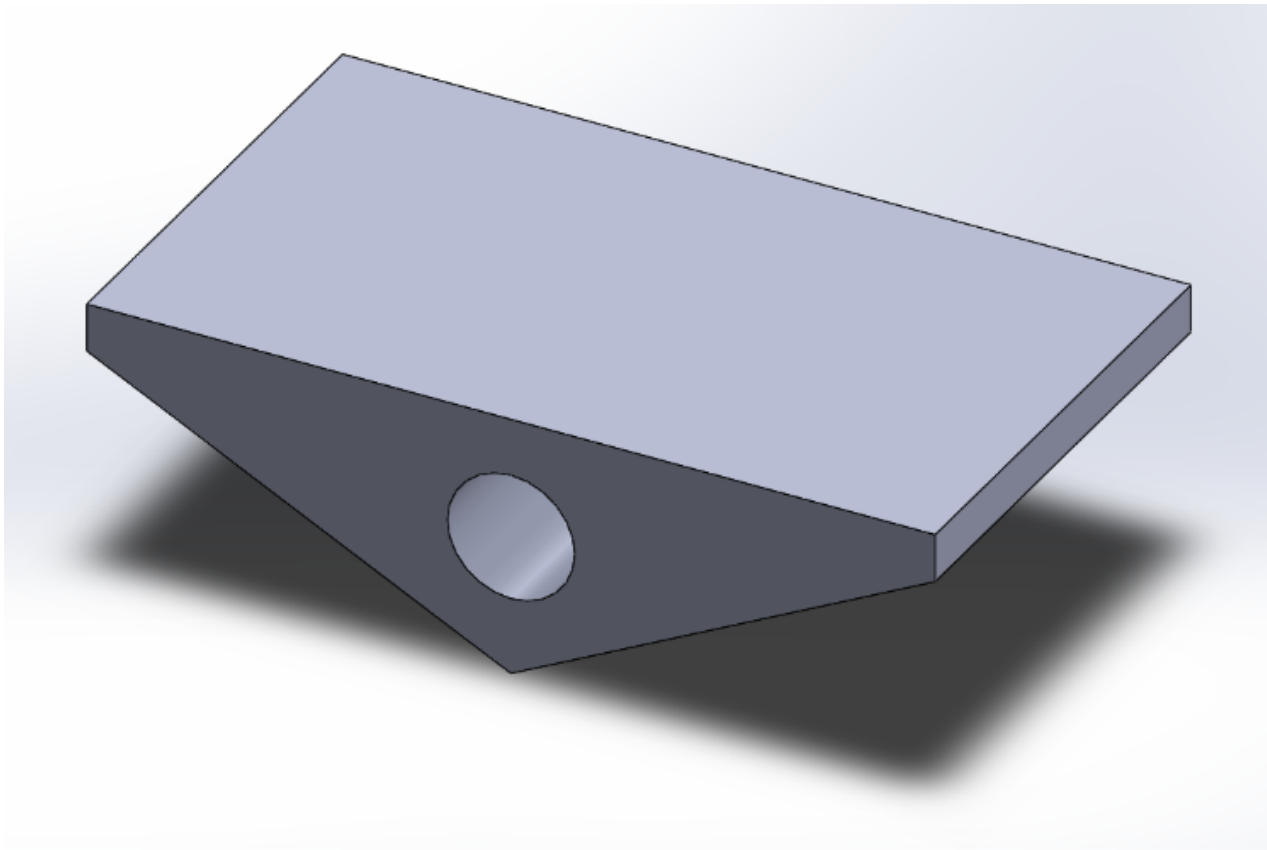
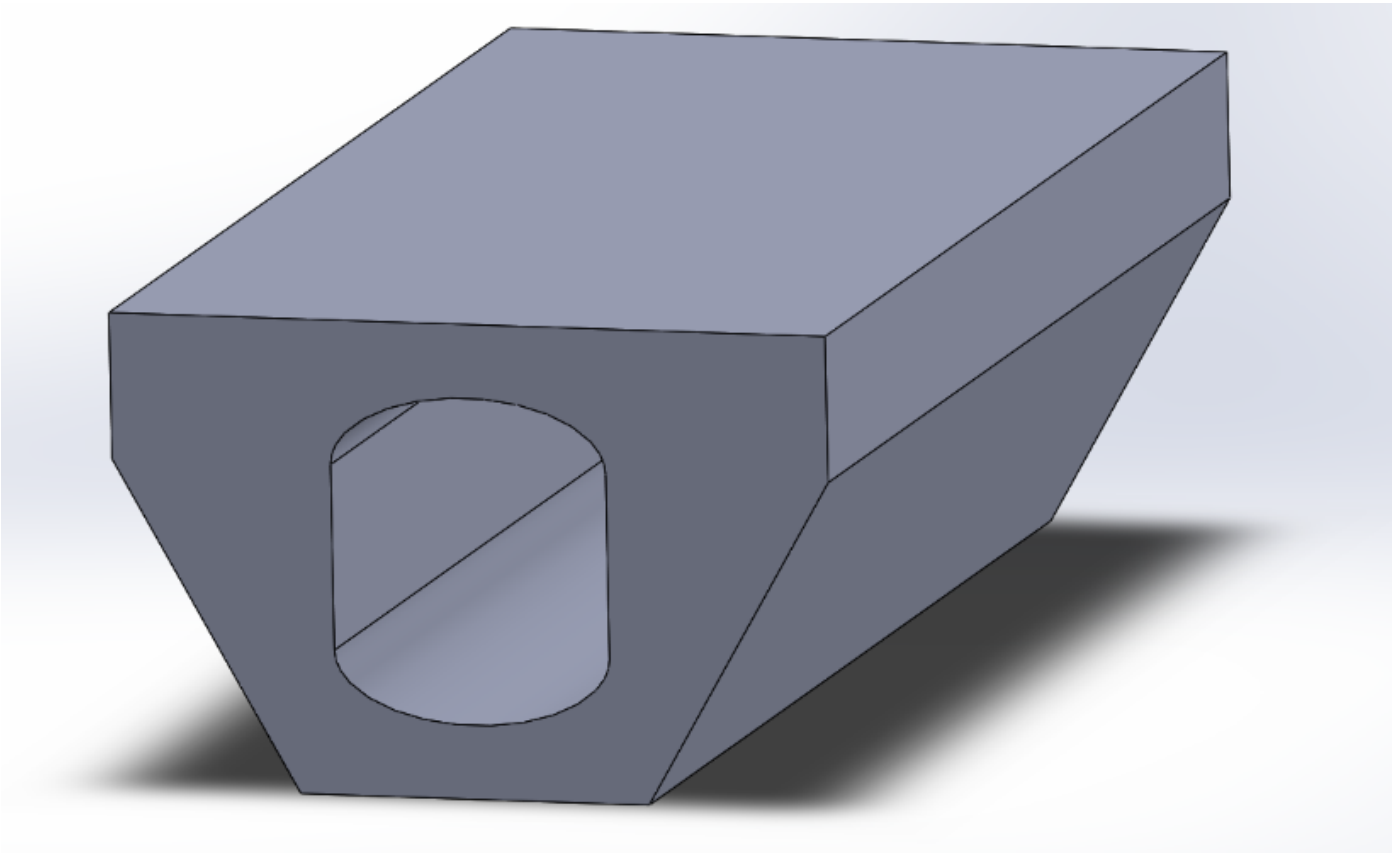**Figure 1.** First platform concept, featuring circular cutout for vibrational motor.

