Somatosensory Stimulation Apparatus for Rodent Cages

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Overview:

- Project Relevance
- Problem Statement
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- Vibration Source Designs/ Design Matrix
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Project Relevance

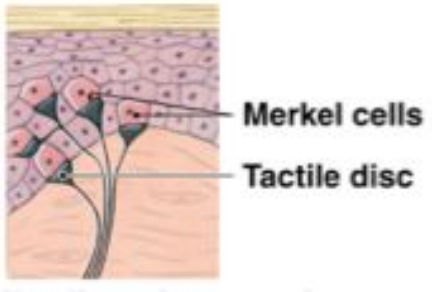
- 185,000 amputee surgeries per year in US [1]
  - 42.2-78.8% of amputees suffer from phantom limb pain [2]
- Dr. Dingle designing an electronic interface for peripheral nerves
  - Electrode allows prosthetics to restore sense of touch and relieve pain
  - Currently in need of method for testing device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

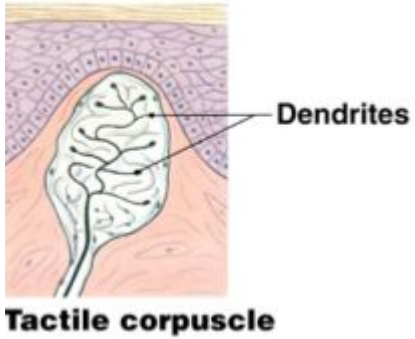
Problem Statement

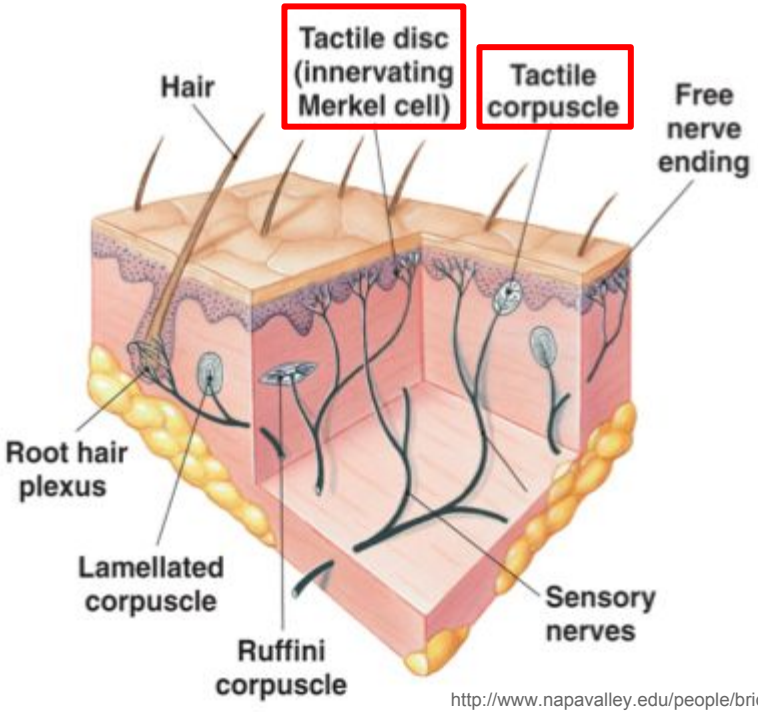
- Design device to provide somatosensory stimulus to rat hindlimbs
  - Provide graded stimulus to each hindlimb individually
  - Include microcontroller to control stimulation
- Device must include cage to train rat
  - Cage must not limit rat’s ability to respond to stimulus

Physiological Background

- Somatosensory system: System of neurons connecting peripherals to brain
- Merkel cells
  - Mechanoreceptors in skin
  - Sense low frequency vibrations 5-15Hz [3]
- Tactile corpuscles
  - Mechanoreceptors in skin
  - Sense 10-50Hz frequencies [3]







