

A snake robot controlled by biomimetic CPGs

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Output of the neural network to control the robot motors. Credit: Blanchard, Aihara & Levi.

In recent years, a growing number of studies has been aimed at developing robots inspired by nature, particularly by certain species of animals. In a study published in [Atlantis Press' Journal of Robotics](#),

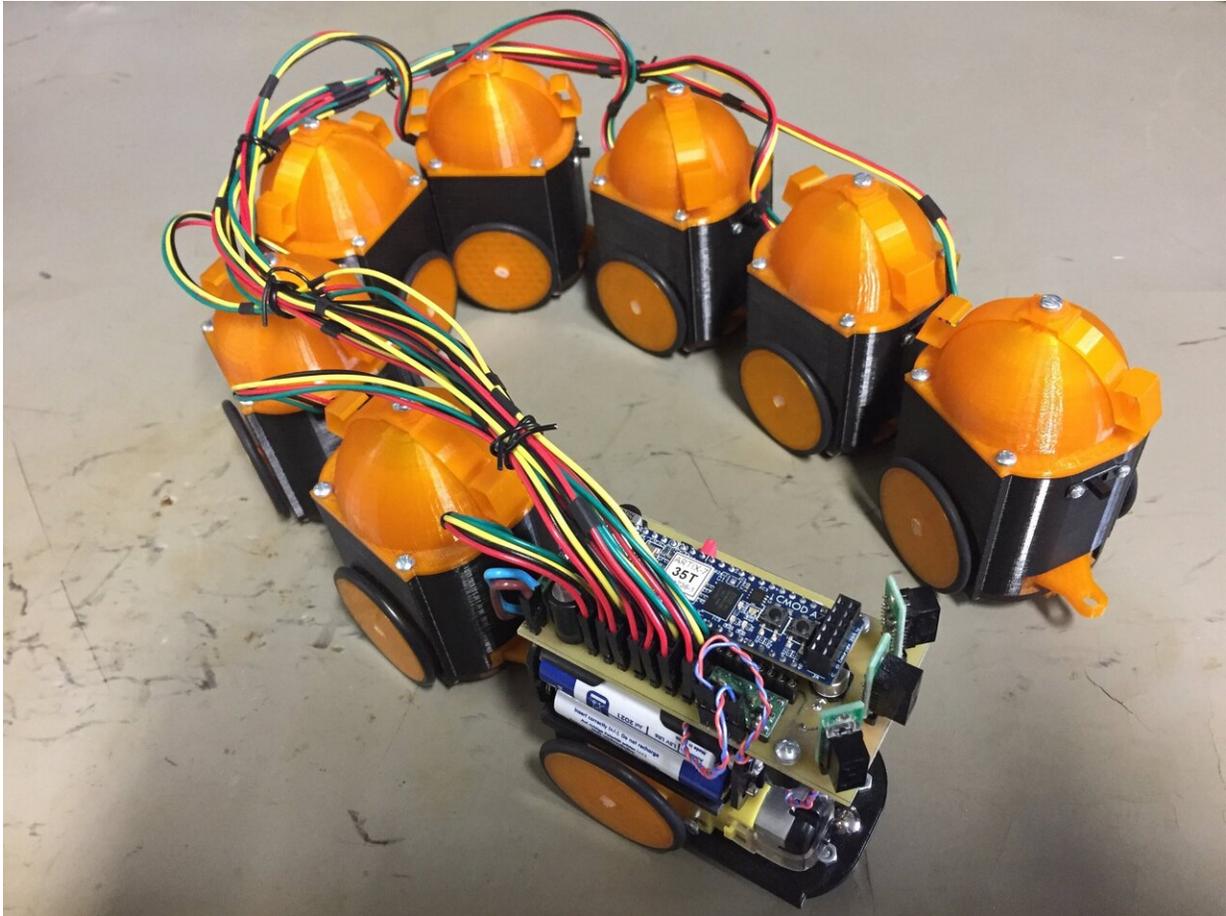
[Networking and Artificial Life](#), a team of researchers at the University of Bordeaux and the University of Tokyo have created a robot that resembles a snake in both its shape and movements.

"The main objective of this research was to develop a robot for [biomedical applications](#), especially [spinal cord injuries](#)," Timothée Levi, one of the researchers who carried out the study, told TechXplore. "We would like to design new neuroprostheses where the [artificial neurons](#) can replace the biological ones. In our robot, we used a biomimetic locomotion using biomimetic spiking [neural networks](#), which reproduces the same behavior that snakes have in nature."

One of the key challenges when developing bio-inspired robots is effectively reproducing the locomotion of the animal of interest. In animals, most movements are generated by the activity of central pattern generation (CPG) networks.

Essentially, CPGs are neuronal circuits that, when activated, can produce rhythmic motor patterns (e.g. walking, breathing, swimming, etc.) in the absence of sensory and timing-related inputs. In the past, CPGs and their effects on animal locomotion have been the focus of a vast number of studies.

Generally, researchers who are trying to develop animal-like robots replicate CPGs using simple neuron models or oscillators, which are not biological time scales, and are thus considered to be bio-inspired systems rather than bio-mimetic ones. These models, however, merely provide sinusoidal oscillations, and are hence unable to faithfully reproduce a variety of animal locomotion patterns.



The snake robot developed by the researchers. Credit: Blanchard, Aihara & Levi.

In their study, Levi and his colleagues set out to develop biomimetic CPGs that can effectively replicate biological behavior, using a digital real-time neuromorphic system. The snake robot they developed has two key components, one acting as its brain and the other as its body.

"Our snake robot can be split in 2 parts," Levi explained. "The first one is its brain, using biomimetic neural networks. This neural network is very close to biology with biophysically neuron model, synapses and plasticity. The second part is the body, which has different "wagons" that

model the different part of the spinal cord and segments of snakes. The signal is created by the snake brain and it is propagated in all the body controlling the different motors."

The snake robot created by Levi and his colleagues is controlled in real time by a network of biomimetic CPGs. The researchers showed that their system can be connected to biological neurons and could also be used to simulate different hypotheses or protocol treatments for biomedical applications, such as spinal cord injuries and neuroprosthetics.

"In my opinion, the most meaningful aspect of our study is that we tried to be faithful to biology and managed to succeed in embedding the neural network in one small electronic bead," Levi said. "Interestingly, the robot we created is working in real-time and has the same specifications as in nature (period of locomotion, variability, noise, etc.)."

In the future, the snake robot developed by Levi and his colleagues could have a variety of interesting applications in robotics and other fields. For instance, it could be used to better understand the behavior of reptilians or it could have multiple bio-hybrid robotics applications.

"We are now planning to add more intelligence in the robot's brain with learning rules, as well as using the different sensors," Levi said.

"Moreover, one of our longer term objectives is to combine artificial neurons and living neurons to create one bio-hybrid [robot](#)."

More information: Snake robot controlled by biomimetic CPGs. [DOI: 10.2991/jrnal.k.190220.010](https://doi.org/10.2991/jrnal.k.190220.010) . www.atlantis-press.com/journals/jrnal/125905736

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