Figure 2. Features a cylindrical shaft with rounded edges that snugly accommodates the ERM motor we purchased. Also features a flat bottom part to stick LRA motor to.

Conclusions/action items:

- If used, need to test that vibrations are transferred 1:1. If not, create tuning curve.

2018/10/09-As of this Date RARC Classes

▪ Stephan Blanz ▪ Oct 09, 2018 @10:58 PM CDT

Title: RARC Training Completed as of this date

Date: 10/9/2018

Content by: Stephan Blanz

Present: Stephan Blanz

Goals: Proof of Training

Content:

− RARC Classes

Completed		
Class	**Supplemental Materials**	**Date**
Mouse -- Covers: mouse c : mus	yes	02/07/18
Lab Animal Surgery		02/01/18
Rat -- Covers: rat c : rattus	yes	01/10/18
LAS Aseptic Technique		12/12/17
LAS Anesthesia		12/12/17
Anesthesia Machine User Guide		12/12/17
Medical Records		12/12/17
Controlled Substances		12/12/17
Animal User Orientation		12/04/17

Conclusions/action items:

None

9/14 - Neural Regeneration

▪ John Beckman ▪ Oct 10, 2018 @01:24 PM CDT

Title: Mammalian Neural Regeneration

Date: 9/14/18

Content by: John Beckman

Present: N/A

Goals: To better understand how Neural Regeneration works in a mammals nervous system

Content:

- Neural Regeneration is almost impossible in the CNS due to the glial scar tissue that forms following nerve damage in the CNS. This is because of the Astrocytes that will cut off the damaged nerve from the rest of the CNS.
- In the PNS however, through a series of processes, Wallerian Degeneration, and axon regeneration allows for the damaged nerves to be encapsulated in the myelin of a Schwann cell. These Schwann cells will also release growth factors after the macrophages clean all the debris out of the space between the damaged neuron and the cell body.

S. Rotshenker, "Wallerian degeneration: the innate-immune response to traumatic nerve injury.," *J. Neuroinflammation*, vol. 8, p. 109, Aug. 2011.

E. Huebner and S.M. Strittmatter, "Axon Regeneration in the Peripheral and Central Nervous Systems," N.p., 27, Mar. 2010. Web.

Conclusions/action items:

The clients are studying how effective nerve regeneration surgery is. For in some situations the nerve is significantly more damaged, and requires a more invasive surgical procedure. Surgery can be used to help guide the axons to the cell body.

9/20 - Surgical Repair of PNS nerves

• John Beckman • Oct 10, 2018 @02:13 PM CDT

Title: Advisor Meeting Notes

Date: 9/20/18

Content by: John Beckman

Present: N/A

Goals: Research how surgical repair of neurons is different than the process of wallerian degeneration

Content:

There are four main steps to surgical repair of nerves in the peripheral nervous system

1. Preparation: removal of necrotic tissue leaving the ends as two normal looking nerve ends.
2. Approximation: The nerve ends are mobilized and brought together leaving a minimal gap by applying appropriate tension. Tensionless repairs have shown to have better results.
3. Alignment: The blood vessels must be aligned, and proper rotational alignment undertaken.
4. Maintenance: Sutures are placed in the epineurium, which is where they are held together. The sutures need to be properly inserted to avoid malrotation of the nerves.

G. M F, M. M, H. S, and W. S. Khan, "Peripheral nerve injury: principles for repair and regeneration.," *Open Orthop. J.*, vol. 8, pp. 199–203, 2014.

Conclusions/action items:

This form of nerve repair is slightly different than wallerian degeneration, and requires a significant amount of invasive operations to complete. However the general procedure is similar, removal of necrotic tissue, followed by growth to the opposite end. The major difference occurs in the lack of growth occurring in the surgical repair, which can lead to a less successful repair than Wallerian Degeneration can provide.

10/01 - Linear Actuator

Title: Linear Actuator Motor for vibrational stimulus

Date: 10/01/18

Content by: John Beckman

Present: N/A

Goals: Find a potential motor to create the desired vibrational stimulus

Content:

A linear actuator or linear servo will allow for a direct linear motion. Utilizing coding to power the actuator we could use a delay to create a varrying vibrational frequency.

Some example Linear actuators or servos can be seen below.

Conclusions/action items:

Add this design to the design matrix, and then evaluate all of the other motors to determine which best meets our design specifications.

11/09 - Headphone voice coil

• John Beckman • Dec 12, 2018 @01:14 PM CST

Title: Alternate stimulus source from an ear bud

Date: 11/09/2018

Content by: John Beckman

Present: N/A

Goals: Determine if using a voice coil from a headphone is a viable alternative source of stimulation

Content:

After taking apart a pair of apple headphones, I took the membrane off of the voice coil itself. The membrane no longer vibrated at all. Additionally, online tone generators can be found which send a sinusoidal sine wave at a given frequency to the ear bud. Seems like a reasonable mode of stimulation which also allows for variable amplitude and frequency.

Conclusions/action items:

There are a few issues with the voice coil that will need to be addressed, a standoff must be built so that the vibration is not blocked by too much force applied to the membrane. Also, a means of attaching the coil to the rats foot must be created, could be as simple as a small elastic band. Additionally, the plastic housing for the headphones must be removed somehow.

12/02 - Motor Wire Soldering

· John Beckman · Dec 12, 2018 @01:21 PM CST

Title: Soldering connections for platform fit

Date: 12/02/2018

Content by: John Beckman

Present: Stephan, Royal, and Rick

Goals: Solder motor wires to allow for long range connection to the Arduino

Content:

Soldered wires to ERM connections, then put heat shrink tubing around the body of the motor and the wires to allow for a stable connection and to make it easier to slide into the platform.