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

Stimulation Modalities Considered

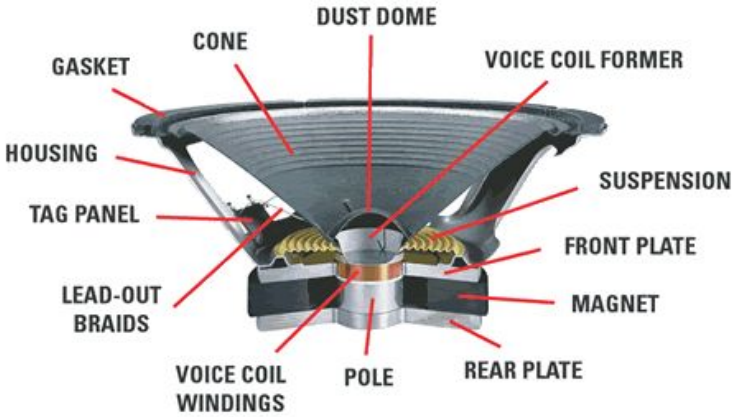
- Electrical Stimulation
  - Too similar to Dr. Dingle's electrodes
- Temperature Stimulation
  - Not instantaneous
  - Potential to harm rat
- Pressure Stimulation
  - Not instantaneous
  - Movement restriction

- Vibration Cuffs
  - Movement restriction

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

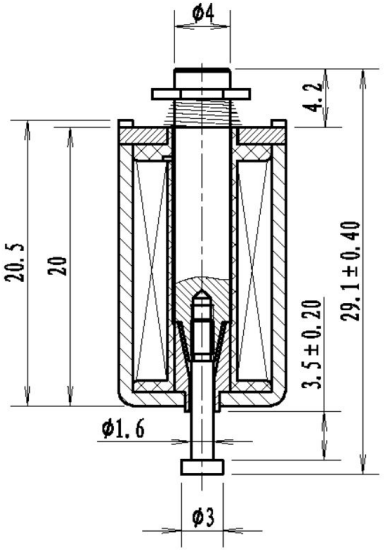
Vibration Source Designs

Speaker Actuator



https://www.sparkfun.com/products/9151
http://www.voodooguitar.net/2016/11/everything-you-ever-wanted-to-know_14.html.

Solenoid Motor



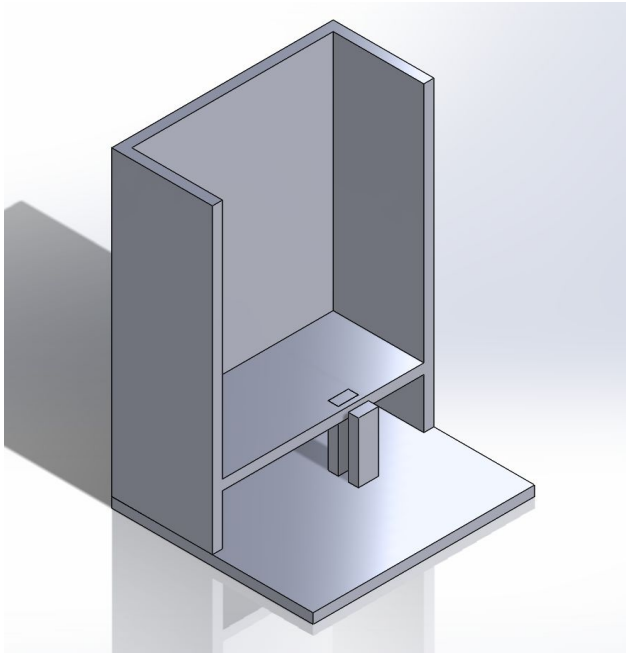
https://www.digikey.com/product-detail/en/sparkfun-electronics/ROB-11015/1568-1592-ND/6163694

