Central vs Decentralized motion control in worm robots.

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Abstract
This paper describes two robotic solutions WAV and CMMWorm that illustrate a distributed and a centralized motion control and mechanism. Both approaches are shown to be equivalent but nature is inherently of a fault tolerant distributed nature while man made designs are centralized for ease of manufacturing. They are also inherently fault tolerant in the need for the replacement of only one control and propulsion mechanism.

Keywords: Computational Neuroscience, Biomimetics, Robotics, Proof of Theory

Introduction.

The following short paper is a review of two theories of locomotion as prevalent in the Neuroscience think tank, centralized motion as practiced in most human made designs and a decentralized approach, as prevalent in nature.(Strachan 2002; Kolers 1972; Yamada, Ogurusu, and Sakata 2010; Franciszek and Jan 2014; Wong and Rankin 2019; Saigusa 2000; Jurado 2007; Abdelhack, n.d.) We publish two robotic models of worm inspired locomotion, one centralized and decentralized in motion.

The following paper proves the viability of a bottom up constructivist approach to robotic simulations for the experimental understanding of theoretical and computational neuroscience, eliminating the need for animal experimentation.

A Worm-like Robot Built from Compliant Modular Mesh

CMMWorm utilizes a compliant mesh actuated at modular segments to create waveforms along its body. These waveforms can generate peristaltic motion of the body similar to that of an earthworm. The modular mesh is constructed from 3-D printed and commercially available parts allowing for the testing of a variety of components that can be easily interchanged. The six-segment robot can traverse flat ground and pipes.

Watch Video.

Fast worm robot

The Single-Actuator Wave robot, or SAW, is a robot that travels by moving its body parts in a wave-like motion. Although the robot functions differently from how a worm would maneuver, it surely looks like one. SAW is an ongoing project developed by a team from Ben-Gurion University of Negev. Team members include David Zarrouk, Nir Degani, Ilanit Waxman, Moshe Mann, Tal Yehuda, Nissan Jerbi, and Amotz Hess.

Watch Video.

Discussion:

We have thus compared two opposing and equivalent designs in worm inspired motion, one in distributed , emergence and the other in a centralized mechanism.
We have proven a successful 3Rs strategy in the use of robotic hardware and software in experimental verification of neuroscience hypothesis. (Cotta et al. 2006; Fang et al. 2014; Chowdhury, Ansari, and Bhaumik 2017; Kanu et al. 2015; Fekrmandi and Hillard 2019; Ishiguro et al. 2012; Seok et al. 2010; Murakami et al. 2006; Omori, Hayakawa, and Nakamura 2008; Spinello and Fattahi 2017; Saga and Nakamura 2004; Ge et al. 2019; Kandhari, Mehringer, et al. 2019; Kandhari, Wang, et al. 2019; Nemitz et al. 2016; Gong et al. 2016)

Future work:

Worms have achieved notoriety in information technology circles, owing to their malware nature, but much of this malalignment can be reversed with the introduction of BEAM robotics for worm robots, use of worm like caricatures in conversational A.I and n the use of friendly worms in cyber security applications with the same memory residence and self replication combined with network persistence.
The centralised vs distributed approach in motion behaviors can be captured in the 'control' taxonomy in a BEAM design where a grandmother active resistor could capture the wave like motion or a distributed circuit of active resistors. This comparison as a dynamical system could form a topic for future research as MFA I or multi functional architecture.

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