Soldered wires to LRA to allow for longer than 2 inch connections to this motor. Then attached it to the bottom of the platform using the adhesive on the motor itself.

Conclusions/action items:

Ready to test frequency of the different motors in many different ways. including offset of the alternate pad during stimulation to test if we can accurately stimulate one limb isolated.

2018/10/09: Vibration Effects On Rats

· Steven Oakes · Oct 09, 2018 @11:23 PM CDT

Title: Vibration Effects on Rats

Date: 10/09/2018

Content by: Royal Oakes

Present: NA

Goals: Describe the effects of vibrations on rats.

Content:

For this project we need to design a rat cage that can stimulate the hind limbs of the rodent with vibrations. It seems appropriate that I conduct preliminary research to understand what frequencies of vibration can elicit a behavioral response from rats. This page will contain citations to the article in IEEE format followed by bullet points indicating important points from the article.

A. M. Garner, J. N. Norton, W. L. Kinard, G. E. Kissling, and R. P. Reynolds, "Vibration-induced Behavioral Responses and Response Threshold in Female C57BL/6 Mice," Sep-2018. [Online]. Available: https://www-ingentaconnect-com.ezproxy.library.wisc.edu/contentone/aalas/jaalas/2018/00000057/00000005/art00003. [Accessed: 30-Sep-2018].

- Rats were subjected to a range of frequencies between 20-190Hz. The greatest behavioral response came from frequencies between 70-100Hz.
- All four limbs of the rats were stimulated.
- Behavioral changes included freezing, hunched posture, and surveying the cage.

Conclusions/action items:

Find more sources on the effect of vibrations on rats.

2018/11/27: Arduino MATLAB Serial Communication

▪ Stephan Blanz ▪ Dec 12, 2018 @01:28 PM CST

Title: Arduino MATLAB Serial Communication

Date: 11/27/2018

Content by: Royal Oakes

Present: Stephan Blanz

Goals: Describe research regarding MATLAB Ardunio communication.

Content:

We will be using an Arduino to record data from an accelerometer. However, the arduino has limited memory and, thus, it is beneficial to use MATLAB to process the data.

There is an Arduino-MATLAB communication toolkit which allows Arduino devices to interface with MATLAB. (https://www.mathworks.com/hardware-support/arduino-matlab.html)

- Communication can be opened using the MATLAB commands serial() and fopen() and the Arduino command Serial.begin().
- MATLAB can read data from the Arduino using fscanf().
- Arduino can write data to MATLAB using Serial.println().

A. Hjort, M. Holmberg, V. Ziemann, and K. Gajewski, "Measuring mechanical vibrations using an Arduino as a slave I/O to an EPICS control system," 2015.

- This paper describes an optimal method for transmitting acceleroemter data from Arduino to MATLAB. Rather than sending data as it is recorded to MATLAB, the Arduino will store data and then transmit the data in batches. This supposedly makes the measurements more accurate because there are unpredictable delays associated with serial communication. If these delays are interspersed with readings, it can lead to samples not being recorded at a constant frequency.

Conclusions/action items:

Implement the method described in A. Hjort *et al*. Perform testing of the motors.

▪ Steven Oakes ▪ Dec 12, 2018 @11:03 AM CST
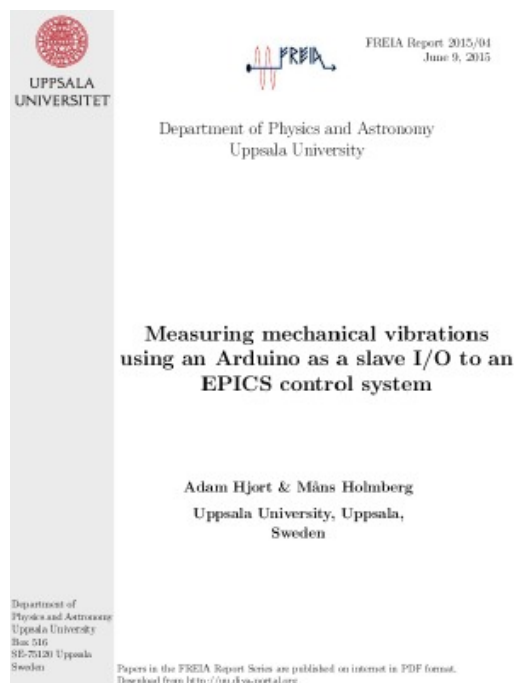
FULLTEXT01.pdf(3.8 MB) - download

2018/11/27: Design of Testing Code

▪ Steven Oakes ▪ Dec 12, 2018 @10:41 AM CST

Title: Design of Testing Code

Date: 11/27/2018

Content by: Royal Oakes

Present: N/A

Goals: Describe the code that was used to test the motors.

