Somatosensory Stimulation Apparatus for Rodent Cages

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Overview:

- Project Relevance
- Problem Statement
- Physiological Background
- Product Design Specifications
- Fall 2017 Prototype
- Electronics Modifications
- Cage Modification
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Project Relevance

- 185,000 amputee surgeries per year in US [1]
  - 42.2-78.8% of amputees suffer from phantom limb pain [2]
- Dr. Dingle designing an electronic interface for peripheral nerves
  - Electrode allows prosthetics to restore sense of touch and relieve pain
  - Need method for testing device in rat models
- Current plan for rat testing:
  - Train healthy rat to respond to somatosensory stimulus on hindlimbs
  - De-aferent hindlimb and implant device
  - Stimulate hindlimbs with electrode and observe if rat responds the same way

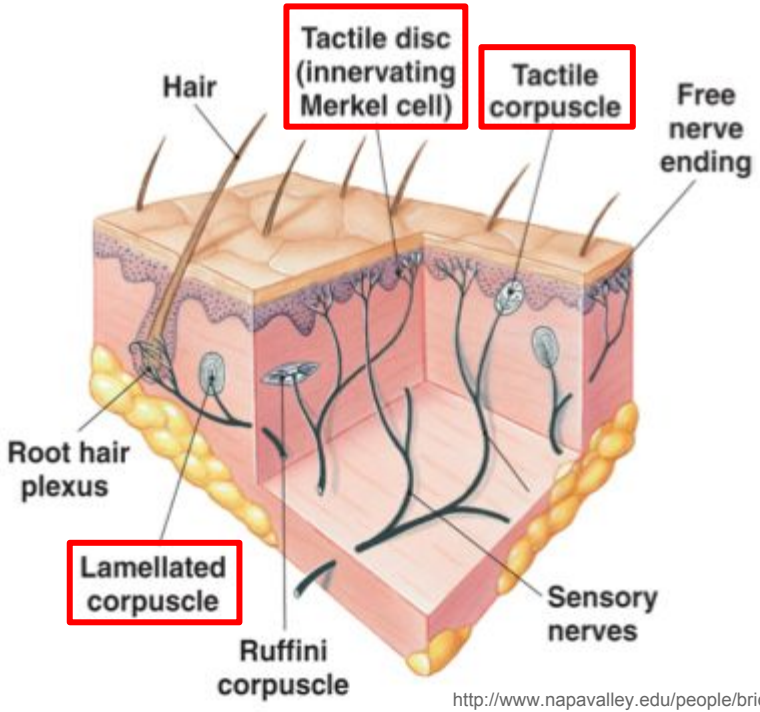
Problem Statement

- Design device to provide somatosensory stimulus to rat hindlimbs
  - Provide graded stimulus to each hindlimb individually
  - Include microcontroller to control stimulation
- Device must include cage to train rat
  - Cage must not limit rat’s ability to respond to stimulus

http://www.noldus.com/EthoVision-XT/Rat-Behavior-Recognition

Physiological Background

- Somatosensory system: System of neurons connecting peripherals to brain
- Merkel cells
  - Nerve endings in basal epidermis
  - Sense low frequency vibrations 5-15Hz [3]
- Tactile corpuscles
  - Mechanoreceptors in dermis
  - Sense 10-50Hz frequencies [3]
- Lamellar corpuscles
  - Mechanoreceptors in hypodermis
  - Sense frequencies up to 250 Hz

