Considering Snake Locomotion with “Continuum Legs”

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1 Motivation

Both legged and limbless animals often exhibit various types of locomotion by adapting to the current circumstances encountered in real time. This ability has been honed by evolutionary selection pressure, and there likely exists an ingenious mechanism that underlies any type of locomotion. Clarifying this mechanism will lead us to elucidate the fundamental principle of animal locomotion as well as to realize “multi-functional robots” that behave like animals.

2 State of the Art

Autonomous decentralized control mechanisms, in which the coordination of simple individual components yields non-trivial macroscopic behavior or functionalities, could be the key to understand this remarkable ability of animals. In fact, autonomous decentralized control mechanisms have been discovered in several living organisms [1]. Thus far, numerous studies have been devoted to elucidate the essence of the autonomous decentralized control mechanisms from biomechanical as well as robotic viewpoint [1]; however, it is not yet clearly understood.

3 Own Approach

To tackle this problem, we focused on snakes as our model. Although snakes have simple one-dimensional bodily structure, they exhibit versatile gait patterns in response to various unstructured environments in real time [2]. This can be achieved by adjusting points of body contact with the ground spatiotemporally. To rephrase, snakes “walk” by using “continuum legs.” In this study, we aimed to clarify the autonomous decentralized mechanism underlying the locomotion of snakes through modeling and simulations.

4 Current Results

We described the musculoskeletal system by a mass-spring-damper model. Each muscle aligned along the backbone is modeled by a spring whose natural length can be actively changed. The natural lengths of the springs are controlled according to the curvature derivative control proposed previously [3]. Since real snakes change their gait patterns by changing points of body contact with the ground, we defined z-coordinate value to each particle and described its time evolution by a simple equation (details will be provided in a camera-ready paper). Simulation results are shown in Fig. 1. By changing parameter values, various gait patterns of real snakes were successfully reproduced.

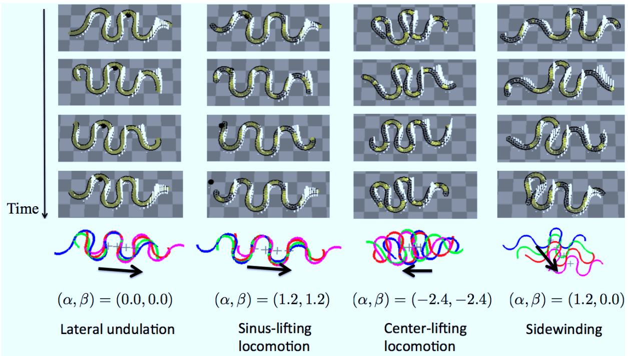

Figure 1: Snapshots (top) and trajectory (bottom) for various parameter values. Arrows indicate moving direction.

5 Best Possible Outcome

We expect that our finding from snakes imparts a novel insight into animals’ versatile locomotion including legged locomotion. Although our proposed model is still specific to the locomotion of snakes, we would like to elucidate a unified principle that underlies various types of animal locomotion on the basis of our finding in the future.

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