Content:

We received two motors from Amazon. One was a eccentric rotating mass (ERM) motor and the other was a linear resonant actuator (LRA) motor. Since these motors were very cheap, there may be discrepancies between the specifications of the motors in their respective datasheets and the actual performance of the motors. To test the actual performance of the motors, as well as to test the motors in the rat cage we have designed, I created code which is able to read information from an accelerometer, transmit that code to MATLAB, and compute the Fourier transform of the data. I have attached the code to this page: sketch_nov25a.ino for the arduino code, and MatlabSerialArduino.m for the MATLAB code.

The Arduino code was designed to take a certain number of samples from the accelerometer at 1000 Hz. The data read from the accelerometer was a vector of three integers, meaning each sample was 12 bytes. For all our experiments, we used 128 samples due to memory limitations of the Arduino. After the 128 samples were collected, the Arduino would then send all 128 samples to MATLAB through serial communication at 9600 baud.

The MATLAB code would receive the 128 samples from the Arduino. Then the norm of each vector was computed. The Fourier transform of the magnitude of the acceleration vectors was then computed. This data was then saved and used to produce graphs.

Conclusions/action items:

One issue with the Arduino and MATLAB code is that if the number of samples were to change, the Arduino and MATLAB code would both have to be changed to reflect the new number of samples. It would be beneficial for future experiments to only have to change one aspect of the code to change these fundamental values. Future work could involve having the arduino send the important information like number of samples to MATLAB, so the values in the MATLAB and Arduino code do not need to be coordinated by a human.

We will need to use this code for testing in the future.

▪ Steven Oakes ▪ Dec 12, 2018 @10:14 AM CST

sketch_nov25a.ino(1.2 KB) - download

▪ Steven Oakes ▪ Dec 12, 2018 @10:14 AM CST

```matlab
clear
close all
clc

% The number of samples in a single package from the Arduino.
PACKAGE_SIZE = 128;
% The number of packages recieved from the Arduino.
PACKAGE_NUM = 1;
% The number of values in each sample from the Arduino.
SAMP_DIM = 3;

xyzData  = zeros(PACKAGE_SIZE, SAMP_DIM);
xData    = zeros(PACKAGE_SIZE * PACKAGE_NUM, 1);
xDataFFT = zeros(PACKAGE_SIZE * PACKAGE_NUM, 1);
t = 1:PACKAGE_SIZE;
mag = zeros(PACKAGE_SIZE * PACKAGE_NUM, 1);
magFFT = zeros(PACKAGE_SIZE * PACKAGE_NUM, 1);

% Initialize communication with Arduino.
try
    s = serial('COM6', 'BaudRate', 9600);
    fopen(s);
    fscanf(s); % Get the first byte to acknowledge Arduino.
catch
    warning('Could not establish connection with Arduino.');
    fclose(s);
end

% Get data from Arduino a certain number of times.
for n = 1:PACKAGE_NUM
    try
        % Send a signal to the Arduino to get another data set.
        fwrite(s, '1', 'uint16');

        fscanf(s);

        % Read data from arduino.
        for i = 1:PACKAGE_SIZE
            for j = 1:SAMP_DIM
                val = fscanf(s);
                xyzData(i,j) = str2double(val([1:length(val) - 2]));
            end
        end

        % Get the magnitude of the acceleration vectors.
        for i = 1:PACKAGE_SIZE
            mag[((n-1)*PACKAGE_SIZE) + i] = norm(xyzData(i, :));
        end

        xData[[((n-1)*PACKAGE_SIZE) + 1]:[(n)*PACKAGE_SIZE]] = xyzData(:,1);

    catch
        warning('Something happened.');
        fclose(s);
    end % End Try-Catch
end % End for loop

fclose(s); % Close serial communication with Arduino.

magFFT = fft(mag);
xDataFFT = fft(xData);
```

MatlabSerialArduino.m(1.8 KB) - download

2018/11/29: MATLAB Code for Plots

▪ Steven Oakes ▪ Dec 12, 2018 @10:41 AM CST

Title: MATLAB Code for Plots

Date: 11/29/2018

Content by: Royal Oakes

Present: N/A

Goals: Describe the code to make the MATLAB plots.

