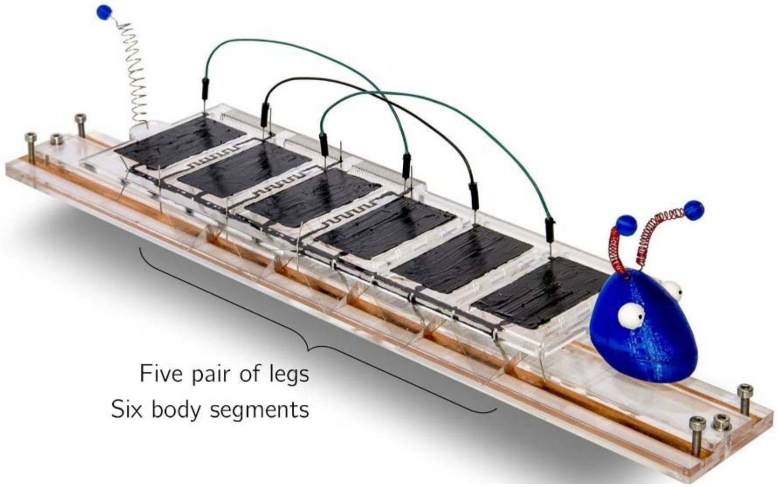
INTERNATIONAL SOCIETY OF
BIONIC ENGINEERING

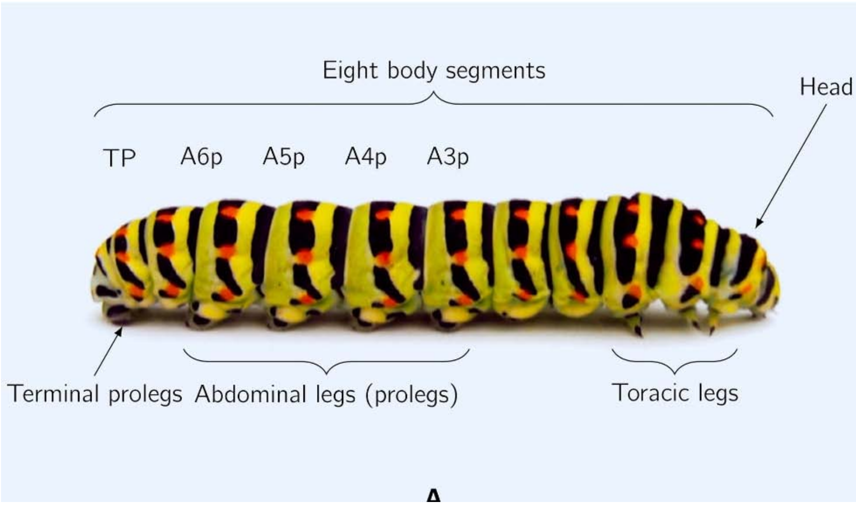
Towards Autonomous Local Control For Robotic Artificial Muscles

Mimicking the central pattern generator

The case was provided by the Individual Member of ISBE: Biomimetics Lab, Auckland Bioengineering Institute, New Zealand