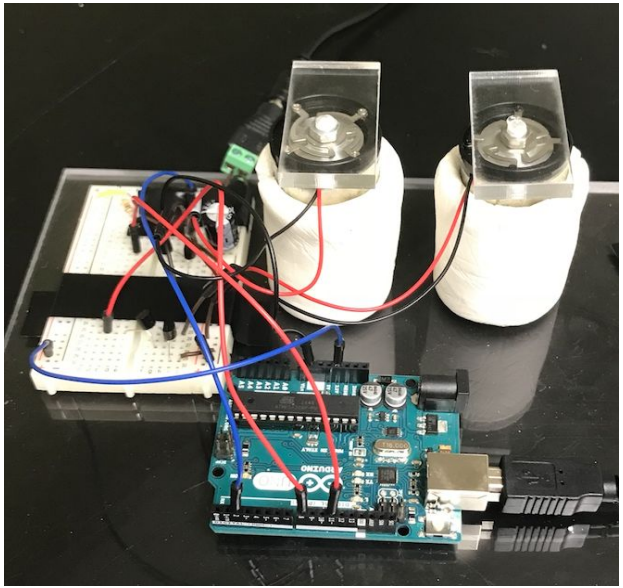


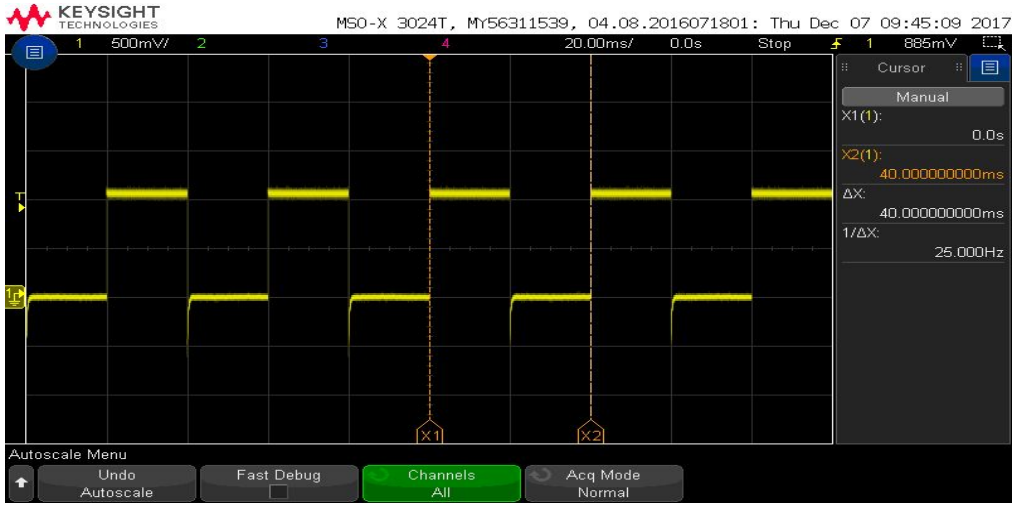
http://www.napavalley.edu/people/briddell/Documents/.../_START_HERE_ch09_lecture.ppt

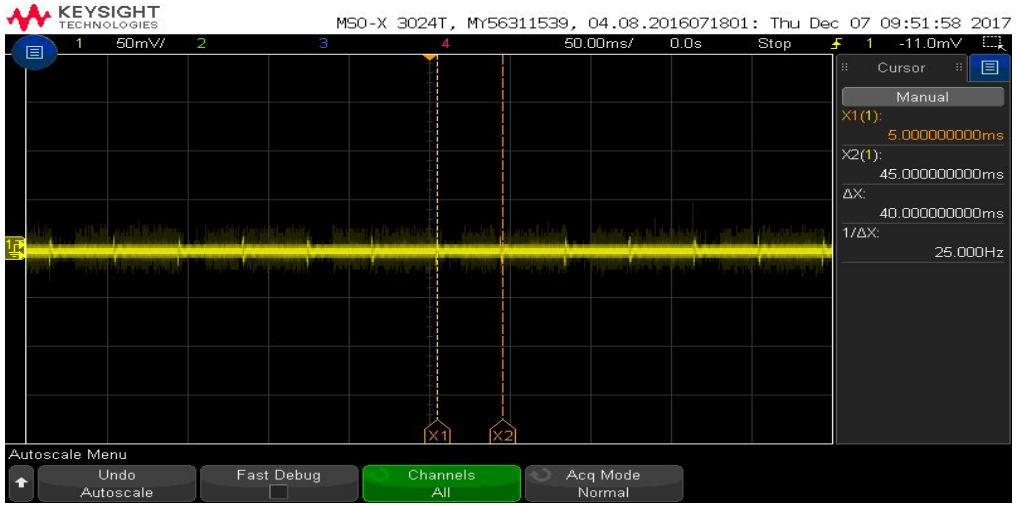
Product Design Specifications

- Provide stimulation to the rat’s hindlimbs. Stimulation must
  - Be isolated to the individual limbs
  - Not interfere with the electrode therapy
  - Allow for varying frequencies
- The cage can not limit the rat’s mobility and ability to respond to the stimulation
- Cage dimensions: 10 in x 11 in x 12 in
  - Must weigh under 5 lbs to allow for easy storage and use
  - Clear polycarbonate walls