Design Matrix: Vibration Sources

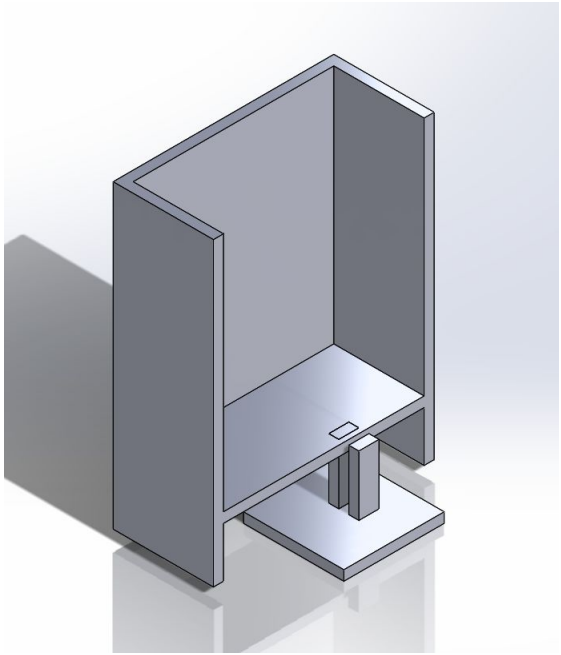
Vibration Source				
Design Criteria (weight)	Solenoid Motor		Speaker Actuator	
Force (20)	4/5	16	5/5	20
Accuracy (15)	4/5	12	5/5	15
Durability (10)	4/5	8	2/5	4
Amplitude (5)	4/5	4	5/5	5
Total	**40**		**44**	

Cage-Motor Interface Designs

Connected



Disconnected

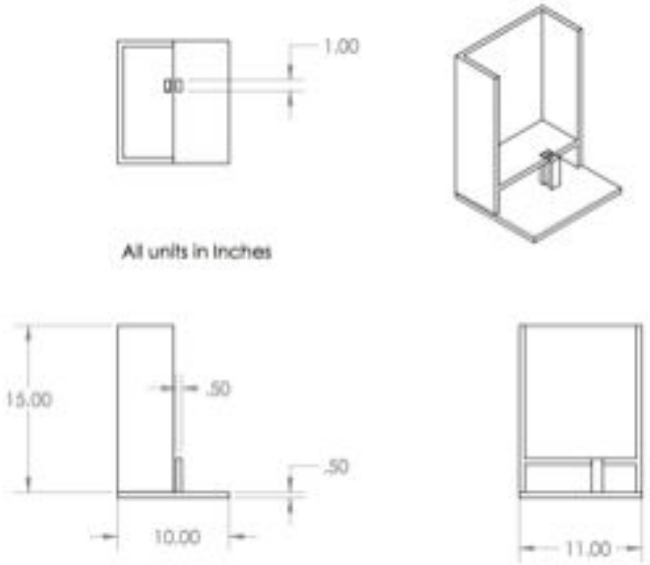


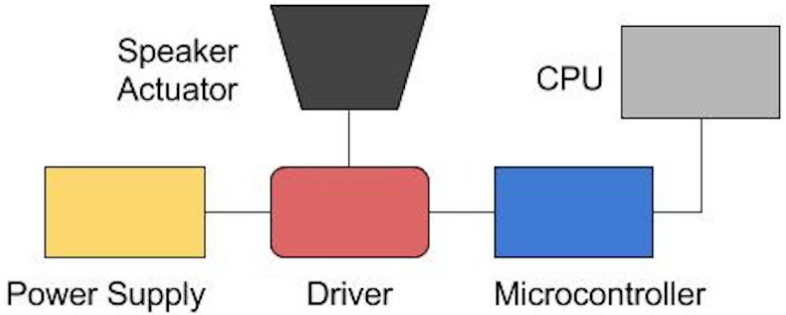
Design Matrix: Cage - Motor Interface

Cage - Motor Interface				
Design Criteria (weight)	Connected		Disconnected	
Stabilization (20)	5/5	20	3/5	12
Isolation (20)	3/5	12	4/5	16
Ease of Use (10)	5/5	10	3/5	6
Total	**42**		**34**	

Final Design

- Speaker actuators combined with the connected interface
- System diagram show the electrical components





Future Work

- Decide on specific components to use
  - Speaker actuator, driver, microcontroller
- Determine how to control the specific frequencies
- Build the prototype
- Test that the output frequencies are correct using accelerometer
  - Goal is within +/- 0.5 Hz

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?