Bioinspired Design (Engn/Biol 267) Hybrid Insect Biobot Unit

Required Reading

1. **Vo Doan TT, Tan MYW, Bui XH, Sato H (2018).** An Ultralightweight and Living Legged Robot. *Soft Robot*, *5*(1), 17-23. [www]

This article details the state-of-the-art, smallest known biobot demonstrated to date. Take particular note of the electronics design and the small packaging. All of this is well within the realm of something we could build and adapt accordingly.

2. **Sanchez CJ, Chiu C-W, Zhou Y, Gonzalez JM, Vinson SB, Liang H (2015)**. Locomotion control of hybrid cockroach robots. *J.R. Soc Interface*, *12*, 20141363. [www]

This article describes an alternative neuroelectric stimulation approach, wherein thoracic ganglia are directly stimulated, instead of antennae and/or cerci. A lot of important details are tucked back in section six.

3**. Erickson J, Herrera M , Bustamante M, Shingiro A, Bowen A (2015)**. Effective Stimulus Parameters for Directed Locomotion in a Madagascar Hissing Cockroach Biobot. *PloS ONE*, *10*(8), e0134348. [www]

This article profiles an experimental tour de force defining what voltage pulses (amplitude, frequency, duration, polarity) actually get cockroaches to walk and not habituate (= ignoring the stimulus), and quantifies how they walk in response. Prior to this time, there was an unfortunate Frankenstein approach of "just plug in an electrode, zap it, and see if it moves" with no consideration of underlying neurobiology. Also, the majority of the experiments were done by former W&L students!

4. **Giampalmo, S., Absher B, Bourne WT, Steves L, Vodenski V, O'Donnell P, and Erickson J. (2011).** Generation of Complex Motor Patterns in American Grasshopper via Current-Controlled Thoracic Electrical Interfacing. *IEEE Engineering in Medicine and Biology Conference Proceedings 2011*, Boston, MA, 1275 – 1278.

This report describes the work of a BioE class project from 2011. They developed a very clever method stimulation method that made grasshoppers hop on command. Note this is essentially the same method employed in #3 above.

Further Reading:

1. H. Sato, C. Berry, Y. Peeri, E. Baghoomian, B. Casey, G. Lavella,J. VandenBrooks, J. Harrison, and M. Maharbiz, “Remote radio control of insect flight,” *Frontiers in integrative neuroscience*, vol. 3, 2009

   This article created quite a stir when it first came, relaunching the biobot research field.

2. M. Maharbiz and H. Sato, “Cyborg Beetles,” *Scientific American Magazine*, vol. 303, no. 6, pp. 94–99, 2010.

   Pop culture article that succinctly answers the question “Why use insects as a robot platform?”

3. Li, Yao, and Hirotaka Sato. "Insect-computer hybrid robot." *Molecular Frontiers Journal* 2, no. 01 (2018): 30-42.

   Good review article on biobots, focusing on development of beetle biobots. Note the tecniques used—modern electronics (we have in the lab) + 3D motion capture (IQ center).

4. Latif, Tahmid, Eric Whitmire, Tristan Novak, and Alper Bozkurt. "Sound localization sensors for search and rescue biobots." *IEEE Sensors Journal* 16, no. 10 (2015): 3444-3453.

   Pushing toward the promise of biobot swarms applied to search and rescue operations and deployment in other hazardous environments.

5. Whitmire, Eric, Tahmid Latif, and Alper Bozkurt. "Acoustic sensors for biobotic search and rescue." In *SENSORS, 2014 IEEE*, pp. 2195-2198. IEEE, 2014.

   First demonstration of 3-microphone array to localize sound source--pushing toward the promise of biobot swarms applied to search and rescue operations and deployment in other hazardous environments.

6. Latif, Tahmid, Michael McKnight, Michael D. Dickey, and Alper Bozkurt. "In vitro electrochemical assessment of electrodes for neurostimulation in roach biobots." *PloS one* 13, no. 10 (2018).

   Electrode material matters! This article describes some of the less glamorous heavy lifting toward making biobots a reality.