ME 599/AA546/EE546: Biology-Inspired Robot Control

University of Washington, Autumn 2016

Instructor: Dr. Sawyer B. Fuller

course survey + paper preferences

If you are registered for this class or intend to register, please return this to Prof. Fuller at the end of class class on Wednesday, September 28.

Name: ______________________________________

Part I. Survey to get a sense of the background and level of students in the class. Please mark your answers in the space provided.

1. What is your department (ME, EE, Aero, etc.)? _______
2. Master's/Ph.D. and year? (M1, M2, Phd1, etc.?) _______
3. Put a check mark next to any of the courses you have already taken. Put a "C" if you are currently enrolled in the course:
   _______ ME 373/374 or equivalent (UG): Analysis of spring-mass-damper lumped-parameter dynamics
   _______ ME 471 or equivalent (UG): Feedback control theory
   _______ ME 489/599: Biomechanics of movement
   _______ CSE 571: Probabilistic robotics
   _______ EE 543/544: Kinematics of robot manipulators
   _______ AMATH/CSE 579: Intelligent control through learning and optimization
   _______ BI 427: Animal biomechanics
   _______ EE 577: Computer vision and robotics
4. Are there specific applications of biology-inspired robot control systems concepts that you are interested in?

Part II. Each student will give 1–2 presentations (depending on number of students), 30–45 minutes in length, about one of the research papers listed below and lead a discussion about it. Please indicate your top four choices by marking "1" through "4" in the spaces below. A "1" denotes your top choice.

1. _______ Brooks R, "A Robust layered control system for a mobile robot," *IEEE Transactions on Robotics*, 1986.
   Suggested additionally: Brooks R, "Intelligence without representation," *Artificial Intelligence*," 1991.
   Rather than robots that perform with a traditional sense-predict-act control loop, Brooks suggests layering

reflexive behaviors, each of which can perform a sense-act loop. Higher layers can inhibit lower layers and produce higher-level behaviors in a biologically-inspired framework.

2. _______ Braitenberg, V., *Vehicles: Experiments in Synthetic Psychology*, 1984.
Simple mobile robots with sight sensors can produce complex and life-like behaviors.

3. _______ Franceschini, Ruffier, Serres, "A Bio-inspired Flying Robot Sheds Light on Insect Piloting Abilities," *Current Biology*, 2007.

4. _______ Cory & Tedrake, "Experiments in Fixed-wing Unmanned Aerial Vehicle Perching," *Proceedings of the Aeronautics and Astronautics Association*, 2008.
Learning to perform aggressive perching maneuvers by estimating aerodynamic forces from data.

5. _______ J. Bongard, "Morphological change in machines accelerates the evolution of robust behavior," *Proc. National Academy of Sciences*, 2011.
Scaffolding – helping the learning process by starting with a comparable but easier-to-learn initial task – can help learning to walk go faster.

6. _______ Srinivasan, Zhang, Lehrer, & Collett, "Honeybee navigation *en route* to the goal: visual flight control and odometry," *Journal of Experimental Biology*, 1996.
The researchers uncover how simple behaviors in the honeybee help them navigate between flowers and the hive.

7. _______ Ijspeert, Crespi, Ryczko, & Cabelguen, "From swimming to walking with a salamander robot driven by a spinal cord model," *Science*, 2007.

8. _______ Smith, "An investigation of the mechanism underlying nest construction in the mud wasp," *Animal Behavior*, 1974.
This paper revealed compelling example of stigmergy, which is how animals can modify their environment so that it triggers a sequence of reflexive behaviors, each of which is dependent on the last. In this case, the result is a completed nest.

9. _______ Jindrich & Full, "Dynamic stabilization of rapid hexapedal locomotion," *Journal of Experimental Biology*, 2002.
A canon mounted to the back of a running cockroach reveals that it recovers from perturbation primarily by properties intrinsic to its musculoskeletal system, rather than by feedback from its nervous system.

10. _______ Fuller, Karpelson, Censi, Ma, and Wood, "Controlling free flight of a robotic fly using an onboard vision sensor inspired by insect ocelli," *J. Royal Society Interface*, 2014.
Suggested Additionally: Ma, Chirarattananon, Fuller, & Wood, "Controlled flight of an insect-scale, biologically-inspired robot," *Science* 2013.
A simple feedback sensor based on a four-pixel camera stabilizes an insect-sized aerial robot.

11. _______SH Collins, Wisse, & Ruina. "A three-dimensional passive-dynamic walking robot with two legs and knees," *The International Journal of Robotics Research*, 2001.
This paper built on a classic passive dynamic walking robot result to add a more realistic 3D walking gait, partly by using swinging arms.

12. _______ Werfel, Petersen, Nagpal, "Designing collective behavior in a termite-inspired robot construction team," *Science*, 2014.
Simple rules are downloaded onto a collection of termite robots that encode the design of a construction. Each robot's interaction with the environment and the portion of the construction that has already been placed determine the shape of the final result.

13. _______ Macnab & Koshland, "The Gradient-Sensing Mechanism in Bacterial Chemotaxis," *Proc. National Academy of Sciences*, 1972.
How do bacteria move toward a source of sugar? Results suggest they tend to swim straight if the density of sugar is perceived to be increasing, and stop and tumble to a random new direction if it is decreasing.