Fall 2017 Prototype







Fall 2017 Prototype

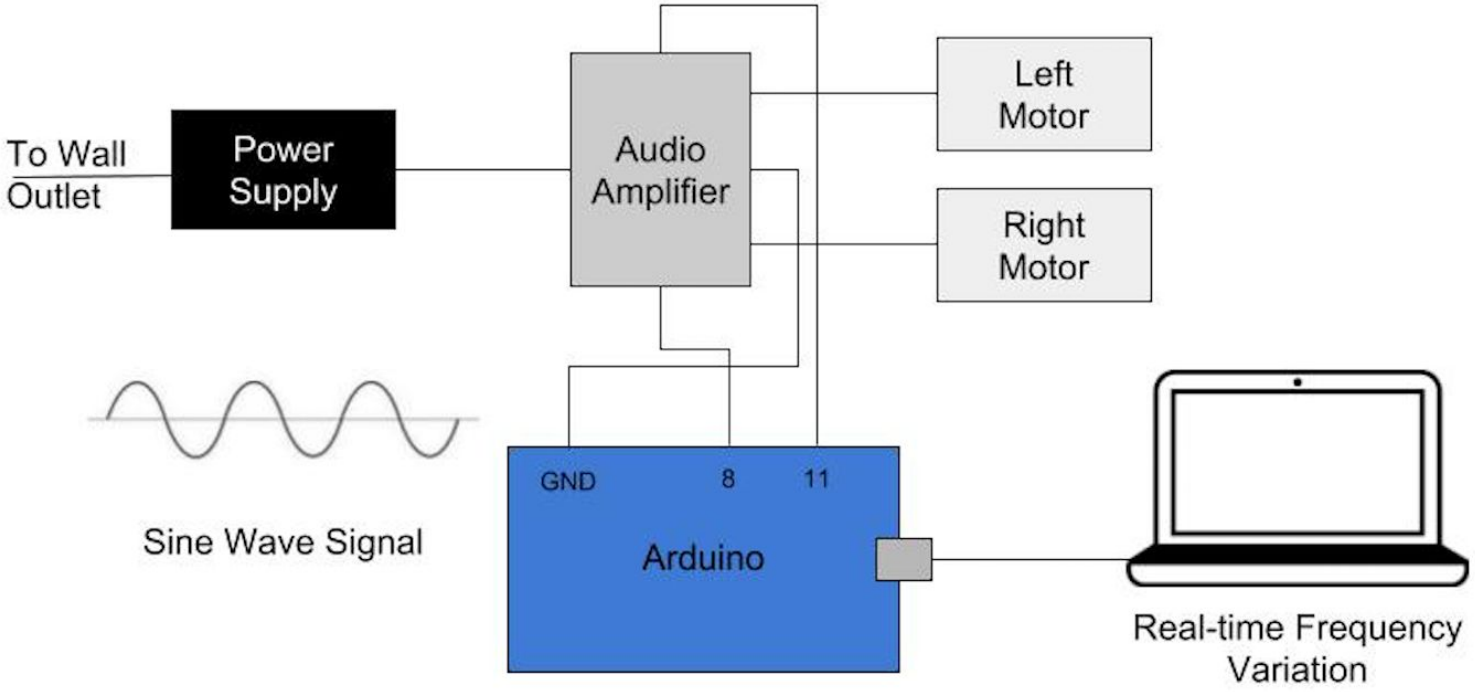
Successes

- Created vibrations within desired frequency range
- Different frequencies of vibration could be delivered simultaneously

Shortcomings

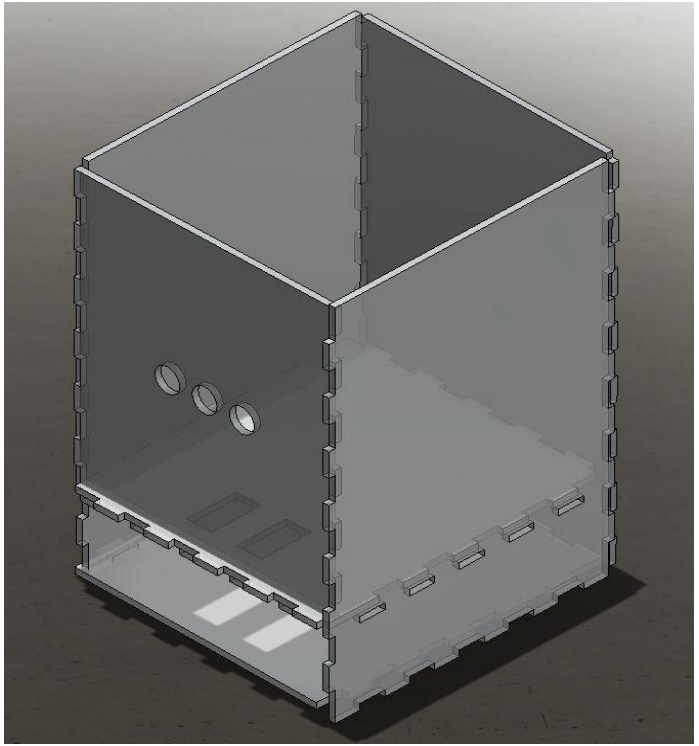
- Square wave introduced unwanted harmonics
- Holes for the rat’s response were at an incorrect height
- Interface was not user friendly
- Overall design was not aesthetically pleasing