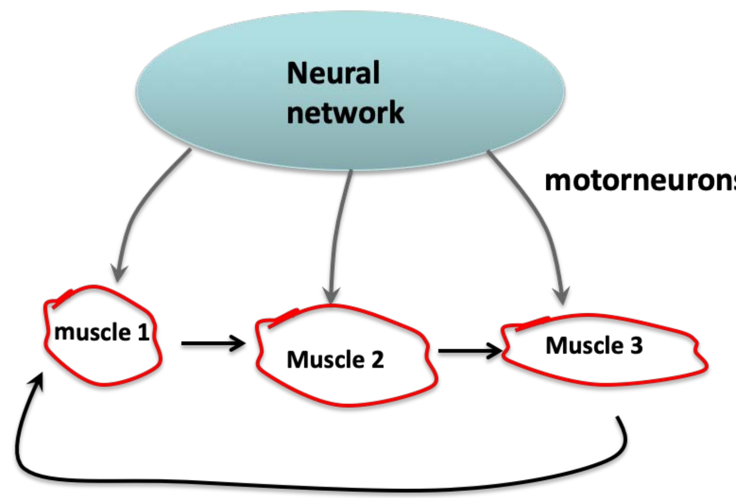
1. Biological Prototype



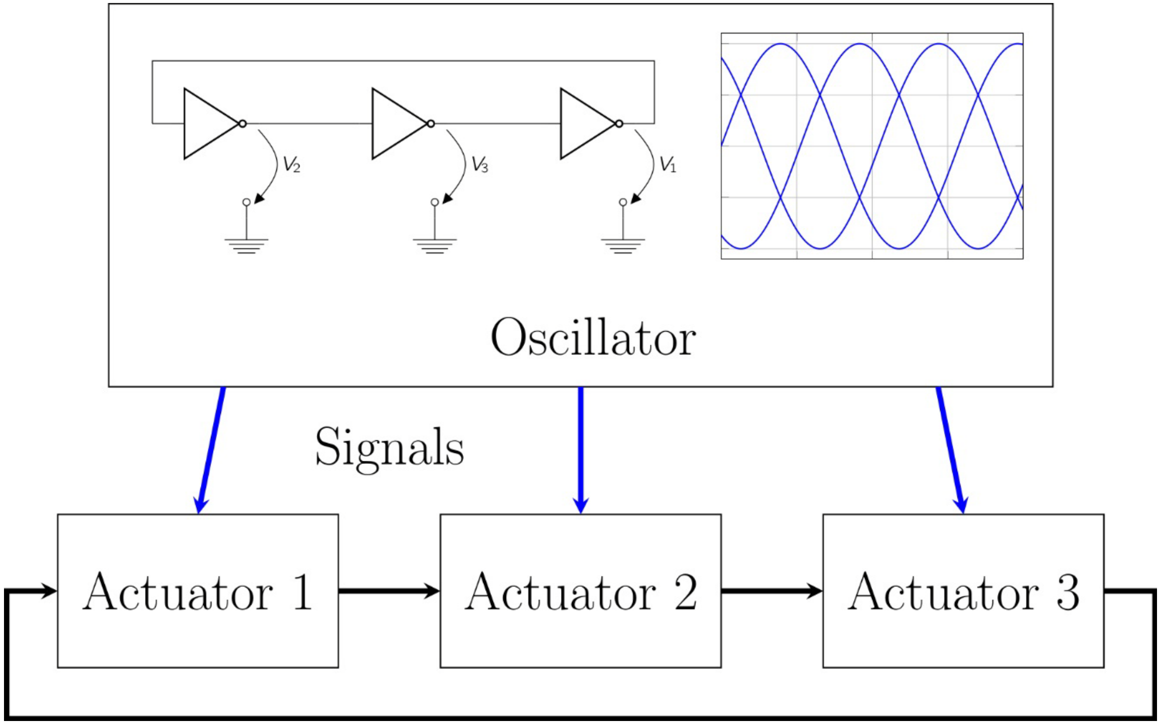
The crawling action of a caterpillar requires patterned rhythmic activation of its segments.

Neural ganglia operating as 'Central pattern generators' (CPGs) provide the rhythmic excitation to arrays of caterpillar muscles.

CPGs can operate autonomously.



2. Bionic Study



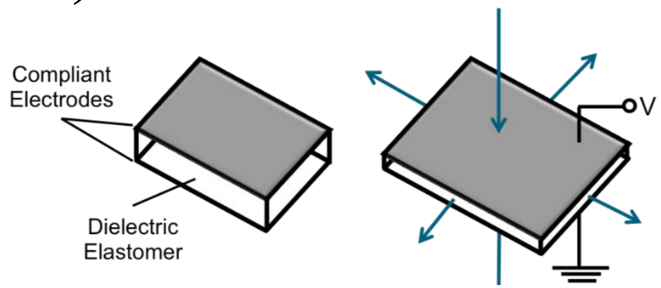
We have mimicked CPG action by designing an autonomous oscillator that rhythmically distributes electric charge to an array of artificial muscle actuators – all with soft and stretchy materials only, no hard electronics.