Content:

We used MATLAB to compute the Fourier transform of our magnitude data from the accelerometer. This script is designed to take the FT data from the MatlabSerialArduino.m script and make plots from it.

The first iteration of the MATLAB code to make plots was called PlotsPlotsPlots.m. This script would require the user to input the names of all the CSV files containing FT data that they want to display on the same axis. Then the script would compute the values for the frequency axis and plot the magnitude of the FT data on the same axis. The plotting was done in such a way that the first CSV file chosen would receive the same color each time the script executed. This allowed the script to create separate plots that had the same color for the same voltage values easily.

The second iteration of the MATLAB code to make plots was called Multiplots.m. This script would execute the same steps from the PlotsPlotsPlots.m script, but could be used to create muti-plots, images with multiple plots. The user would specify which CSV files they wanted to read and which plot the data would be plotted on. This allowed the creation of the plots that will be used in future presentations.

Conclusions/action items:

Use the scripts to make plots for the preliminary presentation and final report.

▪ Steven Oakes ▪ Dec 12, 2018 @10:30 AM CST

Multiplots.m(2.7 KB) - download

▪ Steven Oakes ▪ Dec 12, 2018 @10:30 AM CST

```
% The number of samples in a single package from the Arduino.
PACKAGE_SIZE = 128;
% The number of packages recieved from the Arduino.
PACKAGE_NUM = 1;
% The number of values in each sample from the Arduino.
SAMP_DIM = 2;

% x1 = abs(fftshift(csvread("cyl_dir_mag_102.csv")));
% x2 = abs(fftshift(csvread("cyl_dir_mag_127.csv")));
x3 = abs(fftshift(csvread("cyl_dir_mag_152.csv")));
x4 = abs(fftshift(csvread("cyl_dir_mag_177.csv")));
x5 = abs(fftshift(csvread("cyl_dir_mag_202.csv")));
x6 = abs(fftshift(csvread("cyl_dir_mag_227.csv")));
x7 = abs(fftshift(csvread("cyl_dir_mag_252.csv")));

freq = ((0:(length(x7)-1))-(PACKAGE_SIZE/2)) ./ (0.001*PACKAGE_SIZE);

figure
hold on
% plot(freq, x1, 'color', [1 63/255 66/255])
% plot(freq, x2, 'color', [1 170/255 53/255])
plot(freq, x3, 'color', [1 74/255 166/255])
plot(freq, x4, 'color', [215/255 106/255 1])
plot(freq, x5, 'color', [116/255 116/255 1])
plot(freq, x6, 'color', [0/255 233/255 0])
plot(freq, x7, 'color', [0.0000 115/255 14/255])
hold off

legend('3.0V','3.5V','4.0V','4.5V','5.0V')
axis([0 250 0 50])
xlabel('Frequency (Hz)')
ylabel('Amplitude')
```

PlotsPlotsPlots.m(1.1 KB) - download

Vibration research

• jinyuxuan guo • Oct 10, 2018 @03:40 PM CDT

Title: Vibration Research

Date: 9/18/18

Content by: Rick Guo

Present: Rick Guo

Goals: To find a proper frequency range to stimulate the rodents' hindlimbs

Content:

What I found is that vibrations on hindlimbs at 35 Hz(according to article 1 below) to 90 Hz(according to article 2 below) can do good to rats' intervertebral disk and strengthen their hindlimbs' muscle. Therefore, I believe vibrations at 35 to 90 Hz will be safe to use on rats. And also according to a article found by Stephan, vibrations with a frequency of 50 to 150 Hz can stimulate the rodents effectively.

Here are the articles:

Local vibration enhanced the efficacy of passive exercise on mitigating bone loss in hindlimb unloading rats.
https://www-sciencedirect-com.ezproxy.library.wisc.edu/science/article/pii/S009457651630875X

Low-intensity vibrations partially maintain intervertebral disc mechanics and spinal muscle area during deconditioning
https://www-sciencedirect-com.ezproxy.library.wisc.edu/science/article/pii/S152994301300123X?via%3Dihu

Conclusions/action items:

According to the research, a frequency ranges from 35 Hz to 93 Hz may be appropriate to stimulate the rodents without hurting them.