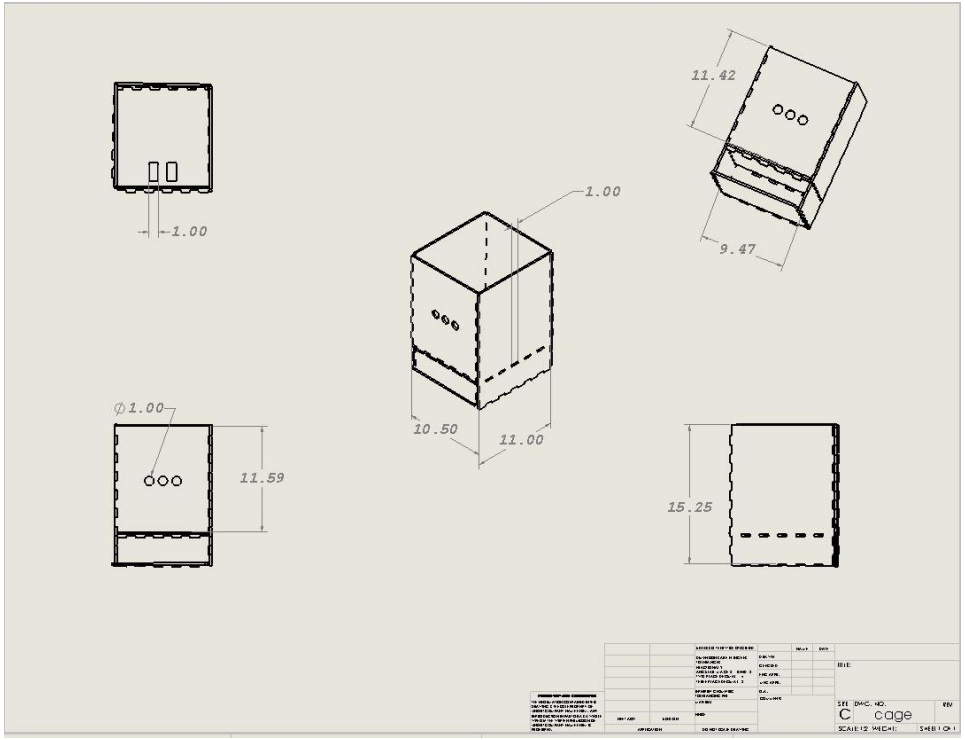
Electronics Modifications



Cage Modifications

- Rodent cage made of 6 pieces with interlocking tabs





Semester Timeline

Prototype Fabrication: 3 Weeks

- Fabricate new cage
- Update electronics and code
- Complete requirements for animal testing

Bench Testing: 2 Weeks

- Ensure the prototype works properly
- Perform bench testing to verify frequency

Semester Timeline

Animal Testing: 3 Weeks

- Ensure the device works in the lab
- Verify the healthy rats respond as predicted
- Perform data analysis

Wrap-up: 1 Week

- Finish data analysis
- Prepare for final presentation

Future Work

- Join client’s pre-existing protocol for testing
- Obtain proper certification necessary for rodent handling
- Use old cage to observe animal behavior
- Fabricate new design and analyze
- Test new electronic components with cage
- Test cage with rodents
- Work with client on analyzing the data

References & Acknowledgements

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[1] "Limb Prosthetics Services and Devices", *Semantic Scholar*, 2017. [Online]. Available: https://pdfs.semanticscholar.org/c3ae/f3563844e2e2835411fcbc2b0fe3091ac30b.pdf. [Accessed: 20- Sep- 2017].

[2] B. Subedi and G. Grossberg, "Phantom Limb Pain: Mechanisms and Treatment Approaches", *Pain Research and Treatment*, vol. 2011, pp. 1-8, 2011.

[3] A. Basbaum, *The Senses: A Comprehensive Reference*. Oxford, U.K.: Elsevier, 2008, pp. 33-38.

Questions?