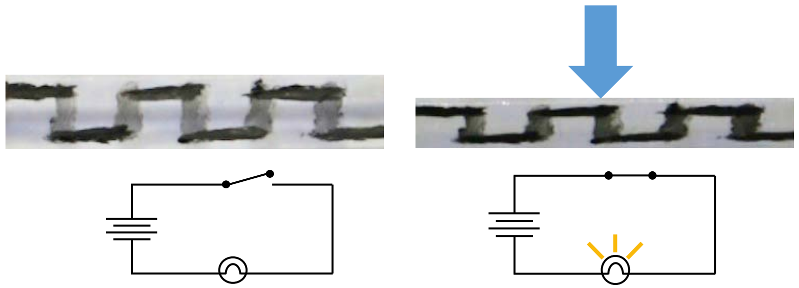
As depicted above, an oscillator can be constructed from an odd number of signal inverters; 3 in this case.

3. Design and Processing

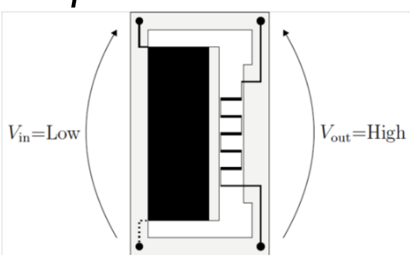
We take 2 ingredients:

Dielectric elastomer actuators (DEA) (artificial muscles) and dielectric elastomer switches (DES)...

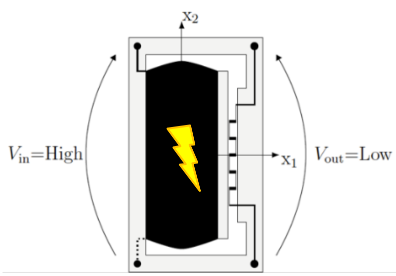




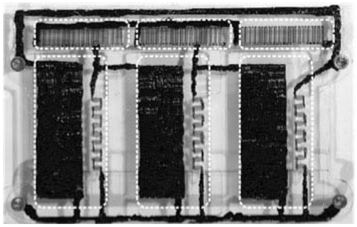
...pair them together to form an inverter...