Client meeting notes

- jinyuxuan guo - Oct 10, 2018 @03:50 PM CDT

Title: Client meeting notes

Date: 9/21/18

Content by: Rick Guo

Present: Stephan Blanz, John Beckman, Royal Oaks, Rick Guo

Goals: Meet with clients to discuss project

Content:

The clients want a device that can hold one rodents and use vibration to stimulate one of its hindlimbs.

It should be:

Fit on a laboratory bench

Has controllable frequency

Stimulates only one leg

Does not injure rodents

Computer controlled

Hold one rodent at a time

Waterproof and easily sanitizable

Conclusions/action items:

Meet with client

2018/12/02 Research for Force testing

Title: research for force testing

Date:12/2/1018

Content by: Jinyuxuan GUO

Present: Jinyuxaun GUO

Goals: To find out the force that our motor can generate

Content:

According to a tutor video found online, F = m r ω, where F is force generated, m is the mass of the eccentric disk, r is the distance from the spinning rod to the center of mass of the eccentric disk and omega is the angular velocity. From the data sheet of the motor, I got the diameter of the eccentric disk is 6mm and the motor is operating at 14000 RPM. Then, I weight the eccentric disk and it is 0.2 grams. See calculations below:

Link of the website: https://www.precisionmicrodrives.com/vibration-motors/

Conclusions/action items:

The result of force generated by the motor is 3.73e-4 N. Then, we can use this number to calculate the acceleration of whole device due to this force.

2018/12/4 Acceleration of the whole device

▪ jinyuxuan guo ▪ Dec 04, 2018 @07:32 PM CST

Title: Acceleration of the whole device

Date: 12/4/2018

Content by: Jinyuxuan Guo

Present: Jinyuxuan Guo

Goals: To calculate the acceleration of the whole device due the force generated by the motor

Content:

Last time, the force generated by the motor is calculated and the result is 3.73e-4 N. According to Newton's Second Law of Motion, F = ma, the acceleration of the whole device can be calculate if the weight data of the whole device is obtained. The team weighted the two parts that make up the device, the motor and the pedal. The motor is 2.63 grams and the pedal is 14 grams, so the total weight of the device is 16.63 grams. Thus, the acceleration of the whole device is the force generated by the motor over the mass of the whole device, which is 3.73e-4 N / 16.63e-3 kg, and the results is 0.02243 m/s^2. That is 2.289e-3 G.

Conclusions/action items:

The acceleration of this device is 2.289e-3 G.

competing design research

Title: Competing design research

Date: 9/16/18

Content by: Rick Guo

Present: Rick Guo

Goals: To find out designs that compete with our project

Content:

There are different types of rodent cages in the market currently. Most of them are not be able to stimulate the rodents. Some of them that can stimulate the rodents mainly uses electric shots or heat. However, cages that can stimulate rodent limbs through vibrations, as required by the clients, are not found. Since the cage will have to fulfill the unique and specific needs of the clients' experiments, competition of this project is limited.

Conclusions/action items: Very Limited competing designs(especially using vibrations to stimulate the rodents)

Micro cell phone vibration motor

Title: Micro cell phone vibration motor

Date: 9/27/18

Content by: Rick Guo

Present: Rick Guo

Goals: To come up with a design idea

Content:

Cell Phone Micro Vibration Motor.

Retrieved from: https://www.amazon.com/uxcell-9000RPM-Yellow-Micro-Vibration/dp/B016VQSZ7Q/ref=pd_sbs_60_4?
_encoding=UTF8&pd_rd_i=B072L7SRRS&pd_rd_r=8a9f34bd-c676-11e8-ac03-
51a7059c8938&pd_rd_w=XL7Ej&pd_rd_wg=DZII7&pf_rd_i=desktop-dp-sims&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=53dead45-2b3d-4b73-bafb-
fe26a7f14aac&pf_rd_r=PKTM989KJF13PWXBNRDW&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&refRID=PKTM989KJF13PWXBNRDW&th=1

1.Produces a vibration through the spin of a head with unbalanced weight

2. Can only work with fixed frequency, 3 motors are needed to control frequency(53Hz 86Hz 150Hz).

3.Cheap, about 1.2 dollars each

Conclusions/action items:

one possible way to develop a vibrational platform using this motor

11/27/2018 Arduino code design to get fft from accelerometer

• Stephan Blanz • Dec 12, 2018 @01:29 PM CST

Title:

