

Simultaneous Evolution of Morphology and Locomotion of Soft Robots by Novelty Search

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June 19, 2014

Introduction

Soft Robots

- ▶ Inspired by nature
- ▶ Completely soft bodies
- ▶ Capable of developing new kinds of locomotion



Soft robots can be actuated through air pressure tubes, environmental changes (temperature, pressure), even explosions.

Related Material



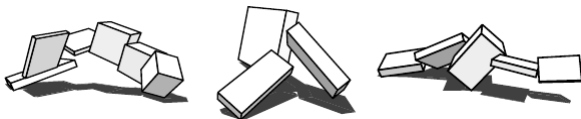
VoxCad Simulator (Hiller & Lipson, 2012)

- ▶ Created by Jonathan Hiller and Hod Lipson
- ▶ Voxel modeling and analyzing software
- ▶ Capable of developing new kinds of locomotion

Related Work I

Evolving virtual creatures (Sims, 1994)

- ▶ Rigid body parts, joints
- ▶ Evolution of the morphology and the control



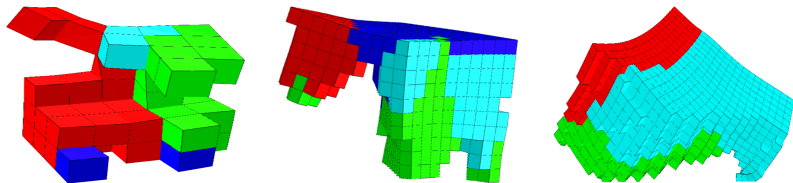
Evolving a diversity of virtual creatures through novelty search and local competition (Lehman & Stanley, 2011)

- ▶ Same experiment
- ▶ Novelty < Fitness
- ▶ Novelty search with global competition has the best average fitness.

Related Work II

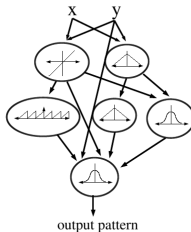
Evolving soft robots with multiple materials and a powerful generative encoding. (Cheney, MacCurdy, Clune, & Lipson, 2013)

- ▶ Generative encoding, Compositional pattern-producing network, CPPN.
- ▶ Neuroevolution of augmenting topologies, NEAT.



Compositional pattern-producing network

- ▶ Similar to artificial neural networks
- ▶ Different set of activation functions



- ▶ Produce symmetrical and repetitive patterns
- ▶ Appropriate for problems with geometrical structure (Board games).

References

- Cheney, N., MacCurdy, R., Clune, J., & Lipson, H. (2013). Unshackling evolution: evolving soft robots with multiple materials and a powerful generative encoding. In *Proceeding of the fifteenth annual conference on genetic and evolutionary computation conference* (pp. 167–174).
- Hiller, J., & Lipson, H. (2012). Dynamic simulation of soft heterogeneous objects. *arXiv preprint arXiv:1212.2845*.
- Lehman, J., & Stanley, K. O. (2011). Evolving a diversity of virtual creatures through novelty search and local competition. In *Proceedings of the 13th annual conference on genetic and evolutionary computation* (pp. 211–218).
- Sims, K. (1994). Evolving virtual creatures. In *Proceedings of the 21st annual conference on computer graphics and interactive techniques* (pp. 15–22).