Apply voltage

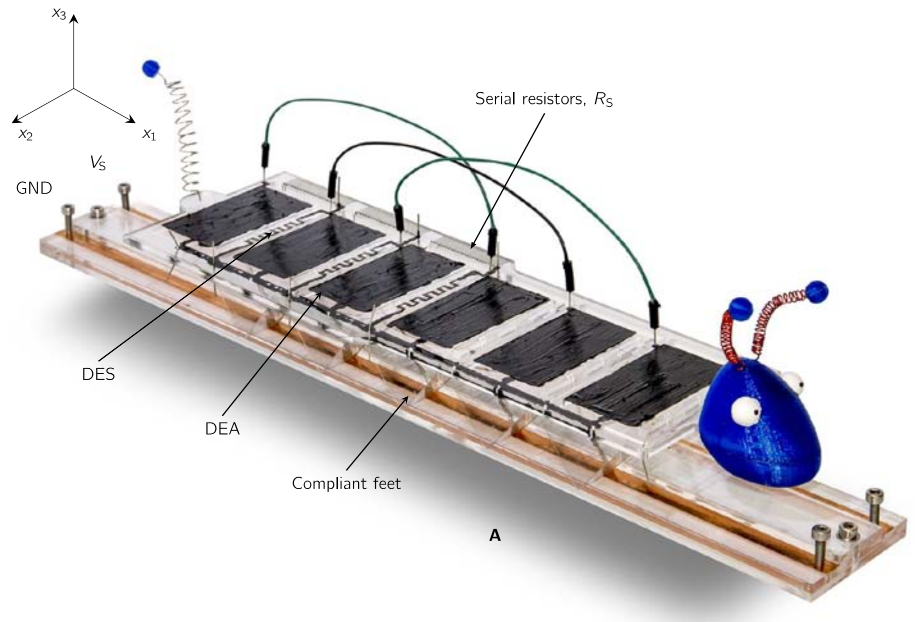


An oscillator for driving artificial muscles can be constructed from an odd number of inverters in a closed loop:



3. Design and Processing

We have placed our oscillator into the back of "Trevor the caterpillar"*



The oscillator (rear 3 panels in Trevor's back) takes the single DC voltage delivered through the copper floor electrodes and converts it to an oscillatory signal that actuates the muscles driving his feet.

*E.-F. M. Henke, S. Schlatter, and I. A. Anderson, "Soft dielectric elastomer oscillators driving bioinspired robots," Soft Robotics 4 (4) (2017).

4. Achievements and Applications

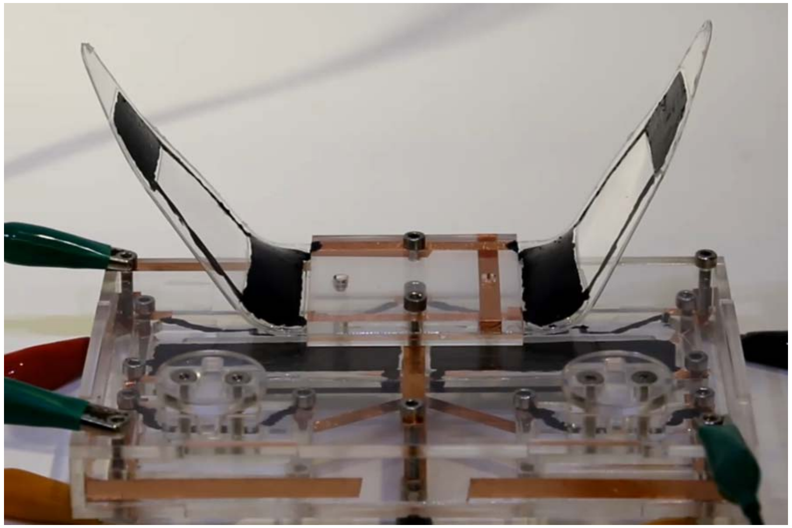
- We have built an oscillator for distributing charge to muscle-like actuators - as demonstrated in this slideshow.

E.-F. M. Henke, S. Schlatter, and I. A. Anderson, "Soft dielectric elastomer oscillators driving bioinspired robots," Soft Robotics 4 (4) (2017).

E. F. Markus Henke, K.E. Wilson, G. A. Slipher, R. A. Mrozek, and I. A. Anderson, "Artificial muscle logic devices for autonomous local control", in *Robotic Systems and Autonomous Platforms*, edited by Shawn M. Walsh and Michael S. Strano (Woodhead Publishing, Elsevier, 2019), pp. 29-40.

- The same technology can be applied to logic gates

K. E. Wilson, E. F. M. Henke, G. A. Slipher, and I. A. Anderson, “Rubbery logic gates,” Extreme Mech. Lett., vol. 9, pp. 188–194, 2016.



Example: A gripper operated by a NAND gate having two input signals from the buttons. While both buttons are pressed the grippers will close, otherwise the grippers remain opened.

INTERNATIONAL SOCIETY OF
BIONIC ENGINEERING

Trevor the Caterpillar provides an example of what can be done by coupling artificial muscles with piezoresistive switches – mimicking the CPG actuated muscle.

We are exploring further uses in wearable devices, appliances and soft robotics.

For further information about our lab visit:

www.biomimeticslab.com

biomimetics laboratory