Date: 11/27/2018

Content by: Jinyuxuan Guo

Present: Jinyuxuan Guo, Stephan Blanz

Goals: Design a code that can give us the frequency that the motor is vibrating at

Content:

I did some research on how to use arduino to give us fft under the help of a accelerometer. I used a code template from the arduino library and modify the parameters of the code. Basically, what it will do is that, it can give us a high magnitude at the frequency that the motor is working at. Using this code, we are be able to test the motors with different voltages to see the the motor's performance under various conditions.

Conclusions/action items:
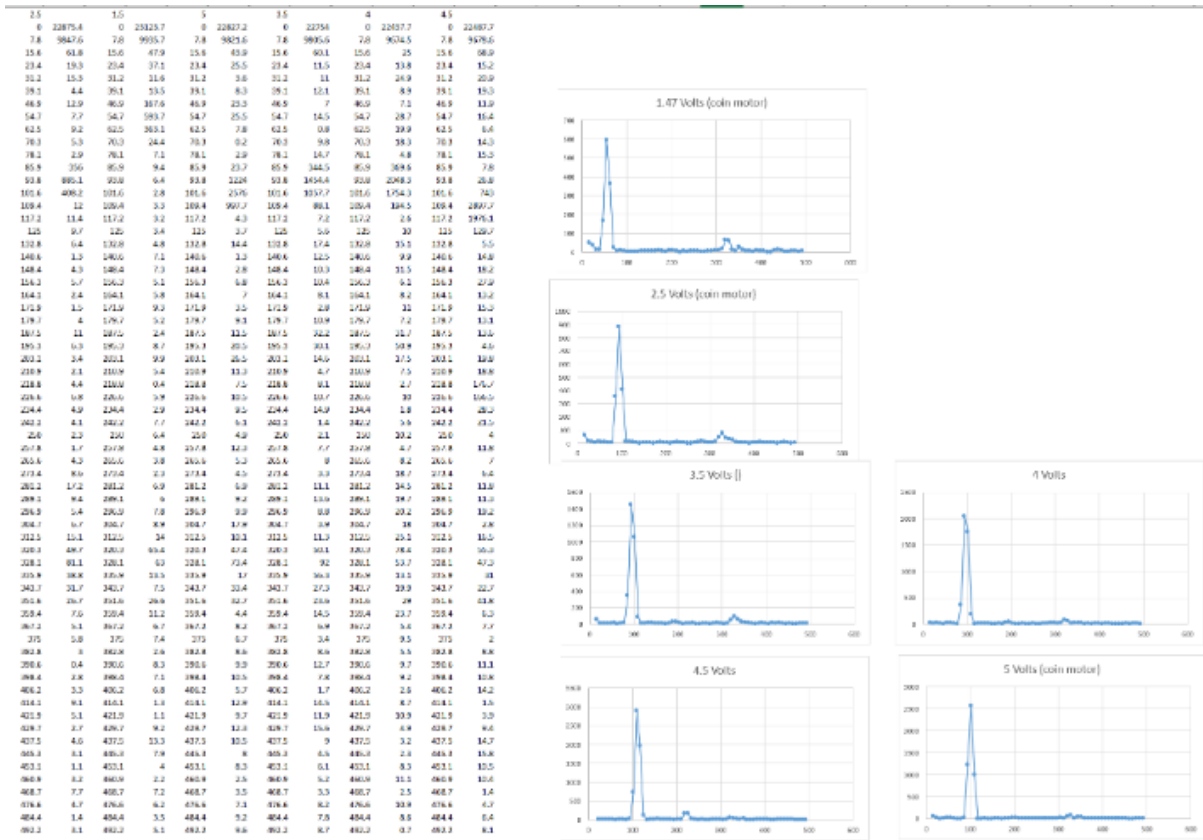
I put the raw data in excel to see the dominant frequency. The results are 50 Hz at 1.5 V, 90 Hz at 2.5 V, 100 Hz at 3.5 V and 110 Hz at 4.5 V.

2016/09/05-Entry guidelines

▪ John Puccinelli ▪ Sep 05, 2016 @01:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

- jinyuxuan guo - Dec 02, 2018 @05:57 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: